GOLDER

REPORT

Peg Leg Pipeline Corridor DEIS Report

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1.0 EXECUTIVE SUMMARY

1.1 Introduction

Resolution Copper Mining (RCM) is evaluating developing a tailings storage facility (TSF) at the “Peg Leg” site in Pinal County, Arizona. The Peg Leg Pipeline Corridor (PLPC) DEIS study considered two potential pipeline corridor alignment options for transport of mill tailings from the West Plant concentrator site to the Peg Leg TSF and return of reclaim water from the Peg Leg TSF back to the West Plant concentrator site. The West Plant Concentrator will produce two types of tailings comprised of Non-Potentially Acid Generating (NPAG) or scavenger tailings (84 percent of whole tailings) and Potentially Acid Generating (PAG) or pyrite tailings (16 percent of whole tailings). The East pipeline corridor is approximately 25 miles long, and it bypasses the town of Superior on the west side along Queen Creek Crossing thus avoiding difficult cross-mountainous terrain associated with the crossing. An alternate option, West, 34 miles is also under consideration. The salient feature of these routes is the fact that the pipelines will be buried, and no intermediate booster pump stations or emergency dump ponds are required thus keeping the disturbance footprint to a minimum and simplification of operations and maintenance of the long-distance slurry transport. Using numerous trade-off studies, benchmark data from similar long-distance tailings pipelines, and a systematic selection approach considering various options that included disturbance footprint acreage, constructability, pump types, and pipeline material types, the most suitable corridor was identified as the East Route.

1.2 Technical Evaluation, Benchmarking and Operational Viability

The commercial transportation of mineral concentrate slurries in buried long-distance pipelines has been successful (technically and economically) for more than 50 years. Since the 1960s, numerous long-distance mineral concentrate slurry pipelines have been constructed; the majority of which are still operational. The development of long distance tailings slurry pipelines has lagged the mineral concentrate pipelines but is becoming more prevalent in recent years with expanding footprint of ore-deposits and general scarcity of land for development of tailings impoundment.

Minera Los Pelambres mine in Chile uses a 36-inch diameter, 30-mile bare carbon-steel pipeline to transport 69 million tons per year (tpy) of whole tailings from the tailings thickeners at the concentrator to the impoundment. The tailings pipeline has been operation since 2003.

In United States, Simplot Phosphates pumps concentrated ore slurry, 87 miles through an underground pressurized pipeline to the manufacturing plant. The Simplot pipeline has a booster pump station at the 60-mile marker. The 8-inch diameter slurry pipeline has been in operation for over 34 years.

Existing tailings pipelines have operated successfully and have demonstrated that with qualified personnel and adherence to operating procedures and maintenance programs, remarkable reliabilities can be achieved. Operating availability of over 98 percent can reasonably be expected for tailings slurry transport systems.

1.3 Constructability

The proposed East and West pipeline corridors are relatively simple than the alternate corridors with sections of moderately difficult construction as compared to similar commercial slurry, oil and gas pipelines. However, with early recognition of the degree of difficulty and with proper planning, including route selection and route geotechnical hazard investigation, the pipeline can be constructed within a predictable cost and schedule, while mitigating impacts to the environment. The PLPC will be constructed in accordance with ASME B31.4 Section 12, Slurry Transportation Piping Systems, and applicable USA, Arizona and local codes and standards. As the project advances, a pipeline corridor construction specification will be formulated for the pipeline corridor construction contractor. It will reflect good pipeline construction practices by using a mix of normal cross-country construction techniques and more advanced techniques such as the Horizontal Directional Drilling (HDD) to minimize environmental impact and mitigate worker health and safety risks.

1.4 Design Basis

The PLPC design is based on the American Society of Mechanical Engineers (ASME) B31.4, Section 12 Code which prescribes requirements for the design, materials, construction, assembly, inspection, testing, operation, and maintenance of piping and transporting aqueous slurries of nonhazardous materials such as mineral ores and concentrates, between a slurry processing plant (West Plant Concentrator) and a receiving plant or terminal (Peg Leg TSF).

1.5 Battery Limits

For the tailings pipelines, the physical battery limits begin at NPAG and PAG thickeners underflow pump discharge at the West Plant Concentrator and ends just upstream of the Peg Leg TSF. For the reclaim water pipeline, the physical battery limits begin at the Peg Leg TSF water tank outlet and ends upstream of the NPAG tailings thickener overflow tank at the West Plant concentrator. For electrical systems, the battery limits begin at a tie-in to the West Plant Substation and ends at various points of use.

1.6 Tailings Throughput

The tailings throughput ramps up to the nominal 121,000 tons per day (tpd) for NPAG and 23,000 tpd for PAG by year 7 of the 41-year life of mine.

1.7 Tailings Characterization

Based on pilot tests and metallurgical test work, the NPAG tailings have a P_{80} (80 percent passing) of 160 microns and the PAG tailings have a P_{80} of 81 microns. NPAG dry solids specific gravity is 2.83 and the PAG dry solids specific gravity is 3.80 due to largely consisting of heavier iron sulfide (pyrite) particles. The viscosity and rheology parameters for the NPAG and the PAG slurries were measured from samples taken during pilot scale testing. The NPAG will be conveyed at a density of 60% solids and the PAG will be at 50% solids.

1.8 Tailings Conveyance

The tailings will be pumped and transported as a thickened slurry in separate carbon steel, buried pipes from the West Plant Site to the Peg Leg TSF, located approximately 25 miles south of the West Plant Site (see Figure 1) following the East route. The slurry conveyance pipelines will be buried steel pipelines for the PAG and NPAG streams. A West route is also being developed that takes a more westerly route and is approximately 34 miles long.

The pipelines will be buried and equipped with a modern control system permitting operation of the entire pipeline from a central control room and including a leak detection system. The leak detection system uses pressure data from the two intermediate pressure monitoring stations which will be located along the pipeline at strategic locations to monitor intermediate conditions in the pipeline. The data supplements pressure and flow data available from the pump station and provides statistical real-time information that supports the leak detection software system and also pipeline operator decision-making.

Specific crossing designs for US 60, Queen Creek and the Gila River have been developed and can be done using aerial span (pipe bridge) or buried crossing using HDD.

All transport pipelines will have intermediate facilities to support ongoing operations and monitoring of the system. These facilities will include emergency isolation valves and pressure monitoring stations. The pipeline Supervisory Control and Data Acquisition (SCADA) system will rely on a fiber optic cable which will be installed along the pipelines in the pipeline corridor and connect remote monitoring stations to a central control room from which the pipeline operation will be monitored on a continuous basis.

All transport pipelines will include facilities to permit routine inspection with intelligent pigs to periodically assess pipeline condition. Intelligent pigs are instrumented plugs that are pumped down the pipeline to assess pipeline integrity through detection of pipeline wall loss due to corrosion and wear. This is consistent with transport pipelines designed in accordance with ASME B31.4 and consistent with anticipated regulatory guidelines for the proposed pipelines.

1.9 Pipeline Corridor

1.9.1 East Route

The East Route starts at the West Plant Concentrator. The early terrain has low difficulty and good topographical conditions for normal pipeline construction. The US 60 crossing will require trenchless technology. After the US 60 crossing and Queen Creek is crossed (the crossing of both will be completed with either Horizontal Directional Drilling and/or Micro Tunneling) and the terrain becomes gentler with flatter slopes and relatively gentle topography with adequate work space. The co-location of the pipeline corridor and existing powerline in the area is envisioned, as it will consolidate the pipeline surface disturbance with the existing power line easement. At about the 8-mile marker, the terrain starts changing again and gradually transitions into “very difficult” Classification Type 4 (see section 1.10) for pipeline construction due to steep slopes and side hill cuts, which will most likely require rock blasting. Tunnel or HDD will be required beneath the high point mountain pass at the 11-mile marker. There is a 3300-foot tunnel through the pass, maintaining the 15 percent pipe slope to the south.

Rock excavation in conglomerate, limestone, metasedimentary and igneous rock will be required until the corridor approaches the Gila River. There are ravine crossings and steep drainages requiring pipe bridges. A pipe bridge or trenchless technology and rock excavation will be required at the Gila River crossing.

