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7.0 TAILINGS

7.1 Disposal Options

During the life of the project it is estimated that 4.1 million t of tailings will be produced which need to be stored in conditions of adequate safety and stability.

During final disposal of the tailings there will be natural degradation of the cyanide in the washed tailings by the exposure to natural UV light in the warm, dry, windy climate assisted by irrigation with industrial water. Weather conditions in the area where the facilities will be located are favourable for cyanide destruction, the risk of contamination of the underground water is very low and there are extensive areas available for the deposition of the tailings in thin layers favouring the degradation process.

These factors will ensure that the system meets the current regulations for residual cyanide at minimal cost, with a high degree of certainty of having a low environmental impact.

The process consists of CCD washing of tailings then filtration and washing with industrial water, to obtain filtered tailings with 10% to 14% moisture. The filtered tailings will be drained in the tailings deposition area, where the tailings will be deposited in thin layers and exposed to the environment to maximize natural cyanide destruction by UV radiation, heat, and oxidation and irrigation with low pH industrial water.

This methodology will meet current environmental regulations, minimizing water and energy consumption and optimizing the cost by balancing capital cost and operating cost.

The characteristics of the tailings that will be sent to the tailings deposit are:

- 80% minus 150 µm
- 50% weight concentration
- 10-14% moisture content
- 300 ppm free cyanide (average).

7.2 Process Selection Fundamentals

7.2.1 Cyanide Degradation

Cyanide can be eliminated when it is contained in wet leached material. Cyanide degrades naturally by photo-decomposition, oxidation, volatilization, adsorption, and bio-degradation. Cyanide can also be chemically destroyed by hydrolysis-oxidation, chlorination, ozonization, or by the action of strong oxidizers.

When cyanide solutions with a pH less than 10.5 are exposed to air, vaporization of the hydrocyanic acid is produced (at temperatures >28˚C). At pH between 7 and 8, 75% of the cyanide is present as hydrocyanic acid which has a high vapour pressure. Materials with high sulphur content can acidify solutions over time, therefore the initial deposition pH of 10.5 will gradually decrease to approximately 9 after the tailings are deposited. The quantity and rate of generation of the hydrocyanic acid is not a danger to the operators because the oxidation occurs a few centimetres below the tailings surface. In addition, the wind dilutes any gas to undetectable concentrations and safe levels. It is probable that volatilization is an important part of the natural loss of cyanide.

The toxicity of cyanide is well known. Solutions with concentrations up to 2 ppm must be considered dangerous. Drainage from the control pits must be treated if cyanide is present. Solids must be considered hazardous if the concentration of cyanide is greater than 2 mg/kg of dry solid.

7.2.2 Natural Degradation of Cyanide

Stacking and ploughing

Once the trucks have dumped the material at the tailings area, a grader will spread the material in 15 to 20 cm thick layers. When a one day working package has been completed the whole area will be ploughed using a disc plough turning the material over to allow oxygenation of the tailings which will facilitate oxidation of the cyanide, a reaction catalyzed by UV light.

Irrigation

In order to increase cyanide destruction, the spread and ploughed material will be irrigated with industrial water containing hydrogen peroxide at a concentration of 40 ppm. Using hydrogen peroxide solution serves two purposes – it hydrolyzes the cyanide and oxidizes the hydrocyanic acid produced during hydrolysis. It is estimated that the sprinkling rate will be 35 to 50 L/t. Sprinkling will be carried out each time the tailings layer moisture falls to between 8% and 10%.

The package under treatment will undergo daily checks of the free cyanide content and the ploughing and irrigation will be repeated until a free cyanide concentration of less than 2 ppm is achieved. The next tailings layer (15 cm thick) will then be deposited on top of the treated layer and ploughing and irrigation of this layer will begin.

Depending on the weather conditions, during the summer a destruction rate of 7 to 8 days is expected however, during the winter this period is expected to be 12 to 18 days. The spreading, ploughing and irrigation steps are repeated until a 0.5 m thick deposit is obtained.

Compaction

When the tailings layer is 0.5 m thick the whole area will be compacted with a 10 t static roller until a compaction level >95% modified Proctor compaction is reached. Each time the deposit increases in thickness by 0.5 m it will be compacted as described above.

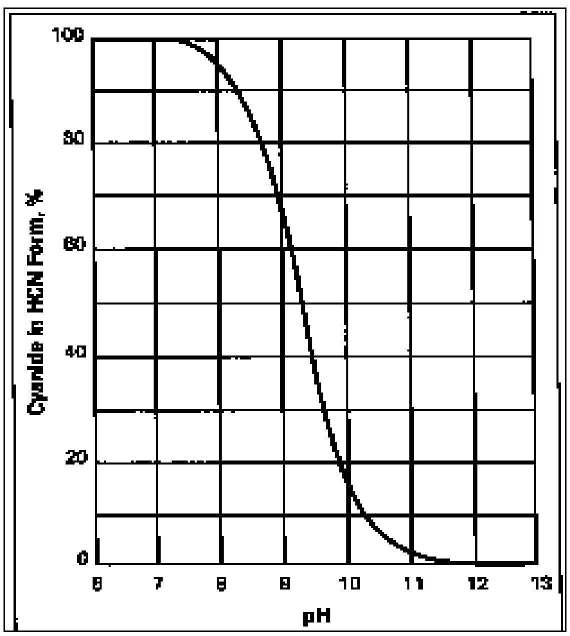
7.2.3 Decomposition by Hydrolysis

Adding water to the tailings encourages decomposition by hydrolysis which occurs due to the decrease of the pH to values less than 10. The reaction is:

$NaCN + H_2O = HCN + NaOH$

Hydrocyanic acid (HCN) oxidizes easily in the presence of ultraviolet light, heat, and oxygen generating cyanate which has low toxicity. Hydrocyanic acid volatilizes at temperatures over 36°C. Figure 7.2-1 shows the dissociation of NaCN to HCN (gas) as a function of the pH.

Figure 7.2-1: Effect of pH on Ionization of Sodium Cyanide



7.3 Tailings Deposit Design

GCM requested Vector Chile Ltda. (Vector) to provide engineering services for the Feasibility Study of the Tailings Deposit Design for GCM's Guanaco gold property.

The study included the design of a dry deposit suitable for the containment of filtered tailings with a containment wall as protection against possible tailings movement, and a catchment and rainwater diversion system. The tailings area will be located to the north of the existing Phase I and Phase II heap leach, in an area determined from a drawing of land use at the Guanaco mine provided by GCM.

7.3.1 Design Criteria

The dry tailings deposit will have a storage capacity of 4.1 million t, which will be deposited at a rate of 1,000 t/d of wet tailings from the filter plant. The surface area prepared for the tailings deposit is 31 hectares. The deposit has been located according to available space, avoiding interferences with gullies, considering the interaction with other facilities, and respecting the property boundaries.

