IRONBARK Zinc Limited

Citronen Zinc-Lead Project

FEASIBILITY STUDY

FEASIBILITY STUDY OUTCOME HIGHLIGHTS

NPV

US$609 MILLION
(POST TAX US$354M)

IRR

32.0% (22.2% POST TAX)

CAPITAL COST

US$429.3 MILLION INC CONTIGENCY
(US$484.8M WITH FIRST FILLS INCLUDED)

OPERATING COST

US$0.68 PER POUND OF ZINC
(NET OF BY-PRODUCT CREDITS, YEARS 1-5)

MINE LIFE

14 YEARS

LIFE OF MINE REVENUE

US$5.65 BILLION

IRONBARK Zinc Limited

Level 1
350 Hay Street
Subiaco WA 6008
Western Australia

PO Box 935
West Perth WA 6872
T: +61 8 6461 6350
F: +61 8 6210 1872
www.ironbark.gl
admin@ironbark.gl

29 April 2013
Company Announcements

Australian Securities Exchange Limited
Exchange Plaza
2 The Esplanade
PERTH WA 6000

FEASIBILITY STUDY CONFIRMS CITRONEN AS A GLOBALLY SIGNIFICANT LEAD-ZINC PROJECT

Ironbark Zinc Limited ("Ironbark") (ASX: IBG) (OTC US: IRBGY) is pleased to provide results from the Feasibility Study of Ironbark's 100% owned Citronen Project.

Highlights of the Citronen Feasibility Study are:

- **NPV** — **US$609 Million (US$354M post tax)**
- **IRR** — **32.0% (22.2% post tax)**
- **Equity Return** — **37.9% (Geared NPV after tax)**
- **Capital Cost** — **US$429.3 Million inc contingency (US$484.8M with First Fills)**
- **Operating Cost** — **US$0.68/lb Zn (Payable, Net of by-product credits, Years 1-5, Smelter fees additional US$0.22/lb Zn)**
- **Mine Life** — **14 years**
- **Life of Mine Revenue** — **US$5.65 Billion**
- **Life of Mine Operating Costs** — **US$3.42 Billion**

The Citronen base metals project benefits from the following favourable characteristics:

- **Located in Greenland – low sovereign risk**
- **Located adjacent to deep, protected water on the doorstep of Europe and North America**
- **Simple, flat and continuous ore zones**
- **Open-pit fresh sulphide potential with very low strip ratios to supplement higher grade underground mined mineralisation**
- **Long mine life, with resource open to further mineralisation in almost every direction**
- **Simple, predominantly underground room and pillar mining operation**
- **One of few world class deposits wholly owned by a junior company**
- **Production scheduled at a time of many planned zinc mine closures, a shortage of zinc supply and anticipated high zinc prices**
- **Ironbark is working with China Nonferrous under a MOU to deliver an EPC fixed price contract and financing for the project**

The Citronen Feasibility Study is the culmination of an enormous amount of work, the main body of which has been derived from the work conducted by independent engineers in 2010 and from significant additional engineering, metallurgical and design evaluation.

The Feasibility Study has incorporated a recent review of capital costs and the 2012 updated Resources Statement. Further advances and improvements, particularly surrounding resource confidence and mine scheduling, were released in 2012 and have been included in the Feasibility Study.

New metallurgical breakthroughs have also been made with zinc flotation recoveries of 90% achieved; however, as testwork remains ongoing, the results cannot be included in the Feasibility Study until feasibility- level engineering confidence is achieved. The higher recoveries will be incorporated into the Feasibility Report following the completion of further studies.

Commenting on the results of the Feasibility Study Ironbark managing director Jonathan Downes said:

"We are delighted the Citronen Project has been ratified as a base metal mining project of global significance. Located in Greenland, a nation actively seeking to foster a mining sector to help support its economy, Citronen's mine life of at least 14 years is defined only by the limits of drilling to date. As such, one of the Project's most exciting aspects remains its exceptional exploration potential with identified mineralisation remaining open in almost every direction."

Ironbark is debt-free and has a strong shareholder base including Nyrstar NV and Glencore AG. Ironbark has an engineering and construction Memorandum of Understanding (MOU) with China Nonferrous Metal Industry's Foreign Engineering and Construction Co. Ltd (NFC) for a fixed price Engineering, Procurement and Construction (EPC) contract. The MOU encompasses a 70% debt funding proposal through Chinese banks and provides NFC with a right to buy a 20% direct interest in the Citronen Project.

Citronen's Feasibility Study with all the supporting studies is being presented to NFC for the purposes of preparing the EPC and financing work. NFC is expected to be in a position to begin delivering the results from their work towards the end of 2013.

The Citronen Project is a relatively simple predominantly underground room and pillar mining operation that concentrates the ore through industry proven Dense Media Separation (DMS) and Flotation techniques to produce saleable separate zinc and lead concentrates to the world markets.

A summary of the Feasibility Study elements describing the sections investigated is included in nominal terms, unless otherwise stated, herein.

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SECTION 1 - INTRODUCTION

1. INTRODUCTION

1.1 Project Status at February 2013

The Citronen Fjord Zinc deposit was discovered by Platinova A/S (Platinova) in 1993. Platinova conducted extensive geological mapping, geophysics and drilling programmes during the summers of 1993 to 1997; over 33,000 metres of diamond drilling for 143 holes were completed and four main prospects were identified (Discovery, Beach, Esrum and the Western Gossans).

Ironbark Zinc Limited (Ironbark) acquired the Citronen Project (Citronen or the Project) in early 2007 and during Greenland's 2007 summer completed an intensive sampling program of previously un-assayed Platinova drill core.

Ironbark has since actively explored the Project and between 2008 and 2011 completed 166 holes for 32,240 metres, bringing the total drilling completed at Citronen to 313 holes for 67,069 metres. This has resulted in a significant resource upgrade in terms of tonnes and confidence.

Wardrop Engineering Inc. (Wardrop) completed a feasibility study report in early 2011. Wardrop completed the report as the study manager in conjunction with the support of other major feasibility study contractors including MTHøjgaard A/S and Metso Corp. (Metso). Subsequent to the completion of the Wardrop feasibility study, Ironbark released an updated resource estimation based on the results of its 2011 drilling programme on 9 January 2012.

Subsequently, Mining Plus Pty Ltd (Mining Plus) optimised the mine plan and updated the mining schedule to first processing the high grade underground ore and commencing open pit mining only once the underground ore was depleted. This change has improved the Project's economics.

Concurrently, Metso completed a process plant capacity review which resulted in Ironbark increasing the plant throughput from 3.0 to 3.3 Mtpa. Ironbark has continued to work on and improve the metallurgical characteristics with ongoing work with Metso Corp. (Metso).

All of the above have positively impacted the outcomes of the Feasibility Study.

SECTION 2 - ZINC & LEAD METAL MARKETING

2. ZINC & LEAD METAL MARKETING

2.1 Introduction to Zinc and the Zinc Market

Zinc is the fourth most used metal in the world. Its applications range from galvanising steel products for rust proofing items including construction steel and car chassis, uses in bronze alloys and even as an essential fertiliser trace element additive. Zinc is not easily substitutable and is an essential metal to modern society.

The zinc market is largely balanced at an annual zinc production rate of 12 million tonnes of metal per annum, with approximately 70% produced from mining and 30% from recycling. Zinc is typically produced on-site to a concentrate level containing in excess of 50% zinc metal along with other waste elements such as sulphur, silica and iron.

In recent years, as the global economy slowed and the consumption of zinc diminished, a zinc surplus has accumulated. The majority of zinc stocks are held in the London Metal Exchange (LME) warehouses and the Shanghai Metal Exchange (SHME) warehouses, where zinc stockpiles are estimated have risen to a record high of 14.7 weeks of global consumption.

2.2 Zinc Price Forecasting

Given the lead time to the construction and commissioning of the Citronen mine, it is important to apply future forecast metal prices to the financial model to more accurately reflect the likely prices at the time of production. Accordingly, the work compiled by the Wood Mackenzie (WM), the owners of Brook Hunt, an independent and globally recognised authority on commodities, has been used in this study.

The WM group has forecast global zinc stocks will fall sharply in 2016. WM expects to see zinc average US$1.31/lb (US$2,897/t) for the five years from 2013 to 2017 in real terms and average US$1.37/lb (US$3020) for the life of mine in real terms. This compares to the preceding seven years from 2006 to 2012 where zinc prices settled at an average of US$1.06/lb (US$2338/t). The zinc price during this period was influenced by the 2007-2008 global financial crises' impact on zinc consumption. Some factors that will influence the zinc price are:

- The current difficulty to secure mine financing, particularly within the zinc sector: this factor can reasonably be expected to compound the effect of an eventual shortage in zinc production due to limited new production being built in the short to medium term.
- Several large zinc and lead mines are due for closure in the near future due to ore body depletion and other factors (Table 2.1).
- While Citronen represents one of the largest scale zinc discoveries of recent times, relatively few new deposits have been recently discovered. Consequently, the depletion of higher grade deposits is forcing the mining of lower grade deposits (Figure 2.1) which will ultimately impact production costs and zinc prices.
- The global consumption of zinc will continue its increasing trend in line with the forecast global economy and population growth (Figure 2.2).

Ironbark has entered into individual offtake agreements for 35% (each) of the production from the Citronen project with two of its significant shareholders, Nyrstar NV (Nyrstar) and Glencore International AG (Glencore), both of which are global commodity market leaders.

Nyrstar is one of the world's largest integrated zinc producers, producing from their mining operations zinc in concentrate, special high grade zinc (SHG), zinc galvanising alloys and zinc die casting alloys, all of which are outcomes of their zinc smelting process. Nyrstar is incorporated in Belgium and has its corporate office in Switzerland; its mining, smelting and other operations are located in Europe, the Americas, China and Australia.

Glencore is an Anglo-Swiss multinational commodity trading and mining company headquartered in Baar, Switzerland. Glencore is one of the world's leading integrated producers and marketers of commodities. As the world's largest commodities trading company, it holds an approximately 60% global market share of the internationally tradeable zinc market. In addition to the 35% offtake agreement for production from Citronen, Glencore has a marketing agreement with Ironbark for all the zinc and lead concentrate product produced from Citronen of $10 per dry metric tonne (dmt), subject to meeting specific market conditions and commodity prices which are currently undefined. This marketing fee has been excluded from the material covered by Glencore's offtake allocation.

Table 2.1 - Major zinc mine closures within four years

Mine	Annual Zinc Production ('000 t)
Century	500
Brunswick	200 (closed March 2013)
Lisheen	167
Skorpion	162
Perseverence	128
Pomorzany-Olkusz	65
Mae Sod	45
Bairendaba Yindu	45
Others	402
Total	**1.7 million tonnes (11% of global supply)**

Figure 2.1 - Strong fall in zinc and lead mine head grades as high grade mines are depleted
(Source: International Lead and Zinc Study Group)

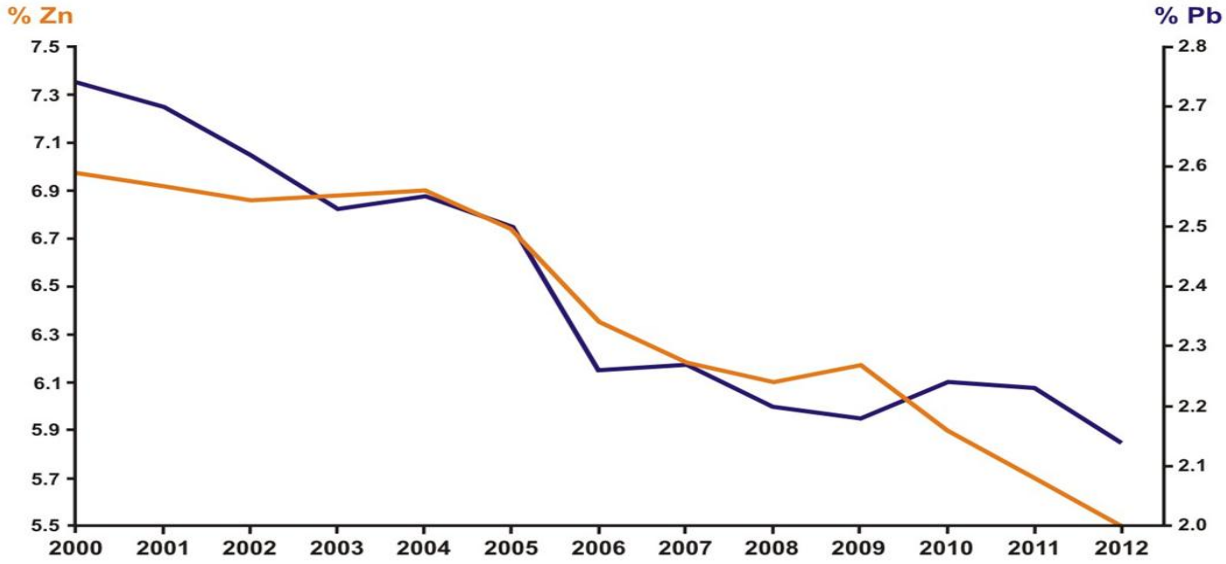
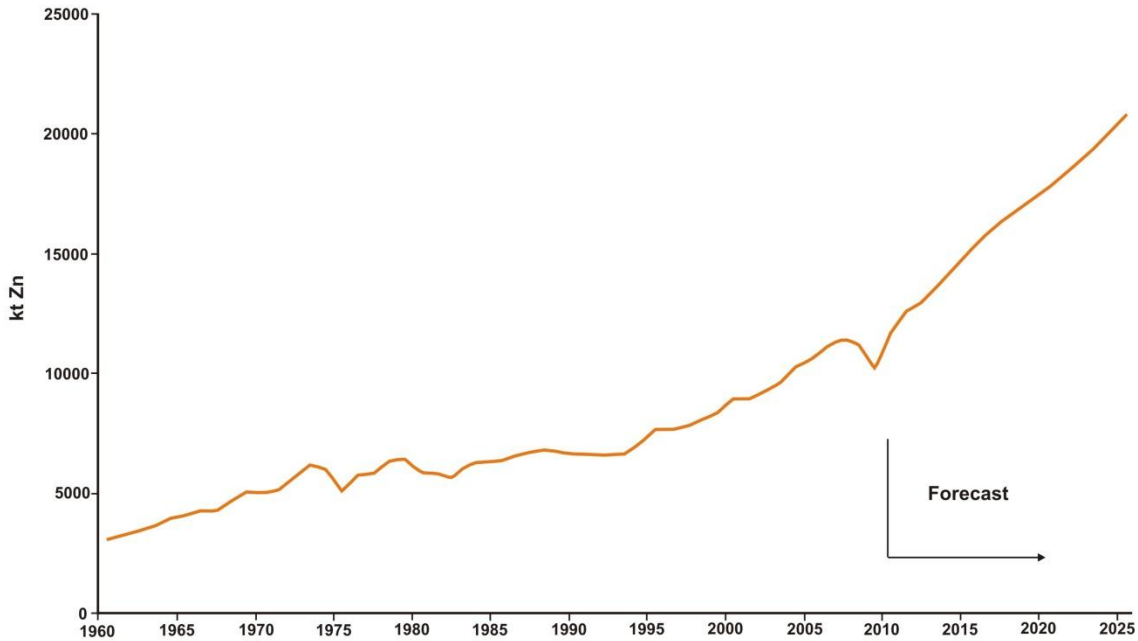


Figure 2.2 - Consistent rise in global zinc consumption
(Source: Mackenzie Wood)



2.3 Introduction to Lead and the Lead Market

Lead is used in lead-acid batteries, building construction, bullets and shots, weights, and in solders, pewters and fusible alloys. Total annual lead production is approximately eight million tonnes, approximately half of which is produced from recycled scrap. Over 50% of the US's lead production is consumed by the automobile industry due to the extensive use of the lead-acid battery as a car battery.

Global lead demand has increased strongly over the past 50 years (Figure 2.3) and is forecast to continue to grow by 3.3% in 2013 (*Source: China International Lead and Zinc Conference 2012, The International Lead and Zinc Study Group*). Representing over 80% of consumption, the largest market for lead is the production of automotive and other lead-acid batteries – a consistently growing market.

2.4 Lead Price Forecasting

The lead time to the construction and commissioning of the Citronen mine makes it important – as with zinc - to apply future forecast metal prices to the financial model to more accurately reflect the likely lead prices at the time of production. Accordingly, Ironbark has applied the work compiled by the Commodity Research Unit (CRU), an independent and globally recognised authority on commodities. The CRU has identified that global lead consumption is set to remain robust, underpinned by the secure and positive outlook for lead-acid battery usage, with Asia highlighted to remain the main engine of global growth.

Lead production is also set to grow, driven by China's internal dynamic of stronger growth in secondary over primary output. Raw material supplies will continue to grow worldwide and the unabating fight for lead metal scrap will only be intensified by the inevitable future closure of smelters. Nevertheless, the market tightness expected for zinc is not anticipated to be as strong in the lead market.

Metal availability is likely to increasingly tighten as swollen LME stocks, which grossly overstate the amount readily available to the lead industry, continue to constrict lead availability until 2017. Lead's tightness is likely to see further upside price forays in the shorter-term, however, wider investor caution over macro and US dollar uncertainties are likely to prevent lead prices straying too much further above the LME metals pack in the near-term. Ultimately, the intensifying physical squeeze will result in a decisive price rally further out. The CRU expects to see lead average US$1.04/lb (US$2,298/t) for the five years between 2013 or 2017 in real terms. The lead price for the life of mine for the Citronen Project is forecast to be US$0.95/lb (US$2096/t) in real terms.

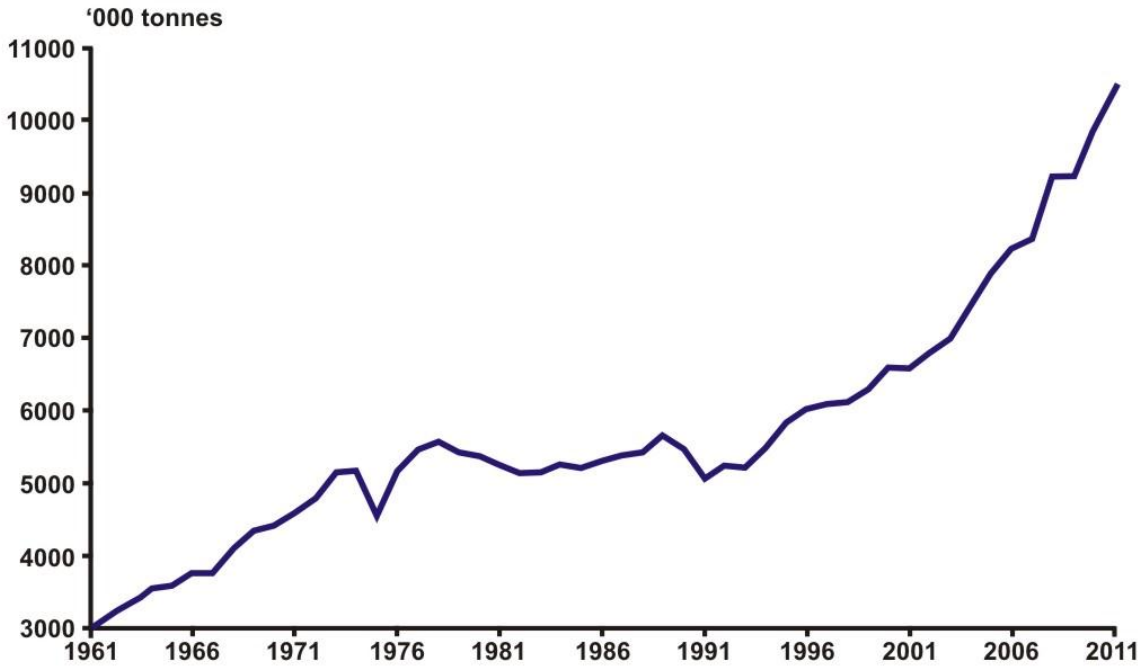
The Citronen mine is projected to produce a simple lead concentrate separate to the zinc concentrate via traditional, proven processing techniques. While the quantities of lead produced will be substantially less than the planned zinc production, it will still be a saleable by-product of the Citronen mine. The lead concentrate is a widely traded commodity and is likely to be shipped to European and Asian smelters.

Ironbark's significant shareholders, Nyrstar and Glencore, are both very active in the lead market. Nyrstar has a market leading position in lead, producing lead concentrate and refined market lead grading 99.9% lead. Ironbark has entered into an offtake agreement with Nyrstar for 35% of the production from the Citronen project.

Ironbark has also entered into an offtake agreement with Glencore for 35% of the production from the Citronen project. In addition, Ironbark shares the marketing rights with Glencore for the zinc and lead concentrate product produced from Citronen of $10/dmt, subject to meeting specific market

conditions and commodity prices which currently remain undefined. The marketing fee has been excluded from the material under Glencore's offtake agreement.

Figure 2.3 - Consistent rise in global lead consumption over the past 50 years
(Source: The International Lead & Zinc Study Group)



SECTION 3 - GEOLOGY & MINERAL RESOURCE

3. GEOLOGY & MINERAL RESOURCE

3.1 Status at February 2013

Two significant geology reports completed by Wardrop and Ironbark and their corresponding resource estimates have been used in this Report.

Wardrop's report included all geological investigations and drilling work up to and including the activities undertaken in 2010. The Wardrop report also included the Ravensgate Minerals Industry Consultants (Ravensgate) resource estimate (2010 model).

Ironbark's report is current at the date of this Report and incorporates the drilling and other geological work undertaken during 2011. It comprises a geology report and includes the updated Ravensgate resource estimate (2012 model).

The Ravensgate 2010 and 2012 resource estimates are summarised and compared in Table 3.1 below.

Table 3.1 - Ravensgate 2010 and 2012 resource estimates and comparison

Model	Measured			Indicated			Inferred		
	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)
2010 (Note 1)	33.23	3.77	0.47	52.22	3.69	0.48	47.20	3.34	0.40
2012 (Note 2)	43.09	4.08	0.48	51.19	4.14	0.44	37.72	3.80	0.41
Delta (2012 minus 2010)	+9.86	+0.31	+0.01	-1.03	+0.45	-0.04	-9.48	+0.46	0.01

Note 1: 2010 Resource Summary - as at January 25th 2011 at 2% zinc (Zn) lower cut-off grade - (Ordinary Kriging (OK) block model) - all material reported within 2% Zn mineralisation shells using OK interpolation.

Note 2: 2012 Resource Summary - as at February 28th 2012 at 2% Zn lower cut-off grade - (OK & ID2 block model Items) - all material reported within 2% Zn mineralisation shells using OK interpolation.

In summary, the result of the comparison between the 2010 and 2012 models was the conversion of approximately 9.5 million tonnes (Mt) of zinc (Zn) from the Inferred to the Measured category. Additionally, there has been a notable increase in the Zn grades in all categories (+8% in Measured, +12% in Indicated and +13% in Inferred).

3.1.1 February 2011 Geology Report

In February 2011 Wardrop completed a feasibility study report that included a section titled "Citronen Fjord Feasibility Study, Greenland – Volume 2: Geology". This report includes the drilling and sampling programmes up to and including those undertaken in 2010.

The 2010 resource model completed by Ravensgate (dated 25 January 2011) is an update to the Ironbark in-house Australasian Joint Ore Reserves Committee (the JORC code) resource estimate of November 2008. It also integrates Ironbark's drilling data from the 2009 and 2010 drilling programmes.