From the Gila River to the Peg Leg TSF, the pipeline corridor generally follows relatively gentle terrain terminating at about mile marker 25.

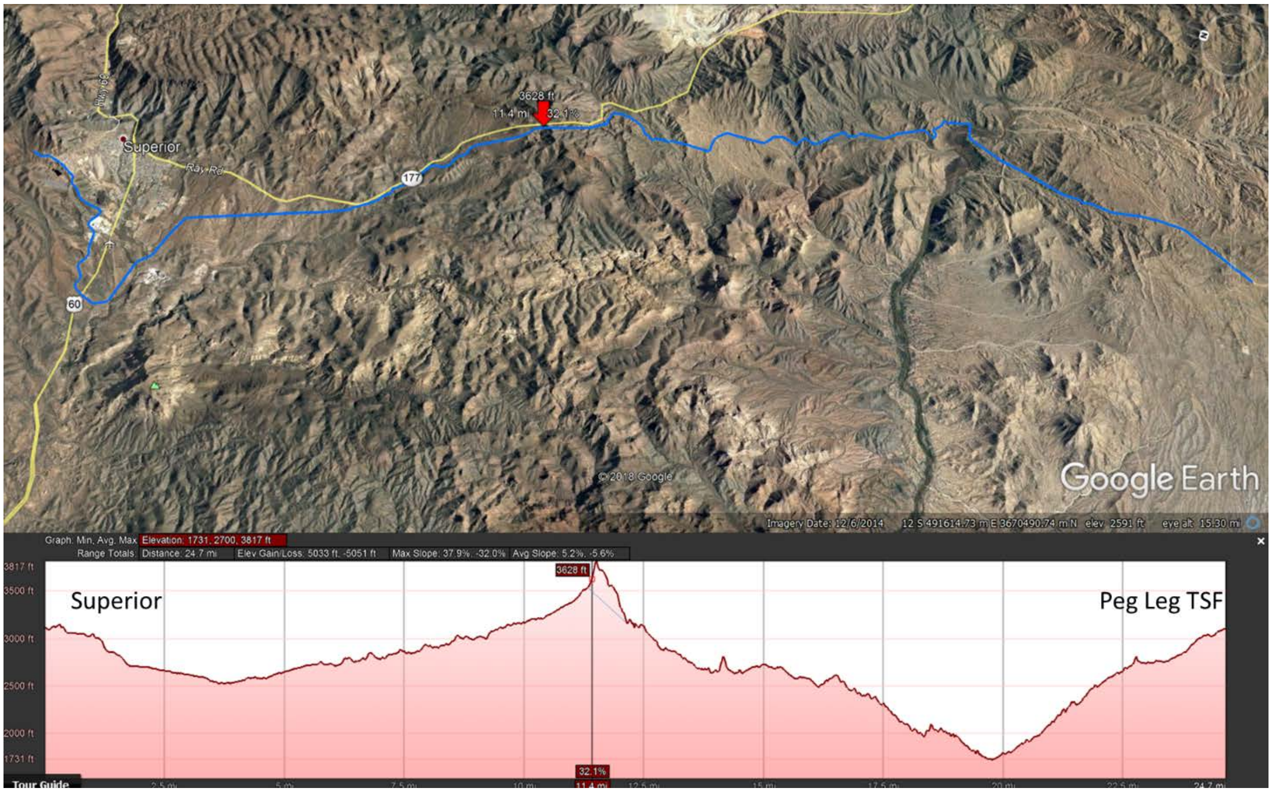

Figure 1 - Pipeline Routing, East route

1.9.2 West Route

The first 5.5 miles of the West route follows the exiting MARRCO railroad right of way. The pipeline diverges to the south off the railroad across both Queen Creek and State Highway 60. The crossing of both will be completed with either Horizontal Directional Drilling and/or Micro Tunneling.

At about mile 7.5 the pipeline enters the low hills, following the existing roads for about 2 miles.

At 9.5 miles the pipeline travels overland to the south for 2.25 miles, where it parallels ridges and the construction is difficult with blasting and steep slopes more prevalent.

At 11.75 miles the pipeline exits the steeper terrain and follows roads and open land routes to the south. For 7.25 miles the alignment has shallow slope with conventional installation. Several incised drainages will be crossed with open cut trench crossing technology.

At 19 miles a small ridge is skirted through and the pipeline turns to the east toward the Gila River Crossing. The terrain is undulating, crossing both larger and smaller drainages which will be crossed with open cut trench crossing technology.

The Copper Basin Railway and Gila River crossing is at about mile 23. The railroad and Gila River are crossed with either HDD or Micro Tunneling. The Gila River crossing is about 1200 feet in length. No surface features will remain following the installation of the rail or river crossing.

South of the Gila River the pipeline follows gentle terrain for two miles, climbs over the south flank of Grayback Mountain for about a mile and continues to the TSF at mile 33.5. Drainages are crossed throughout this section and will be crossed with open cut trench crossing technology.

This route follows a significant length of road and Rail reducing the amount of access road and new disturbance required during construction. The northern section can be accessed from Hwy 60 and the southern section can be access via the Florence Kelvin highway. Re-grading and maintenance of smaller tracks to the pipeline will be necessary to deliver pipe and operators to the ROW. Where possible the ROW will be used for ROW access.