Due to the size and the hazards implicit in a tailings deposit GCM must comply with the legal requirements established in Chile, as listed below:

- Ministry of Public Works, General Direction of Water. Implementation of the Water Code DFL N°1.122, August 13, 1981, and DO N° 31.102, October 29, 1981, Article 20 and other pertinent sections.
- National Sanitary Works Service. Implementation of Law 3.133 and regulations for neutralizing industrial and mining wastes.
- Ministry of Mines, National Service of Geology and Mining (Sernageomín). Implementation of regulations for the Construction and Operation of Tailings Dams approved by DS N°86, July 31, 1970 of the Ministry of Mines.
- Ministry of Health. National Health Service. Implementation of Articles 71, 72, 73, and 74 of the Sanitary Code (DFL 725, Ministry of Health).
- Ministry of Agriculture, Agricultural and Cattle Service.
- Curator of Mines (Conservador de Minas). Obtaining mining claims in the area where a tailings dam will be located. Implementation of Law N°16.640, 1967, Article 229, letter d) agrarian reforms. DFL 1980, DFL 18.129, June 11, 1982.

The design conditions for the tailings deposit are shown in Table 7.3-1. The requirements for the tailings deposit stability analysis are shown in Table 7.3-2.

Table 7.3-1: Conditions of Tailings Deposit Design

Parameter	Unit	Value
Tailings Deposit		
Tailings daily production	t/d	1,500
Annual tonnage deposited	t/a	550,000
Life of the design	years	7
Expansion possibilities	%	35
Tailings moisture exiting the pressure filters	%	10-14
Specific gravity of the solids	t/m^3	2.6
Density of the deposited tailings (dry)	t/m^3	1.6
Capacity of the tailings dam	million t	4.1
Thickness of deposited layers	cm	15
Tailings size distribution(P80)	µm	150
Height of Sector 1 of the tailings deposit	m	10
Height of Sector 2 of the tailings deposit	m	5
Crest Wall		
Elevation of the containment wall crest	masl	2,761
Length of the containment wall crest	m	600
Width of the containment wall crest	m	5
Minimum height of the containment wall	m	1.4
Maximum height of the containment wall	m	8.6
Slope of crest wall	(H:V)	1.3:1

Table 7.3-2: Requirements for the Deposit Stability Analysis

Parameter	Value	Source
Seismic Zone [1]	3	NCh 433 Of 1996
Maximum Acceleration	0.40 g	NCh 433 Of 1996
Safety Factors for the containment wall	Static: FS>1.3 Seismic: FS>1.0	Vector
Safety Factors for the deposit	Static: FS> 1.2 Seismic: FS> 1.2	DS N°248 Art 14

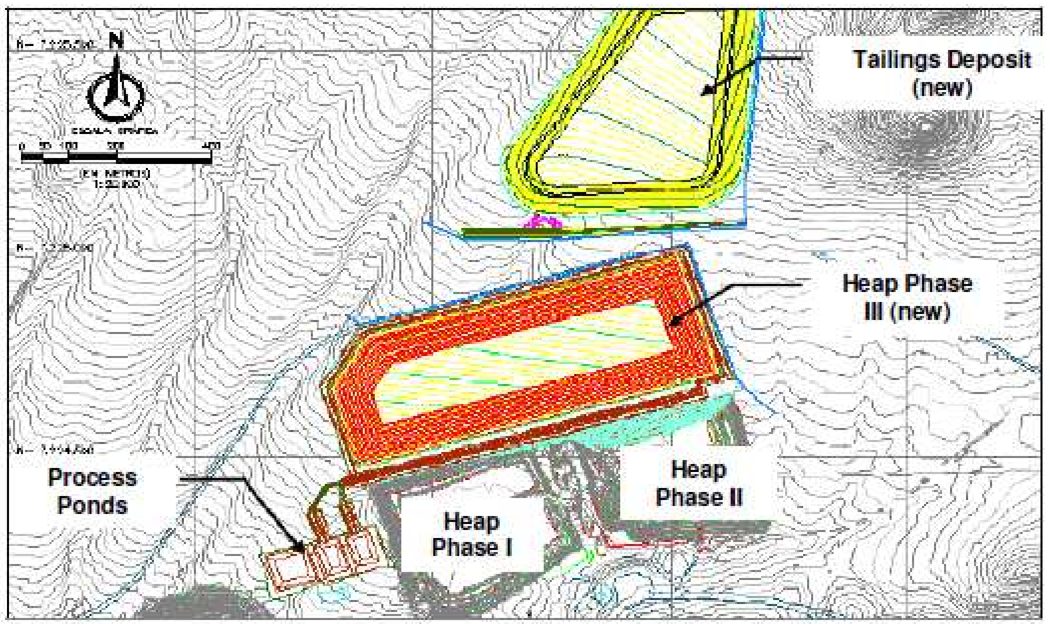
[1] Uniform Building Code UBC 1997 Zone 4

7.3.2 Location of Tailings Deposit

In order to confirm the location of the tailings deposit the advantages and disadvantages of the chosen location were analyzed technically, geographically, for quality of soils, presence of underground water, legally, and for public interaction. The distance between the plant and interference with mining roads were also considered when determining the location of the tailings deposit.

Figure 7.3-1 shows the general location of the planned tailings deposit.

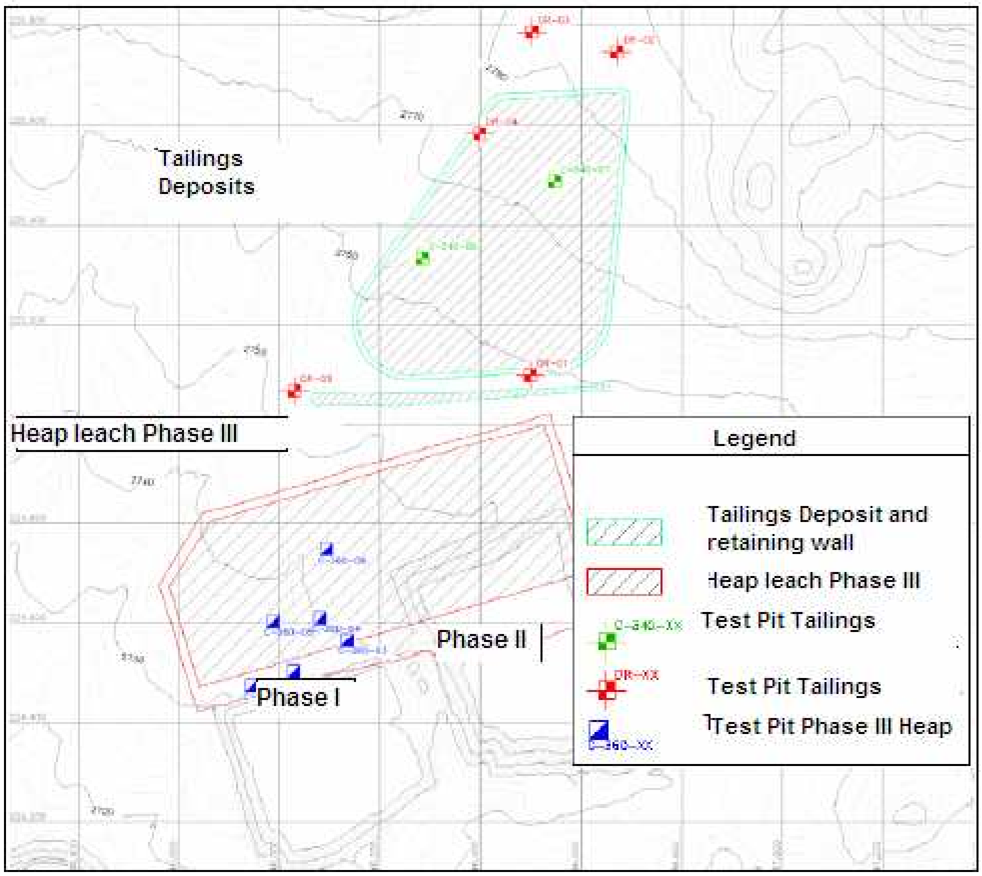
Figure 7.3-1: Location of the Tailings Deposit



7.3.3 Characterization of the Ground beneath the Tailings Deposit

Figure 7.3-2 shows the locations of test pits where samples were taken to characterize the soil.