The summarised 2010 resource estimate is presented in Table 3.2.

Table 3.2 - Ravensgate 2010 resource estimate

Model	Measured			Indicated			Inferred		
	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)
2010	33.23	3.77	0.47	52.22	3.69	0.48	47.20	3.34	0.40

2010 Resource Summary – as at January 25th, 2011 at 2% Zn lower cut-off grade – (OK block model) – all material reported within 2% Zn mineralisation shells using OK interpolation.

This estimate and reporting of identified mineral resources was undertaken in line with the mineral resource reporting guidelines as outlined in the JORC Code (December 2004).

3.1.2 February 2012 Geology Report

Ironbark prepared a report titled "Citronen Fjord Feasibility Study, Greenland - Volume 2: Geology" (dated 19 November 2012) that is similar to and represents an update of the aforementioned Wardrop geology report. Ironbark's November 2012 report is summarised in Section 3.2 of this report.

Ravensgate updated the resource model again following the 2011 field season. The resource model completed by Ravensgate titled "End of 2011 Resource Estimation Report on the Citronen Fjord Zinc Project, Northeast Greenland – Resource Block Model Revisions for Ironbark Zinc Limited" was finalised in February 2012 and is referred to as the "2012 Model".

The "2012 Model" model is current at the date of this Report and is summarised in Table 3.3.

Table 3.3 - Ravensgate resource estimate "2012 Model"

Model	Measured			Indicated			Inferred		
	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)	Mt	Zn (%)	Pb (%)
2012	43.09	4.08	0.48	51.19	4.14	0.44	37.72	3.80	0.41

2012 Resource Summary – as at February 28th 2012 at 2% Zn Lower cut-off grade – (OK & ID2 block model Items) – all material reported within 2% Zn mineralisation shells using OK interpolation.

This estimate and reporting of identified mineral resources has been undertaken in line with the mineral resource reporting guidelines as outlined in the JORC Code (December 2004).

3.2 Geology & Mineral Resources

3.2.1 Project History

The sediment-hosted Citronen Fjord Zinc-Lead (Zn-Pb) Deposit represents a recent discovery and the first and only known Sedimentary-Exhalative (SEDEX) deposit in the Franklinian Basin of northern Greenland.

Gossanous material was first noted in the vicinity of Citronen Fjord in 1969 during a British Joint Services Expedition to Peary Land - Johannes V. Jensen Land. A Greenland Geological Survey regional mapping project in the late 1970s-1980s reported mineralised debris flow with Zn (5.4%) and minor copper (Cu), several kilometres south of Citronen Fjord. In 1993, Platinova A/S (Platinova) discovered significant massive sulphide mineralisation outcropping, in what is now known as the 'Discovery Gossan' (Figure 3.1).

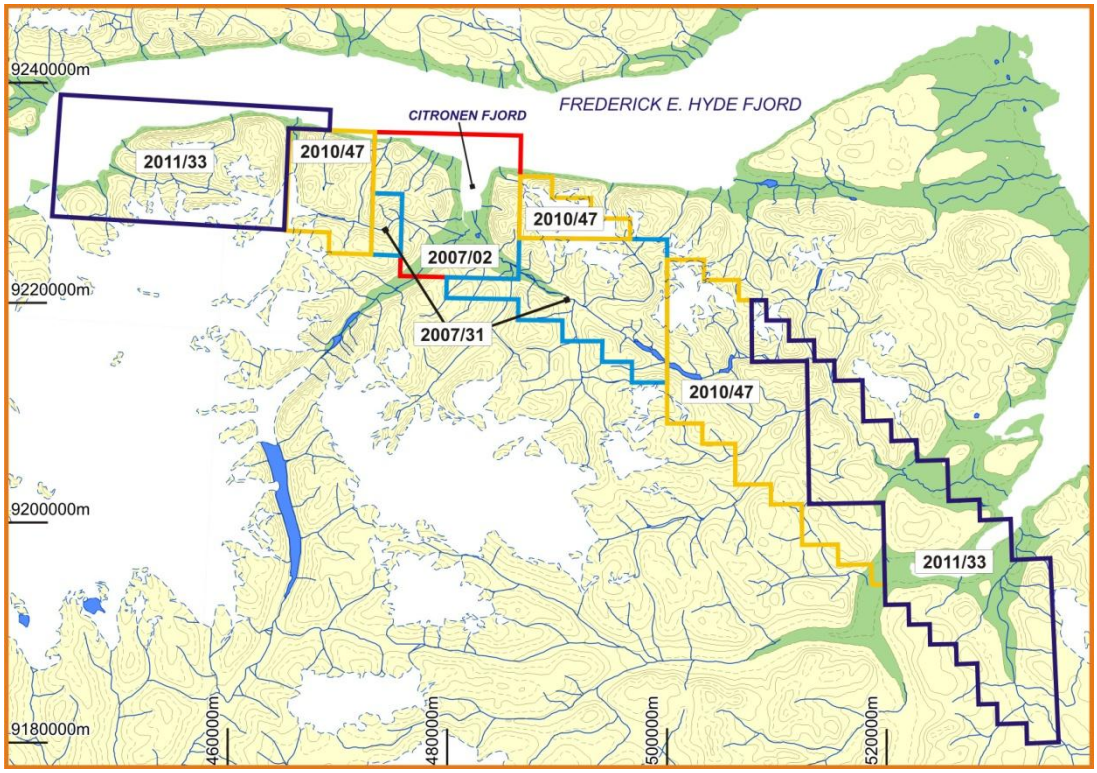
Figure 3.1 - Gossanous outcrop of Level 1 sulphides at the Discovery Zone

Platinova investigated the area between 1993 and 1997, drilling 148 diamond drill holes for a total length of 32,702 m, indicating mineralisation over a strike length of 15 km estimated to contain in excess of 1.5 Mt of Zn metal. A period of depressed base metal prices during the late 1990s and early 2000s saw fieldwork halted until the project was purchased by Ironbark in 2006.

In 2007, Ironbark initiated investigations via extensive re-sampling of Platinova diamond drill core, followed by the construction of a 40-person camp and a diamond drill programme in 2008. Ironbark has now completed four consecutive years of diamond drilling on the project for a total of 34,240 m, bringing the total metres drilled at the project to date to over 66,000 m.

The drilling conducted, the resource and camp are located within tenement 2007/02 (Figure 3.2) held by Bedford (No. 3) Limited, a wholly owned subsidiary of Ironbark. Ironbark additionally holds extensive exploration rights over the prospective ground surrounding the main Citronen tenement, comprising of three licences 2011/33, 2010/47 and 2007/31 (Figure 3.2).

Figure 3.2 - Ironbark's tenement holding in the Citronen Fjord region



3.2.2 Geological Setting

The Citronen Fjord Zn-Pb Deposit is located within the Lower Palaeozoic Franklinian basin of northern Greenland, which extends westward from Kronprins Christian Land in north-eastern Greenland for over 2,000 km into the Canadian arctic islands. The basin consists of a sequence of siliciclastics and carbonates, with sedimentation initiated during an interior sag phase in the Proterozoic and ceasing during the Devonian-Carboniferous Ellesmerian orogeny.

The basin architecture during deposition of the Palaeozoic sequences comprised a stable carbonate platform to the south and a deep-water trough to the north. The Citronen Fjord Zn-Pb Deposit is hosted within the Ordovician deep-water trough sedimentary rocks of the Amundsen Land Group, located in the eastern portion of the basin. The morphology of the eastern portion of the basin during its formation consisted of an inner carbonate platform to the south and a deep-water trough to the north, with the boundary between these two environments being relatively abrupt and termed the Navarana Fjord escarpment (NFE). The Citronen Deposit formed approximately five kilometres north of the NFE.

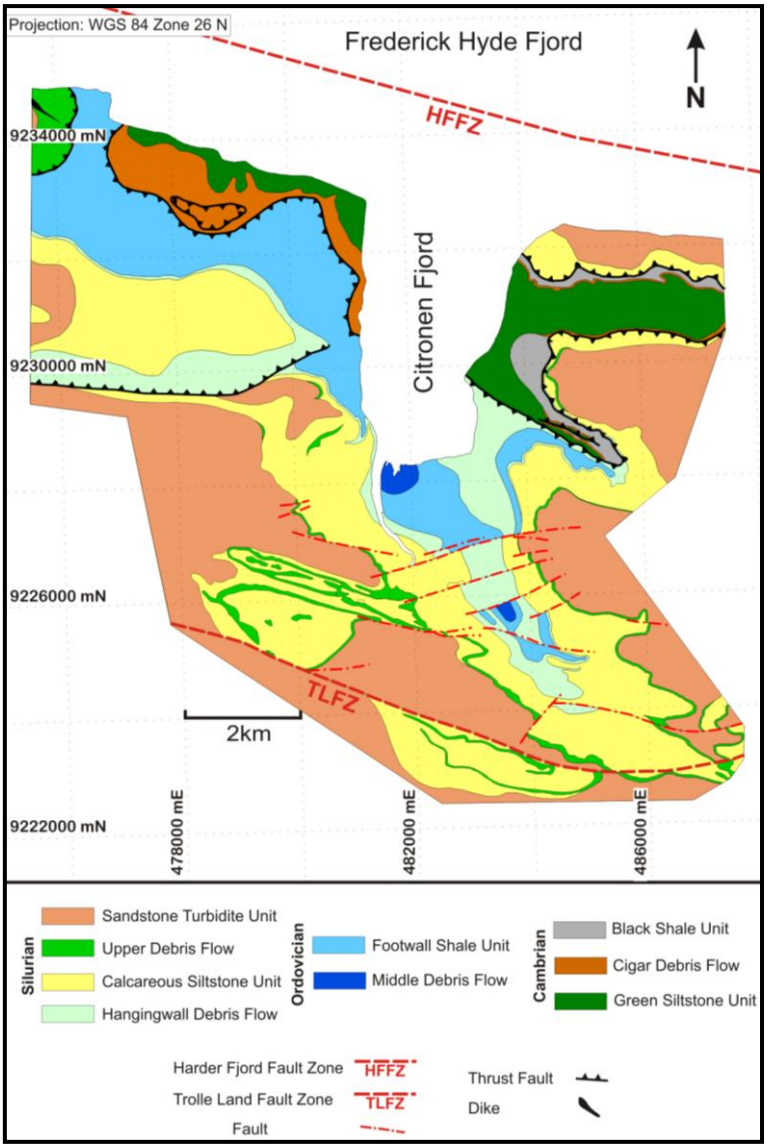
During Ordovician expansion of the basin, the trough environment was oxygen starved and anoxic dark mudstones, black and green cherts and thin-bedded turbidites were deposited. Inter-bedded

with these slowly accumulated fine-grained sedimentary rocks are thick carbonate conglomerates (debris flows) sourced from the carbonate platform.

The local geology at Citronen Fjord consists primarily of Cambrian to Silurian deep-water trough sediments punctuated with coarse carbonate debris flows overlain by Silurian sandstone turbidites (Figure 3.3). The carbonate debris flows are useful stratigraphic markers and are present at Citronen Fjord in the vicinity of the major sulphide horizons.

The region is part of a major fold and thrust belt, although the mineralised stratigraphy at Citronen is relatively undeformed with only minor folding and faulting. The Citronen Fjord Deposit sits between two major regional structures, the Harder Fjord Fault Zone (HFFZ) and the Trolle Land Fault Zone (TLFZ) (Figure 3.3). The TLFZ is interpreted to have been a conduit for mineralising fluids. Another major structural feature in the vicinity are thrust faults juxtaposing older Cambrian stratigraphy over younger material in the mountains surrounding the fjord (Figure 3.3); these thrust structures do not affect the mineralised domains.

Figure 3.3 - Local geology of the Citronen Fjord area



3.2.3 Deposit Type

The Citronen Deposit is interpreted as belonging to the SEDEX deposit class, forming syn-depositionally with sedimentation. The geology of northern Greenland is contemporaneous to that of parts of the Canadian arctic islands, which also host several large base metal deposits of SEDEX and Mississippi Valley Type (MVT) type.

SEDEX deposits are formed in submarine environments by the precipitation of sulphides from metal bearing fluids introduced onto the seafloor through underlying fractures which act as metal-bearing fluid conduits. Large amounts of sulphur are precipitated principally as pyrite and focused around vent areas or 'mounds' on the sea floor. Base metal (Zn + Pb) bearing sulphides at Citronen are predominantly located within laminate horizons surrounding these larger sulphide accumulations.

3.2.4 Mineralisation

Mineralisation at the Citronen Fjord Zn-Pb Deposit comprises several distinct sulphide mounds containing massive and net-textured pyrite-rich mineralisation, interpreted to represent the focal point of fluid influx, flanked by pyritic laminated sulphides that are locally sphalerite and galena-rich. These laminated sulphides host the majority of economic grade mineralisation.

The deposit consists of multiple sulphide mounds forming in three lateral positions ("vents"), defined as the Discovery, Beach and Esrum ore bodies (Figure 3.4). The mounds are present within three stratigraphic positions, termed Levels 1, 2 and 3 (Figure 3.5). Level 3 represents the lowest and oldest stratigraphic position of mineralisation and Level 1 the highest and youngest (Figure 3.5).

Figure 3.4 - Topographic map showing the location of the major ore bodies at Citronen
(red dots signify diamond drill-hole collar locations)

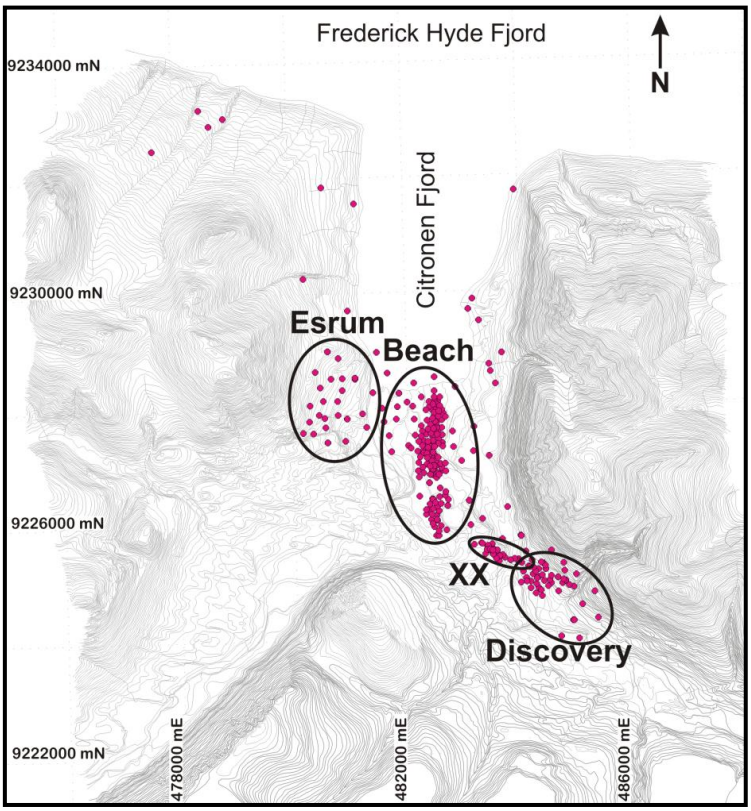
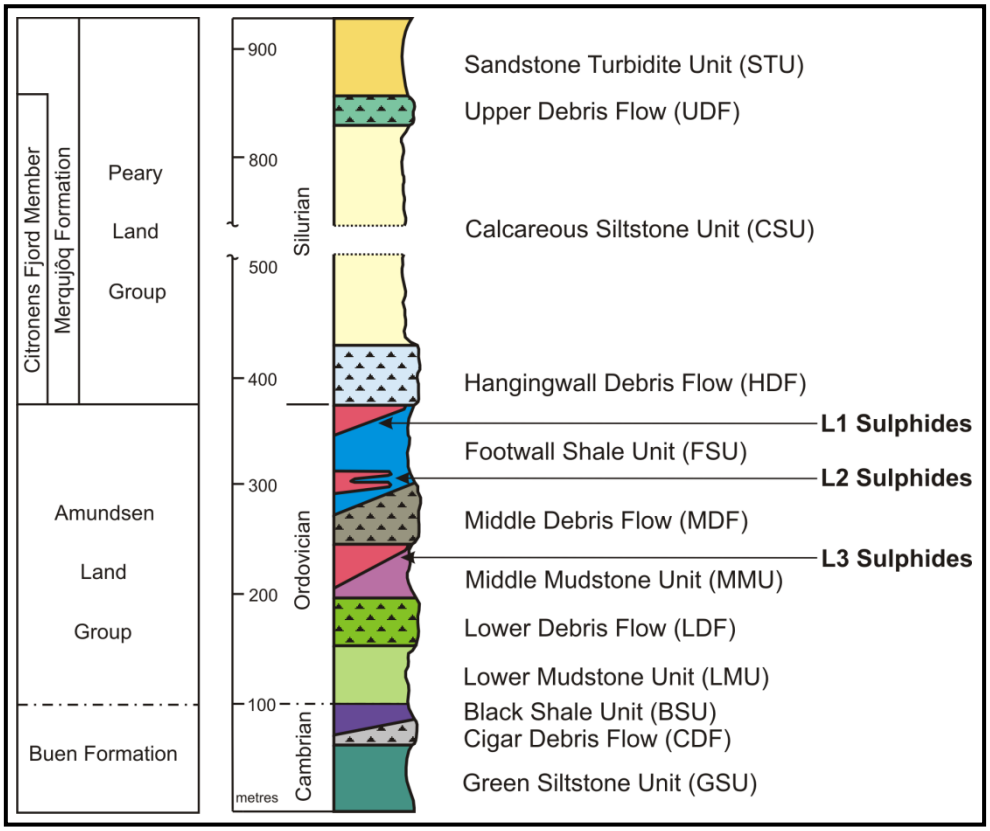


Figure 3.5 - Stratigraphic column for the Citronen Fjord Zn-Pb Deposit



The mineralisation is hosted within two fine-grained sedimentary units, separated by a mass carbonate debris flow. The majority of mineralisation is stratiform, with semi-massive net-textured to massive sulphides accumulating in the core of the mound structure. Structurally controlled stock-work style mineralisation is present within the carbonate debris flows, with the most notable termed the XX ore body (Figure 3.4). The stratiform mineralisation has been identified from outcrop to a depth of approximately 500 m, with the mineralisation open at depth. Level 1 is located predominantly within the Discovery ore body, Level 2 is evident discontinuously across all three ore bodies and Level 3 contains the largest volume of sulphides, with a lateral extent of over 3,000 m between the Beach and Esrum ore bodies.

The mineralisation is pyrite dominated with variable amounts of sphalerite ((Zn/Fe)S) and lesser galena (PbS) present as sulphide species. Minor chalcopyrite ($CuFeS_2$) has been documented and interpreted as having formed during remobilisation and enrichment of primary stratiform-hosted mineralisation. No economically significant Cu or silver (Ag) has been identified to be associated with the sulphide mineralisation.

Primary mineralisation is generally fine to medium grained, weakly to moderately laminated and bedded parallel with regionally deposited sediments. Gangue mineralogy is primarily silt and clay from mudstones deposited contemporaneously with sulphide mineralisation.

3.2.5 Zinc Exploration Potential

To date, exploration has not constrained sulphide mineralisation within the Citronen area. Several geophysical, geochemical and structural targets within the project area which have the potential to host further significant Zn and Pb mineralisation are yet to be tested.

The Exploration Target identified using geological modelling is based in the immediate project area and is covered within the 120 km^2 of Exploration Licence 2007/02. A target of 165–190 Mt @ 5.7 to 6.5% Zn+Pb (at a 3.5% cut-off) within a target of 302-347 Mt @ 4.4-5.0% Zn + Pb (at a 2.0% cut-off) has been defined. The potential quantity and grade of this Exploration Target is conceptual in nature. There has been insufficient exploration to estimate a Mineral Resource and it is uncertain whether further exploration will result in the estimation of a Mineral Resource.

On a local scale, the deposit shows considerable exploration potential based on open-ended drill results and geophysical survey data. Ironbark is progressively testing gravity anomalies identified by Platinova as part of its current exploration work and there is strong exploration potential to both extend zones of current resources and find new zones of mineralisation.

On a regional scale, SEDEX deposits do not tend to appear as single entities but are generally part of a larger scale 'camp' of deposits; examples include the Mount Isa-McArthur Basin in Australia with seven deposits, and the Selwyn Basin in Canada with 17 deposits. This highlights the prospectivity surrounding Citronen within Ironbark's extensive tenement package in the underexplored Franklinian Basin. Ironbark holds in excess of 1,100 km^2 of 100%-owned tenure surrounding Citronen. The tenure covers the prospective Trolle Land Fault Zone, which has been interpreted to be the main feeder zone for the mineralisation at Citronen Fjord.

3.2.6 Drilling

Platinova drilled 148 diamond holes for 32,702 m between 1993 and 1997. Diamond drilling was by either NQ or, more commonly, BQ diameter. To date, Ironbark has completed 166 diamond holes in BQ, NQ, and HQ for 34,240 m, bringing the total metres drilled at Citronen to date in excess of 66,000 m.

Drilling at Citronen is conducted using heli-portable diamond drill rigs. There is extensive permafrost in the region and specialised drilling techniques are required to ensure productivity and avoiding loss of drilling equipment through freezing. Drilling is conducted from April to mid-September. Drill core is photographed and non-assayed material is stored on-site.

3.2.7 Sampling Method and Approach

Sampling techniques will be discussed by company and period:

- Platinova: 1993-1997
- Ironbark: re-sampling 2007
- Ironbark: 2008-2011

1993-1997 Sampling Method

Drill core was logged on-site by geologists and zones of sulphide mineralisation were tested using a portable x-ray fluorescence (XRF) apparatus. Intercepts deemed to be of economic significance were split on-site and half-core samples were transported to assay laboratories in Canada. A broad consensus for economic significance was approximately 2-3% Zn over one metre. Sampling was

done on a geological basis with sample lengths between 0.15 m and 1.3 m selected for chemical analysis in Canada.

Platinova collected 1,534 samples for analysis from drilling between 1993 and 1997.

2007 Sampling Method

Ironbark did not conduct new drilling in 2007; instead, all drill core was examined on-site using a handheld XRF and a lower cut-off of 1% Zn to select samples for chemical analysis. Further to this, samples were selected on a 0.5 m or 1.0 m basis. When sampling was conducted around zones of previously sampled material, sample interval lengths were selected so as to round-off intervals to multiples of 0.5 m. Samples were transported to ALS Chemex Laboratories Ltd (ALS Chemex) in Vancouver for analysis, using inductively coupled plasma (ICP) and XRF techniques. Ironbark analysed all material for Zn, Pb, and Fe.

Ironbark submitted 2,765 samples for analysis in 2007. The sampling procedure followed by Ironbark involved:

- drill core inspection by a geologist
- analysis by XRF
- samples selected, marked and then sawn in half with a diamond saw
- half-core samples placed in a calico bag, which were individually numbered referencing the drill hole identification and the sample number from that hole

In addition to core sampling, 54 sample standards were used in 2007, provided by Geostats Pty Ltd, Australia (Geostats). Three different standards were used.

Quality assurance/quality control (QA/QC) sampling was conducted to confirm Platinova's work and several zones of previously assayed material (remaining half core) were assayed.