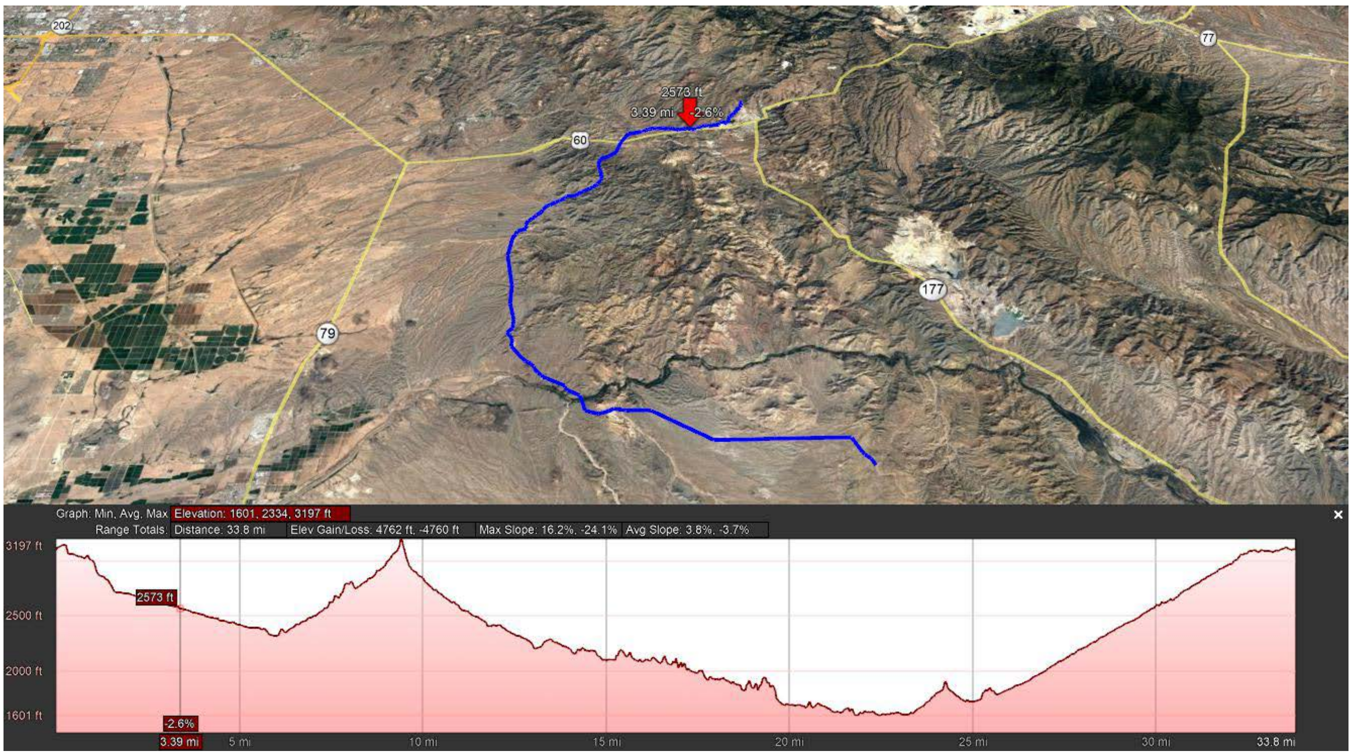

Figure 2 - Pipeline Routing, West route

1.10 Pipeline Corridor Construction Types

Classification of the Construction Type was defined by Golder during the January 2018 site inspection. The pipeline corridor construction was classified into four types. The construction classification type also relates to the disturbance area. Classification Type 1 (Easy) is for flat and light rolling hills where double jointing is possible. Classification Type 2 (Average) is reserved for rolling hilly terrain with some difficulty however double jointing is practical in majority of the areas. Classification Type 3 (Difficult) is hilly terrain with steep slopes, where double jointing is not practical and side hill cuts, box cuts, and side casting construction methodology will be required. Classification Type 4 (very difficult) consists of hills and valleys with very steep slopes and high degree of difficulty with major constraints; side hill cuts, box cuts, side casting, solid rock excavation and blasting are required.

1.11 Pipeline Disturbance Area

Based on the disturbance width associated with each construction type – 110 feet (Type 1), 160 feet (Type 2), 190 feet (Type 3), and 230 feet (Type 4), the disturbance area associated with East route is 465 acres and is estimated to be approximately 628 acres with West route (based on limited review).

Existing roads will be used to access the pipeline ROW and no new disturbance is anticipated. Re-grading and maintenance of smaller tracks to the pipeline will be necessary to deliver pipe and operators to the ROW. Where possible the ROW will be used for ROW access.

1.12 Scope of Facilities

The OOM level developed for the slurry pump and pipeline system is based on the slurry properties from testing performed by RCM in previous studies.

The following facilities are included in the PLPC system:

- Linear Screens at the West Plant Concentrator
- Holding and Buffer tanks at the West Plant Concentrator
- Slurry Pump Stations (NPAG & PAG) at the West Plant Concentrator including charge pumps and mainline piston diaphragm (PD) pumps
- Water supply, seal water filtering and storage at the West Plant Concentrator
- NPAG and PAG Slurry Pipelines and Reclaim Water Pipeline
- Reclaim Water Pumps
- Corrosion inhibitor system such as the Cathodic protection system
- SCADA System
- Electric power distribution at the pump station

1.12.1 West Plant Concentrator Facilities

PLPC facilities located at the West Plant Concentrator includes screens, holding tanks, NPAG and PAG charge pump stations and PD pump stations, E-house facility and sumps.

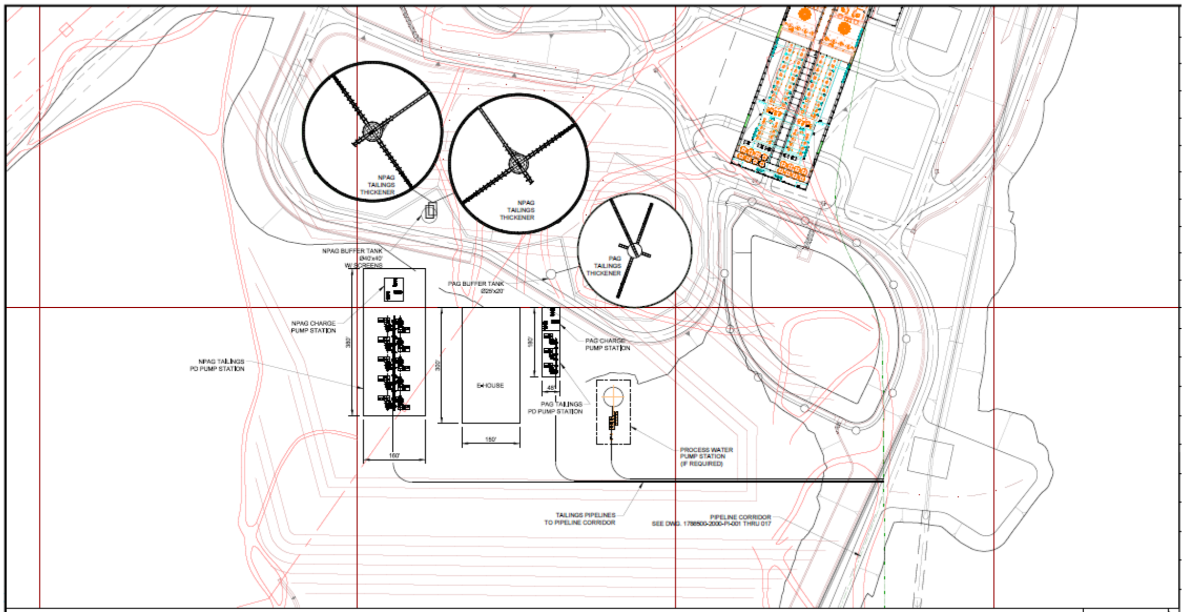

Figure 3 - General Layout of the Peg Leg Pipeline Facilities at the West Plant Concentrator Site

The PLPC begins at the designated discharge pipe flanges of the PAG and NPAG thickeners (by others) at the West Plant Concentrator. Process makeup water and pipeline flushing water for the NPAG and PAG pump stations will be provided from the process water storage tank/pond. The electric power supply to the concentrate pumping system will be from the West Plant Concentrator main electrical power supply system.

1.12.2 Pipelines

Three pipelines are envisioned to handle the nominal design slurry flows during the mine-life. These pipelines are 34-inch bare carbon steel pipeline for NPAG (1.25-inch wall, 22-inch (0.375-inch wall thickness) with 0.5-inch HDPE lined PAG pipe, and a 16-inch bare carbon steel reclaim water pipe (0.375-inch thickness). These thicknesses are required to handle the pressure and for wear allowance to transport the slurry the distance between the concentrator and the TSF.

Tailings Slurry Transport Process Description

As shown on drawings in Appendix A, Process Flow Diagrams, the NPAG and PAG slurry from the West Plant Concentrator will be thickened to 60 percent (w/w) and 50 percent (w/w), respectively. For both NPAG and PAG, a pair of centrifugal charge pumps with variable speed drives, will draw slurry from the agitated slurry buffer tanks which are downstream of the thickeners and discharge slurry to feed the mainline PD pumps.

For PAG, all three mainline PD pumps are driven with variable speed motors, normally two are operating and one is on standby. The PD pumps provide the necessary pressure to overcome pipeline elevation changes and frictional losses. Similar, albeit more (seven operating and one standby) and larger mainline PD pumps are required for the NPAG transport.

Except when stopped for emergency, pipeline pigging, maintenance or due to power outage, the pipelines will operate continuously.

Two pressure monitoring stations will be located along the PLPC at key locations to monitor intermediate conditions in the pipeline. This data supplements pressure data available from the pump stations, provides information that supports operator decision-making and the leak detection system. A third monitoring station will be incorporated into the Modified West route due to its further length.

The pipeline corridor ends at the Peg Leg TSF whereby the PAG tailings are sub-aqueous delivered to the PAG cells and the NPAG streams are delivered to the NPAG sump from where they are either cycloned to provide sand for dam construction or spigot discharged into the TSF after water recovery using thickeners.

1.13 Pipelines Operation and Control

The slurry pipelines system is designed to operate continuously. Long-term shutdowns with slurry (duration greater than 24 hours) will be avoided as it will require complete pipeline flushing with water. An important operational safety feature includes the pipeline SCADA leak detection system located at the West Plant control room and at the Peg Leg TSF control room. The pump stations, intermediate pressure monitoring stations and the terminal points of the pipelines at the Peg Leg TSF are connected via a fiber optic communications link that follows the pipeline right of way. The pipeline and its facilities are monitored and controlled by the SCADA system. This system is based on programmable logic controllers (PLC), which handle all primary control and interface with field equipment. The PLCs report to the West Plant control room.