Figure 7.3-2: Test Pit Locations



Basic characterization tests were performed (properties and compaction tests) for the foundation soils in Vector's laboratories in Antofagasta. Tests for soluble salts were performed in. Héctor Varela's soils laboratory. The laboratory tests performed are listed in Table 7.3-3.

The results indicated that it is possible to identify two horizons in the foundation substrata: the first is 0.2 m thick and consists of silty sand and isolated gravel, with medium compactability, the second is a caliche of indefinite thickness. No phreatic level was detected.

Table 7.3-3: Tests of Tailings Deposit Foundations Soils

Test	Number of Tests
Size Distribution, above 200 mesh	1
Atterberg Limits	1
Specific Gravity	1
Maximum Density	1
Minimum Density	1
Modified Proctor	1
Soluble Salts Content	4

The geotechnical properties of the silty sand horizon indicated 23% fines, a plasticity index of 3.6, and a dry compacted maximum density between 1.86 and 1.94 t/m^3 with optimal moisture between 12 and 13.3%, 1.91 t/m^3 maximum density, and 1.40 t/m^3 minimum density. The material presented a low content of soluble salts.

7.3.4 Tailings Characterization

Vector performed tailings characterization and analyzed the test results. All tests were performed by Universidad de Chile's Instituto de Investigacion y Ensayo de Materiales (IDIEM) on samples provided by GCM. The laboratory tests performed are listed in Table 7.3-4.

In order to estimate the tailings shear resistance, Vector tested four test probes in triaxial equipment, all of them under consolidated, isotropic, undrained (CIU) conditions, for effective chamber pressures ($\sigma c'$) equal to 1, 3, 5, and 7 kg/cm^2, equivalent to 6, 17, 28, and 38 m of deposit height, respectively. Vector concluded that the tailings provided by GCM are mainly composed of silts with 73% non-plastic fines and 27% sand. Permeability decreases from 1.6 x 10^{-05} cm/s to 1.1 x 10^{-06} cm/s when applying a maximum vertical force of 7 kg/cm^2. These values correspond to low permeability material, according to the Casagrande (Terzaghi & Peck, 1967)[2] criterion of classification.

[2] Terzaghi & Peak (1967). Soil Mechanics in Engineering Practice

Table 7.3-4: Tests of Tailings Material

Tests	Number of Tests
Size Distribution, above 200 mesh	1
Size Distribution, up to 0.001 mm	1
Atterberg Limits	1
Specific Gravity	1
Contraction Limit	1
Modified Proctor	1
Maximum density by vibrator	1
Minimum density	1
Maximum density by drying	1
Triaxial cycle	1
Steady CIU triaxial	1
Isotropic consolidation	1
Flexible wall permeability in triaxial cell	1

To establish the most suitable method of control for compaction, Vector developed a comparative analysis between the results obtained through the tests of modified Proctor and relative density, and concluded that the modified Proctor should be the control mechanism, given that the 95% dry compacted maximum density (1.81 t/m^3) is considerably higher than the 85% relative density (1.76 t/m^3)[3].

In the analysis of the plane e – p' ultimate stress line, it was observed that at 95% DMCS density, the compacted material has a dilatant behaviour for the effective level of stress generated by the deposit height. Hence, the verification of the stability should be performed using the shear resistance parameters in drained condition, 33° internal friction, and a null cohesion.

A series of three consolidated, isotropic, undrained cyclic tests at an effective chamber pressure (σc') of 1 kg/cm^2 and a dry density equal to the maximum allowed the cyclic resistance of the filtered tailings to be estimated. A value of 0.10 to 20 load cycles

[3] Verdugo & Bard (1995). Maximum and Minimum Densities in Non-Cohesive Soils

equivalent to the cyclic resistance of a Richter magnitude 7.5 earthquake was determined. In order to assess the liquefaction potential, this value was corrected according to the literature[4].

If compaction of material is controlled at 95% DMCS of the modified Proctor (1.817 t/m^3), an analysis of the material cyclic resistance at the new compaction density is recommended, because the tests performed used a dry maximum density (1.720 t/m^3), therefore the tailings cyclic resistance will be higher as a result of the increase in the compaction.

7.3.5 Stability Analysis of the Tailings Deposit

The deposit stability is dependent on the physical characteristics of the deposited material (affected by the size of the particles and the initial moisture of the deposit). Compaction is produced by the traffic of heavy vehicles as they deposit the material and by mechanical compaction performed each time a layer is 0.5 m thick. Technically, the tailings are a fine soil which is classified as a silt or mud with low plasticity because it is produced by grinding. Component particles of the tailings are angular, this results in the deposit having good resistance to shear. This resistance to shear is not lost due to seismic liquefaction because the material is deposited with less than saturation moisture.

The design is considered stable if the analysis provides the following minimum safety factors:

- Static FS ≥ 1.5
- Pseudo-static FS ≥ 1.2.

These minimum safety factors are required by Supreme Decree N° 248, Regulation for the Approval of Design, Construction, Operation, and Closure of Tailings Deposits, Sernageomin. This regulation applies to tailings deposits with a maximum height of 15 m ([5]).

Slide software version 5.0 was used for the stability analysis, which uses the arch stone method together with the limit equilibrium method to calculate the safety factor for a circular or block surface failure. The material properties used in the stability analysis are shown in Table 7.3-5.

[4] Seed & Idriss (1970). A simplified procedure for evaluating soil liquefaction potential
[5] If in the future the deposit will exceed this height, additional dynamic analyses of deformations must be performed.

Table 7.3-5: Material Properties for Stability Analysis

Material	Total Density (kN/m^3)	Cohesion (kN/m^2)	Friction Angle (º)
Filtered Integral Tailing	16.7	0	33
Foundation Ground	19.6	90	30
Containing Wall	19.6	4	40

The analysis showed (see Tables 7.3-6 and 7.3.7 for the tailings deposit and the containing wall respectively) that the design meets the minimum criteria required by the current Chilean regulations.