2008-2011 Sampling Method

Sampling of drill core obtained by Ironbark during the 2008-2011 drill programmes is as per Platinova/Ironbark methods (i.e. the drill core is logged, photographed, and sulphide intercepts checked by portable XRF on-site). Intervals deemed to be 1% Zn or greater were half-cored and transported for analysis. Samples were transported to ALS Chemex in Sweden for analysis using ICP atomic emission spectroscopy (ICP-AES) (laboratory technique ME-ICP81). A suite of 26 elements were analysed for, including Zn, Pb, Ag, Fe, Cu and S.

Duplicate analyses were conducted on an average of one per 25 samples. ALS Chemex performed the duplicate analyses on selected sample intervals, with two representative splits taken from the same interval.

As in 2007, Geostats standards were used for QA/QC control. On average, one standard was analysed for every 20 samples sent to the laboratory.

3.2.8 Data Verification

Ironbark has undertaken adequate measures to ensure the integrity of assay data used in the resource estimation. Due to previous exploration being conducted relatively recently and by only one company, Ironbark has been able to produce a complete and very well audited database. Assay sample pulps from the 2007-2011 analyses were transported to Perth, Western Australia, and stored by Ironbark.

Since acquiring the Citronen Fjord Project, Ironbark has employed numerous consultant companies to review and assess the data validity for the Project. Expedio (based in Perth, Western Australia)

managed Ironbark's database off-site from 2008-2010, with the small additional data obtained from the 2011 field season integrated in-house by Ironbark personnel.

A number of quality controls were undertaken during Ironbark's initial 2007 investigation of the deposit in order to correlate Ironbark's new data (original assaying of Platinova core) to that of the historic data compiled by Platinova. Ironbark took the remaining half core for 15 of Platinova's samples and had it assayed by the same laboratory (now ALS Chemex of Vancouver, Canada). Comparison of the Ironbark and Platinova assay data showed a 0.98 correlation coefficient for Zn and 0.96 for Pb.

Duplicate chemical assays were regularly performed with a total of 123 duplicate analyses performed during 2007-2011. The correlation of these beta samples to the original alpha sample was exceptional with both Zn and Pb having a correlation coefficient of effectively one (1) (0.9978 for Zn and 0.9973 for Pb).

Certified laboratory standards were regularly submitted with a total of 170 included during Ironbark's exploration. The six standard varieties comprised GBM301-6, GBM309-16, GBM901-5, GBM906-15, GBM907-14 and GBM996-3 and were produced by Geostats Pty Ltd (based in Perth, Western Australia). Five of the six standard varieties returned Zn and Pb values within acceptable limits; taking into account assay precision, these results are deemed acceptable (i.e. within 2 standard deviations). One standard (GBM906-15) returned numerous Zn and Pb values that fell outside of the acceptable range. This standard was irregularly submitted over numerous batches and years (2009, 2008 & 2011). Other standards, duplicates and internal laboratory standards in the same batches all returned within acceptable ranges. It is assumed the batch of GBM906-15 reference standards used was not reliable.

To cross check assay results, and as an exploration aid, Platinova and Ironbark routinely took handheld XRF measurements of the drill core. Ironbark took readings every five centimetres and averaged these values to the corresponding sample interval. These results were compared with the actual assay values to provide a quality check of assays, i.e. any grossly different values would be obvious.

A detailed study of the 2010 season data, based on over 18,000 individual XRF readings and their corresponding 736 chemical assays, looked at the correlation and variations in relation to mineralisation style. The results were remarkably accurate with a correlation coefficient of 0.93 for all readings (with 98% of readings falling within ±5% of the chemical assay), 0.96 for laminated sulphides (predominant host to economic mineralisation) and 0.89 for massive/dendritic sulphides. These results add another level of confidence to the chemical assay information.

3.2.9 Geological Modelling

Geological modelling of the Citronen Fjord Deposit is aided by the relatively simple nature of the mudstone-debris flow horizons and the stratiform nature of mineralisation centred on vent-mound locations. Working with observed (mapping and drilling) geological information, a robust geological model has been prepared to allow for statistical analysis, domaining and resource estimation.

Three geological models and resource estimates have been produced by Ironbark since 2007. The first was by Wardrop in 2007 who modelled mineralisation as four geological solids as part of the National Instrument 43-101 resource estimate. The solids created were Hanging-wall Debris Flow (DF1), Inter-bedded Sulphide Level 1 (IBS1), Middle Debris Flow (DF2) and Inter-bedded Sulphide Level 2 (IBS2).

In 2007-2008, Ironbark developed the Wardrop model further, adding smaller zones of fault controlled (remobilised) mineralisation and further constraining zones around specific down-hole

mineralised intercepts to reflect grade continuity; it should be noted that essentially the same geological horizons as defined by Wardrop were maintained during Ironbark's development of the Wardrop model. Ironbark's modelling was done in Perth using Maptek Pty Ltd's Vulcan™ software. Geological surfaces and solids include extrapolation of several normal faults associated with areas close to the Trolle Land Fault (outside resource and development areas) as well as within the Discovery Zone (the volumetrically minor XX Zone mineralisation is fault hosted).

In late 2009-2010, Ravensgate updated Ironbark's in-house JORC code resource estimate, using a model that integrated the drilling data from the 2009 drilling programme. The domains originally modelled by Ironbark were updated using Mintec Inc's MineSight® (MineSight) 3D modelling software to create a new JORC-compliant resource.

Ravensgate updated the model after the 2010 field season and then again after the 2011 field season. The current resource model completed by Ravensgate was finalised in February 2012 and is referred to as the "2012 Model".

3.2.10 Bulk Density

Ironbark conducted numerous empirical Specific Gravity (SG) measurements of drill core from a large range of different rock types and mineralisation styles from the deposit. Ironbark also examined statistical methods to calculate bulk density based on mineral abundance and stoichiometric density.

To calculate the bulk density in the deposit, Ironbark produced a theoretical density for each block in the model based upon the modelled value of Fe, Pb and Zn and rock type coding. This approach is thought to be more accurate than using an averaged density value for each domain.

The interpolated densities for each block were calculated using a formula that utilised the Ordinary Kriged Fe, Pb and Zn values for that block. The formula assumes that all Zn is reporting to sphalerite (SG of 4.05), Pb to galena (SG of 7.4) and Fe to pyrite (SG of 5.01), with the remainder consisting of mudstone gangue (SG of 2.78).

3.2.11 Variography

The deposit statistics were thoroughly reviewed using both raw sample and composite data. A standard one metre length down-hole composite was used. All compositing, data processing and statistical analyses were conducted in MineSight Compass software by geological consultants Ravensgate.

It was determined the majority of mineralised domains display relatively low composite population variances and low coefficients of variation. The distribution of Zn and Pb within the defined domains at Beach, Discovery and Esrum is observed to be relatively predictable and mostly display low coefficients of variation.

A 340 m interpolation range was used for primary interpolation runs, based on the broad 'between hole' variography; the range is also a practical distance required to adequately 'fill' blocks within mineralisation shells in the block model. The nominal 50 x 50 m drilling pattern present throughout the main parts of the deposit is adequate to attain sufficient numbers of sample composites used within interpolation search ellipsoids.

3.2.12 Grade Estimation

It was determined the optimal estimation block size, based on the data density and ore zone geometry, was 10 m x 10 m x 1 m – East (X), North (Y), Elevation (Z).

The current resource model was produced using the Ordinary Kriging interpolation technique for all block model interpolation and the resulting kriged items for Zn, Pb and Fe were used for all subsequent resource reporting.

A series of Ordinary Kriging and Inverse Distance Squared interpolation runs were conducted separately for each mineralised domain, with parameters adjusted for each particular domain orientation, statistics and variography. Each of the individual domains was assigned specific 'nugget', 'sill' and search ellipsoid parameters for Zn, Pb and Fe items.

3.2.13 Mineral Resource Statement

The resource estimate developed by Ravensgate is based on a series of Ordinary Kriging interpolation runs for each of the separate mineralised domains, using a 3.5% Zn cut-off as shown in Table 3.4 and a 2% Zn cut-off as shown in Table 3.5.

Table 3.4 - Medium grade resource estimate based on mineralisation contained within 3.5% Zn shells, produced by Ravensgate

Resource Category	Mt	Zn%	Pb%	Zn+Pb%
Measured	25.0	5.0	0.5	5.5
Indicated	26.5	5.5	0.5	6.0
Inferred	19.3	4.7	0.4	5.1
Total	70.8	5.1	0.5	5.7

Using OK interpolation and reported at a 3.5% Zn cut-off. Figures rounded to one decimal place.

Table 3.5 - Within a larger resource estimate based on mineralisation contained within 2.0% Zn shells, produced by Ravensgate

Resource Category	Mt	Zn%	Pb%	Zn+Pb%
Measured	43.1	4.1	0.5	4.6
Indicated	51.2	4.1	0.4	4.6
Inferred	37.7	3.8	0.4	4.2
Total	132.0	4.0	0.4	4.5

Using OK interpolation and reported at a 2.0% Zn cut-off. Figures rounded to one decimal place.

This estimate and reporting of identified mineral resources has been undertaken in line with the mineral resource reporting guidelines as outlined in the JORC Code (December 2004).

SECTION 4 - MINING

4. MINING

Two significant mining studies have been used in this Report, namely, the Wardrop Engineering Inc. (Wardrop) report of May 2011 and Mining Plus Pty Ltd (Mining Plus) report of March 2012.

4.1 Wardrop Mining Report, June 2011

The Wardrop mining feasibility study report included both open pit and underground mine planning and design, potential mineable resource estimates, production schedules and cost estimates. The Wardrop report was completed in June 2011.

Wardrop used the 2010 Resource model (dated 25th January 2011) for mine planning and optimisation. The resource model was derived from the Ravensgate "2010 Resource Estimate Report".

Total mining production from the surface and underground mines was set at three million tonnes per annum (Mtpa). The underground mine was planned to produce at a rate of 1.5 Mtpa initially with the additional 1.5 Mtpa to come from the open pit. Once the open pit resources were consumed, the production rate at the underground mine would ramp up to 3.0 Mtpa during Years 6 and 7 to give the project a total mine life from open pit and underground mine of 14 years.

4.2 Mining Plus Mining Report, March 2012

The second significant mining study is the Mining Optimisation, Design & Schedule of the underground and open pit zinc-lead resources prepared by Mining Plus (dated March 2012). The Mining Plus work represents the optimisation and further detail study of the Wardrop work.

A major difference between the Mining Plus and Wardrop reports is Mining Plus' use of the updated 2012 Resource Model, which included the results of the 2011 drilling programme. The new resource model was derived from the Ravensgate "End of 2011 Resource Estimation Report" and is referred to as the 2012 Resource Summary. As a result of this work and the enhanced resource definition, the Wardrop mining schedules became redundant and are superseded by the Mining Plus data.

The Mining Plus underground and open pit mine designs were conducted, sequenced and scheduled based on three ore production rates of 3.0 Mtpa, 3.3 Mtpa, and 3.6 Mtpa using a 4.5% Zn cut-off grade. This is consistent with the current process plant design throughput of 3.3 Mtpa, with the capacity to increase to 3.6 Mtpa.

In addition to basing mine planning and optimisation on the updated resource block model, Mining Plus conducted optimisations and comparative evaluations. The Mining Plus document is current at the date of this report.

The underground and open pit mining schedules are summarised respectively in Table 4.1 and Table 4.2. In order to take advantage of the significantly higher underground ore grades and for financial modelling purposes to enhance the project economics, the underground mining operation 3.3 Mta scenario is scheduled to take place in Years 1 to 11 (one year more or less for the 3.0 Mtpa and 3.6 Mtpa scenarios respectively). Following the depletion of underground resources, the open pit ore production will commence during Year 11 to maintain the 3.3 Mtpa ore production level. This reversing of underground and open pit schedules is a significant point of difference between the Mining Plus and the Wardrop reports.

Table 4.1 - 3.3 Mtpa yearly underground schedule summary

		Yr 0	Yr 1	Yr 2	Yr 3	Yr 4	Yr 5	Yr 6	Yr 7	Yr 8	Yr 9	Yr 10	Yr 11	Total
Ore Tonnes	Mt	0.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.6	35.8
Zn Grade	%	4.94	7.81	7.02	6.00	5.42	5.98	5.53	5.62	5.46	5.01	5.04	5.45	5.85
Pb Grade	%	0.52	0.65	0.65	0.62	0.51	0.46	0.44	0.37	0.41	0.36	0.41	0.64	0.50
Fe Grade	%	16.21	11.89	14.43	16.78	17.16	18.83	17.74	19.68	17.70	14.72	18.99	19.51	16.99

Table 4.2 - 3.3 Mtpa yearly open pit schedule summary

		Year 0	Year 1(Note 1)	Year 2	Year 3	Year 4	Total
Ore Tonnes	Mt	Minimal	3.3	3.3	2.6	0	9.2
Zn Grade	%	3.35	3.23	2.82	3.31	0.00	3.10
Pb Grade	%	0.63	0.59	0.54	0.59	0.00	0.57
Fe Grade	%	27.03	22.70	22.43	19.43	0.00	21.70

Note 1: 0.7 Mt of this ore is combined with underground ore in Year 11 to maintain the 3.3 Mtpa ore mining rate.

4.3 Summary of Mining Plus Mining Study (2012)

4.3.1 Resource Model Comparison

The grade estimation conducted in the 2012 Resource model provided to Mining Plus for optimisation and evaluation involved two grade estimate techniques, namely inverse distance (ID) and Ordinary Kriging (OK). A comparison of the two grade fields on the overall potential underground project tonnes and grade was conducted by Mining Plus through interpolation of grade tonnage report curves.

The comparison of ID and OK techniques displays immaterial differences with regards to the mine design, sequence and final extraction data. At the proposed cut-off grade of 4.50% Zn there is a difference of 0.8 Mt for 145 Zn metal tonnes and 11 Pb metal tonnes in the 2012 Resource. This represents a difference in the order of 2.0% in tonnes and 5.0% to 6.0% in grade.

4.3.2 Underground Optimisations

Due to the nature of the ore zones indicated by the underground geological model, a comparative study was undertaken to quantify the potential benefits of implementing a mining width of two metres compared to the Wardrop mining study width of four metres. A software program was used to assess the resource block model to determine the optimal size, shape and location of stopes based on various input and grade cut-off criteria. The resultant potential mining inventory output allowed for an evaluation and determination of the most suitable stope shape (extraction dimensions) to pursue for a more detailed mine design.

Mining Plus concluded that at a 4.50% Zn cut-off grade the two metre minimum mining thickness displays a slightly greater tonnage and higher zinc grade than the four metre scenario. However, in the opinion of Mining Plus, this increase is not of sufficiently significant quantity to justify the specialised mining equipment and possible production rate constraints of a smaller capacity fleet. Mining Plus continued through mine design, sequencing and scheduling with the four metre minimum mining thickness scenario at a 4.50% Zn cut-off grade.

4.3.3 Underground Design

Mining Plus continued with the Wardrop study information and data for room and pillar design, all geotechnical information, mining recovery ratios and all ventilation information.

Ironbark requested a dilution skin be added into the design to allow for over break. The design skin was calculated by adjusting the "pillar drive" and "ore drive strips" to be mined at a height of 0.3 m above the planned height.

With the mining method being room and pillar, a recovery factor of 100% recovery was assumed as ore loss should be negligible provided that a tele-remote bogging system is used for the recovery of the ore drive strip material. The likelihood of ore loss would increase if a line of site remote bogging system was used.

All mining has been planned for conduction via development jumbo and, as such, minimal overbreak (i.e. unplanned dilution) outside of the planned dilution skin is expected. As a result, no tonnage factors were applied to this design.

As reported by Wardrop, underground mine backfill will be from process plant tailings slurry that will be pumped into place and then freeze naturally due to the permafrost conditions. As deposition and freezing occurs, the excess water from the tailings will be pumped from the mine.

4.3.4 Incremental Ore

Incremental ore is defined as that material that must be excavated in order to gain access ore. As such this material must be drilled, blasted and hauled as part of the course of mining. Typically it would be classified as waste because it is below the economic mining cut-off grade. However, should this material be suitably mineralised to cover the cost difference between hauling and dumping as waste and delivery to the mill, together with processing, shipping and royalty payments, it then becomes economically valuable and can be considered incremental ore.

For the Mining Plus evaluation, all material (stope and development) above an incremental cut-off grade of 3.50% Zn was progressed to the scheduling stage of the study.

4.3.5 Underground Mine Scheduling

The underground mine has been scheduled at production rates of 3.0 Mtpa, 3.3 Mtpa and 3.6 Mtpa, with Year 1 considered to be the first year of full production. As per the schedules, the project has one year of pre-production and an overall mine life in the order of 10 to 12 years dependant on available material and scheduled production rate.

The majority of the resource is contained within the Esrum L3N, Beach L2N and Beach L3N domains. Mining Plus undertook detailed development and stope designs on these three domains for scheduling purposes. In addition to this, two smaller lodes in the South of the Beach deposit (Beach L2S and Beach L3S) contain material above the 4.50% Zn cut-off grade. This material contains relatively low tonnages and would require substantial additional development to access. However, as it would be extracted at the end of the underground mine life, the scheduled extraction of the Beach South material has also been included.

A comparative summary of the three production scenarios is presented in Table 4.3. A more detailed summary of the 3.3 Mtpa production rate is presented in Table 4.4.

Table 4.3 - Summary production schedule

Item	Unit	Quantity
Mine life		
3.0 Mtpa production	Years	12.9
3.3 Mtpa production	Years	11.8
3.6 Mtpa production	Years	10.9
Ore tonnes	Mt	**35.8**
Zn grade	%	5.85
Zn metal	Kt	2,094
Pb grade	%	0.50
Pb metal	Kt	178.2
Fe grade	%	16.99
Fe metal	Kt	6,076
Bogged waste	Kt	410.3
Total bogged	Mt	36.2
Total development		
Lateral - capital	metres	5,903
Lateral - operating	metres	180,283
Vertical - capital	metres	1,906

At the point in time when the underground resources are depleted the underground mine will be closed down, subject to further resources being discovered in the intervening period.

Table 4.4 - 3.3 Mtpa production schedule

		TOTAL	YR -2	YR -1	YR 1	YR 2	YR 3	YR 4	YR 5	YR 6	YR 7	YR 8	YR 9	YR 10	YR 11
Ore tonnes	**Mt**	35.8		0.1	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	3.3	2.6
Zn grade	**%**	5.85		4.94	7.81	7.02	6.00	5.42	5.98	5.53	5.62	5.46	5.01	5.04	5.45
Zn metal	**kt**	2,094		3.6	257.7	232.8	198.8	179.9	197.4	184.3	186.2	180.3	165.7	167.2	140.3
Pb grade	**%**	0.50		0.52	0.65	0.65	0.62	0.51	0.46	0.44	0.37	0.41	0.36	0.41	0.64
Pb metal	**kt**	178.2		0.4	21.5	21.5	20.5	17.0	15.3	14.7	12.2	13.4	11.7	13.5	16.5
Fe grade	**%**	16.99		16.21	11.89	14.43	16.78	17.16	18.83	17.74	19.68	17.70	14.72	18.99	19.51
Fe metal	**kt**	6,076		11.6	392.4	478.7	556.2	569.5	621.7	590.7	652.0	584.1	486.5	630.1	502.3
Development															
Ore Tonnes	**Mt**	14.8		0.1	1.5	1.5	1.4	1.9	1.0	1.1	1.3	1.4	1.3	1.2	1.2
Zn Grade	**%**	5.34		4.94	7.75	6.78	5.85	5.31	5.77	5.49	5.68	5.32	4.90	4.89	0.05
Zn Metal	**kt**	788.8		3.6	113.3	102.5	82.8	98.3	56.5	61.2	72.0	75.1	64.8	58.0	0.6
Pb Grade	**%**	0.45		0.52	0.64	0.66	0.62	0.48	0.41	0.44	0.38	0.41	0.35	0.38	0.01
Pb Metal	**kt**	66.2		0.4	9.3	10.0	8.8	8.9	4.0	4.9	4.8	5.8	4.6	4.6	0.1
Fe Grade	**%**	15.42		16.21	11.96	15.22	16.89	17.72	18.01	18.10	19.84	17.22	14.46	18.99	0.20
Fe Metal	**kt**	2,276		11.6	174.9	230.3	239.1	328.2	176.3	201.6	251.5	243.0	191.4	225.5	2.3
Stope															
Ore Tonnes	**Mt**	21.0		0.0	1.8	1.8	1.9	1.5	2.3	2.2	2.0	1.9	2.0	2.1	1.4
Zn Grade	**%**	6.21		0.00	7.86	7.22	6.10	5.56	6.07	5.55	5.58	5.57	5.09	5.12	9.88
Zn Metal	**kt**	1,305		0.0	144.4	130.3	115.9	81.6	140.9	123.1	114.2	105.2	100.9	109.1	139.7
Pb Grade	**%**	0.53		0.00	0.66	0.64	0.62	0.56	0.48	0.44	0.36	0.40	0.36	0.42	1.16
Pb Metal	**kt**	112.0		0.0	12.2	11.5	11.7	8.2	11.2	9.8	7.4	7.6	7.1	9.0	16.4
Fe Grade	**%**	18.09		0.00	11.83	13.76	16.69	16.45	19.17	17.55	19.59	18.06	14.89	18.99	35.35
Fe Metal	**kt**	3,800		0.0	217.5	248.3	317.1	241.3	445.4	389.1	400.5	341.1	295.1	404.6	500.0
Bogged Waste	**kt**	410.3		54.1	23.6	12.4	97.1	97.4	11.3	10.6	35.1	19.3	20.8	3.3	25.3
Total Bogged	**Mt**	36.2		0.1	3.3	3.3	3.4	3.4	3.3	3.3	3.3	3.3	3.3	3.3	2.6
Total Dev (Lateral & Vertical)	**m**	186,392		3,052	19,134	17,878	19,199	23,840	15,639	14,245	15,892	16,906	14,342	13,400	12,865
Ore Development	**m**	169,910		1,256	18,468	17,649	16,417	20,972	14,792	13,380	14,075	16,474	13,755	12,355	10,316
Waste Development	**m**	16,482		1,796	666	229	2,782	2,868	847	865	1,817	432	587	1,044	2,550
Lateral Dev Metres															
Capital	**m**	5,903		1,784	262	0	1,941	206	0	0	9	0	0	0	1,700
Operating	**m**	180,283		1,268	18,639	17,878	17,039	22,879	15,639	14,245	15,884	16,906	14,342	13,400	12,165
Vertical Dev Metres															
Capital	**m**	1,906		0	233	0	218	755	0	0	0	0	0	0	700
Operating	**m**	0		0	0	0	0	0	0	0	0	0	0	0	0
Fill Volume	**m3**	2,567,906		0	222,924	251,320	287,899	257,112	298,729	230,158	412,308	189,935	81,553	265,156	70,812

4.3.6 Decline Haulage Capacity

The Mining Plus study shows ore haulage via the decline is feasible up to and including the highest ore production rate that has been studied (3.6 Mtpa). This conclusion is based upon using the 60 tonne capacity trucks suggested in the Wardrop report.

Mining Plus developed an underground haulage profile based on travel distances and road gradient. Trucking fleet requirements were calculated based on the possible production rates of 3.0 Mtpa and 3.6 Mtpa. The results indicate nine trucks are required for the 3.0 Mtpa case and 11 trucks for the 3.6 Mtpa case.