Control and monitoring of the tailings pipelines will normally be from the West Plant Concentrator control room at the mine site. All system controls and operating data will be available in the control room, which is manned 24 hours per day. Control of the system will be automatic in the steady state mode with operator intervention required during process upsets, shutdowns, and restarts. A local PLC will be provided at each PAG and NPAG PD pump station, pressure monitoring stations and at the Peg Leg TSF control room.

All pertinent pipeline data will be available at the West Plant control room and alerts will be developed that will automatically indicate if abnormal or emergency conditions exist such as off-specification slurry or a leak or plug in the pipelines.

Shutdown with tailings in the pipelines will be accomplished by a sequenced de-energization of pump stations. Restart will be accomplished with a measured slow start of each pump station (including the charge pump station) in a predetermined sequence. Prior to an extended planned shutdown, the pipelines will be flushed with water. However, this is not a frequent event during normal operation once the mine reaches full production capacity.

2.0 PIPELINE DESIGN BASIS

2.1 Throughput

The tailings production schedule provided by RCM (2016 GPO) is summarized in Table 1 and was used as the basis for developing hydraulic calculations.

Table 1: Tailings GPO Basis used for Throughput

Year	Scavenger Tailings Tons/year	Pyrite Tailings Tons/year	Total Tailings Tons/year	Scavenger Tailings Cumulative Tons	Pyrite Tailings Cumulative Tons	Total Tailings Cumulative Tons
1	5,346,486	766,631	6,113,118	5,346,486	766,631	6,113,118
2	7,187,504	991,640	8,179,144	12,533,990	1,758,272	14,292,262
3	7,897,945	1,014,556	8,912,501	20,431,935	2,772,828	23,204,763
4	15,085,826	2,110,526	17,196,352	35,517,761	4,883,354	40,401,115
5	21,902,288	3,328,288	25,230,577	57,420,049	8,211,642	65,631,691

Year	Scavenger Tailings Tons/year	Pyrite Tailings Tons/year	Total Tailings Tons/year	Scavenger Tailings Cumulative Tons	Pyrite Tailings Cumulative Tons	Total Tailings Cumulative Tons
6	28,780,765	4,569,518	33,350,283	86,200,814	12,781,160	98,981,974
7	34,178,734	5,793,075	39,971,810	120,379,548	18,574,236	138,953,784
8	37,849,588	7,340,459	45,190,047	158,229,136	25,914,695	184,143,831
9	37,128,274	8,184,034	45,312,308	195,357,410	34,098,729	229,456,139
10	36,749,978	8,772,867	45,522,845	232,107,388	42,871,596	274,978,984
11	37,121,210	8,792,910	45,914,120	269,228,598	51,664,506	320,893,104
12	38,040,923	8,019,027	46,059,950	307,269,521	59,683,534	366,953,054
13	37,486,298	6,800,935	44,287,232	344,755,818	66,484,468	411,240,286
14	39,582,789	6,518,836	46,101,626	384,338,608	73,003,305	457,341,912
15	39,666,729	6,589,905	46,256,634	424,005,337	79,593,209	503,598,546
16	39,211,923	6,919,174	46,131,097	463,217,260	86,512,384	549,729,644
17	38,679,739	7,360,739	46,040,478	501,896,999	93,873,123	595,770,121
18	38,273,841	7,838,027	46,111,868	540,170,839	101,711,149	641,881,989
19	38,130,733	8,150,877	46,281,610	578,301,573	109,862,027	688,163,599
20	38,448,597	7,968,471	46,417,068	616,750,170	117,830,497	734,580,668
21	38,926,908	7,537,946	46,464,854	655,677,079	125,368,443	781,045,522
22	39,028,952	7,382,565	46,411,517	694,706,031	132,751,008	827,457,039
23	39,006,219	7,367,901	46,374,120	733,712,249	140,118,909	873,831,159
24	38,564,309	7,824,341	46,388,650	772,276,558	147,943,251	920,219,809
25	38,008,651	8,406,901	46,415,552	810,285,209	156,350,152	966,635,361
26	37,822,090	8,629,862	46,451,952	848,107,300	164,980,014	1,013,087,313
27	38,599,981	7,902,469	46,502,450	886,707,281	172,882,483	1,059,589,764
28	39,472,443	6,988,070	46,460,513	926,179,724	179,870,553	1,106,050,277
29	39,579,974	6,796,869	46,376,843	965,759,698	186,667,422	1,152,427,120
30	39,595,841	6,786,681	46,382,522	1,005,355,539	193,454,103	1,198,809,642
31	39,503,382	6,740,343	46,243,725	1,044,858,921	200,194,445	1,245,053,366
32	31,481,866	5,391,484	36,873,350	1,076,340,787	205,585,929	1,281,926,716
33	24,576,943	4,320,111	28,897,054	1,100,917,730	209,906,040	1,310,823,770
34	18,707,166	3,478,519	22,185,685	1,119,624,896	213,384,559	1,333,009,455
35	13,146,108	2,643,079	15,789,186	1,132,771,004	216,027,637	1,348,798,641
36	9,566,562	1,952,428	11,518,989	1,142,337,565	217,980,065	1,360,317,631
37	4,993,554	1,079,281	6,072,835	1,147,331,119	219,059,346	1,366,390,465
38	2,121,484	545,241	2,666,725	1,149,452,603	219,604,587	1,369,057,190
39	928,110	274,819	1,202,929	1,150,380,713	219,879,406	1,370,260,119
40	326,877	99,724	426,602	1,150,707,590	219,979,130	1,370,686,720
41	19,505	4,936	24,440	1,150,727,095	219,984,066	1,370,711,161

2.2 Tailings Particle Size Distribution

2.2.1 NPAG Tailings

Table 2 shows the particle size distribution (PSD) for NPAG scavenger tailings that was used for the pipeline design.

Table 2: NPAG Tailings PSD

Size (µm)	U.S. Mesh	Wt. % Retained	Cumulative Wt. % Passing	Cumulative Wt. % Retained
300	50	0.50	99.50	0.50
212	70	7.50	92.00	8.00
145	100	16.00	76.00	24.00
106	140	14.00	62.00	38.00
74	200	11.00	51.00	49.00
53	270	8.00	43.00	57.00
37	400	6.00	37.00	63.00
-37		37.00		100.00
	Total	100%		

- P_{95} – 244 microns
- P_{80} – 159 microns
- D_{50} – 71 microns

2.2.2 PAG Tailings

Table 3 shows the particle size distribution (PSD) for PAG pyrite tailings that was used for the pipeline design.

Table 3: PAG Tailings PSD

Size (µm)	U.S. Mesh	Wt. % Retained	Cumulative Wt. % Passing	Cumulative Wt. % Retained
300	50	0.2	99.8	0.2
212	70	2.0	97.8	2.2
150	100	5.4	92.4	7.6
106	140	6.2	86.2	13.8
75	200	8.0	78.2	21.8
53	270	9.7	68.5	31.5
45	325	5.8	62.7	37.3
37	400	5.5	57.2	42.8
-37		57.3		100.0
	Total	100%		

- P_{95} – 177 microns
- P_{80} – 81 microns
- D_{50} – 31 microns

2.3 Pipeline Design Standards

The design criteria shall be according to the Peg Leg TSF Pipeline Corridor Project's General Specifications for mechanical equipment, electrical, piping, civil, structural steel, concrete, and materials. The design shall also be in accordance with the requirements of U.S. national and local laws, ordinances, and regulations. Table 8 includes the design standards to which this project will adhere to.

Table 4: Pipeline Design Standards

Standard	Document Title
ASME B31.4 – 2012	Slurry Transportation Piping Systems
Relevant regulatory standards governing pipeline	Includes Leak Detection system, might include segmentation valve or isolation valves at river crossings
Slope restriction on route	12% max
Gradient line clearance	82 feet (25 meter)
Length factor for route/cost	5%
Safety factor for sizing pumps	+10% of volumetric flow for head loss calculation
Discipline standards	Golder developed

2.4 Pipeline Head Losses

The tailings pipeline head losses have been calculated using a proprietary slurry model developed by Golder. The water pipeline head losses were calculated using the Darcy-Welsbach equation.