Table 7.3-6: Tailings Deposit Safety Factors

Circular Fault	Safety Factors	
	Section A	Section B
Static	3.18	2.66
Pseudo-static (kh=0.20)	1.56	1.41

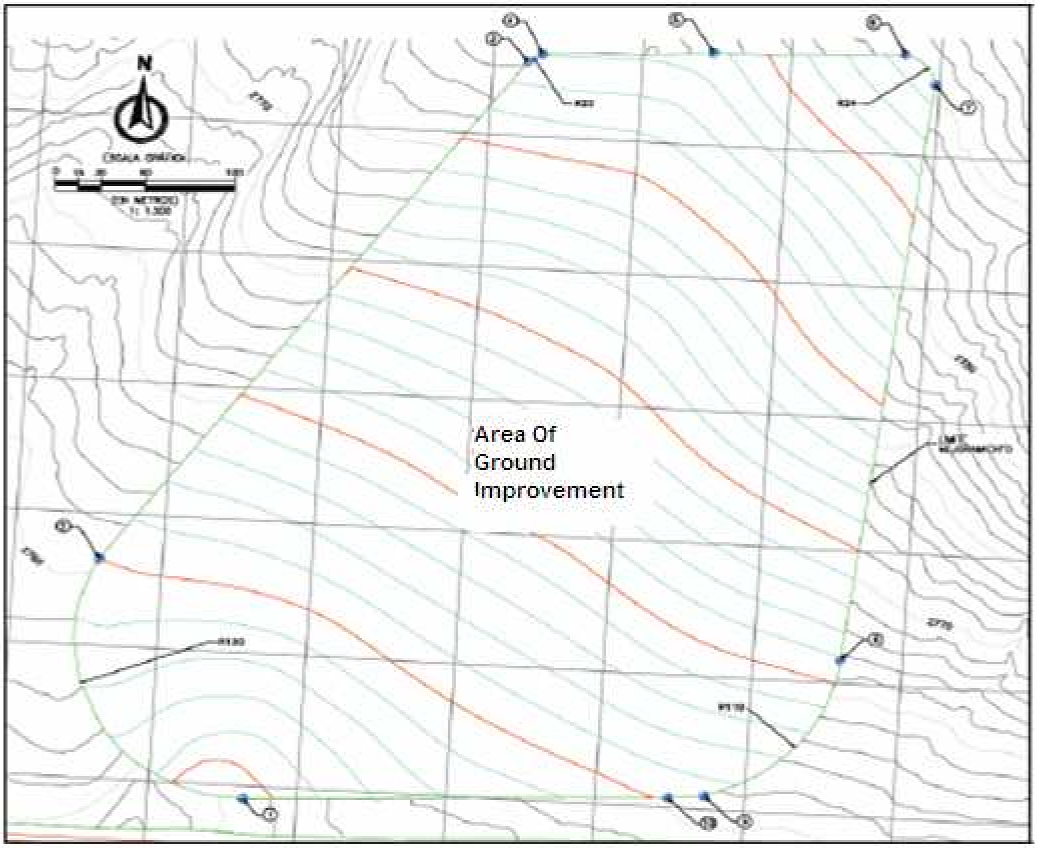
Table 7.3-7: Containing Wall Safety Factors

Circular Fault	Safety Factors	
	Section A	Section B
Static	1.92	2.55
Pseudo-static (kh=0.20)	1.30	1.70

7.3.6 Ground Improvement

The ground under the tailings deposit will be improved by levelling and grading to a constant slope to provide a supporting surface which will contribute to the stability of the deposit and facilitate the loading operation. The improvement uses slopes of 2:1 (H:V) for cut and fill. Figure 7.3-3 shows the ground improvement required for the tailings deposit.

Figure 7.3-3: Ground Improvement for the Tailings Deposit



The surface area to be improved is 235.833 m^2 and the average slope of the planned improvement will be 4.16%. The shape of the improvement is similar to that of the final deposit but there will be a 10 m space between the bottom of the deposit and the outer edge of the improved area. The base surface area of the deposit will be 216,457 m^2, and the planned capacity is 2,542,868 m^3 or 4,068,589 t. The deposit will be built in two levels, the first will be 10 m high and the second will be 5 m high. Slopes will be 4:1 (H:V) with a 5 m wide stability berm.

Figure 7.3-4 shows the shape of the projected tailings deposit and Figure 7.3-5 shows a cross section.