Haulage interactions were studied in various scenarios of truck and loader combinations. Mining Plus concluded the high level review conducted of the decline capacity adequately displays proof of concept and demonstrates within an acceptable level of accuracy that haulage of 3.0 Mtpa and 3.6 Mtpa can feasibly be moved. This is based on the current proposed design through the single access/entry decline.

4.3.7 Open Pit Study

Based on the most recent geological model (Ravensgate End of 2011 Resource Estimation Report – "2012 Resource"), Mining Plus undertook open pit block model data validation and mining block model evaluation. Based on this work, an open pit optimisation study was carried out using Whittle Four-X (Whittle) pit optimising software and a final pit design was produced using Surpac software. A summary is provided below.

Pit scheduling was done for the 3.0 Mtpa, 3.3 Mtpa and 3.6 Mtpa cases. The 3.3 Mtpa open pit schedule, which is the base case ore production rate for this Report, is presented in Table 4.5 below.

Table 4.5 - 3.3 Mtpa yearly open pit schedule summary

		Year 0	Year 1	Year 2	Year 3	Year 4	Total
Ore Volume	m^3	1,100	840,514	855,765	695,236	0	2,392,615
Ore Tonnes	t	4,355	3,292,982	3,308,937	2,570,458	0	9,176,731
Zn Grade	%	3.35	3.23	2.82	3.31	0.00	3.10
Pb Grade	%	0.63	0.59	0.54	0.59	0.00	0.57
Fe Grade	%	27.03	22.70	22.43	19.43	0.00	21.70
Zn Recovery	%	83.16	82.29	81.41	82.31	0.00	81.97
NSR		46.63	44.7	39.4	45.8	0.0	43.1
Waste Volume	m^3	393,922	1,517,890	2,445,897	2,181,208	0	6,466,899
Waste Tonnes	t	1,102,982	4,261,310	6,948,366	6,182,398	0	18,293,405
Stripping Ratio	W:O	253.0	1.29	2.10	2.41	0.00	1.99
Total Volume	m^3	395,022	2,358,404	3,301,662	2,876,444	0	8,859,514
Total Tonnes	t	1,107,337	7,554,292	10,257,303	8,752,855	0	27,470,136

For the purpose of this Report, open pit mining operations have been scheduled to commence at the end of the life of the underground mine in Year 11 (3.3 Mtpa scenario). Thus, Year 0 in Table 4.5 becomes Year 11 and adjustments are made to the open pit mining rate to continue to maintain a total ore feed rate of 3.3 Mtpa to the process plant until the open pit is depleted. At this point the project is closed out, subject to the discovery of additional resources.

SECTION 5 - TESTWORK & PROCESS PLANT

5. TESTWORK & PROCESS PLANT

5.1 March 2013 Status

In February 2011 Wardrop Engineering Inc. (Wardrop) completed a feasibility study which included a section on Process that is summarised in Section 5.4 of this Report.

In February 2012, Metso revised the study completed by Wardrop to review the plant capacity. The "Process Plant Capacity Review" report developed by Metso is summarised in Section 5.4 of this Report.

This Report compiles the current study development status. The current status and corresponding nameplate applicable to key documents is presented below:

Table 5.1 - Current status and corresponding nameplate applicable to key documents

Key Deliverable	Author	Nameplate, Mtpa ore feed	Last Updated
Process Design Criteria	Metso	3.0	2010 (Note 1)
Process Flow Diagrams	Metso	3.0	2010
Mass Balance	Metso	3.0	2010
Equipment List	Metso	3.3 (Note 2)	2010
General Drawings	Wardrop	3.3 (Note 2)	2010
P&IDs	Metso	3.0	2010

Note 1: assumed
Note 2: subject to minor revisions

5.2 Introduction

Arccon (WA) Pty Ltd (Arccon) was appointed in mid-2012 to review a Definitive Feasibility Study (DFS) prepared by Metso (under Wardrop as the lead contractor) for the Citronen Project. Arccon reviewed the DFS and all existing testwork provided by Ironbark, and concluded the current concentrator design is conservative and throughput could be increased by 10% to 3.3 Mtpa.

In March 2012, Ironbark received Mining Plus' Mining Optimisation Design Schedule (Section 4 of this Report), that designed, sequenced and scheduled underground and open pit ore production rates up to and including 3.6 Mtpa. Also in March 2012, Ironbark received an investigative report by Metso concerning the concentrator performance at 3.6 Mtpa, based on and developed from the Wardrop 2010 plant capacity of 3.0 Mtpa. The Metso Process Plant Capacity Review was completed in February 2012.

The Metso review concluded, inter alia, that all main equipment sections within the process plant, with the exception of the crushing plant, may have up to 20% additional capacity (i.e. to 3.6 Mtpa).

The DFS prepared by Metso has been revised by Arccon, utilising all available testwork data and Metso's investigation into the increased throughput, to produce the Testwork and Process Plant section of the Report. This document is concise and highlights the major testwork updates and the critical features of the concentrator design.

5.3 Process Testwork

ALS Ammtec prepared new testwork reports in December 2011 and January 2012 to include Citronen Beach L2 North. Complementary testwork reports from 2010 were written by Metso.

5.3.1 The Samples

In December 2011, ALS Ammtec performed grinding and heavy media separation testwork. The samples used for these tests were selected by Ironbark and were combined to produce the following composites:

- Citronen Beach L2 Composite
- Citronen Discovery Composite
- Citronen Beach L2 North Reject Drill Core Composite

5.3.2 Testwork Results

Head Assays

The head assay results are presented in Table 5.2.

Table 5.2 - Head assays

Analyte	Unit	Citronen Beach L2 Comp	Citronen Discovery Comp	Citronen Beach L2 North Comp
Pb	ppm	4307	3834	7580
Zn	%	3.89	2.78	9.35
Fe	%	17.1	13.6	16.0
SiO_2	%	18.8	22.6	19.4
S_{TOTAL}	%	22.7	16.9	21.7
$S_{SULPHIDE}$	%	21.2	16.6	21.5
True SG	g/ml	3.4558	3.3294	3.4900

Table 5.2 shows almost all of the sulphur is present as sulphides, indicating the majority of the lead and zinc in each composite would be present as galena (PbS) and sphalerite (ZnS) type minerals. Iron in the composites would be expected to be present in pyritic minerals instead of oxide minerals such as hematite and magnetite.

Unconfined Compressive Strength (UCS)

UCS testwork was carried out on ten (10) specimens selected from the Beach L2, Discovery and Beach L2 North Reject Drill Core composites.

A summary of results from the Beach L2 Composite UCS testwork is presented in Table 5.3.

Table 5.3 - Beach L2 composite UCS testwork results

Sample Identity	UCS (MPa)	Failure Mode	Strength Description
Beach L2 93.40-93.48 m	120.501	Columnar	Strong
Beach L2 93.48-93.68 m	105.887	Columnar	Strong
Beach L2 94.06-94.29 m	146.252	Columnar	Strong
Beach L2 94.29-94.55 m	124.702	Columnar	Strong
Beach L2 97.06-98.02 m	128.182	Cataclasis	Strong
Beach L2 98.02-98.22 m	115.453	Columnar	Strong
Beach L2 88.00-88.26 m	166.766	Cataclasis	Strong
Beach L2 88.32-88.50 m	194.438	Cataclasis	Strong
Beach L2 82.10-82.38 m	155.414	Columnar	Strong
Beach L2 89.00-89.21 m	126.193	Shear	Strong

A summary of results from the Discovery Composite UCS testwork is presented in Table 5.3.

Table 5.4 - Discovery composite UCS testwork results

Sample Identity	UCS (MPa)	Failure Mode	Strength Description
Discovery 29.10-29.28 m	135.639	Columnar	Strong
Discovery 29.28-29.53 m	89.922	Columnar	Strong
Discovery 29.53-29.71 m	57.920	Shear	Medium Strong
Discovery 25.77-26.00 m	110.671	Shear	Strong
Discovery 26.00-26.21 m	79.298	Shear	Strong
Discovery 24.08-24.40 m	110.846	Cataclasis	Strong
Discovery 24.40-24.61 m	70.626	Columnar	Strong
Discovery 24.61-24.85 m	98.522	Shear	Strong
Discovery 25.59-25.79 m	101.124	Shear	Strong
Discovery 11.52-11.76 m	75.561	Shear	Strong

A summary of results from the Beach L2 North composite UCS testwork is presented in Table 5.5.

Table 5.5 - Beach L2 North composite UCS testwork results

Sample Identity	UCS (MPa)	Failure Mode	Strength Description
Beach L2 North 157.0-158.5 m	112.897	Columnar	Strong
Beach L2 North 159.5-161.5 m	73.623	Columnar	Strong
Beach L2 North 129.9-135.7 m	128.027	Columnar	Strong
Beach L2 North 94.35-99.95 m	101.673	Columnar	Strong
Beach L2 North 108.1-113.75 m	111.463	Columnar	Strong
Beach L2 North 108.1-113.75 m	63.976	Columnar	Strong
Beach L2 North 91.35-96.95 m	58.385	Columnar	Medium Strong
Beach L2 North 85.70-91.35 m	65.825	Columnar	Strong
Beach L2 North 105.4-109.5 m	127.142	Columnar	Strong
Beach L2 North 106.95-112.65 m	54.076	Columnar	Medium Strong

Bond Impact Crushing Work Index

The average Bond Impact Crushing Work Index for all three ore samples is compared in Table 5.6.

Table 5.6 - Bond Impact Crushing Work Index test results

Sample Identity	No. of Specimens Tested	Bond Impact Crushing Work Index (kWh/t)			
		Average	Maximum	Minimum	Standard Deviation
Beach L2 Composite	10	7.3	13.0	4.3	3.1
Discovery Composite	10	9.8	16.7	5.0	3.7
Beach L2 North Composite	10	6.5	13.7	3.4	4.0

SMC Testwork

The Semi-Autogenous Mill Comminution (SMC) testwork results are shown below in Table 5.7.

Table 5.7 - SMC testwork results

Sample Identity	DWi (kWh/m³)	SG	Derived Values					
			A	b	Mia	Mih	Mic	t_a
Beach L2 Composite	7.21	3.43	73.9	0.64	16.2	12.2	6.3	0.36
Discovery Composite	9.07	3.72	61.9	0.66	18.0	14.1	7.3	0.29
Beach L2 North Composite	7.21	3.12	77.9	0.56	17.9	13.4	6.9	0.36

Bond Ball Mill Work Index

The Bond Ball Mill Work Index is shown below in Table 5.8.

Table 5.8 - Bond Ball Mill Work Index

Sample Identity	Micrometres		Gbp (g/rev)	Test Aperture Pi (µm)	Bond Ball Mill Work Index (kWh/t)
	F_{80}	P_{80}			
Beach L2 Composite	2600	55	0.792	75	19.1
	2686	31	0.893	45	14.0
Discovery Composite	2425	58	1.296	75	13.2
	2881	36	0.827	45	16.2
Beach L2 North Composite	2424	56	1.039	75	15.6

Bond Abrasion Index

The Bond Abrasion Index is shown in Table 5.9.

Table 5.9 - Bond Abrasion Index

Sample Identity	Feed Particle Size (mm)	Bond Abrasion Index (Ai)
Beach L2 Composite	-19.0 + 12.7	0.3153
Discovery Composite	-19.0 + 12.7	0.1356
Beach L2 North Composite	-19.0 + 12.7	0.1361

Heavy Liquid Separation: Crush Optimisation

Sub-samples of the Beach L2 and Discovery composites were utilised for heavy liquid separation at several crush sizes to establish the optimum size for the remainder of the test program. Separations were conducted at a solution SG of 2.95.

A summary of selected data is presented in Table 5.10 and Table 5.11.

Table 5.10 - Crush optimisation tests on Beach L2 composite

Product Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
BEACH L2 COMPOSITE P_{100}:38 mm					
2.95 SG Sink	74.59	0.7675	98.00	6.24	99.29
2.95 SG Float	25.41	0.0459	2.00	0.1308	0.71
BEACH L2 COMPOSITE P100: 32mm					
2.95 SG Sink	73.42	1.03	98.68	6.07	96.87
2.95 SG Float	26.58	0.0382	1.32	0.5425	3.13
BEACH L2 COMPOSITE P100: 25mm					
2.95 SG Sink	72.08	1.89	98.18	9.71	99.53
2.95 SG Float	27.92	0.0214	1.82	0.1191	0.47
BEACH L2 COMPOSITE P100: 19mm					
2.95 SG Sink	60.34	0.5269	95.96	5.35	97.68
2.95 SG Float	39.66	0.0264	4.04	0.1930	2.32
BEACH L2 COMPOSITE P100: 12mm					
2.95 SG Sink	66.84	0.5435	95.83	5.35	97.66
2.95 SG Float	33.16	0.0340	4.17	0.2584	2.34
BEACH L2 COMPOSITE P100: 9.5mm					
2.95 SG Sink	76.98	0.6060	95.36	8.33	97.85
2.95 SG Float	23.02	0.0601	4.64	0.6133	2.15

Table 5.11 - Crush optimization test in Discovery composite

Product Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
DISCOVERY COMPOSITE P_{100}:38 mm					
2.95 SG Sink	47.33	0.7167	96.44	6.53	96.56
2.95 SG Float	52.67	0.0238	3.56	0.2087	3.44
DISCOVERY COMPOSITE P100: 32mm					
2.95 SG Sink	51.94	1.42	98.12	4.89	97.62
2.95 SG Float	48.06	0.0294	1.88	0.1289	2.38
DISCOVERY COMPOSITE P100: 25mm					
2.95 SG Sink	62.15	0.9962	98.32	3.70	98.39
2.95 SG Float	37.85	0.0263	1.68	0.0997	1.61
DISCOVERY COMPOSITE P100: 19mm					
2.95 SG Sink	51.38	2.44	99.47	6.26	97.88
2.95 SG Float	48.62	0.0276	1.53	0.1433	2.12
DISCOVERY COMPOSITE P100: 12mm					
2.95 SG Sink	56.52	1.14	98.16	4.81	98.22
2.95 SG Float	43.48	0.0232	1.54	0.1133	1.78
DISCOVERY COMPOSITE P100: 9.5mm					
2.95 SG Sink	52.46	1.80	96.09	4.32	96.76
2.95 SG Float	47.54	0.0466	3.91	0.1597	3.24

Bulk Heavy Media Separation Testwork

Sub-samples of the Beach L2, Discovery and Beach L2 North Reject Drill Core composites were utilised for bulk heavy media separation testwork. Separations were conducted at a crush size of 100% passing 38 mm, utilising an *Erickson* cone machine with a media SG of 3.0.

A summary of selected data is presented in Table 5.12.

Table 5.12 - Bulk heavy media separation results

Product Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
BEACH L2 COMPOSITE P_{100}:38 mm					
+5 mm HMS Sink	67.45	1.160	93.27	9.81	92.21
+5 mm HMS Float	25.01	0.032	0.95	0.413	1.44
-5+2 mm HMS Sink	2.57	0.896	2.75	8.87	3.18
-5+2 mm HMS Float	1.13	0.036	0.05	0.253	0.04
-2+0.07 5mm HMS Sink	2.16	0.960	2.47	8.80	2.65
-2+0.075 mm HMS Float	1.17	0.060	0.08	0.593	0.10
-0.075 Fines	0.51	0.692	0.42	5.38	0.38
DISCOVERY COMPOSITE P_{100}:38 mm					
+5 mm HMS Sink	51.01	3.18	91.38	5.97	88.58
+5 mm HMS Float	39.68	0.120	2.68	0.341	3.94
-5+2 mm HMS Sink	2.09	1.72	2.02	5.62	3.41
-5+2 mm HMS Float	2.43	0.028	0.04	0.119	0.08
-2+0.07 5mm HMS Sink	1.86	2.96	3.09	6.00	3.24
-2+0.075 mm HMS Float	2.16	0.040	0.05	0.258	0.16
-0.075 Fines	0.78	1.69	0.74	2.62	0.59
BEACH L2 NORTH COMPOSITE P_{100}:38 mm					
+5 mm HMS Sink	63.43	1.48	94.45	13.6	94.43
+5 mm HMS Float	33.54	0.090	3.04	0.700	2.56
-5+2 mm HMS Sink	1.00	1.21	1.21	14.5	1.58
-5+2 mm HMS Float	0.62	0.080	0.05	0.600	0.04
-2+0.075 mm HMS Sink	0.73	1.45	1.07	14.9	1.20
-2+0.075 mm HMS Float	0.56	0.130	0.07	1.30	0.08
-0.075 Fines	0.12	0.880	0.11	7.87	0.11

SMC Testwork: HMS Sinks

SMC testwork was conducted on the +5.0 mm-heavy media separation sinks products for the Beach L2, Discovery and Beach L2 North composites.

The summary of selected results is presented in Table 5.13.

Table 5.13 - SMC testwork results of HMS sinks

Sample Identity	DWi (kWh/m³)	SG	Derived Values					
			A	b	Mia	Mih	Mic	t_a
Beach L2 HMS Sinks	7.75	3.74	76.4	0.63	15.8	12.0	6.2	0.33
Discovery HMS Sinks	7.53	3.77	70.8	0.71	15.3	11.6	6.0	0.34
Beach L2 North HMS Sinks	5.81	4.21	72.2	1.00	11.1	8.0	4.1	0.45

Size-by-Size Analysis: HMS Products

A particle size distribution determination and subsequent size-by-size analysis was undertaken on a sub-sample of each +5.0 mm HMS SG 3.0 float and sink products.

The summary of selected results is presented in Table 5.14 and Table 5.15.

Table 5.14 - Size-by-size analysis sinks

Sample Identity	Calc'd P_{80} (mm)	Lead Distribution % @ Size (mm)						
		+31.5	-31.5 +19.0	-19.0 +11.2	-11.2 +5.60	-5.60 +2.80	-2.80 +1.00	-1.00
Beach L2 +5.0 mm HMS Sink	31.23	16.51	62.34	13.26	6.41	1.34	0.07	0.06
Beach L2 +5.0 mm HMS Float	30.77	6.66	69.29	13.07	6.87	3.66	0.30	0.14
Discovery +5.0 mm HMS Sink	32.62	6.72	81.49	7.93	3.46	0.11	0.06	0.22
Discovery +5.0 mm HMS Float	32.67	19.16	45.73	13.70	19.07	1.73	0.19	0.43
Beach L2 North +5.0 mm HMS Sink	30.66	8.60	56.81	21.29	10.92	2.27	0.08	0.03
Beach L2 North +5.0 mm HMS North	27.69	1.96	59.85	19.43	13.53	5.00	0.13	0.10

Table 5.15 - Size-by-size analysis floats

Sample Identity	Calc'd P_{80} (mm)	Zinc Distribution % @ Size (mm)						
		+31.5	-31.5 +19.0	-19.0 +11.2	-11.2 +5.60	-5.60 +2.80	-2.80 +1.00	-1.00
Beach L2 +5.0 mm HMS Sink	31.23	27.88	50.55	13.43	6.99	1.03	0.06	0.06
Beach L2 +5.0 mm HMS Float	30.77	3.25	76.18	12.20	5.77	2.37	0.12	0.11
Discovery +5.0 mm HMS Sink	32.62	21.22	62.31	11.32	4.57	0.47	0.04	0.06
Discovery +5.0 mm HMS Float	32.67	15.02	50.71	15.88	15.44	2.26	0.31	0.38
Beach L2 North +5.0 mm HMS Sink	30.66	8.45	56.22	22.02	10.54	2.60	0.12	0.04
Beach L2 North +5.0 mm HMS North	27.69	1.49	64.35	18.85	11.48	3.60	0.16	0.08

Bond Rod Mill Work Index Determination: HMS Sinks

A sub-sample of each of the heavy media separation SG 3.0 sink products was tested using the standardised procedure detailed by F.C. Bond to determine the Bond Rod Mill Work Index at a closing screen size of 1180 µm. A sub-sample of the Beach L2 North whole ore composite was also tested.

The summary of selected results is presented in the Table 5.16.

Table 5.16 - Bond Rod Mill Work Index HMS Sinks

Sample Identity	Micrometres		Grp (g/rev)	Test Aperture Pi (µm)	Bond Rod Mill Work Index (kWh/t)
	F_{80}	P_{80}			
Beach L2 +5.0 mm HMS Sink	11211	678	3.880	1180	19.9
Discovery +5.0 mm HMS Sink	10827	711	4.600	1180	18.6
Beach L2 North +5.0 mm HMS Sink	11117	769	5.023	1180	18.4
Beach L2 North Comp Whole Ore	10366	821	4.405	1180	21.2

Bond Ball Mill Work Index Determination: HMS Sinks

Sub-sample of the Beach L2, Discovery and Beach L2 North Composites HMS sink products were tested using the standardised procedure detailed by F.C. Bond to determine the Bond Ball Mill Work Index of each sample at the selected closing screen sizes of 850, 75 and 45 microns.

The summary of selected results is presented in the Table 5.17.

Table 5.17 - Bond Ball Mill Work Index HMS Sinks

Sample Identity	Micrometres		Grp (g/rev)	Test Aperture Pi (µm)	Bond Rod Mill Work Index (kWh/t)
	F_{80}	P_{80}			
Beach L2 Comp HMS SG 3.0 Sink Prod	2733	648	2.906	850	21.5
	2519	50	1.282	75	12.2
	2823	29	0.864	45	13.9
Discovery Comp HMS SG 3.0 Sink Prod	2411	649	3.739	850	18.6
	2103	48	1.412	75	11.1
	2569	32	0.894	45	14.2
Beach L2 North Comp HMS SG 3.0 Sink Prod	2637	56	1.300	75	12.8

Heavy Liquid Separation Testwork Optimised Conditions

A summary of selected data is presented in Table 5.18, Table 5.19 and Table 5.20.

Table 5.18 - Heavy liquid separation of Beach L2 composite

BEACH L2 COMPOSITE P_{100}:38 mm					
Product Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
2.8 SG Float	0.07	INS	N/A	INS	N/A
2.9 SG Float	17.65	0.014	0.22	0.028	0.09
2.96 SG Float	7.93	0.028	0.20	0.062	0.09
3.1 SG Float	2.93	0.102	0.27	0.6095	0.33
3.2 SG Float	0.03	INS	N/A	INS	N/A
3.3 SG Float	0.00	INS	N/A	INS	N/A
3.3 SG Sink	71.39	1.54	99.31	7.67	99.50

Table 5.19 - Heavy liquid separation of Discovery composite

DISCOVERY COMPOSITE P_{100}:38 mm					
Product Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
2.8 SG Float	1.47	0.016	0.03	0.2435	0.13
2.9 SG Float	34.63	0.012	0.58	0.0300	0.38
2.96 SG Float	7.31	0.100	1.02	0.1375	0.37
3.1 SG Float	0.37	0.046	0.02	0.1585	0.02
3.2 SG Float	1.11	0.172	0.27	2.53	1.03
3.3 SG Float	4.33	0.130	0.79	0.7820	1.24
3.3 SG Sink	50.77	1.37	97.28	5.22	96.84

Table 5.20 - Heavy liquid separation

Sample Identity	Calc'd P_{80} (mm)	Weight % Passing @ Size (mm)						
		31.5	19.0	11.2	5.60	2.80	2.00	1.00
Beach L2 -38 mm HLS Feed	31.235	82.28	14.49	5.19	1.20	0.26	0.17	0.10
Discovery -38 mm HLS Feed	32.680	75.57	30.51	16.00	6.63	2.91	2.12	1.19

Jar Mill (Verti-Mill) Testwork

Jar Mill testing was carried out on -850 µm products of the Beach L2 and Discovery composites using the method proposed by Metso Minerals.