2.5 Pipeline Operating Pressures

The maximum allowable steady-state operating pressure for carbon steel pipe has been calculated using Barlow's formula with a design factor of 0.80 per B31.4, or 0.60 in critical sections.

The maximum allowable steady-state operating pressure for HDPE pipe will be 80 percent of the manufacturer's pressure rating for the specified DR of the pipe. For the pipeline corridor, HDPE pipe is not under consideration except as a liner which is not affected by temperature.

For the PAG slurry line, the operating pressure will be a maximum of 1193 psi for the modified 2E route and 1622 psi for the modified West route. For the NPAG slurry line, the maximum operating pressure is 1111 psi for the modified 2E route and 1428 psi for the modified West route. For the reclaim water pipeline, the maximum operating pressure is 1034 psi for the East route and 1174 psi for the West route

2.6 Pipeline Life

Pipeline life is dependent on erosion (wear) due to abrasion and erosion (chemistry). Corrosion and erosion testing have not been performed at this time. Golder will evaluate the process water chemistry for corrosion in future design optimizations. To be conservative, corrosion was determined to be likely and pipeline thickness was increased to account for it. Pipeline material was selected based on benchmark operational data available from similar projects. Golder will identify sections of pipelines that may be susceptible to high wear and provide alternate options such as rubber-lining. The objective will be to design the pipeline system to last 41 years (life of the project).

2.7 Pipeline Wear

The material loss rate in a slurry pipeline termed wear is caused by two components: corrosion and/or erosion/abrasion.

2.7.1 Corrosion

Corrosion in tailings is driven by water quality. If the process water contains a high level of dissolved solids, it will have a high conductivity which is the key indicator for corrosion potential. A conductivity level higher than 1000 micro-siemens/cm is considered to indicate corrosion is likely in a steel pipeline. Water quality data provided by RCM did not include conductivity – however, the presence of more than 1700 ppm of sulfates indicates that conductivity is likely more than 1000 micro-siemens/cm. For Peg Leg evaluation, the process water is considered corrosive.

2.7.2 Erosion

Erosion is caused by the dynamic action of moving particles either by the particles impinging the pipe wall (impact abrasion) or by the particles sliding against the pipe wall (abrasive erosion). Major factors which effect erosion include the following:

- Particle size distribution – quantity of “coarse” material (+65 mesh, ~ 0.21 mm) is an indicator of the erosion potential. Although this material is generally suspended in the slurry stream, it tends to accumulate in the lower half of the pipeline increasing the risk of erosion.
- Oversize material – generally considered anything over ~1 mm particles. These cannot be suspended in the slurry stream irrespective of pipeline velocity – bounces or drags along the bottom of the transport pipeline causing accelerated bottom wear.
- Age of the particles – freshly ground material has sharp edges which increases the erosion potential – mature particles (such as beach sand) have rounded edges and have low erosion potential despite a generally coarse particle size.
- Slurry Flow Regime – slurry velocity, whether the pipeline is operating in laminar or turbulent flow.

In the Peg Leg long distance pipelines, the properties of the solids are controlled to ensure the risk of erosion is minimized. Erosion control will primarily be achieved by ensuring the pipeline is operating in turbulent flow regime to prevent particles from dragging at the bottom of the pipe. NPAG particles which are coarser (P_{80} ~ 159 microns), will be screened for oversize upstream of the pump-station before the pumps thus, minimizing the oversize. No upstream screening of PAG slurry is required as it consists of finer particles with a P_{80} of 81 microns.

2.8 Pipeline Material Selection

Pipeline materials considered for NPAG and PAG slurry transport were bare Carbon Steel (CS), High-density polyethylene (HDPE), HDPE lined CS, Rubber-lined CS, and Polyurethane lined CS. Based on benchmark data from two long-distance tailings pipelines operating in South America, bare CS pipe with a wall thickness of 1.25 inch was chosen for NPAG tailings. For finer PAG tailings, 0.5-inch HDPE lined CS pipe with a wall thickness of 0.375-inch was chosen based other commercial operations and material trade-off study. The reclaim water will be bare CS pipe with a wall thickness of 0.375 inch.

3.0 HYDRAULIC DESIGN - NPAG AND PAG TAILINGS TRANSPORT

3.1 Design Methodology

The NPAG and PAG tailings transportation lines are pressurized slurry lines. The pipe diameter, pipe material specification, pipe wall thickness, pumping power, pump technology and number of pumps for the slurry lines are determined based on the operating pressure of the pipe and minimum velocity considerations.

3.1.1 Minimum Velocity

The pipe diameter was determined so that operating velocity is higher than three velocities; the deposition velocity, the transition velocity, and the critical inflection velocity. Deposition velocity is the velocity at which the heaviest particles in the stream start to deposit as the turbulent energy in the fluid is not enough to suspend them in the flow stream. Transition velocity is the velocity at which the flow transitions from turbulent to laminar flow. The critical inflection velocity refers to the point of inflection which results when plotting friction loss head against velocity. In laminar flow, the operating velocity at the pipe wall is zero which results in solids accumulating in the bottom of the pipe. If the operating velocity is below any of these three velocities, a bed of slurry particles starts to form at the bottom of the pipe. These velocities are dependent on the rheological properties of the slurry material, solids concentration, and pipeline diameter, among other factors. The deposition velocity is determined using models provided by McElvain & Cave. The transition velocity is calculated based on a Bingham plastic model developed by Slatter and Wasp.

At the design transport concentrations for NPAG tailings, the deposition velocity was found to be the limiting minimum velocity and was used to determine the diameter of the pipelines. However, for the PAG tailings the transition velocity was limiting factor for sizing the pipeline. A 34-inch bare carbon steel pipeline for NPAG (1.25-inch wall) resulting in 31.5-inch internal diameter and a 22-inch (0.375-inch wall thickness) with 0.5-inch HDPE lined carbon steel pipe for PAG resulting in an internal diameter of 19.5-inch satisfied the minimum slurry criteria described above.

3.2 Pump Station Design

A trade-off study between Centrifugal pumps that are limited to 800 psi maximum pressure versus PD pumps, which can handle a much higher operating pressure resulted in selection of PD pumps for NPAG and PAG pumping. This also resulted in the elimination of any booster pumps along the route and the associated infrastructure, disturbance, spill potential, and contingency ponds.

3.3 Hydraulic Design

3.3.1 Steady State (Beyond Year 7)

3.3.1.1 NPAG Tailings

The thickened NPAG tailings will be pumped from the NPAG storage tank at the West Plant Concentrator site via a 34-inch carbon steel pipeline to the TSF. This line is sized for the minimum velocity as described in Section 3.1.1 for the design flow rate of 22,327 gpm. To account for corrosion and wear allowance, a wall thickness of 1.25-inches was chosen for the pipeline.

3.3.1.2 PAG Tailings

The thickened PAG thickened tailings will be pumped to the Peg Leg TSF via a 22-inch HDPE lined carbon steel pipeline from the PAG storage tank located in the West Plant Concentrator area at a design flowrate of

6,389 gpm. This pipeline is sized for the minimum velocity as described in Section 3.1.1 for the design flow rate. Table 9 summarizes the hydraulic design of the NPAG and PAG pipelines.