Figure 7.3-4: Tailings Deposit

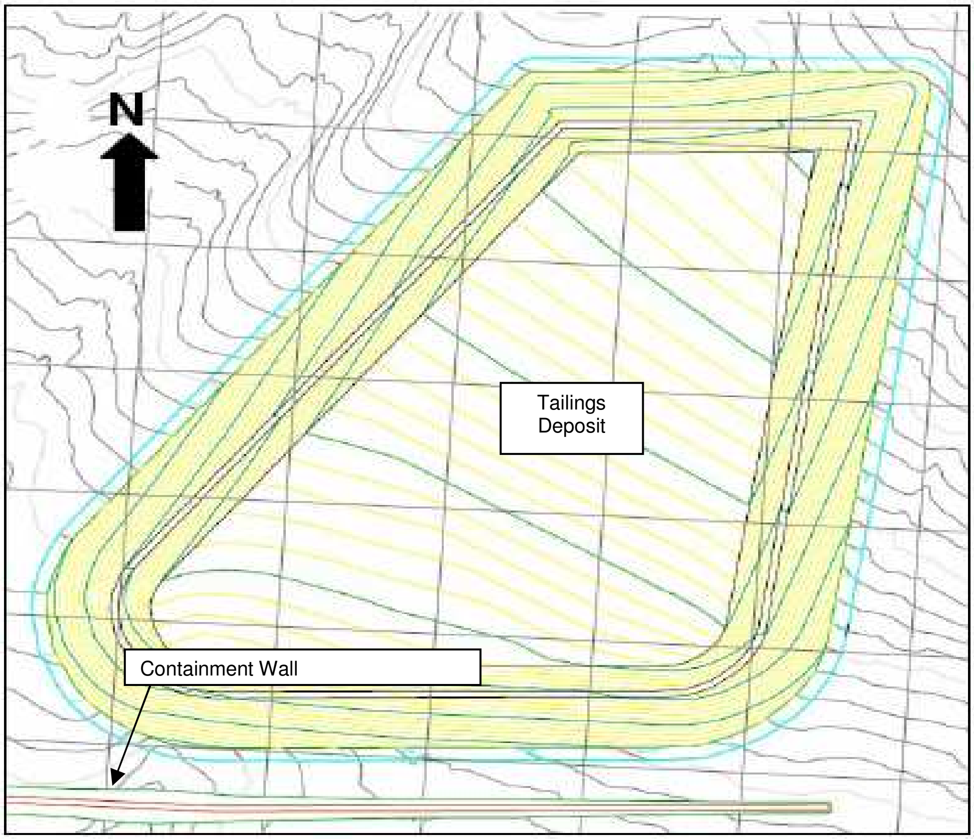


Figure 7.3-5: Cross Section through the Tailings Deposit

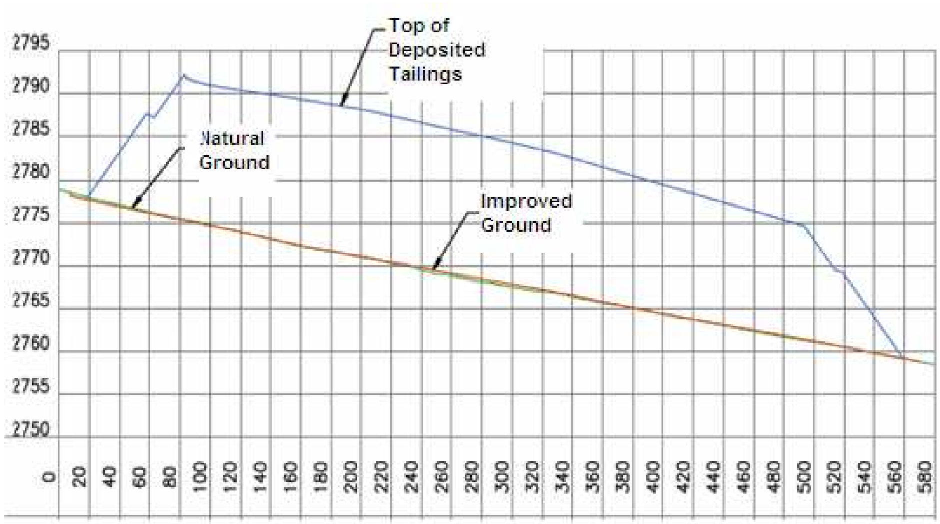


Table 7.3-8 summarizes the geometrical characteristics of the planned tailings deposit.

Table 7.3-8: Geometrical Characteristics of the Tailings Deposit

Parameter	Value	Source
Final capacity of the deposit	2.54 Mm^3 / 4.07 Mt	Calculation
Deposit base area	216,457 m^2	Vector
Height Level 1	10 m	Vector
Height Level 2	5 m	Vector
Deposition slope between berms	4:1 (H:V)	Vector
Final slope of the crest of the deposit	Parallel to the improved surface	Vector
Width of the stability berm	5 m (min.)	Calculation
Maximum crest elevation	2,976 masl	Calculation
Minimum crest elevation	2,770 masl	Calculation

7.3.7 Containing Wall

The containing wall (see Table 7.3-9) will be located downstream of the tailings deposit and it will protect the mine facilities located south of the tailings deposit from any possible movement of the tailings.

Table 7.3-9: Geometrical Characteristics of the Containing Wall

Parameter	Rate	Source
Crest minimum width	5 m	Vector
Wall slope	1.3:1 (H:V)	Client
Coast slope top	2,761 masl	Vector
Volume of earthworks	34,437 m^3	Calculation

7.3.8 Rain Water Diversion System

A system of ditches will be built to evacuate rain water to the ravine to the west of the deposit as shown in Figure 7.3-6. This will divert run-off from rain water around the deposit. The diversion ditches will be trapezoidal in section, 2 m wide at the bottom, 1:1 slopes, and 1 m deep. On one side of the ditch a 1 m high safety berm with a 1:1 slope will be built so that any overflow from the ditch will not flow towards the tailings deposit.

The diversion ditches will be lined with a layer of 10 cm thick, 4" angular gravel. Figure 7.3-7 shows the diversion ditch cross section.

Figure 7.3-6: Rain Water Diversion System Layout

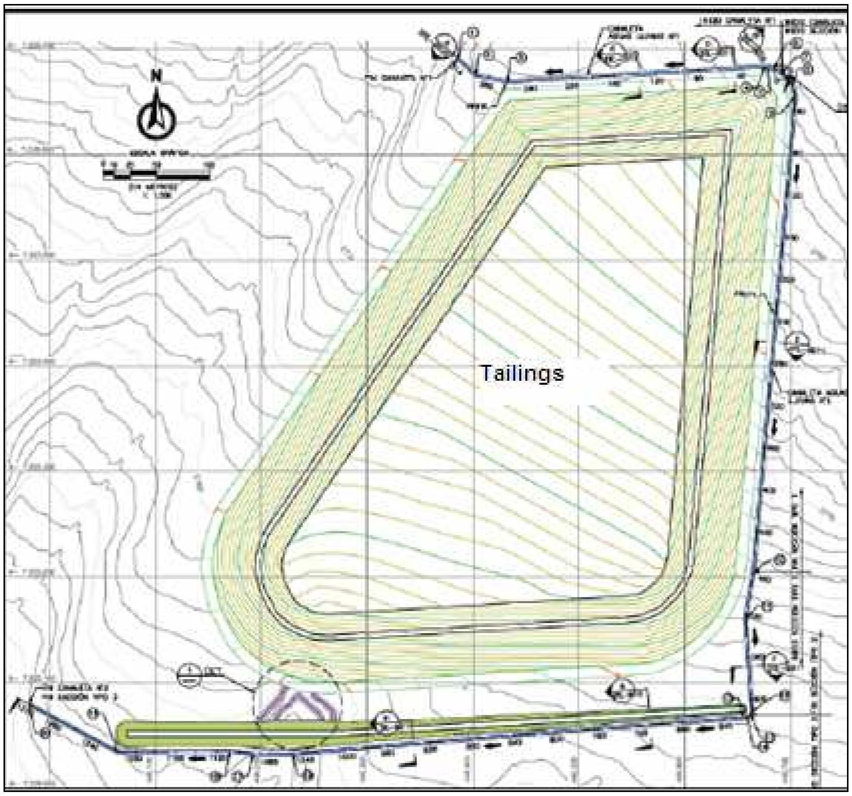
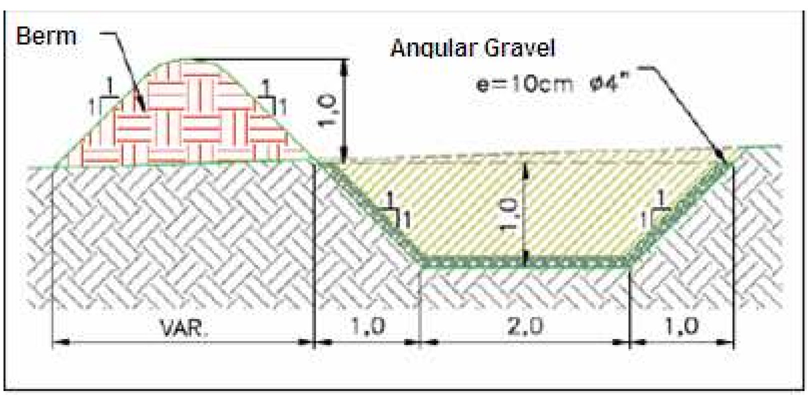


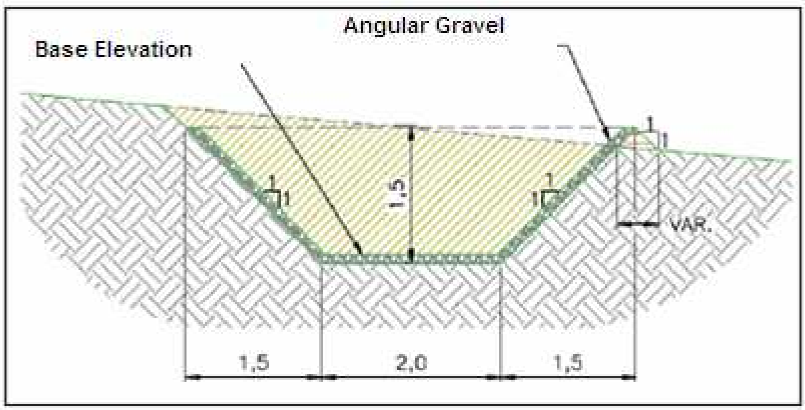
Figure 7.3-7: Typical Diversion Ditch Cross Section



7.3.9 Tailings Deposit Rain Water Collection System

Rain water falling directly onto the tailings deposit will be captured by a system of collection ditches. The ditches will be trapezoidal in section, 2 m wide at the bottom, 1:1 slope, and 1.5 m depth. The ditches will be lined with 10 cm thick, 4" angular gravel. The bottom elevation of the ditches will be constant, in order to collect the rainwater that falls on the deposit. Figure 7.3-8 shows a typical cross section of the ditch.