A summary of selected results is presented in Table 5.21.

Table 5.21 - Verti-Mill testwork results

Sample Identity	Density % Solids (w/w)	Media	Measured P_{80} @ Applied Run Time (mins)							
			0	5	10	20	40	60	80	120
Beach L2 Comp -850 µm	60.0	19 mm Steel Balls	656	166.8	157.6	106.9	84.8	46.5	37.1	N/A
Discovery Comp -850 µm	60.0	19 mm Steel Balls	644	167.6	169.7	104.8	42.2	28.2	N/A	N/A

Heavy Liquid Separation Testwork: Variability Samples

Twenty-three selected variability samples were utilised for heavy media separation testwork. Separations were conducted at a crush size of 100% passing 38 mm, utilising an Erickson cone machine with a media SG of 3.0.

A summary of selected data is presented in Table 5.22 and Table 5.23.

Table 5.22 - Heavy liquid separation testwork results

-38+5.0 mm HMS SINK PRODUCT					
Sample Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
CF08-158 30-31 m	14.99	0.880	63.18	2.83	74.97
CF08-160 11-11.7 m	37.56	0.528	88.61	9.85	84.96
CF08-160 28.7-30 m	10.90	0.636	79.23	2.19	91.08
CF08-162 30.45-30.75 m	27.44	0.360	87.75	4.33	91.18
CF08-163 27.1-28 m	17.18	0.564	79.07	6.79	74.19
CF08-165 5-6 m	90.59	0.384	92.31	1.17	92.41

Table 5.23 - Heavy liquid separation testwork results

-38+5.0 mm HMS SINK PRODUCT (Cont'd)					
Sample Identity	Weight (%)	Assay Pb (%)	Dist'n Pb (%)	Assay Zn (%)	Dist'n Zn (%)
CF09-182 95-96 m	71.19	0.652	93.52	6.50	94.42
CF09-183 97-97.7 m	71.01	1.68	93.94	20.00	94.17
CF09-185 101-102 m	74.19	1.67	89.91	17.00	94.55
CF09-186 102-103 m	84.81	1.14	94.11	6.47	94.33
CF09-187 113-114 m	83.69	2.08	90.49	8.11	92.74
CF09-191 80-81 m	78.80	1.01	90.29	13.50	91.23
CF09-192 69-70 m	91.83	0.368	90.95	0.95	88.55
CF09-195 45-46 m	22.56	0.388	77.11	9.69	78.87
CF09-197 54-55 m	14.87	1.90	91.28	10.90	93.23
CF09-197 61-62 m	34.82	1.42	90.19	17.80	92.07
CF09-198 86-87 m	91.95	0.596	93.47	2.99	90.54
CF09-200 89.3-90 m	75.59	0.252	90.56	3.14	89.46
CF09-201 89-90 m	57.45	1.10	79.73	26.80	85.58
CF09-202 96-96 m	39.07	0.108	46.43	1.37	73.44
CF09-202 105.4-106 m	20.79	1.34	72.67	20.30	77.29
CF09-204 74.5-75.2 m	95.26	2.44	79.15	13.30	94.54
CF09-204 81-82 m	92.57	0.208	97.19	4.10	96.59

Quantitative Optical Mineralogical Examination

A defined programme of metallurgical testwork was conducted on spiral separation testwork tail samples from the Citronen Project in January 2012.

Samples were prepared for mineralogical testwork in ALS Ammtec and then sent for Qualitative Optical Mineralogical Examination via Roger Townend and Associates.

For the test programme, ALS Ammtec was supplied with three spiral separation testwork tail samples from the Ironbark Citronen Project in Greenland:

- Sample # 1: Spiral Cut 6 Product: 3285
- Sample # 2: Spiral Cut 7 Product: 3286
- Sample # 3: Spiral Cut 8 Product: 3287

Final results can be seen in Table 5.24.

Table 5.24 - Mineralogical exam results

Material	Sample ID		
	Spiral Cut 6 Product: 3285	Spiral Cut 7 Product: 3286	Spiral Cut 8 Product: 3287
Ores	Minor	Minor	Minor
Pyrite	Dominant	Dominant	Dominant
Sphalerite	Major	Minor	Minor
Galena	Accessory	Trace	Trace
Marcasite	Accessory	Trace	-
Hematite	-	-	Trace
Gangue	Dominant	Dominant	Dominant
Ankerite	Major	Major	Major
Quartz	Major	Minor	Minor
Calcite	Minor	Major	Major
Mica	Accessory	Minor	Minor

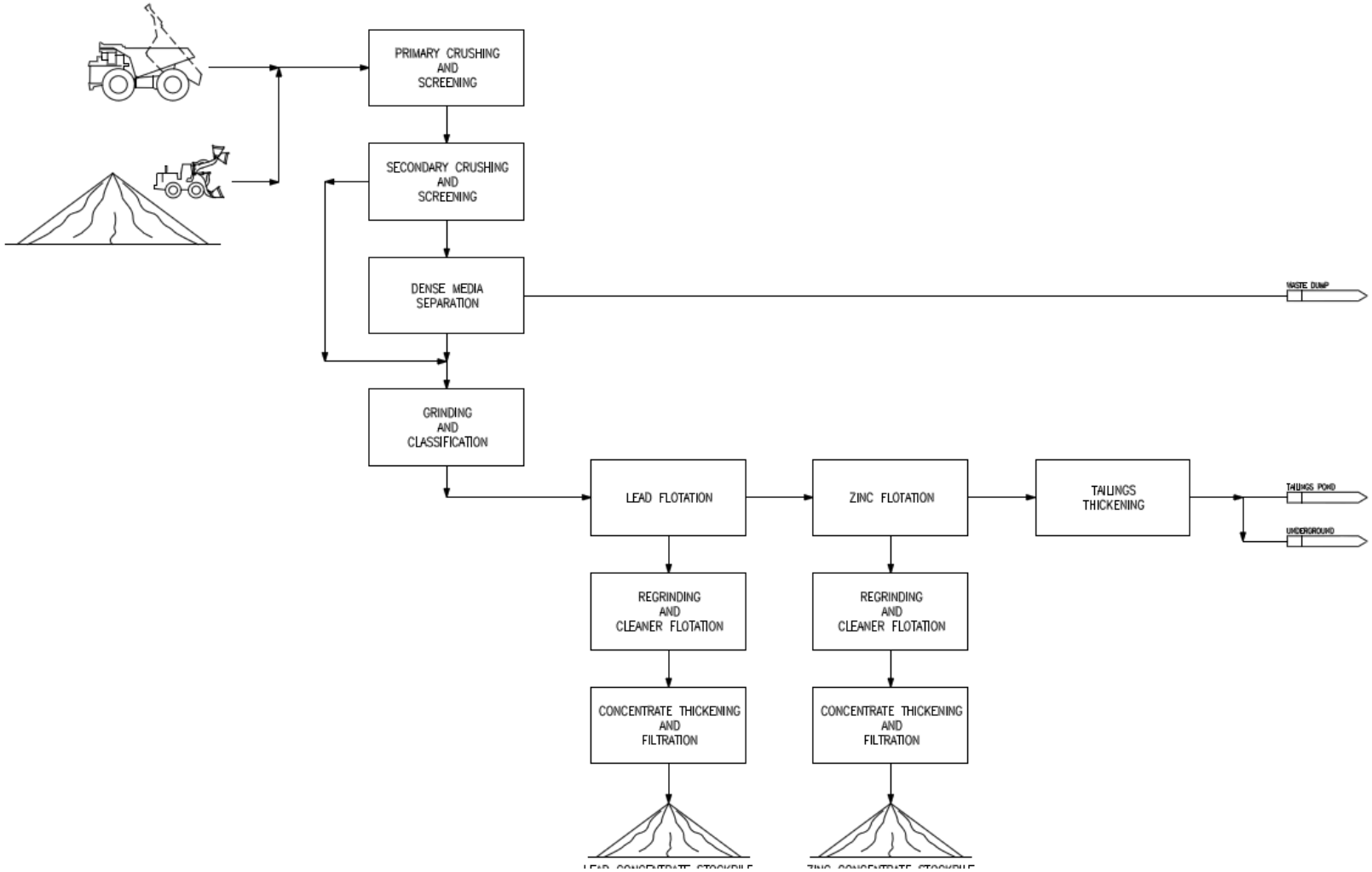
5.4 Process Plant

5.4.1 Process Description

The process description was prepared by Wardrop in 2011 in line with the flow sheets developed by Metso; a transcript is included in this section.

The simplified flow sheet is show on Figure 5.1.

Figure 5.1 - Simplified flow sheet



Crushing

Crushing equipment selection and circuit configuration is based upon UCS, Bond Crushing Work Index and Macon testing (Metso's in-house testing method) of both the Discovery and Beach ore composites. A compact two stage crushing plant has been selected, with DMS testwork indicating acceptable metal recovery and mass rejection can be obtained with a primary crusher discharge P_{80} of 130 mm reduced to a P_{80} of 35 mm in the second stage.

The circuit equipment has been selected to achieve approximately 550 t/h average throughput levels at 18 h/d operation (6.5 d/wk, 365 d/a). The ore is delivered by haul truck and either direct dumped into the run of min (ROM) bin or onto the ROM pad and later transferred by front-end loader (FEL) to the ROM bin. The ROM bin is protected by an 800 x 800 mm grizzly, and a rock breaker is mounted adjacent to break up oversize.

The ore is fed by a vibratory grizzly feeder drawing ore from the ROM bin and feeding into the jaw crusher where it is crushed to a P_{80} of 130 mm. A primary jaw crusher size has been selected to minimise the probability of blockages.

A high frequency vibratory double-deck secondary screen precedes the secondary cone crusher with undersize reporting to the crushed ore product transfer point. Tramp steel is removed by two magnets located over the conveyor. A metal detector is located on the secondary crusher feed bin feed conveyor with an interlock hardwired to the conveyors.

The secondary screen oversize is conveyed to the secondary crusher feed bin where a vibrating feeder feeds the secondary crusher. The secondary crusher discharge is conveyed to the high frequency vibratory double deck screen. The screen undersize is conveyed over a weightometer to the DMS feed bin.

Dust suppression is by individual suction hoods at transfer points ducted to a central fan and bag-house.

Buffer storage of crushed ore and mill feed is minimised due to space constraints.

Dense Media Separation (DMS)

DMS performance at a 2.96 to 3.10 separation SG provides recoveries in excess of 97% of lead and zinc to the sinks plus the -1.0 mm fines product bypass throughout the size ranges tested.

The DMS feed bin discharges at an approximate average of 375 t/h by belt feeders to a wet feed preparation screen that removes all -1.0 mm material, with the screen oversize feeding into the DMS cyclone feed hopper.

The DMS cyclone pump feeds -38+1 mm material combined with dense medium to the DMS cyclones. The DMS cyclone overflow is stripped of medium on a drain-and-rinse dual screening system with screen oversize conveyed to the external floats stockpile. The DMS cyclone underflow is stripped of medium on a drain rinse screen system, and the screen oversize is conveyed to the sinks (ball mill feed) bin.

The DMS feed fines are separated at the wet feed preparation screen. Sixteen percent of the ore feed weight reports as -1 mm fines. The fines are directed to the fines dewatering cyclone feed hopper where they are pumped to the cyclone, which dewaters the stream. The fines are then directed to the secondary milling circuit

The sinks are drawn from the mill feed bin by belt feeders and conveyed to the primary mill feed, where the feeder rate is regulated by a weightometer.

Grinding

Ball Milling

A 4.42 m diameter x 7.5 m long 2.2 MW grate discharge primary ball mill operates at an approximate average of 298 t/h treatment rate in closed circuit with a scat recycle screen with a bottom deck aperture of 1.2 mm.

The screen separation at nominally 1 mm is facilitated by high volume water sprays, and uses the entire water requirement for the grinding circuit to achieve a clean separation. The screen undersize flows to a common pump hopper that also receives DMS fines spiral concentrate and secondary grinding mill discharge.

The mill has sufficient power to achieve the design grind size of 850 µm P_{80}. The mill is rubber lined, takes up to a 24% by volume steel charge and operates at 71% of critical speed. Balls of 90 mm to 120 mm size are added by kibble at the mill feed chute.

Vertical Stirred Milling (VTM)

Primary screen undersize, VTM discharge and DMS fines spiral concentrate are combined in a hopper and then pumped to a cyclone cluster at a density that enables a 53 µm cut point to provide a P_{80} of 45 µm to flotation. The cyclone cluster holds 6+2 400 mm diameter cyclones. Cyclone underflow feeds the VTM circuit and cyclone overflow is gravity fed to a trash screen. The VTM unit discharges overflow back to the cyclone feed hopper.

Two 2.2 MW VTM units have been selected with 24 mm x 24 mm recharge size high chrome cylpebs that are added by kibble at the mill feed chute. A proprietary blocker reagent (D200) may be added to the cyclone feed hopper.

Flotation and Re-grinding

The mill cyclone overflow of P_{80} size 45 µm gravity flows to a trash screen of 0.8 mm aperture. The trash screen undersize is pumped to a single conditioner that overflows to a pre-flotation circuit. The pre-flotation (pre-float) stage is necessitated by a carbonaceous population that would otherwise impact downstream grades and froth stability. Dextrin depressant and frother are dosed to the conditioner tank. Trash screen oversize is collected in a trash bunker for disposal.

The pre-flotation concentrate is discarded to the tailings thickener, and the intermediate tailing flows to two conditioner tanks in series (three minute residence time in each) in which lead circuit pyrite depressants and collector are dosed. The conditioners overflow in sequence to the lead rougher scavenger flotation cells at a design rate of approximately 310 t/h. Frother is dosed to the conditioner discharge and rougher cell junction boxes.

First rougher lead concentrates are diverted to final concentrate, cleaner feed or regrind feed depending on grade in the cleaner circuit. Second lead rougher and scavenger lead concentrates are pump-fed to 100 mm diameter dewatering cyclones and the cyclone underflow is reground to a P_{80} of 10 µm to 15 µm in two 185 kW stirred media detritors (SMDs) using 3 mm ceramic beads. Lime at 30% solids w/w concentration and ligno-sulphonate solution at 10% w/v strength are added to the lead regrind mills to depress pyrite.

The reground lead concentrate and first rougher lead concentrate are pumped to the first cleaner and first cleaner concentrate is pumped to the second cleaner feed. First cleaner lead tail is open circuited to the zinc flotation conditioners with the rougher lead scavenger tail.

Copper sulphate at 10% w/v strength is added to the zinc conditioner feed pump (Pb rougher tail) hopper for the re-activation of sphalerite.

The flotation of zinc is preceded by two conditioning tanks in series each of three minute residence time for the addition of lime and the flotation collector, respectively. Frother is added in stages to the zinc second conditioner discharge and rougher flotation cell junction boxes. The zinc conditioners overflow in sequence to the zinc rougher scavenger flotation cells.

Depending on grade, first rougher zinc concentrates can be diverted to final zinc concentrate, zinc cleaner feed or zinc regrind feed. The zinc second rougher and scavenger concentrates are pump-fed to 100 mm diameter dewatering cyclones and the cyclone underflow is reground to a P_{80} of 10 µm to 15 µm in five 355 kW SMDs. Lime and ligno-sulphonate are added to the zinc regrind mills to depress pyrite.

The reground zinc concentrate and the first rougher zinc concentrate with regrind zinc cyclone overflow are pumped to the first cleaner bank. The zinc cleaner circuit can be operated as either a three-stage cleaner, or a cleaner and re-cleaner system as required. The first zinc cleaner tail is pumped open circuit to the final tail thickener where it is combined with pre-flotation concentrate, DMS fines spiral lights, and rougher scavenger tailing.

Concentrate Dewatering

Each concentrate is dewatered to a minimum of 60% solids by weight in a conventional thickener. The thickener underflow is pumped to an agitated stock tank. A plate and frame pressure filter is fed by a variable speed pump from the agitated concentrate stock tank and filtrate is recycled to the appropriate concentrate thickener feed.

The overflows from the zinc concentrate thickener and the lead concentrate thickener flow to the process water tank. The filter cake discharge is conveyed to and stacked in the covered storage area.

The filters selected have the capacity to filter at peak concentrate production rates of 4 t/h and 40 t/h for lead and zinc concentrates, respectively, and produce a filter cake with a design moisture allowance of 10% to 12%. The lead concentrate is batch filtered as required in one of the two filter units.

Concentrate is loaded to a reclaim conveyor by FEL from the covered storage area, using a load cell on the FEL to determine loaded wet weight. Moisture and assay samples enable calculation of the dry tonnes and metal contained for consolidation with the ship-loading weights and assays and customer shipment receival weights and assays. This concentrate production data is also used to back-calculate plant performance using the flotation shift sample assays and the mill feed weightometer.

Tailings

The final tailings are made up of the zinc scavenger tail, zinc cleaner tail, pre-flotation concentrate and the silicate rich slime reject solids from the fines spirals. The final tailings are dewatered in an 18 m diameter high-rate thickener to 58% solids by weight and transferred by the underflow pumps to a pump hopper. The thickener overflow is returned to the process water tank.

Thickened tailings are pumped from the pump hopper with other effluent streams to the tailings storage facility (TSF) or diverted for use underground as frozen backfill when required.

The tails thickener overflow may require future installation of a clarification stage should carbonaceous material threaten to contaminate the process water. Thickener overflow clarity in a confined plant can be an operational issue; however, this is relieved by the design of the process water tank to promote settling and reclaim of solids. A separate process water tank may be installed at a future date should process water alkalinity build up and impact the lead circuit performance.

Reagents

Pre-flotation of carbonaceous mineral requires IF6-3N frother and Dextrin depressant addition. Dextrin is mixed continuously, direct from the bulk-bag using a 'jet-wet'-style system to a 10% w/v strength.

Some proprietary carbonaceous blocker D200 may be added to the milling circuit and the pre-float conditioner. The D200 is in liquid form and is batch mixed with water to 25% w/v strength.

For mineral collection in the lead flotation circuit a Cytec 3406 dithio/monothio-phosphate blend at 100% w/v mix strength is added to the second conditioner and IF6-3N frother to the conditioner discharge and first lead rougher junction boxes. Additional stages of collector addition and frother are made through the cleaner circuit. A pH modifier or naphthalene sulphonate depressant is also added to the cleaner feed to depress pyrite.

Ligno-sulphonate is readily dissolved in water at 10% w/v and is mixed in batch mode. Addition is to both regrind circuits.

Lime is delivered as burnt lime (CaO) and is fed from a silo into a slaking mill which discharges to a slaked lime tank. The lime slurry at 25% solids w/w is added to both the lead and zinc concentrate regrind mills. The regrind mill additions maintain a pH setpoint at approximately 10.5 in the first cleaner of the cleaner flotation circuits. Lime can be added to the first conditioner in the zinc rougher circuit to control pH.

Copper sulphate solution is mixed at 10% w/v strength in batch mode and is used as an activator for flotation of zinc minerals. It is added to both the first zinc conditioner feed pump and the zinc regrind discharge hopper by a dosing pump.

The zinc flotation collector Cytec 9323 is a blend of dithiophosphates and mono-thionocarbamates. The collector is added at full strength to the second flotation feed conditioner tank by a dosing pump. Stage additions downstream of collector and frother may also be used by the operators. A facility is provided for dosing of a second collector.

IF6-3N frother is dosed as 100% solution by a dosing pump (as required) to sustain the optimum froth characteristics throughout the flotation circuits.

A pH modifier or naphthalene sulphonate depressant is mixed in batch mode to 10% strength w/v and is also added to both of the cleaner feeds to depress pyrite.

Flocculant is mixed from bulk powder storage in a packaged continuous mixing plant at 2.5 g/L and held in a storage tank for one hour for hydration. The stored flocculant solution is further diluted in-line and dosed to each thickener feed box and the thickener feed well sparger pipes at a volumetric flow determined by the thickener control system.

A spare jet-wet mixing facility is provided for an additional depressant (nominally PC100 poly-acrylamide) and spare pumps for an additional collector. All mixed reagents have a mixing system and tank that transfers the mixed reagent to a storage tank. The reagents are dosed to the process from the storage tank by metering pumps.

Process Plant Services

Water Distribution

The continuous plant process raw makeup water requirement is approximately 180 m^3/h (i.e. the loss to filtered concentrate and thickened tails). Some reduction is available through reclaim of a portion of the water from the tails dam (summer months only) or from underground mine dewatering.

Raw Water Pond Supply Pumps

The raw water supply design is based on delivery from Lake Platinova to a raw water tank. Raw water will be pumped to the process plant raw water tank using a submersible pump. The pump will draw water from the bottom of the lake to ensure availability year round. Further discussion is provided in Section 6, "Infrastructure", of this Report.

Plant Operational Requirements

The water demand is divided into:

- process water make-up from raw water for the losses to product streams and tails dam
- reagent mixing requirements
- machine seal and cooling requirements: crusher dust seals, lube system cooling and mill feed seal wash water

The raw water pumps deliver water to:

- the process water tank for make-up needs
- the gland water pump mains
- the reagent water pumps
- the process raw water pumps
- the clean water tank for potable and fire water supply

The clean water tank feeds the potable water treatment plant, which in turn maintains level in the potable water system. Separate pumps feed the domestic areas and safety showers from this tank. The clean water tank also provides a reservoir of firewater and supplies water to the process water tank for make-up as required.

No allowance has been made for gland water, based on the use of mechanical seals on centrifugal pumps.

No return from the tailings storage facility has been allowed.

Other Water Demands

The less well defined demands at this time are:

- dust suppression requirements
- hose-down water in plant

The dust suppression that may be required in summer months can be estimated by assuming that a 10 m^3 truckload is consumed five times per day on roads and crushing plant sprays operate at a continuous 3.6 m^3/h. The hose-down demand is estimated to be a similar quantity at a continuous 3.6 m^3/h. Neither usage is included in the water balance at this point.

Air Supply and Distribution

Three separate 110 kW air compressors provide 700 kPa air for:

- instrument air and workshop service air into two separate receivers feeding driers and two area receivers
- general services plant air via two area air receivers

The air is distributed in steel lines around the plant for use in tools and general blowdown and auxiliary requirements.