Table 5: NPAG and PAG Tailings Pipeline Hydraulic Design

Parameter	NPAG Tailings	PAG Tailings
Pipe Nominal Size	34 inch	22 inch
Pipe Material	Carbon Steel API 5L X70 [4]	Carbon Steel API 5L X70
Pipe Liner	None	HDPE
Pipe Thickness	1.25 inch CS	0.375 inch CS 0.5 in HDPE Liner
Pipe I.D.	31.5 inch	20.25 inch
Pipe Absolute Roughness	0.0018 inch	0.00006 inch
Transport Concentration	60 wt.%	50 wt.%
Slurry S.G.	1.62	1.56
Slurry Dynamic Viscosity	0.020375 Pa.s	0.014293 Pa.s
Slurry Yield Stress	3.55 Pa	2.70 Pa
Design Flow Rate [1]	22,327 gpm	6,389 gpm
Nominal Flow Rate [2]	20,741 gpm	5,100 gpm
Deposition Velocity	8.1 fps	5.12 fps
Critical Inflection Velocity	4.79 fps	5.63 fps
Transition Velocity	3.99 fps	3.55 fps
Operating Velocity @ Maximum Flow	9.19 fps	8.05 fps
Operating Velocity @ Nominal Flow	8.54 fps	6.43 fps
Friction Head Loss @ Maximum Flow [3]	0.84 ft/100 ft	1.17 ft/100 ft
Friction Head Loss @ Nominal Flow [3]	0.73 ft/100 ft	0.87 ft/100 ft

Notes:
1. Maximum flow rates are based on the GPO.
2. Nominal flow rates are based on total nominal ore production of 132,000 STPD which include 84% NPAG tailings and 16% PAG tailings.
3. The friction head loss includes 10% safety factor.
4. The two-digit number following the “X” indicated the Minimum Yield Strength (in 000’s psi) of pipe produced to this grade, e.g. X70 grade pipe requires to have a Minimum Yield Strength of 70,000 psi.

Figure 4 and Figure 5 illustrate the NPAG and PAG pipeline profile, hydraulic gradient, and Maximum Allowable Operating Head (MAOH) for the slurry system from the process plant pump station to the Peg Leg TSF utilizing the East route at design flow rates.

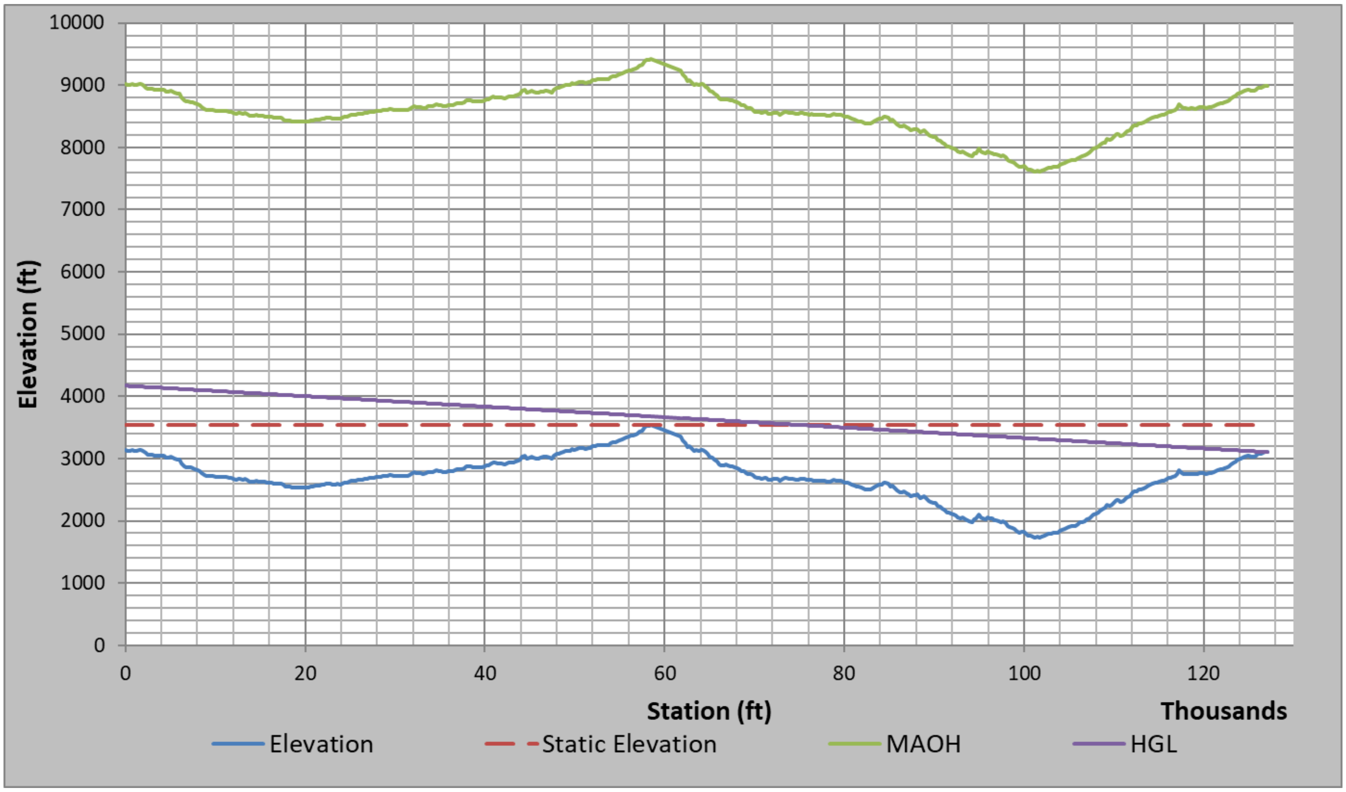

Figure 4 - NPAG Tailings, East Pipeline Hydraulic Gradient Line

Notes:

1. The MAOH shown in feet of head for 34-inch API 5L X70 carbon steel pipe.
2. The static elevation line is the expected condition when the pipeline is shut down, full of slurry.
3. The hydraulic gradient line (HGL) is the expected operating condition reflecting estimated pipeline friction loss and approximate pump station location and the pump required head.

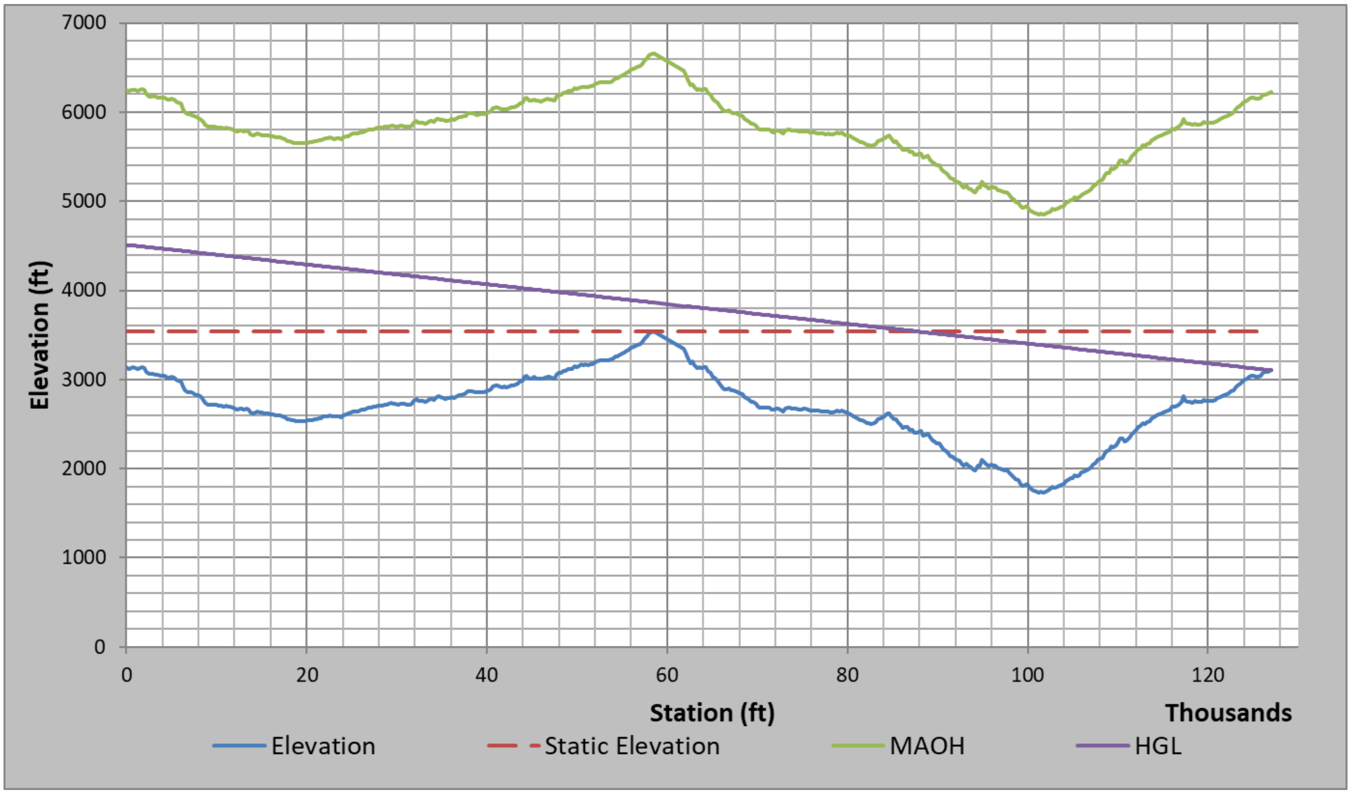

Figure 5 - PAG Tailings, East Pipeline Hydraulic Gradient Line

Notes:

1. The MAOH shown in feet of head for 20-inch API 5L X70 carbon steel pipe.
2. The static elevation line is the expected condition when the pipeline is shut down, full of slurry.
3. The hydraulic gradient line (HGL) is the expected operating condition reflecting estimated pipeline friction loss and approximate pump station location and the pump required head.