Figure 7.3-8: Rain Water Collection Ditch Typical Cross Section



7.3.10 Preparation of the Tailings Deposit Area

The topography of the tailings deposit area indicates that macro-levelling will be required to allow the operation of the mobile equipment without difficulties. The natural slope of the area is 2.9%, and therefore only one bulldozer will be needed to level the area and no borrow material will be required. This macro-levelling will allow the operation of a vibrating roller and a water tanker.

The base of the tailings deposit will then be compacted using an 8 to 10 t vibrating roller. Prior to compaction, the ground will be moistened to optimal humidity. The roller will pass at least three times over each point. The surface to be compacted is 28 to 30 hectares not including the access roads.

7.4 Deposit Operation

7.4.1 General

The tailings will be transported by 14 m^3 capacity trucks from the filter plant to the tailings deposit.

Figure 7.4-1 shows the route planned for the tailings transportation from the plant to the deposit. The maximum distance that the trucks must travel is 2,150 m, which was used as the most conservative value.

GCM required that the operation of the tailings disposal system must fulfill with the following:

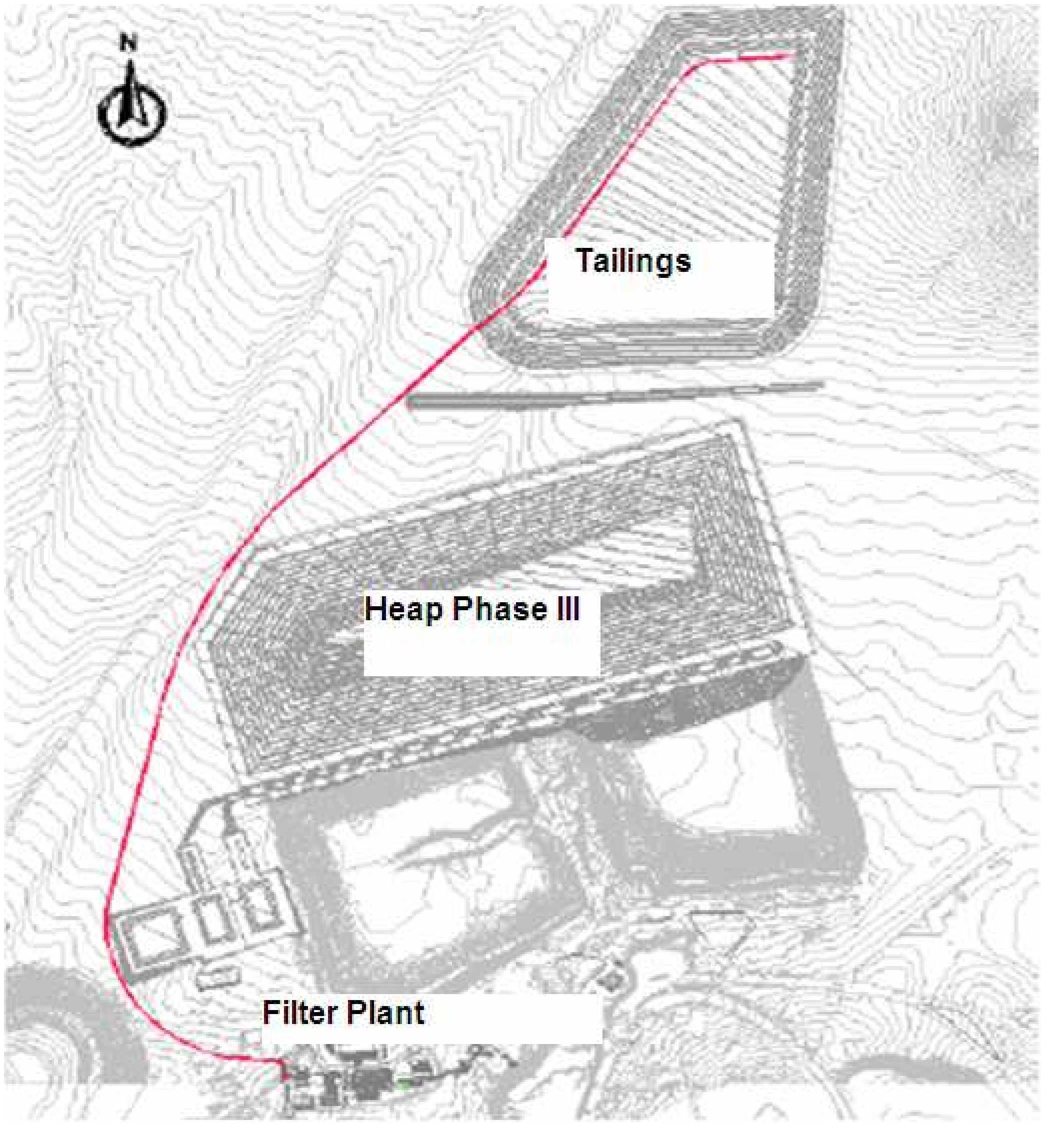
Loading and Transportation: At the filter plant stockpile a front end loader fills the trucks with tailings to be transported to the tailings deposit.

Stacking and Ploughing: Once tailings are unloaded at the tailings deposit by the trucks, the tailings will be spread in layers 0.15 m to 0.2 m thick. An agricultural plough will be used on the tailings layer to provide better aeration for cyanide degradation. In general, the tailings will be deposited in two 0.15 m thick layers and then in one 0.2 m thick layer to achieve a height of 0.5 m. Approximately 18 days of aeration will be allowed between layers. When the cyanide content has fallen to 2 ppm free cyanide (between 5 to 18 days depending on the temperature) deposition of a new tailings layer will begin with a new 0.15 m layer.

Irrigation: Irrigation of the tailings will be done using industrial water from a 15 m^3 water truck to achieve cyanide degradation down to a concentration of 2 ppm. This will be regularly monitored to ensure that the expected concentration is reached.

Compaction: Once the tailings layer is 0.5 m high, a smooth vibrating roller will compact the tailings. The smooth roller must have a minimum static weight of 10 t and will pass over each point at least three times.

Figure 7.4-1: Tailings Transportation from the Filter Plant to the Tailings Deposit



7.4.2 General Description of the Tailings Treatment Process

The process includes two stages of washing of the leached slurry before it is sent to the tailings deposit. It is first washed in a counter current circuit with barren solution and then given a second wash in the filter presses with fresh water. The barren solution wash is intended to remove any remaining gold and silver content into the wash solution. The wash with industrial water in the filter presses is to reduce the NaCN content from 2 g/L to 200 to 300 ppm in the liquid in the tailings.