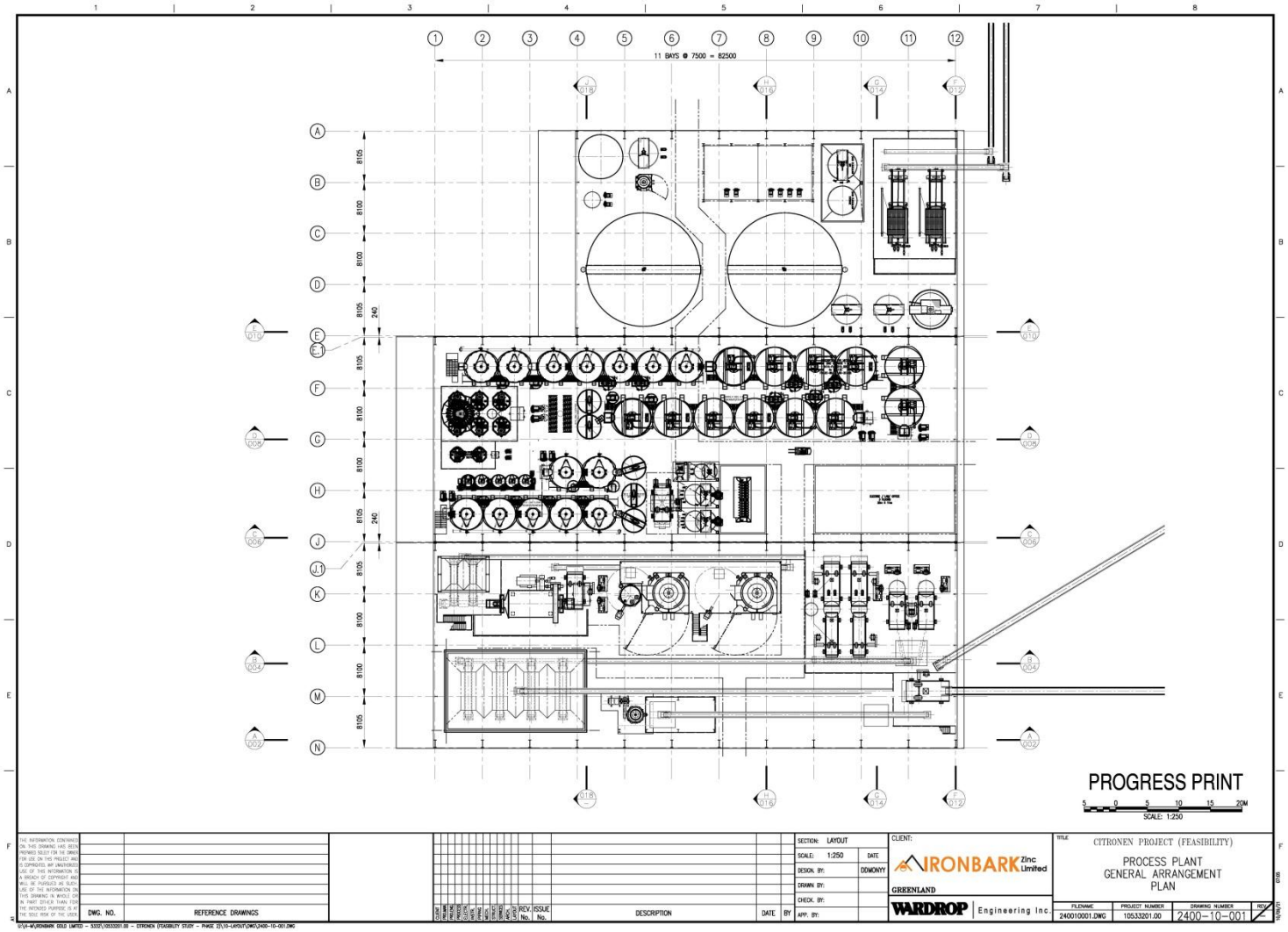
The cake blow air supply for the lead and zinc concentrate filters is provided from the main air system at reduced pressure via dedicated local receivers.

The air for flotation is provided via dedicated low-pressure blowers.

5.4.2 Plant Layout

The plant layouts were developed by Wardrop (Figure 5.2).

Figure 5.2 - Processing plant general arrangement plan



5.5 Electrical and Instrumentation

Power to the process barge ground floor main electrical room will be via two 6.9 kV feeder cable bus systems from the main power plant. These cable buses will be routed into the room via fire rated separations and will terminate in a 7.2 kV double-ended vacuum circuit breaker switchgear line-up.

Power from this switchgear line-up will:

- Be delivered to an adjacent 6.9 kV motor control centre for major motors.
- Be delivered (as 690 V power) to the process barge 690 V MCCs in the first floor electrical room.
- Provide 690 V power for low voltage motor and other loads through three step-down dry type transformers.

The dry type transformers are located adjacent to the main floor electrical room but outside of the electrical room ventilation envelope. A louvered wall with fans will be used to cool these main transformers without adding to the heat load of the electrical room.

Cables will be routed internally within the process barges via galvanized steel cable tray systems.

5.6 Plant Performance Guarantees

Metso has undertaken the provision of an overall process guarantee for the plant within the battery limits of supply, so long as the equipment listed is used and installed in accordance with the Metso instructions, other relevant sections of the process report and the process guarantee document.

5.7 Conclusions and Recommendations

Increasing throughput from 3.0 to 3.3 Mtpa will increase the operational revenue by 10%. Capital and operating costs will not increase by the same proportion and will therefore increase the profitability of the Citronen project.

The Metso review indicated the secondary crusher would currently operate at high load and may require upgrading to handle an increased load. Only minor modification to ancillary equipment such as pipes, pumps, conveyors etc will need to be made. All other equipment is expected to have contingency capacity such that a 10% increase in load is possible without modification.

It should be noted the equipment list, general arrangement drawings and layout drawings reasonably reflect the latest 3.3 Mtpa plant design. The process design criteria, mass balance and process flow diagrams are based on the 3.0 Mtpa design.

SECTION 6 - INFRASTRUCTURE & ANCILLARY FACILITIES

6. INFRASTRUCTURE & ANCILLARY FACILITIES

6.1 Introduction

The Citronen Fjord Zinc Project is located in north-eastern Greenland approximately 2,100 km north of the capital Nuuk. It is located at 83°05′N, 28°16′W.

There is no existing infrastructure at the site and consequently all infrastructure and ancillary facilities need to be developed as part of the project. The facilities and infrastructure to be developed are based on the original 2010 studies.

Figure 6.1 - General site layout

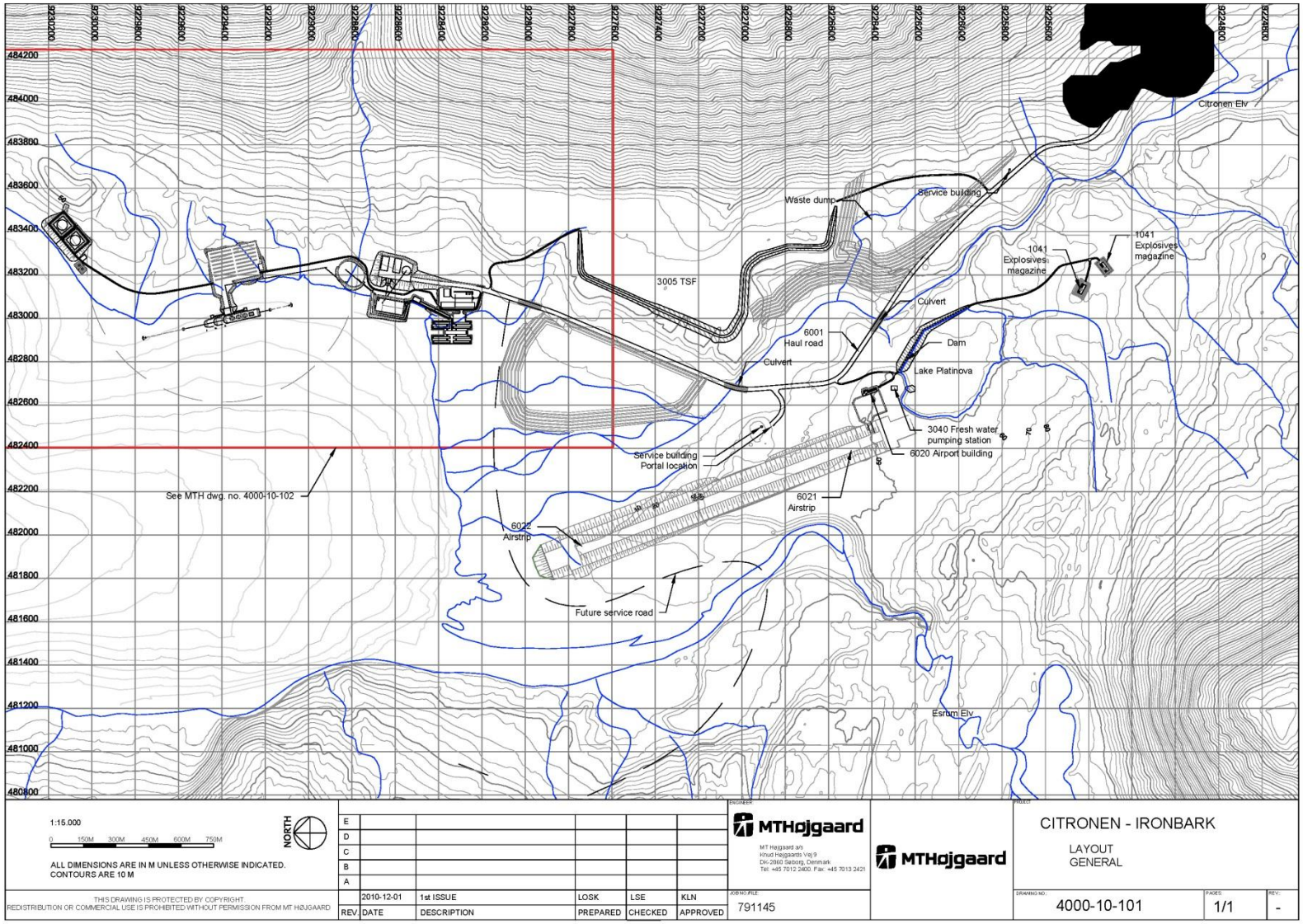
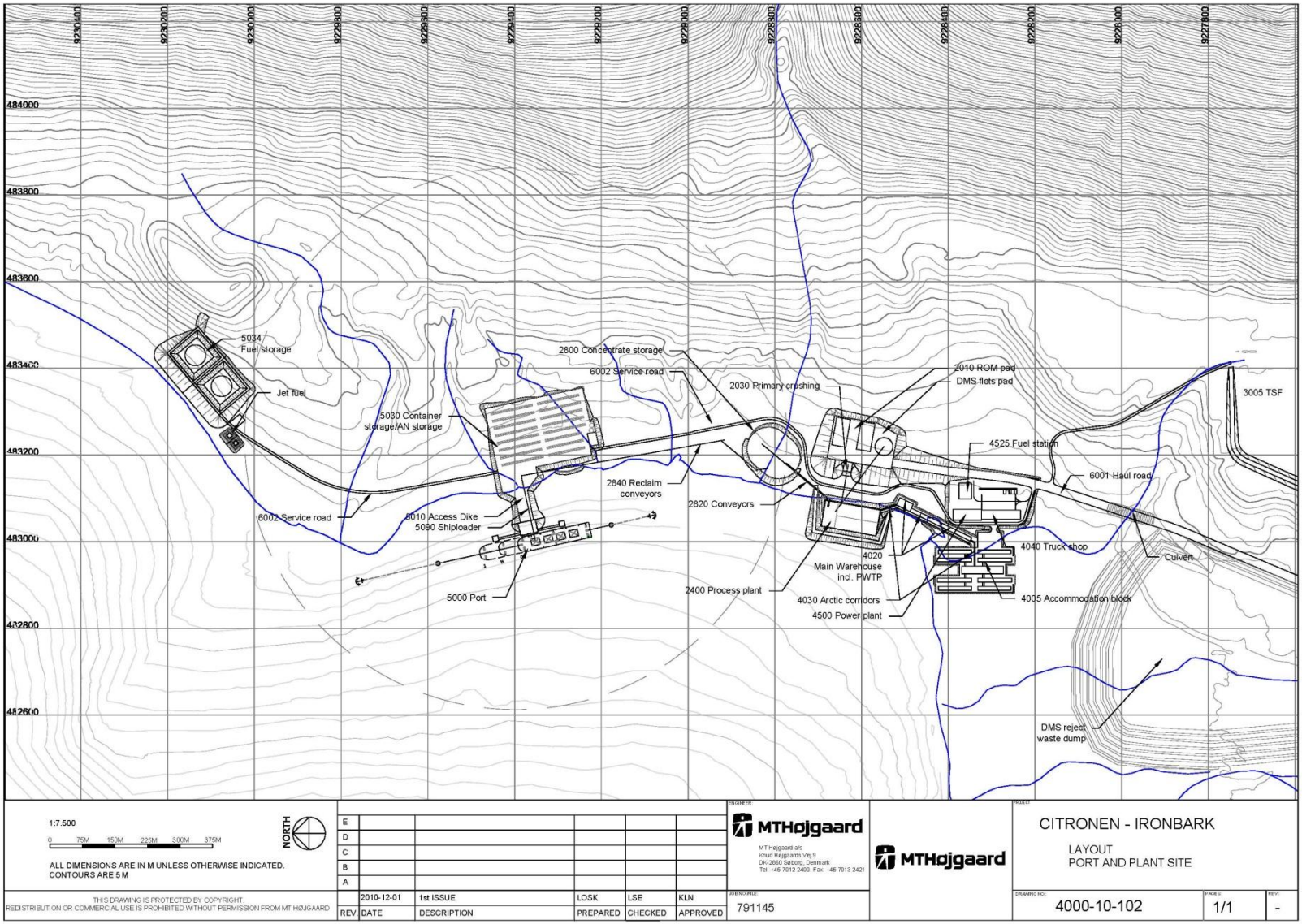


Figure 6.2 - Port and plant site layout



6.2 Haul and Service Roads

Roads will be established as privately financed roads and are to be used solely for mining works at Citronen. They will be designed, constructed and maintained in accordance with established mining industry practice.

Horizontal alignment will have a minimum radius down to 150 m for haul roads, and down to 20 m for service roads. The maximum longitudinal grade is 8% for haul roads and 12% for service roads. The general cross sections are based on normal road building practices in arctic areas.

In general, roads will be constructed upon the existing ground, either on bed rock or on permafrozen ground. The road substructure will generally be constructed with locally excavated soil reclaimed as part of cutting or from nearby borrow pits, depending on the earthworks balance. The road superstructure will generally be constructed with gravel soils from borrow pits or with quarry run.

Permafrost is present in the entire area and preliminary investigations show a thaw zone of approximately one metre. On permafrozen ground the road superstructure will be minimum of one metre thick, constructed from non-frost sensitive (NFS) gravel to build up permafrost in the underlying existing soil. It is assumed the NFS gravel can be taken from borrow pits in the area.

Culverts will be designed and placed to allow melting water and rainwater to cross the roads. Culverts will be constructed with steel pipes. All culverts will be designed for actual axle loads and to relevant design standards.

6.2.1 Haul Roads

Haul roads required include open pit to run-of-mine (ROM) pad (approximately 3,880 m) and to portal location (approximately 200 m).

The dominant traffic on haul roads will be heavy off-highway trucks similar to 2-axle Caterpillar 777F.

Due to the planned standard of roads, the average speed will be relatively low, namely 40 km/h for surface mobile equipment and 30 km/h for underground mobile equipment.

The maximum speed will depend on grade, ability, and operating weight. Assuming a maximum operating load of 163 t and maximum grade of 8%, speed may locally be reduced to 8 to 10 km/h. At sharp bends in hilly sections, the speed will be even lower. Maximum speed on service roads should be set to no more than 40 km/h.

6.2.2 Service Roads

The dominant traffic on service roads will be four-wheel drive multi-purpose vehicles (MPVs), off-roaders, and small to medium size trucks and fuel trucks.

Maximum speed on service roads should be set to no more than 40 km/h.

Service roads will be 3.5 m wide single-lane gravel roads. The total width of the roads will typically be 5.0 m, inclusive of shoulders. As the service roads are relatively short, passing places will not be provided.

6.2.3 Safety Bunds

During the detailed design phase, a risk assessment will be carried out to determine where safety bunds are needed. They will be constructed according to general practice for mine haul roads, i.e. with the minimum height of berm being 0.5 x biggest wheel diameter.

The use of steel barriers in lieu of safety berms will not permit the removal of snow; consequently, this form of safety barrier has not been considered for the project.

6.3 Site Services and Utilities

6.3.1 Fresh Water Distribution

Lake Platinova is the source for fresh, raw water for the project. Raw water will be pumped to the process plant raw water tank using a submersible pump. The pump will draw water from the bottom of the lake to ensure availability year round.

From the process, a raw water tank water will be pumped to the process plant and the water treatment plant at the main warehouse. Water piping will run in arctic corridors between the process plant and the main warehouse (potable water treatment plant) and on to the accommodation complex and truckshop.

6.3.2 Potable Water Treatment, Supply and Distribution

Raw water will be pumped from the process plant raw water tank to the potable water treatment plant located within the main warehouse. Treated water will then be pumped to the permanent camp, administration facilities and process plant.

The average person in Greenland consumes approximately 155 litres (L) per day of potable water. With an expected manpower of 250 persons at Citronen, approximately 35 m^3/d of potable water is required. A small containerised treatment plant is proposed for the treatment of 40 m^3/d of lake water. This gives an average of 160 L per person per day.

The potable water treatment plant is a standard technology that is able to treat surface water taken from collection reservoirs in the mountains. The water is double filtered for the reduction of pollution from surface or groundwater. After filtration, the water will be disinfected by a UV unit.

6.3.3 Fire Protection Systems

The plant site facilities will be protected with a pressurised fire protection system comprising a fire water reserve, an electric driven jockey pump, an electric driven fire pump and an emergency diesel driven fire pump. The fire water reserve will be contained in a dedicated portion of the raw water tank in the process plant.

Due to the severe climate and the geology, there will not be any buried firewater lines or any “standard” yard hydrants. The majority of fire piping will be within buildings and within connecting arctic corridors between buildings. In place of yard hydrants, there will be wall hydrants housed in heated and insulated wall cabinets mounted on the outside walls of the buildings. The wall hydrants will be served by fire water loops within the buildings.

The firewater demand has been based on established criteria for fire protection of similar projects.

The crushing plant will not be serviced by the firewater supply and the critical areas (such as the control room) will be protected with a clean agent suppression system. The lube oil system, the air compressor room and the conveyor within the structure will be protected by a dry chemical suppression system.

All areas will be provided with hand-held fire extinguishers.

On the process plant, sprinkler systems will be limited to the protection of hydraulic systems with an oil capacity in excess of 390 L and conveyors located in hard to reach confined areas. The laboratory and offices will also contain sprinkler systems.

Sprinkler protection in non-process areas includes the camp, warehouse and maintenance shops.

Provision for a digital fire alarm system has been included for the main process plant areas. This system will include a central password-protected operator interface terminal, graphic display of all operating zones, trouble and alarm logging historian, and control panel. The system will have the ability to incorporate a single alarm and trouble dry contact type signals from other standalone and pre-manufactured buildings into a centralised facility. Each separate facility will be tracked as a separate zone only.

6.3.4 Sewage Treatment and Disposal

Sewage and waste water from buildings at the plant site will be sent to the sewage treatment plant. Dry closets will be used at the airport building.

The sewage treatment plant will be a standard containerised solution which can treat approximately 40 m^3 of waste water per day and is based on a three-step biological cleaning system:

1. Pre-treatment particle separation in a settling tank built into half of a 40-foot (ft) open top container.
2. Biological treatment built into the second half of the 40 ft container.
3. Sludge handling inclusive arrangement for placing and dewatering of the sludge bags before discharge into the incinerator (this system is built into a 20 ft sea container).

The sewage treatment plant and the dewatering system will be installed inside the main warehouse building close to the incinerator for ease the sludge handling.

Effluent from the camp site will be carried to the sewage treatment plant through pipelines running below the arctic corridors to the main warehouse. Effluent from waste water will go into the process plant.

6.3.5 Incinerator and Hydrocarbon Waste Facility

An incinerator capable of dealing with combustible waste, lubricants, fuel and oil will be installed in the main warehouse. Installation in the warehouse will reduce the need for heating due to utilisation of the radiant heat from the combustion chamber.

A flue gas treatment plant is not included as it is anticipated it will be possible to obtain a dispensation from the rules regarding flue gas emission. This will need to be discussed with the Bureau of Minerals and Petroleum (BMP) during the detailed design phase of the project. The incinerator at Station Nord provides a precedent for this scenario.

Solid waste is fed into the combustion chamber in 120 L waste bags via the waste sluice. Likewise, sludge from the sewage plant can be collected and burnt as long as the water content in the sludge

meets specifications. Medical waste and small metal parts such as frames from oil filters can be burnt.

Sludge oil will be fed into a sludge oil mixing tank and piped to the incinerator where it will be burnt. The incinerator can burn between 135 and 200 L of sludge oil per hour and it is able to continue with this capacity for as long as it is necessary.

The incinerator cannot be used for burning larger metal parts, batteries or chemical waste. These types of waste will be collected and stored for later disposal off site.

The incinerator has fully electronic-controlled burners with automatic spark ignition and safety devices. It is controlled by two temperature controllers and the operating temperature is 850-950°C, which should ensure clean emissions.

6.3.6 Lighting and Area Lighting

Indoor lighting will be designed according to National Danish Code DS 700.

For area lighting, LED lighting fixtures have been selected and are assumed to be LED Light-type "CrystalLed" with 72 LEDs. The CrystalLed fixture is preferred as it has a life expectancy of more than 80,000 hours and the relative high output of more than 100 lm/W.

Light poles will be installed in order to obtain satisfactory light levels at various sites, roads and intersections. At roads and intersections, 10 m light poles are used with one fixture at each pole. On work sites, 12 m light poles are used with one or two fixtures at each pole.

Sites near buildings will be illuminated from fixtures installed in wall brackets on buildings and will serve as parking and entrance lighting. Roads will not be directly illuminated, however, as a minimum, the light poles at fixed locations will indicate the location of the road. Basic lighting will be installed at intersections and culverts for safety purposes.

On outdoor work site such as the fuel station, container storage, concentrate storage and ROM pad basic lighting will be installed to create an overview of the work site. A mobile lighting plant will be used for maintenance or other work on these areas.

Although there is no fixed lighting at the port, it will be possible to plug in some mobile lighting equipment should this be necessary.

Lighting will be controlled by locally installed daylight sensors and/or manually installed on/off switches. To reduce energy consumption, use will be made of two or more illumination level switches, motion detection switches, photocells and dimmer switches.

6.3.7 Site Control System and Communications

Fibre Optic Network and Site Control System

A fibre optic network will be installed around the site to facilitate plant control system and communication between process areas. The fibre network will also be utilised for the process of closed circuit television (CCTV) system signal transmissions. Generally, the network routing will follow that of the site power distribution.

A programmable logic controller (PLC) based system will be used for monitoring and control of the entire site. PLC input/output (I/O) cabinets located in electrical rooms throughout the plant will be used to interface all field instrumentation, equipment and motor controls.

External Site Communication

Citronen is located above 83°N latitude and no communications satellites are visible. Consequently, external communications will be provided by Iridium Communications Inc. (Iridium), as this is the only option available. Iridium has an internet protocol (IP) data and voice service for the maritime market called Iridium OpenPort® (OpenPort) that, according to Iridium, is the best solution for the Citronen Project.

OpenPort provides a data capacity of 128 kb/s and three telephone lines working simultaneously while data is being transmitted. The installation of two OpenPort systems is recommended, which provides the opportunity for six telephones and 516 kb/s in data capacity.

The two OpenPort satellites are mounted as close to each other as possible on top of the process building. Three telephones and a data box are connected to each OpenPort satellite. One data box receives incoming mail and the other sends outgoing mail. The two data boxes are connected to a switch where users can connect externally to the internet.