Figure 6 and Figure 7 illustrate the NPAG and PAG pipeline profile, hydraulic gradient, and Maximum Allowable Operating Head (MAOH) for the slurry system from the process plant pump station to the Peg Leg TSF utilizing the modified West route at design flow rates.

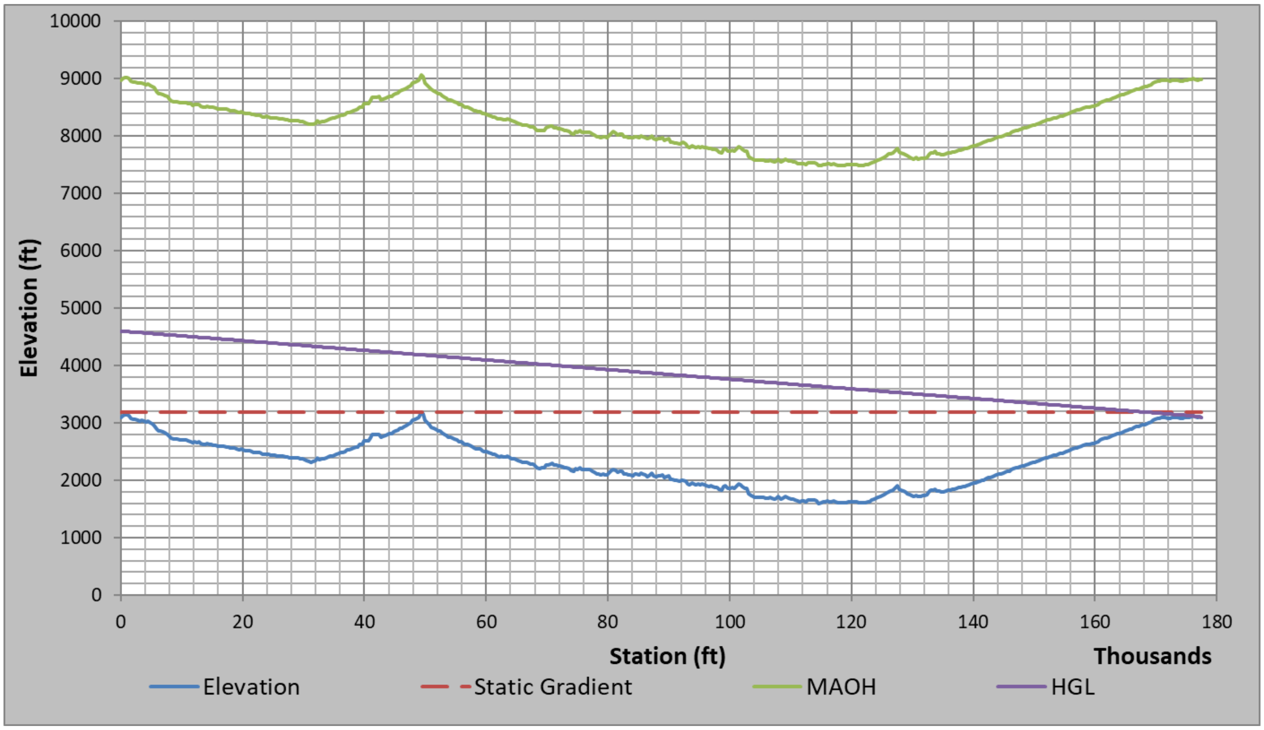

Figure 6 - NPAG Tailings, West Pipeline Hydraulic Gradient Line

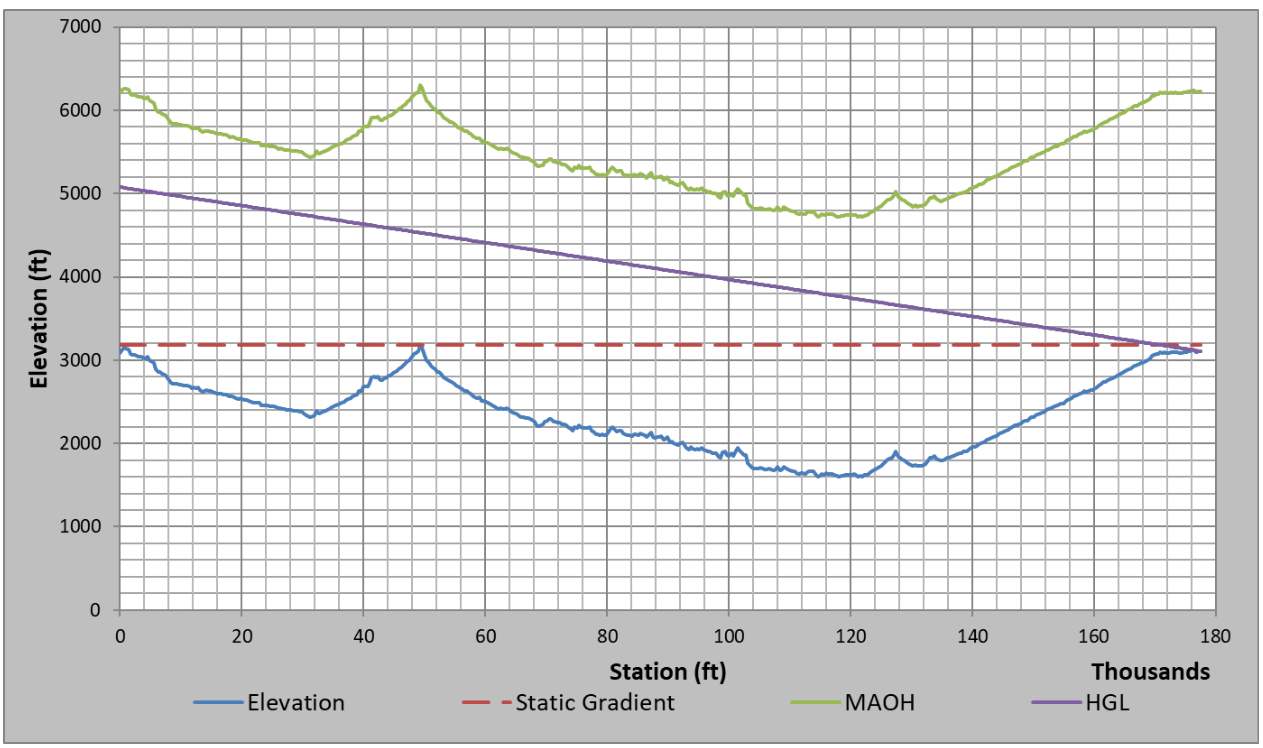

Figure 7 - PAG Tailings, West Pipeline Hydraulic Gradient Line

3.3.2 Reclaim Water

Reclaim water will be pumped from the Peg Leg TSF reclaim water tank to the West Plant Concentrator Area. Based on the Peg Leg TSF water balance, 16-inch standard weight bare carbon-steel pipe will be used for the reclaim water pipeline. The analysis is based on a reclaim water flowrate of 4,314 gpm.