The process of tailings deposition starts with the unloading of filtered material (a cake between 10 to 14% moisture) in the tailings stockpile from the filter discharge conveyor. There is a tailings moisture sampler and an unloading and distribution chute at the stockpile.

The tailings stockpile is a concrete slab with a containing wall with a live capacity of 2,000 t. The slab has a sump pump to collect solution and washdown water that are recycled to the CCD wash circuit.

At the tailings deposit stacking will be done at night when possible so that the ploughing and irrigation can be done during the day. Ploughing and irrigation with industrial water will be done once or twice per day. Irrigation rates will fluctuate between 35 and 50 L/t (0.4 and 0.6 L/s) depending on the ambient temperature. This aeration and irrigation process will be repeated at least daily until the cyanide concentration in the tailings is less than 2 ppm.

After 72 hours the residual free cyanide will be tested and if the concentration has reached 2 ppm the next layer of tailings will be deposited. If the residual free cyanide maximum limit has not been reached, irrigation and ploughing will continue until the required cyanide level is reached. Deposition will continue until a height of 0.5 m is achieved, the tailings will then be compacted using a 10 t vibrating roller.

This deposition, cyanide degradation, and compaction of tailings will result in a deposit that is mechanically stable, free of contamination, and with access roads that will allow circulation of vehicles for the operation.

The management of the tailings deposit includes a monthly monitoring program that can be audited at any moment during the life of the deposit.

7.4.3 Operation of the Tailings Deposit

The deposition schedule for the operation of the tailings deposit will use packages, equivalent to the area covered by the daily production of tailings (1,500 dry t). With a daily production of 1,700 wet t with a density of 1.6 t/m^3, deposited in layers of 15 cm, each package will cover an area of approximately 5,800 m^2.

The deposition schedule considers that during the start-up tailings will be deposited in areas where there are ground depressions, until a flat surface is achieved with a maximum slope of 5%.

Management of a Deposition Package

The tailings deposition schedule will establish a package for each day of the month which will be marked with stakes for truck dumping. Subsequently the bulldozer will spread the material in 0.15 m thick layers.

Compaction of a Sector

Each time the deposit reaches 0.5 or 0.6 m thick the area will be compacted with a 10 t vibrating roller. When the tailings are 1 m thick (compacted) deposition will restart 5 m in from the preceding layer to form a stepped pyramid.

Once a 10 m high deposit is completed it will be sealed with coarse gravel (½" to 1") and compacted to stop fine material blowing away.

The second stage will start 5 m in from the first stage using the same procedure described above. This process will continue until the end of the project. Finally, all horizontal surfaces will be compacted and covered with coarse material (1" to 3") from the waste rock dump.

7.5 Capital Cost

The capital cost estimate presented in this section is a Class 3 estimate according to the AACE classification equivalent to a feasibility level estimate. The costs were estimated based on the quantities obtained from the drawings generated during the feasibility engineering and from budget pricing. Information sources included budget quotations and information from Vector Chile's database for both direct and indirect costs.

The capital cost estimate includes the following:

- Direct Costs, including the cost of purchasing equipment and materials, transportation, construction, and assembly; general expenses and utilities associated with the construction and installation of the tailings deposit.
- Indirect Costs, including temporary installations, quality assurance services (QA), and general expenses.

7.5.1 Basis of Estimate

WBS

The direct costs for the estimate were developed by area according to the project work breakdown structure (WBS).

Accuracy of the Estimate

The capital cost estimate developed for the feasibility study corresponds to a Class 3, estimate according to the AACE (Association for the Advancement of Cost Engineering) recommendations and has an accuracy of -10% +15%.

Exchange Rate

An exchange rate of US$1 (US Dollar) equal to Ch$529.69 (Chilean Pesos) was used (the rate on February 26, 2010).

Unit Costs

Unit costs for construction were obtained from the bids presented by construction contractors during the bidding process for the construction of the Phase III Heap for GCM during February 2010, and from Vector Chile's database for similar projects in Region II. Unit costs were divided into purchase costs of equipment and materials, and construction and installation costs. Construction and installation costs were divided into manpower and machinery. Unit costs were net values without taxes.

Transport costs were included in the purchase cost of equipment and materials as a factor where necessary. This transport factor was 10% of the cost of materials and equipment.

Estimation of Quantities

Quantities were calculated from the feasibility level engineering.

Growth Factors

In order to account for errors in estimating quantities due to the use of scale drawings, material losses, and swelling and compaction of material a growth factor for earthworks of 8% was added to the net volume take-offs.

Direct Costs

This is the total cost for construction items. It includes the cost of manpower, equipment, and materials to be installed, construction subcontracts, and construction contractor's general expenses, overhead, and profit.

The construction contractor's general expenses, overhead, and profit are included in the direct costs and were calculated as shown in Table 7.5-1. These factors were obtained from the bid presented by construction contractors during the bidding process for the construction of the Phase II heap in February 2010.

Table 7.5-1: Construction Contractor's General Expenses, Overhead, and Profit

Description	Factor
General Expenses and Overhead	13% of the Direct Cost of the Item
Profit	6% of the Direct Cost of the Item

Indirect Costs

Owner's costs were excluded, however these are included in the consolidated capital cost of the project (see Section 14).

Contingency

The contingency allows for possible increases in the capital cost for the scope of the items. It is not intended to cover scope changes. The contingency is intended to cover possible errors in the take-offs, omissions, variations in the price of the equipment and materials, and higher labour costs.

Contingency is included in the consolidated capital cost of the project (see Section 14).

7.5.2 Estimate of Costs

Direct Costs

The total direct cost was estimated at US$719,017 including construction contractor's general expenses, overhead, and profit. Details are provided in Appendix B.

Indirect Costs

Indirect costs estimated for the project are US$106,509 as shown in Table 7.5-2.

Table 7.5-2: Distribution of Indirect Costs

Description	Incidence	Cost (US$)
Work Installation	39.7%	42,295
Detail Engineering	23.5%	25,000
QA Services	25.5%	37,130
Miscellaneous Expenses	11.3%	12,084
Total Indirect Costs	100%	106,509

7.5.3 Costs Summary

Table 7.5-3 summarizes the total capital cost estimate for the tailings deposition system.

Table 7.5-3: Summary of Investment Costs of the Tailings Deposit

Description	Cost (US$)
Direct Costs	719,017
Indirect Costs	106,509
Total Direct and Indirect Costs	825,526

7.5.4 Exclusions

In the cost estimate above the following are excluded:

- Operating costs
- Start-up costs
- Project financial evaluation
- Owner's costs
- Closure costs.

7.6 Operating Cost

7.6.1 General Criteria for the Estimate

The facilities and equipment will operate continuously, 365 days per year, 24 hours per day. General design factors were used to absorb fluctuations in operations as indicated in Table 7.6-1.