To control data usage, an email server will be set-up in connection with the switch and will filter all emails larger than one megabyte. A similar mail server will be placed in, for example, Iceland where there is internet access, to catch all mail larger than one megabyte going to site. If an important email is stuck on the email server (given that it is larger than one megabyte), the sender or receiver will be able to contact the administrator and have the email released.

External site communications will also be governed by the below guidelines:

- Employees will not be permitted to use the internet for personal reasons. All employees must have a Citronen email address so there is no need to connect to external email.
- Only approved personnel will be able use the telephones for external business calls. Two of the telephones will be placed in a locked office that only authorised personnel will be able to access.
- For private calls, one or two telephones will be placed in the camp library; these telephones will be monitored.
- Emergency telephones will be placed throughout the site. These telephones may be normal Iridium phones, which are not connected to the OpenPort satellite.
- For business related external internet communication, computers will be installed in the offices where external internet communication is needed.
- For private external internet communication, two or three computers will be installed in the camp library. Employees will not be allowed to surf the internet and use will be restricted to home contact.

6.4 Power Supply and Distribution

6.4.1 Plant Power Generation

Electricity production and supply will comply with Greenlandic electrical regulations and will be based on European standards with 50 Hz frequency and 400/230 service voltage.

The required power consumption of approximately 23 MW will be met by a total of six generator units, with four in operation and two on stand-by duty/ maintenance.

The generators will be medium speed units rated for continuous operation in an arctic environment for a service life of at least 25 years. With four units running at a long-term average operating load of approximately 80%, the power plant will have a rated capacity of 23 MW.

Each generator unit has a rated capacity of 7.124 MW on 100% load. The engines are designed for a continuous base load operation and can operate at any load between 30% and 100%. The system will be complete with fuel handling, lubrication, air handling, exhaust system, starting equipment, electrical distribution switchgear, heat recovery system and ancillary equipment. Each generator unit is made up of a four stroke engine complete with direct injection and trunk piston. They will also be turbocharged and intercooled.

6.4.2 Power Distribution

General

Power from the generator plant is delivered at 6.9 kV throughout the facilities. Substations are complete with step-down transformers (6.9/0.4 kV) and are rated 200 kW, 500 kW or 1,000 kW, depending on the requirements at each substation. The substations will be located centrally within areas (to be determined at the appropriate time), where practical, to minimise distribution losses.

Generally, all indoor electrical equipment will be IP54-type enclosures with characteristics to suit the duty required. However the indoor electrical equipment located in accommodation, administration/mine dry and airport buildings will be IP20-type.

All cables for 6.9 kV distributions and 400 V main cables are aluminium cables. All other electrical cables will be copper conductors with an outer armour and PVC jacket. Cables will be installed in cable trays when necessary. Voltage, insulation class, colour and spacing will be as needed for the application. Generally, motor cables are de-rated by a minimum of 30% to account for proximity de-rating rules when installed in cable trays.

According to Greenlandic standards, all cables for distribution will run in T179 conduit in the terrain along roads and walkways. Cables will be placed under the surface to protect them from wind, weather and snowploughs.

The power distribution cables consist of three single conductor metal screened cables and a bare copper cable, twisted together and insulated with two blow tubes for later installation of fibre optic cables.

Substations will be installed in 20 ft containers placed directly on the ground with a 10 kV section (50%) and a 400 V section (50%) separated by wire mesh. Lighting and heating is included. In the 400 V section, a Main Distribution Panel (MDP) will be installed for supply of consumers, buildings, heat tracing, and outdoor lighting. All substations will be fully equipped before being shipped to site.

For ease of maintenance, where practical, most electrical equipment will be located in indoor electrical rooms, either in buildings or in the 20 ft containers in the 400 V end.

Load Requirements

Voltages of 6.9 kV and 690 V are designated for motor application voltages for all but the smallest loads. Lower voltages such as 400/220 V may be used for control power and lighting.

Motors up to 250 kW are designated for full voltage starting. Larger motors at the 6.9 kV level will generally be full voltage started. The major mills will be provided with soft starting equipment. The

remaining fixed speed medium voltage motors will be fed from 6.9 kV motor starters located in the barge main electrical room.

Electrical rooms will be pressurised and ventilated.

Within the process plant, a double ended 690 V switchboard will provide power feeds to the 690 V motor control centres located in the 690 V motor control centre (MCC) room above. The 690 V MCC's are complete with a communication link such that the plant control distributed control system (DCS) can communicate and control the motors without hardwiring of I/O points from MCC's to the DCS.

Medium voltage power distribution equipment will be located at the surface portal area of the underground mine in order to power the main vent fans. Power to the underground workings will be via armoured medium voltage cables extending into and throughout the mine.

As determined by load concentration and type, power for underground equipment will be tapped off the main underground medium voltage cables via standalone starters for major equipment and movable unit substations (disconnect switch, step-down transformer, and low voltage motor starters) for 690 V motors. Separate medium voltage and low voltage grounding systems will be established at each voltage step-down point in order to utilise separate neutral grounding systems ensuring personnel safety.

Low Voltage Installations

Except for the main cables, all power cabling will use copper conductor. Buried cables will be underground in T179 conduits, as per the 6.9 KV cables. If the cables run along buildings raised above the ground, the cables may instead be attached to the buildings.

6.4.3 Emergency Power

The main generating facility has a standby generator black start system which will provide power for the start-up of the facility after a complete shutdown or system failure. In the event of a catastrophic failure of the main power plant, emergency power for the accommodation camp, warehouse and airport will be supplied by mobile generators.

The backup generators at both the accommodation camp and warehouse are not large enough to maintain full power for the area, so during the detail design phase it will be necessary to outline the systems where back up power is critical. The units for these buildings will have to be manually started when the areas not included in the emergency power run have been shut down.

An emergency power unit is placed in the airport building for emergency power to the airstrip and control tower in case of breakdown of the power plant. The unit for the airport is designed as a short break unit, so that, theoretically, the airstrip can be without light for a maximum of 30 seconds before the power unit commences running correctly. Other facilities at the airport are not included in the power backup.

6.5 Fuel Storage and Distribution

6.5.1 General

The fuel storage area consists of:

- two tanks each with a capacity of 25,000 m^3 fuel for arctic diesel

- two tanks each with a capacity of 250 m^3 jet fuel
- hose station and lines
- pipelines for both arctic diesel and jet fuel
- fuel station for arctic diesel

The fuel storage area has a safety distance of at least 625 m to the ammonium nitrate storage located at the container storage by the port.

All the pumps and automation for fuel distribution at the site will be fully electrically integrated.

6.5.2 Arctic Fuel Storage Tanks

The fuel tanks will be single shell, placed in a reservoir with a secondary safety containment of 1.15 times the tank containment. When entering the detailed design phase, the BMP will need to approve the reservoir size.

The tanks are 48 m in diameter and 14 m high with a fixed roof and will be designed and constructed according to the EN 14015, including manholes, drainage etc. Oil is expected to be arctic gas oil (AGO); hence, thermal insulation and heating of the tanks is not included.

Due to the permafrost, each tank will be founded on a built-up NFS gravel pad and an in-situ concrete ring beam. The thickness of the gravel pad will be a minimum of two metres. To preserve the permafrost, the tank bottom will be placed on a heat insulation layer. The secondary containment reservoir will be lined with a HDPP membrane and drainage provisions will be built into the gravel fill embankments.

6.5.3 Jet Fuel Tanks

The two jet fuel tanks have a capacity of 250 m^3 each. Spillage containment will be the same method used for the Arctic Fuel storage tanks.

The tanks will be nine metres in diameter, four metres high and will be designed according to EN 14015, including manholes, drainage and piping. As the tanks will not be insulated, they will be founded on a built-up NFS gravel pad similar to the arctic fuel storage tanks. The secondary containment reservoir will be the same as for the arctic fuel tanks.

6.5.4 Hose Station

The hose station is placed at the pier of the port and is designed for filling both the arctic fuel storage tanks and the jet fuel tanks. Fuel is transported to Citronen Fjord on the concentrate barges and the barge is anchored in approximately 15 m of water depth and at a maximum distance of 150 m from the coast line. The barges will have their own equipment for pumping fuel to the fuel storage tanks.

The hose station includes three lines: two lines for simultaneous emptying of the barge tanks with arctic diesel and one line for emptying the barge tank with jet fuel. The hoses from the pier head are connected to the pipelines running up to the fuel storage by a fixed pipeline placed along the access dike. Hoses will be running on top of the barges and not in the water and will be placed by the crane.

6.5.5 Pipelines for Arctic Fuel and Jet Fuel

The main arctic fuel pipeline will run from the fuel storage area to the power plant with a secondary pipeline running from the hose station at the port to the main pipeline. A connection pipeline from the main pipeline will be located at the concentrate storage area up to the fuel station and is located close to the power plant.

Pumps will be installed in the fuel storage area. Pumps on the barges will pump fuel to the storage area and additional pumps at the fuel storage area will pump fuel to the power plant and the fuel station.

The jet fuel pipeline will run from the hose station to the fuel storage area and is only used when loading the tanks in the storage area. Jet fuel is transported from the tanks to the airstrip on an as required basis via a fuel bowser which is filled by a truck filling pump.

6.5.6 Fuel Station

The fuel station is located next to the power plant/truckshop. It will be a containerised unit mounted on a concrete bottom plate for collection of any spilled oil.

The container is designed with a 5,900 L oil tank with pump and filling nozzle measured automatically for controlling fuel delivery. There will be one manually operated loading arm articulated in two links to be used for loading vehicle tanks. The container will be connected to the main site power distribution grid and equipped with lights on the loading arm and on the container.

6.6 Plant Site

6.6.1 Administration and Mine Dry Buildings

The buildings will be constructed from pre-fabricated modules. They will be elevated from the ground, integrated with the main warehouse and will be part of the walkway system between the camp and the process plant.

The administration building is a single story structure and will have a total area of 700 m^2. It will include office space for 35 people, laboratories, meeting, instruction and conference rooms and other necessary facilities.

The mine dry building will be a single story structure with a total area of 730 m^2. It will include dry room and bath facilities for 160 men and 30 women, a medical room, laundry and drying rooms, pre-shift briefing room with standing room for 50-60 people, a lamp room for underground personnel and other necessary facilities.

Heat traced sewage piping will be installed under the buildings and pumped to the sewage treatment plant. Water, electrical and heating services will be run along the building hallways.

Potable water will be supplied from the potable water treatment plant within the main warehouse and heating will be based on glycol which is distributed from the power plant through buried piping. Glycol heating systems will be utilised within the building.

6.6.2 Main Warehouse and Plant Workshop

The main warehouse and plant workshop will be connected directly to the administration building and to the process plant via arctic corridors that form part of the walkway system between the process plant and the camp.

Access from the service road will be through a four metre by three metre door into the warehouse section via an air lock. The warehouse will be serviced by indoor forklifts. There is no provision for an overhead crane within the building.

The structure will be steel framed with steel cassettes for the roof and insulated panels for cladding. The floor and foundations will be reinforced concrete. The building will be placed on a gravel pad including insulation to preserve the permafrost.

The building facilities will include storage are for spare parts, a workshop area for fixing small equipment, the incinerator, potable water treatment plant, the sewage treatment plant and subsidiary facilities.

Potable water, heating systems, sewage piping and electrical services will be similar to the administration and mine dry buildings.

6.6.3 Vehicle Parking

A vehicle parking area will be constructed as part of the gravel pad for the fuel station, truckshop and power plant. A ready line will be provided with outdoor parking for 10 vehicles and each stall will be sized to accommodate both small vehicles and a 163 t haul truck.

A ready rail will be constructed which will supply the parking stalls with 35 kW for truck warming and 2 kW for lighting. Electrical installations comprise of outlets for cars and trucks and outdoor lighting for the parking.

6.6.4 Truckshop

The truckshop building will be a pre-engineered steel structure 98 m long by 21 m wide with 10.5 m height to underside hook of an overhead crane. The structure will be clad with insulated metal roof and wall sandwich panels.

The building has been sized to accommodate 90 t open pit trucks and 60 t underground haul trucks. The building and truck door height are sized to accommodate a 90 tonne open pit truck with its rock box in dump position.

The facilities will include four repair bays, a 25-t/10-t auxiliary crane, a wash bay with oil/water separator, a light vehicle repair bay, an emergency vehicle storage bay and offices and other subsidiary facilities.

6.6.5 Accommodation Complex

Accommodations and Centre Facilities

The camp is designed to accommodate 250 people based on an 8+1 concept and comprises eight accommodation blocks spread around a central reception block. This layout was selected to enable camp residents to access central facilities through small connection corridors without having to go outdoors.

All buildings, ancillary facilities and electrics will be designed and constructed according to the Greenlandic Building Regulations, adhering to requirements including those for heating insulation and fire safety. The camp will be divided into several fire sections to avoid fire spreading.

It is planned to erect the camp as early as possible so that it can be utilised for the construction workers and subsequently refurbished for use by operations personnel.

The buildings will be delivered as fully fitted-out prefabricated modules equipped with on-site works being foundations, connection of services reticulation systems, fitting-up and furnishing. The foundations will comprise of prefabricated components and will consist of steel frames fixed to buried concrete slabs. The buildings will be placed with the floor level raised one metre above the ground to preserve the permafrost.

Sewage piping will be installed under the buildings and pumped to the sewage treatment plant and sewage piping will be heat traced. Water, electrical and heating services will be run along the building hallways.

The buildings are heated by glycol from the boiler plant placed in the power plant.

Accommodation Blocks

Accommodation blocks will be single storey and contain 31 to 33 single bedrooms, one common room and a plant room. Accommodation rooms will include a private bathroom with shower facility and will be completely furnished, inclusive of a TV with DVD player and phone/internet connection for internal communication.

Common rooms will include a small kitchen area with coffee machines and dishwasher, a relaxing area with sofas and armchairs and an area for dining.

Ventilation will be by two ventilation systems with heat recovery. Each room will be ventilated by an exhaust system in the bathrooms and with injection in the hallway.

Centre Facilities and Reception Block

The centre block will be one storey and the total area will be 1,800 m^2.

The facility will include a reception area with a lounge, camp manager's office, a meeting room, storage area, laundry, small supermarket, a fitness room, library with internet and telephone for external communication, canteen area for 132 persons dining at the same time, a kitchen and bakery with cooling and freezing storage, two open relaxing areas, staff office, and other facilities.

Glycol heat radiators are placed under each window and areas are ventilated by three ventilation systems with heat recovery.

Arctic Corridors

Arctic corridors will be used for the connection of:

- accommodation blocks and centre building in the camp
- centre building and administration/dry/main warehouse
- main warehouse and the process plant

The corridors will also be utilised for distribution of services such as water, heating and electricity. Sewage pipes will run below the corridors.

The corridors will be constructed from prefabricated modules elevated from the ground similar to the camp.

The corridors are heated by glycol systems to a temperature of +5°C and exterior doors are heat traced to ensure they will open and close.

6.7 Heating, Ventilation and Air Conditioning System

Due to the on-site climate conditions, it is necessary to provide heating to the plant site buildings to enable regular maintenance and operations to be carried out. The heating, ventilation and air conditioning (HVAC) system will utilise waste heat recovered from the power plant.

Initial indications show there will be sufficient waste heat at the generator heat exchangers to provide heating to all of the plant site buildings under normal operating conditions. When power generation is at lower than normal levels, an oil-fired boiler plant will be required which will consist of two 300 BHP boilers which will be located in a boiler room adjacent to the power plant.

The recovered heat will be in the form of a 60/40% glycol solution that will be delivered at 90°C into a piping distribution network. The heating distribution system is based upon a primary and a secondary system where the glycol solution will be pumped in loop from the power plant to all of the heated plant site buildings, and then back to the power plant. Secondary pumped loops will be installed at each heated building to provide an effective and flexible method of heating.

Distribution pipes between buildings will be insulated and will be within heated arctic corridors to minimise heat losses from the piping.

The primary pumps will be located close to the power plant where the heat is generated and secondary pumps will be located within the heated buildings.

The heating loops will be connected to unit heaters and air handling units. The unit heaters will be sized to maintain the space temperature above freezing when the plant is inoperative and the outdoor air temperature is at the design winter condition. The air handling units will handle outdoor air to provide the required ventilation, or make up air quantities necessary to offset sensible and latent gains within the buildings.

Heat recovery fans will be provided in process areas to draw stratified air down to the lower levels and exhaust fans will be provided to remove excess humidity from the buildings.

6.8 Explosives Mixing and Storage Facilities

6.8.1 General Concept

Ammonium nitrate and fuel oil (ANFO) will be mixed on-site which will require shipping of the following:

- ammonium nitrate
- initiation devices, including electronic detonators, non-electric (nonel) detonators, signal tube, programmable detonators, surface delays, down the hole delays, etc.
- high explosives (HE) – packaged cartridge explosives, cast primers, detonating cord, and perimeter products
- blasting accessories

The required storage capacity will correspond to one year's use of explosives requiring 2,000 t of ANFO. The corresponding quantity of explosives materials is assumed to be approximately 10%, i.e. 200 t/a.

The ammonium nitrate will be delivered in bulk-bags and containerised in containers which will be placed in a storage location at the port area. The explosives materials will be stored in two separate explosives magazines. A mobile mixing will be used to prepare the ANFO mixture.

6.8.2 Explosives Magazines

The use of two explosives magazines instead of one ensures a supply of explosives in case of an accident and reduces the required safety distances to other facilities. Each magazine is designed to contain up to 100 t of explosives and will be barricaded by embankments.

Explosives materials will be stored in approved explosives containers. Initiation products (electric and nonel detonators, surface delays) will be stored in separate magazines to high explosives (packaged explosives, detonating cord, and blasting agents).

The required number of containers per magazine will be at minimum six containers for boosters, dynamite and detonator cord plus two separate containers with detonators and connectors. The containers with detonators are placed at a minimum distance of 10 metres from the other containers and embankments will be constructed to protect the HE/blasting agents from an explosion in the detonators magazines.

Containers will be founded on a levelled gravel pad and drainage ditches will be constructed as needed to deal with melting water. Wind loads at the site will require the containers to be fixed to steel frames anchored to buried slabs.

The design of the explosives magazines requires compliance with Greenland's BMP guidelines (July 2010). These guidelines include the following considerations:

- Protection against avalanches, falling rocks, and flooding: avalanches and falling rocks are not considered a high risk in the area and flooding will be avoided by drainage ditches that will be built.
- Fences: Around the magazine, a fence must be established of at least 2.40 metre high with three strands of barbed wire at an angle of 45° outwards. It must be possible to remove snow on both sides of the fence.
- Safety distances: Safety distances to the magazines depend on the quantity of stored explosive materials. Safety distances are reduced when the magazine is protected by a barricade.

6.8.3 Explosives Mixing Facilities

A mobile mixer unit will be utilised which will be built on a truck chassis and hold two tanks, one for ammonium nitrate and the other for fuel oil. The products are dosed from the tanks and travel down a hose where they mix at the nozzle. The mixer unit will be utilised to directly load open pit blast holes and will be used to load ANFO into 500 kg bulk bags for transport to the underground magazine and later use.

6.9 Port

6.9.1 Introduction

The marine facilities will be located in the south-eastern corner of the Citronen Fjord, behind the small cape where adequate land areas for container and winter storage yards are available.

The average shipping window for access to the Citronen Fjord is approximately six weeks each year and shipping requires assistance from icebreakers. During this period, loading of concentrate and unloading of supplies will take place on a 24 hour per day basis.

The proposed port facilities are of a simple design to enable them to be established swiftly with a reduced amount of site work.

The port facilities will comprise:

- pier head
- two berthing/mooring dolphins
- longitudinal moorings
- access dike
- land areas

For filling of all hatches from the statically placed shiploader, the concentrate barges need to be moved back and forth utilising the longitudinal moorings. The hauling force required to warp the barge with a reasonable velocity is rather limited, however the longitudinal hawsers are also used as ordinary moorings.

Outside of the shipping season the buoys and fenders will be dismantled and moved onto land in order to avoid damage from ice.

6.9.2 Design Vessel

An unmanned, dry cargo barge without propulsion system is proposed as the concentrate carrier. It will have the following estimated data and dimensions:

- dead weight tonnage (DWT): 32,000 t
- fuel tank capacity: 8,000 m^3
- length, overall (Loa): 170.0 m
- beam: 35.0 m
- depth: 12.5 m
- draught, fully loaded: 9.50 m
- displacement, lightship: 10,000 t
- displacement, fully loaded: 46,000 t

6.9.3 Port Design Considerations

Tides

The following tides are assumed:

- highest astronomical tide: plus 0.25 m
- mean sea level (MSL): 0.00 m
- lowest astronomical tide: minus 0.25 m

Wind

The mooring system will be designed for the characteristic one minute average design wind speed, as occurs during the expected shipping season expected to fall in the period of July, August and September

Current and Waves

No information is currently available, however a small tidal current is expected and some currents from the rivers flowing out into the Fjord must be anticipated.

Ice

In the winter season the ice thickness in the Fjord can reach 1.80 to 2.50 m. The pier head works must be designed for the adverse effects of this ice apron.

By and large, the bottom of the Citronen Fjord is expected to be ice-free during the shipping season, however, some ice floes must be expected and therefore have been considered in the design of the port elements.

Sea Bed Conditions

In general, the sea bed is assumed to consist of deposits of clayey silt. There is a variable active layer of silt which needs to be considered during detailed design.

Offshore Moorings

The offshore moorings will consist of mooring buoys, anchor chains and seabed drag anchors. Traditionally, the hawsers and associated mooring winches will be located on the vessel and these components are thus regarded as part of the ship's equipment.

For efficient loading operations, a control system where the winches and hooks are controlled from land by means of telemetry will be implemented. The system will include controls for tensioning and slackening of each wire as well as information on the actual tension level in the wires.

Mooring Buoys

The mooring buoys will be fitted with quick release mooring hooks. Outside the shipping season the buoys will be separated from the anchor chains and lifted onto land for maintenance and repair.

Anchor Chains

The mooring buoys are anchored to the seabed anchors by means of studless anchor chains, steel grade R3. Studless chains are preferred for permanent installations as they weigh less than stud link chains and are more elastic.

The chain cable will form a centenary curve between the buoy and the seabed and have a factor of safety of three for the minimum breaking load.

Anchors

The anchor chains are anchored to the seabed by means of drag embedment anchors and will have a factor of safety of 1.5 to 2.0 on the ultimate holding capacity of the anchor. The ultimate holding capacity is conservatively assessed based on soft clay.

Fender Works

Protective fenders will be provided to protect the pier head and dolphins from berthing impact damages by the concentrate barges.

The ship impact calculations will be based on a fully laden concentrate barge with the fenders designed for a perpendicular berthing velocity corresponding to the fully laden displacement of the vessel assuming easy berthing and an exposed location.

A floating foam fender type fitted out with a chain tyre net for protection is proposed. Unlike floating pneumatic fenders, the foam fenders will not sink if the skin should be damaged. The fenders are loosely secured with chains to the sheet pile cells.

Outside the shipping season the fenders will be lifted on land for storage and maintenance.

6.9.4 Demands on the Berth

The water depth requirements at MSL for the concentrate barge are estimated from the following criteria:

- lowest astronomical tide: approximately 0.25 m
- draught of the barge, fully loaded: 9.5 m
- additional under-keel clearance, 20% of draught: 1.9 m

The barge will therefore need a total minimum water depth of 12.0 m relative to MSL.