3.3.3 Ramp Up (Year 1 to Year 7)

Because of the minimum velocity criterion, slurry pipelines are sized so that the pipeline operating velocity remains above the minimum velocity at all times. As such, the turn down ratio of slurry pipelines is limited. This limitation poses a challenge during the ramp-up years (year 1 to year 7) when the mill and concentrator are operating with solids throughput significantly lower than the steady state operation in the out-years. Minimum velocities for various solids concentrations for NPAG and PAG slurries were calculated using the particle size distribution and rheology parameters determined from pilot-scale testing.

During the ramp-up years, NPAG tailings stream will be pumped using the 22-inch pipeline which will be used later for steady state PAG transport. For PAG tailings during the ramp-up years, a 10-inch carbon steel pipeline will be used. Hydraulic design of the pipelines is summarized in Table 6.

Table 6: Hydraulic Design of Startup NPAG, Startup PAG and Water pipeline (LOF)

Parameter	PAG Tailings (Yr 1 – Yr 6)	NPAG Tailings (Yr 1 – Yr 5)	Reclaim Water (LOF)
Pipe Nominal Size (in)	10	22	16
Pipe Material	Carbon Steel API 5L X70 [3]	Carbon Steel API 5L X70	Carbon Steel
Pipe Liner	None	HDPE	None
Pipe Thickness (in)	0.365	0.375 CS 0.5 Liner	0.375 CS
Pipe I.D. (in)	10.02	20.25	15.25
Pipe Absolute Roughness (in)	0.0018	0.00006	0.0018
Transport Concentration (wt%)	Varies (26% - 50%)	Varies (28% - 60%)	n/a
Slurry S.G.	Varies (1.23 – 1.56)	Varies (1.22 – 1.62)	1.00
Slurry Dynamic Viscosity (Pa.s)	Varies (0.0017 – 0.0049)	Varies (0.0022 – 0.0204)	n/a
Slurry Yield Stress (Pa)	Varies (0.0001 – 0.0905)	Varies (0.0009 – 3.5492)	n/a
Flow Rate [1] (gpm)	Varies (1,227 – 3,016) [1]	Varies (5,070 – 11,600) [1]	4,314
Minimum Required Velocity (fps)	Varies (4.8 – 4.9)	Varies (4.9 – 8.7)	n/a
Operating Velocity (fps)	Varies (5.0 – 8.9)	Varies (5.0 – 9.5)	7.98
Design Friction Head Loss [2] (ft/100 ft)	1.55	1.31	0.69

Notes:

1. Design ramp-up flow rates are based on the GPO year 1 to 5.
2. The friction head loss includes 10% safety factor.
3. The two-digit number following the "X" indicated the Minimum Yield Strength (in 000's psi) of pipe produced to this grade, e.g. X70 grade pipe requires to have a Minimum Yield Strength of 70,000 psi.

3.4 Peg Leg Pipeline Summary

Table 7 summarizes the four (4) pipelines that will be used for NPAG and PAG tailings slurry transport to the Peg Leg TSF and the reclaim water pump back to the concentrator.

Table 7: Peg Leg Pipeline Configuration and Duty

Year of Operation	10-inch CS Pipe 0.375-inch wall	22-inch CS pipe 0.375-inch wall 0.5-inch HDPE liner	34-inch CS Pipe 1.25-inch wall	16-inch CS Pipe 0.375-inch wall
1-5 (Ramp-up)	PAG	NPAG		Reclaim Water
6 (Ramp-up)	PAG		NPAG	Reclaim Water
7 – 41 (Steady State)		PAG	NPAG	Reclaim Water

4.0 FACILITIES (EXCLUDING PIPELINES)

4.1 Screens and Buffer Tanks

4.1.1 NPAG

Particle oversize control to mitigate wear in the bare-carbon steel NPAG pipeline requires use of linear screens. The use of linear screens will limit the slurry particle size to 0.04-inch. To handle the throughput of 120,000 tpd NPAG, a total of seven screens (each 270 ft^2) will be required. The use of screens will ensure the NPAG slurry pipeline will last the entire 41-year mine life. However, the initial 2 to 4 miles pipeline sections may need earlier replacement due to corrosion. To mitigate against corrosion, pH adjustments can be made upstream of the pump station or thicker pipe can be used. A NPAG buffer tank 40 feet x 40 feet is included as a part of the screen system between the tailings thickener and the tailings transport pumps.

4.1.2 PAG

The PAG stream will not require screens for wear mitigation as it is relatively fine with a P_{80} of approximately 81 microns that is similar to mineral concentrates. Thus, no screens are envisioned for the PAG slurry and only a buffer tank of 25 feet x 20 feet is required downstream of the PAG thickener and upstream of the PAG charge pumps that feed the PAG delivery pumps for ultimate transport to the TSF.

4.2 Charge Pump Stations

Low head, high flow centrifugal charge pumps are required to direct the feed into the high-pressure PD pumps that ultimately provide the pressure for the long-distance slurry transport. Both the NPAG and the PAG requires one (1) charge pump. NPAG pumps are larger size with 1000 hp motor and the PAG motor is 300 hp.

4.3 Mainline Slurry Delivery PD Pump Stations

Table 6 summarizes the mainline slurry transport pumps. NPAG mainline slurry delivery pumps consist of seven operating and one standby whereas the PAG mainline slurry delivery pumps are two operating and one standby. These are 2,000 hp pumps. These PD pumps have been widely used in numerous similar slurry applications worldwide. The NPAG mainline slurry delivery pumps have 1750 hp motors, with seven (7) operating and one (1) standby.

All the mainline pumps are driven with variable speed motors. Each pump is isolated on the suction and discharge side with slurry valves. On the discharge of each pump is a slurry relief valve to protect the station and the mainline pipeline from overpressure. At the end of the pump discharge header is a flanged elbow that is designed to be removed for inserting “smart pigs” if and when required for cleaning or surveying wall thickness and pipeline condition.

Table 8 Tailings Mainline Pump System for East Route

NPAG	PAG
No of PD Pumps: 7 Operating, 1 standby	No of Pumps: 2 Operating, 1 standby
Flow Rate = 3,189 gpm	Flow Rate = 3,194 gpm
Total Flow = 22,327 gpm	Total Flow = 6,389 gpm
Discharge Pressure = 724 psig	Discharge Pressure = 926 psig
Eff = 93%	Eff = 93%
Power = 1,497 HP (1,750 HP Motor)	Power = 1,793 HP (2,000 HP Motor)
Total Power = 12,250 HP (7 x 1,750 HP Motor)	Total Power = 4,000 HP (2 x 2,000 HP Motor)

For the West route, it is anticipated that larger motors are required; 3,000 hp motors for NPAG slurry line and 3,500 hp motors for the PAG slurry line.

Signature Page

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RS/JN

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July 2, 2018

Mary Rasmussen
US Forest Service
Supervisor's Office
2324 East McDowell Road
Phoenix, AZ 85006-2496

Subject: Resolution Copper Mining, LLC – Mine Plan of Operations and Land Exchange – Skunk Camp & Peg Leg Corridor DEIS Reports

Dear Ms. Rasmussen,

Enclosed for your review and consideration, please find copies of the following baseline reports for the Mine Plan of Operations and Alternatives:

Document Title	Document Date	Author (Organization)	File Key
DEIS Report Skunk Camp Pipeline Corridor	JUL 2018	Golder Associates Inc.	Skunk Camp Corridor DEIS Report.pdf
Peg Leg Pipeline Corridor DEIS Report	JUL 2018	Golder Associates Inc.	Peg Leg Corridor DEIS Report_Final 20180702.pdf

Should you have any questions or require further information please do not hesitate to contact me.

Sincerely,

Vicky Peacey,
Senior Manager, Permitting and Approvals; Resolution Copper Company, as Manager of Resolution Copper Mining, LLC

Cc: Ms. Mary Morissette; Senior Environmental Specialist; Resolution Copper Company

Enclosure(s): *DEIS Report Skunk Camp Pipeline Corridor*

Peg Leg Pipeline Corridor DEIS Report