Table 7.6-1: General Design Factors

Property	Unit	Value
Material density	m^3/t	1.9
Material size distribution (P_{100})	mm	10
Moisture	%	20
Process plant utilization	%	70
Design factor	-	1.2
Capacity	t/h	107
Water retained in the tailings	m^3/t	0.05

The following equipment was considered for the transport and stacking of tailings:

14 m^3 Trucks

- Truck utilization factor; 75%
- Operating factor; 90% of the material transported
- Truck fill factor; 90%
- Average truck speed; 30 km/h
- Rental cost of tailings transport equipment; US$2.60 /t.

Bulldozer

- Bulldozer utilization factor; 75%
- Operating factor for tailings spreading; 90%
- Average speed; 30 km/h
- Rental cost; US$94 /h.

Smooth vibrating roller (10 t static weight)

- Roller utilization factor; 75%
- Compaction operating factor; 90%
- Rental cost; US$66 /h.

15 m^3 Water Truck

- Truck utilization factor; 75%
- Operating factor; 90%
- Average speed; 30 km/h
- Rental cost; US$66 /h.

7.6.2 Description of the Operation

The operating methodology for the tailings deposition system by truck from the filter plant, unloading, and handling is described in Section 7.4.

The maximum distance that trucks will have to travel from the filter plant to the tailings deposition area is 2,150 m. Deposition will consist of the following stages:

- Stacking and ploughing
- Irrigation
- Compaction.

7.6.3 Transport Estimation

The build-up and results of the estimate of the tailings transport costs are shown in Table 7.6-2 and the tailings stacking costs are shown in Table 7.6-3. Table 7.6-4 summarizes the operating costs for tailings transport and stacking by year.

Table 7.6-2: Operating Cost Estimate for Tailings Transport

Material Handling Design Criteria	Unit	Value
Required capacity	t/d	1,500
Plant utilization	-	70%
Truck utilization	-	75%
Job efficiency	-	90%
Nominal capacity	t/h	89.3
Design capacity	t/h	107
Tailings density	t/m^3	1.92
Average transport velocity	km/h	30
Dollar cost (at 30/12/2009)	Ch pesos/US$	506.43
Interest rate		10%
Trucks	**Unit**	**Value**
Capacity	m^3	14
Fill factor	-	90%
Operating capacity	m^3	12.6
Operating capacity	t	24.2
Productivity Calculation	**Unit**	**Value**
Hauling distance	m	2,150
Transport time	s	516
Dumping time	s	120
Loading time	s	813
Cycle time	s	1,610
Cycle time	h	0.45
Material per truck	t/h	41
Truck quantity	unit	3
Rate of Increase in Size of Tailings Deposit	**Unit**	**Value**
Volume per day	m^3	781
Area per day	m^2	5,208

Table 7.6-3: Operating Cost Estimate for Tailings Stacking

Vibrating Roller	**Unit**	**Value**
Static weight [6]	t	10
Passes required [6]	unit	3
Travel speed	km/h	5
Utilization	-	75%
Operating time	h	18
Job efficiency	-	90%
Drum width	m	0.2
Compaction area per day	m^2	5,400
Maximum area for compaction	m^2	216,457
Loading time 15 cm layer	d	42
Time for maximum compaction of area	d	40
Equipment required	unit	1
Motor Grader	**Unit**	**Value**
Model (or similar)	-	120K
Blade length	m	3.66
Utilization	-	55%
Operating factor	-	90%
Operating speed	km/h	10
Reverse speed	km/h	5
Advance distance	m	15
Cycle	h	0.01
Hourly operating area	m^2/h	402
Required area	m^2/h	372
Equipment required	unit	1
Water truck	**Unit**	**Value**
Water requirement	m^3/t	0.05
Water flow required	m^3/d	75
Utilization	-	75%
Vehicle speed	km/h	30
Working distance	m	2,500

[6] From Arcadis study – Doc. Nº 3127-0000-GA-INF-001

Time taken	s	600
Watering time	s	9,000
Filling time	s	1,800
Cycle time	s	12,667
Cycle time	h	3.52
Tank capacity	m^3	15
Cycles per day	unit	5
Equipment required	unit	1.0

Table 7.6-4: Operating Cost Estimate by Year

Estimated cost		
Road	70	[US$/m]
Transport	2.7	[US$/$m^3$]
Vibratory roller	69	[US$/HM]
Motor grader	99	[US$/HM]
Water truck	69	[US$/HM]

ITEM	year 0	year 1	year 2	year 3	year 4	year 5	year 6	year 7
Investment								
road	150,500	0	0	0	0	0	0	0
Total investment	**150,500**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Operational cost								
Trucks	0	775,349	775,349	775,349	775,349	775,349	775,349	775,349
Vibratory roller	0	99,731	99,731	99,731	99,731	99,731	99,731	99,731
Motor grader	0	475,683	475,683	475,683	475,683	475,683	475,683	475,683
Water truck	0	454,061	454,061	454,061	454,061	454,061	454,061	454,061
Total operational cost	**0**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**
TOTAL	**150,500**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**	**1,804,824**

Total costs	Transport	Stacking	Total	
Investment cost	0	0	150,500	[US$]
Operational cost	5,427,445	7,206,320	12,633,765	[US$]
Total	5,427,445	7,206,320	12,784,265	[US$]

Average cost	Transport	Stacking	Total	
Operational cost	1.42	1.88	3.30	[US$/t]

Cost Present value	Transport	Stacking	Total	
Investment	150,500	0	150,500	[US$]
Operational	3,774,725	5,011,912	8,786,637	[US$]
Total	3,925,225	5,011,912	8,937,137	[US$]

Cost present value	Transport	Stacking	Total	
Investment	151	0	151	[kUS$]
Operational	3,775	5,012	8,787	[kUS$]
Total	3,925	5,012	8,937	[kUS$]

7.6.4 Results

A fleet of three 14 m^3 capacity trucks must be available to meet the transport needs. A 10 t smooth vibrating roller (CAT 553 or similar) will be used for surface compaction, however, this equipment will only be required each time a 0.5 m thick tailings layer needs to be compacted, approximately every 6 months.

For tailings spreading and ploughing a CAT 120K bulldozer or similar should be used equipped with a back ripper/scarifier for ploughing. The real utilization of this equipment will not exceed 55%.

For irrigation a 15 m^3 water truck is required which must perform the equivalent to 5 trips per day in order to meet with the requirements for irrigation of the tailings deposition.

Table 7.6-5 summarizes the equipment requirements for tailings transport and stacking.

Table 7.6-5: Summary of Tailings Transport and Stacking

Item	Quantity	Model	Description
Truck	3	IC [7]	Capacity = 14 m^3
Bulldozer	1	120K or similar	Blade Width = 3.66 m with scarifier
Smooth vibrating roller	1	CAT553 or similar	Static weight = 10 t
Water truck	1	IC[7]	Capacity = 15 m^3, with spreaders

7.6.5 Operating Cost Summary

Table 7.6-6 shows the breakdown of operating costs for the tailings transportation and stacking.

Table 7.6-6: Operating Cost Summary

Item	Average Cost (US$/t)
Transport	1.42
Tailings stacking and cyanide destruction	1.88
Total	**3.30**

[7] IC represents a standard truck that will provide the required capacity.