A bathymetric survey was carried out in the summer of 2010. Prior to commencement of detailed design, a depth sounding survey will be completed to ensure that this minimum water depth is available over the port area and its approaches, in order to avoid any requirements for dredging.

The quay elevation is determined to be +2.00 m relative to MSL, which will give a reasonable air gap to the highest water level.

6.9.5 Access Dike, Pier Head and Dolphins

General

The access dike will be made of gravel from a borrow pit and will be finished with a compacted top wearing course and the sides will be protected by layers of large stones. To avoid stability failures, side slopes will be 1:3 for this arctic environment. The crown elevation is +2.00 at MSL, corresponding to the elevation of the pier head. The crown width will allow space for two-way heavy traffic and for a concentrate conveyor belt.

The pier head will be rectangular in shape and constructed from sheet pile filled with local gravel. Two berthing/mooring dolphins will also be constructed in the same manner. The sides of the pier and dolphins will serve as service quays for minor service vessels. The pier and the dolphins will be connected by bridges (e.g. old army bridges or similar).

The elevation of the quay aprons is +2.00 at MSL which will be satisfactory for the limited tidal range experienced at the site. The characteristic live load on the quay aprons is 20 kN/m^2, which is valid for bulk quays.

Design Particulars

The sheet piles will be driven to the permafrost table or to refusal. No passive resistance from the limited active layer of soft soils will be taken into account, hence internal anchors are proposed. The sheet pile walls will be anchored by means of upper waling and mutual upper and lower anchor rods.

The quay apron on the pier will be finished with a compacted top wearing course, and the dolphins will be completed by a stabilising slab of structural concrete.

Ice aprons adhering to the walls will, in conjunction with a rise of the water level, cause vertical lift forces on the sheet pile walls. This will be prevented by uplift brackets welded to the inside lower part of the sheet pile walls.

The cells will be furnished with a number of bollards for mooring the access barges and the service ships.

6.9.6 Additional Facilities

Additional facilities for navigational and personal safety will be implemented provided, as described below.

Cranage

Cranage equipment will be available for lift of twenty-foot equivalent unit (TEU) shipping containers (maximum 30 t), buoys (approximately 20 t) and fenders (approximately 5 t).

Navigational Aids

All requirements from the Danish Maritime Safety Administration or the Danish Maritime Authority must be complied with. It is envisaged these will include a system including navigational lights , fog horns etc.

Safety Equipment

The access barges and the pier head must be equipped with appropriate safety features including rescue ladders, recue posts etc. as required by the Danish Maritime Authorities.

Inspection, Maintenance and Repair

The inspection, maintenance, and repair activities will include the following:

- buoy inspected and repaired as necessary
- the access dike and the pier head will be inspected for damage from ice and repaired as required
- when the harbour area is ice-free, the anchor chains on the seabed must be inspected by a diver and replaced if necessary
- the level of the seabed in the harbour area must be checked from time to time

6.9.7 Shiploader

A fixed shiploader has been selected for loading of barges with lead and zinc bulk concentrate. The shiploader is designed to load the barges with a beam up to 32 metres at a maximum rate of 2,000 t/h.

The shiploader consists of a fixed belt conveyor, fitted with a weigh belt, which is loaded from the reclaim system and a movable belt conveyor. To optimise loading, the movable part of the shiploader is fitted with a radial telescopic chute to enable trimming of the vessel.

To prevent pollution of the surroundings caused by the lead and zinc concentrate while loading the barges, all the transfer points have a dust collection system. To protect the concentrate on the belt conveyors from the wind, the conveyors are covered and placed inside a covered bridge. The conveyor bridges are provided with one metre of free space on each side of the machinery for maintenance access.

6.9.8 Container Storage

The container storage area and has a total area of 42,550 m^2. It is designed for handling and storage of:

- ammonium nitrate in 100 20-ft containers
- frozen groceries in 30 20-ft refrigerator containers (reefers)
- other supplies in 870 20-ft containers
- oil and grease storage: 600 m^2

The prepared area will have a final drainage cross-gradient of four percent and will be covered with mechanically stabilised gravel. The thickness of the gravel layer will be minimum 0.5 m to build up permafrost in the underlying original soils.

Containers are placed in two layers in the north-south direction corresponding to the dominant wind direction. Due to heavy winds, it may be necessary to anchor containers, especially empty ones. This will be considered in the detailed design phase.

The storage area will be provided with exterior lighting for 24-hour operation which will be 12 m lighting poles equipped with two or three floodlights.

6.10 Shipping Logistics

6.10.1 Introduction

The Citronen Zinc Project is located in north-eastern Greenland surrounded by the waters of Wandel Sea and Fram Strait. The assumptions for the navigational access have been made from the data given in a report by Enfotec. Average opening dates for ice class PC 4-5 to navigate to the Citronen Fjord are indicated in this report to be from late July to early September every year.

In addition, Captain Kimmo Lehto, a private contractor, reviewed the ice situation in August 2010 between Citronen Fjord and South to latitude 80°37'N (Lehto, 2010) and supported the proposed sail route with a Polar Class vessel.

In October 2010, DMI Ice Services (DMI) was commissioned by Ironbark to look at the navigation route to Citronen in the light of the reports from Enfotec and Captain Lehto. DMI has submitted short supplements to these reports.

6.10.2 Routing

The proposed sail route to site can be divided into three ice zones according to Enfotec:

1. the pack ice of the northern Greenland Sea from open water to Cape Nordostrundingen
2. the pack ice of the Wandel Sea from Cape Nordostrundingen to Frederick E. Hyde Fjord
3. the fast ice zone of Frederick E. Hyde Fjord, including the offshore fast ice

Open Waters/Ice Edge to Nordostrundingen

The distance is approximately 300 NM from the meeting point around the ice edge to Nordostrundingen. From Nordostrundingen and approximately up to 230 NM south of this point the waters can be expected to be covered with an ice concentration of 8/10 (multiyear close drift ice).

Nordostrundingen to Frederick E. Hyde Fjord

The distance from Nordostrundingen to the entrance of Frederick E. Hyde Fjord can be expected to be covered with an ice concentration of up to 9/10 (multiyear close drift ice) for a distance of up to 160 NM.

Frederick E. Hyde Fjord to Citronen Fjord

The distance from the entrance of Frederick E. Hyde Fjord to Citronen Fjord can be expected to be covered with an ice concentration of up to 10/10 (multiyear fast ice of up to 2.5 to 3.0 m thick) for a distance of up to 35 NM. This distance was based on Enfotec's observances from June 14, 1997, where the ice concentration was quite large. However, the ice concentration does not diverge significantly from the average.

Further investigations for navigation of the route were not considered for the Feasibility Study.

6.10.3 Shipping Concept

The annual amount of the cargo to and from Citronen Fjord during operation of the mine (based on the 2010 studies) is planned as:

- approximately 300,000 t of concentrate out of Citronen Fjord
- approximately 75,000 m^3 arctic diesel fuel to Citronen Fjord
- approximately 1,000 TEUs of supply to Citronen Fjord including spares and consumables

In total, six concentrate barges will be operated with two or three icebreaking tugboats and two or three normal ocean going tugboats. The barges will be 32,000 DWT of Polar Class PC-5. The ice breaking tugboats will need to be ice class DNV 1A1 Polar-10. The total bollard pull for the tugboats should be a minimum of 100 t.

A marshalling area will be required for outgoing and incoming transport, which could be Akureyri in Iceland.

The barges will each be loaded with approximately 100 TEUs and 8,000 m^3 of arctic diesel fuel. They will then be towed to a meeting point south of Cape Nordostrundingen by the ocean-going tug boats. At the meeting point, the ocean-going tug boats will meet with the icebreaking tug boats approaching from Citronen Fjord with fully loaded barges.

In order to keep to schedule, the barges will have to arrive simultaneously at the meeting point to minimise redundant waiting time.

From the meeting point, the loaded barges will be towed back to Akureyri, where the concentrate will be unloaded and shipped later the same year with 50,000 DWT bulk carriers.

The barges loaded with fuel and containers are towed back to Citronen Fjord. At Citronen Fjord the barges are exchanged for two fully loaded concentrate barges, which are then towed back to the meeting point for a new rotation.

Transportation of supply, spares, fuel and consumables for one year plus backhauling of one year's production of concentrate entails that eight to ten trips are accomplished within the shipping window.

The last two incoming concentrate barges to Citronen Fjord will remain over winter and will be loaded with concentrate prior to receiving the first ice-breaking tug boats in the next year's shipping

window. The shipping window is estimated to be approximately 45 days from mid-July to early September.

No allowance has been made for further ice-breaker assistance than that of the ice-breaking tugboats. However, consideration of the use of a pure ice-breaker in combination with the ice-breaking tugboats needs to be reviewed in order to make the operation easier.

Approximate charter times are shown in Table 6.1.

Table 6.1 - Vessel Charter Times

Vessel	No.	Approximate Charter Time
Icebreaking Tug Boats	2 - 3	70 days
Ocean Going Tug Boats	2 - 3	50 days
Supplementary Ice Breaker	1	50 days

6.11 Airport

6.11.1 Introduction

The airstrip will be used for transportation of staff to and from site and for supplies that are required to be flown in (e.g. fresh groceries and spare parts required at short notice). Outside the September to July shipping season the airstrip will be the only access to the project.

During the project operations phase air traffic is expected to be for personnel (50 people in and out) as well as supply of fresh groceries. This can be maintained by two aircraft flights per week on average plus one cargo aircraft for delivery of spares and replacement parts when needed.

The airport facilities will be constructed in two stages. Aircraft which could potentially use the airstrip during each stage include:

- Stage 1: DHC-6 Twin Otter, DHC-7 and Hercules C-130H
- Stage 2: Dash 8 (Q400), Hercules C-130H and Fokker 50

In Stage 1, a temporary airstrip will include lighting and navigation systems to enable operation on a 24 hour basis. It will have a 900 m runway for the operation of passenger/freight aircraft similar in size to the Twin Otter or DHC-7.

In Stage 2, the temporary facilities will be upgraded to a permanent airstrip with a 1,500 metre runway to handle larger aircraft such as a Fokker 50 and Dash 8 (Q400). Stage 2 will be constructed with the use of dense medium separation reject materials from the process plant which will be available in Year 3 of the mining plan.

During the construction phase, the current airstrip will handle passenger aircraft sizes such as a Twin Otter, while freight aircrafts such as a Hercules can operate with cargo on a temporary runway on fjord ice during the winter.

The proposed location of the airstrip is 0.5 km to the south of the plant site where the terrain is relatively flat.

The airport is considered to be a public instrument meteorological conditions (IMC) airport. The airport is considered public as it will be used for passenger flights to and from site. An IMC airport refers to an airport being operable in the dark, which, as it is dark throughout half of the year is necessary at Citronen.

The proposed layout of the airport includes a control tower, a garage/technical building for some mobile equipment and emergency power, and a terminal building designed for 50 incoming and 50 outgoing passengers.

6.11.2 Logistics

Travel to Citronen is currently achieved via airplane from Oslo to Longyearbyen on Svalbard, then by charter from Svalbard to Citronen stopping at Station Nord for refuelling. The total route is approximately 3,010 km. The airports in both Oslo and Longyearbyen have runways that can handle larger aircrafts such as a Hercules C130, Fokker 50, and Dash 8 Q400. The runway in Longyearbyen has a length of 2,300 m, while the two parallel north-south runways at the Oslo airport have lengths of 3,600 m and 2,950 m.

An alternative route to Citronen Fjord is by airplane from Akureyri, Iceland to Citronen directly or via Station Nord to Citronen. This route is approximately 2,030 km. The airport in Akureyri has a runway 1,900 m long. The runway at Station Nord is 1740 metre and it is able to handle bigger aircraft such as Hercules C130, Fokker 50 and Dash 8 Q400. The only reasonable access from the Longyearbyen and Akureyri airports to Station Nord is by chartered flight.

During construction and the first three years of operation, the proposed route will be from Akureyri or Keflavik, Iceland to Station Nord by Dash 8 Q400 or larger plane and from Station Nord to Citronen by Twin Otter.

After three years of operation, the proposed route will be directly from Akureyri to Citronen Fjord by Dash 8 Q400, Fokker 50, or Hercules C130.

6.11.3 Design Criteria and Authorities Approval

With a runway of approximately 1,500 m, it is planned that the airstrip will only be used for the project and ongoing operations, however, it is expected the civil aviation authorities will request the airstrip also be open to other aircrafts in the event of an emergency.

The approval of the airport is to be handled by the Greenlandic aviation authorities and Greenland's BMP.

All requirements of the airstrip, technical facilities, mobile equipment and staff required for operations are to be in accordance with international standards and require approval by the Greenlandic and Danish Civil Aviation Authorities.

The Danish Civil Aviation Authority usually requires a preliminary application of establishment before the detailed design. Overall processing time for this approval can be up to 12 months and technical approval up to three months before the start of construction.

Both the temporary and permanent runways are classified for non-precision approach with decision height at approach a minimum of 150 m above thresholds.

All aircraft must be approved for landing and take-off on a gravel runway.

6.11.4 Site Data and Climate Conditions

Topography

The site is located in the middle of a glacial valley surrounded by mountains of up to 1,000 m elevation to the north and east. The location of the major mountains restricts aerial approaches to the proposed airstrip location.

The proposed location of the airport is at an approximate elevation of +50 m and situated on a relatively flat plateau in the direction NNW (340°) to SSE (160°). The proposed location is the area where the current airstrip is located.

An obstacle survey based on available maps shows the northern sector has only limited obstacles and therefore allows take-off at night and instrument approach operations to this runway end. The southern sector has many obstacles and operations will follow a narrow valley with a 30° direction change from the direction of the runway. Operations in this sector are limited to visual conditions and daylight only. Icebergs are not a concern inside the Citronen Fjord.

Weather and Climate

The climate conditions are based on data recorded at Kap Morris Jessup, located approximately 85 km to the NNW of Citronen Fjord. Supplementary climate data was obtained at Citronen Fjord during site investigations in 1993-1996 and 2008-2009.

The observations indicate maximum wind speeds more than 40 m/s, recorded as 10 minute averages. The Citronen Fjord weather station observations in 1995-1996 indicate NNW winds in the period from May to Aug and SSE/SW winds in the period from February to April.

The yearly precipitation in the northern part of Greenland is expected to be approximately 125-250 mm (water equivalent). Due to the low temperatures, precipitation at Citronen Fjord will generally fall as snow.

No data concerning relative humidity and evaporation is available at the moment.

The characteristic minimum and maximum air temperatures for structural design are:

- maximum temperature: +15°C
- minimum temperature: - 50°C

It should be noted the lowest temperature recorded at Citronen was -37.5°C (recorded by an on-site weather station).

6.11.5 Permanent Airstrip

General Arrangement

The permanent facilities will comprise the following:

- runway
- taxiway and apron
- navigation and communication instruments
- runway approach lights
- control tower
- terminal building with check-in, security, etc.
- garage/technical building for mobile and emergency power unit
- parking area

The main power supply will be from the site grid. Emergency power will be available from a mobile generator placed in the airport building.

Runway and Apron

The runway will be approximately 1,500 m long and 45 m wide surrounded by a prepared area resulting in overall dimensions with a length of 1,620 m and a width of 150 m. At each end of the runway is a 90 m by 90 m runway safety area. The location allows for a longer runway with a minor length of approach lights.

The apron and terminal area are located at the southeast part of the runway with one 18 m wide taxiway from the runway to the apron area. The apron area is situated with a distance from the centreline that allows the tower and parked aircraft to be below the obstacle surface. The apron is sized for either two passenger aircrafts or one Hercules C-130.

Based on the geotechnical site investigations, the recommended minimum fill height including base and pavement materials is approximately 1.0 m to minimise frost and thaw problems and provide the necessary bearing capacity for a Hercules C130 aircraft. However, since the material at the airport site is equivalent to the material used as fill, the height may be reduced to a 150 mm corresponding to the pavement thickness.

The pavement is a 150 mm well-graded layer of crushed and screened gravel with a maximum grain size of 16 mm.

Navigational Aids

A non-directional beacon (NDB) will be installed near the extended centreline of the runway having a range of more than 25 NM and with a transmitting antenna on top of a pole. At one side of the runway, distance measurement equipment with a transmitting antenna will be placed on top of a pole. For each, a shack will be placed nearby with a transmitting unit, back-up power supply, and external power supply.

All systems have to be tested on ground and from an aircraft before commissioning.

Navigation based on satellites will be used as a supplement to the navigational aids mentioned.

Runway and Approach Lights

The runway will be equipped with lights which will receive power supply from transformers connected to two separate 3 kV conduits from two regulator units.

At the northern end, approach lights will be placed in a row at a distance of up to 420 m from thresholds at 60 m intervals. At a distance of 300 m from thresholds, a crossbar will be positioned with a width of 30 m. The lights will receive their power supply from transformers connected to two separate 3 kV conduits from two regulator units.

To support the approach angle, precision approach path indicators are placed in four light units to the left of the touch-down zone at the northern runway end. The lights will get their power supply from transformers connected to two separate 3 kV circuits from two regulator units.

The light system includes low intensity blue taxiway and apron lights, obstacle lights, runway guard lights, lighted wind socks and an airport light beacon on top of the tower.

Lights can be switched on and off at a panel in the tower and regulated up and down in intensity.

All light systems must be tested on ground and observed from an aircraft before commissioning.

Power outlets will be placed along the edges of the apron for aircraft.

Meteorological Equipment

At the each end of the runway, a pole will be located containing meteorological measurement equipment for wind direction and speed and will be heated for arctic conditions. Equipment for measuring temperature and humidity will also be installed.

Equipment should also be installed for cloud base measurement in the strip area near the apron. The tower will hold a barometer.

The recordings from the measurement equipment are sent by cable to a receiver/computer in the tower for readings, calculations, and forwarding.

Airport Flight Information Service and Communication Equipment

The following equipment is installed in the tower:

- airport flight information service console with panels
- tower control system
- voice communication switching system
- VHF radio equipment for air to ground communication
- VHF radio system for local communication
- VHF radio system for communication for fire-fighting service
- equipment for speech recording
- clock system
- electrical drapes in windows

Some of the equipment will be placed in a separate technical room with a 24 V DC no-break system and antennas for communication will be installed on top of the tower.

Airport Buildings

Requirements for the buildings are as follows:

- buildings will be designed and constructed to comply with the Greenland Building Regulations
- buildings will be electrically heated when in use
- foundations will be in-situ concrete and on are on soil with permafrost

The control tower will be a prefabricated 5.4 m by 5.4 m steel frame building with three levels and a height of 11 m. The ground level and first floor will contain technical equipment and instruments; the third level will be the flight control room.

The building will be covered with steel panel cladding with tilted windows 360° around the control room. The roof will be steel panels with asphalt roofing. The deck in the technical room will be steel grating, and the deck in the control room will be steel beams with plywood floor and vinyl flooring. Interior walls and the underside of decks will be made with or covered by fire-resistant plasterboards.

Terminal Building

Passengers will be transported to and from the terminal in buses and will have to be cleared for international travel.

During flight departure and arrival periods, five to eight personnel will be working on the airstrip, depending on the aircraft being dealt with. These personnel will handle flight operations, check-in

and security, baggage and cargo handling, preparation of aircraft, and fire and emergency contingency during landing and take-off.

When flight arrivals and departures are not scheduled, these personnel will perform maintenance activities and facility cleaning. Occasionally flight operators or authorities are expected to be at the airstrip to perform administrative tasks including staff training, customs duties, or immigration, etc.

The terminal building is a one-level, 17 m long, 9 m wide building equipped with:

- check-in and security
- scanning facilities for outgoing baggage
- common departure and arrival lounge
- departure lobby with information desk (and if required customs/immigration)
- toilets, depots, and technical rooms
- baggage will be handled on trolleys or designated aircraft containers

Garage/Technical Building

The garage will be constructed as a continuation of the terminal building for housing mobile equipment required for operation of the airstrip.

Other mobile equipment for use at the airstrip will be located at the plant site when not in use and will be located in a carport attached to the garage when the airport is in use.

The building will be heated and insulated for a temperature of +5°C. The floor will be concrete in the technical section and gravel in the garage building.

Fuel for Aircraft

A fuel bowser placed in the garage building for refuelling aircraft. Jet fuel is stored at the fuel storage area north of the port site.

Water

Fresh water will be delivered by truck from the plant site where it will be stored in a one cubic metre tank equipped with pumps for distribution purposes.

Wastewater

Wastewater from sinks will be collected in a prefabricated three cubic metre tank unit with electrical heating. The tank will be emptied and waste water will be trucked to the sewage treatment plant at the main warehouse.

Dry or chemical toilets will be installed with waste collected and transported for disposal in the incinerator at the main ware house.

Fire Safety

Fire water will be pumped from Lake Platinova. The tower, terminal and garage will be equipped with hand extinguishers for use when people are at the airstrip site. The fire alarm system will be integrated with the overall site control system via an optic fibre cable which will be installed with the power cable.

Mobile Equipment for Operation

Mobile equipment will be required for the following operations:

- rescue and fire fighting service

- fire-fighting water supply
- snow removal
- baggage handling
- cars and buses for transportation
- runway and apron maintenance

The size and number of fire trucks depends on the size of the aircrafts. For traffic using DHC-8-Q400, Fokker 50, Hercules, or similar, requirements are equivalent to one crash tender (fire truck) with more than 5,400 litre of water. Furthermore, services should include a dry powder battery, first aid equipment, etc.

Snow removal includes one front-end loader with a snow blower equipped with a sand dispenser.

The garage should contain a silo for heated sand.

6.11.6 Temporary Airstrip

The temporary airstrip will be the initial part of the permanent airstrip. Up to 650 m non-approved runway for DHC-6 (Twin Otter) will be constructed as soon as possible, to be continued by a 900 m runway approved for operation of a DHC-7. The existing runway for a Twin-Otter is situated west of the planned runway and may be used during a part of the construction phase with navigational lights.

For both the 650 m and the 900 m runway, the following is assumed:

- non-precision approach with navigation installations and lights
- gravel runway with substructure as the permanent airstrip
- width of the runway is at least 30 m
- a graded safety zone at least 70 m or 80 m wide and with a 30 m or 60 m extension at each end of the runway
- necessary parts of the permanent apron and terminal area
- all buildings except the tower will be temporary, either shacks or tents

Building and ancillary facilities are expected to include the below:

- flight tower – erected for the permanent airstrip
- communication systems and meteorological instruments
- diesel power supply – could be the emergency power unit for the permanent airstrip but then there will be no secondary power
- diesel fuel storage – temporary tank has to be provided
- shelter for crash tender and de-icer – could be a temporary tent
- shelter for staff and passengers – could be part of the construction camp on the site

A fire truck is required for operation with DHC-7 and similar aircraft. All other equipment (excluding the de-icing and friction tester) will be part of the construction equipment on-site.

6.11.7 Jet Fuel Storage and Refuelling Facilities

Jet fuel is brought to the airport from the fuel storage by a fuel bowser. Jet fuel will not be stored at the airport and only mobile refuelling facilities will be used.

6.11.8 Power and Communications

Electrical power will be supplied from the power plant by a medium voltage cable to a transformer located at the airport for power requirements to the facilities including all lighting.

A 200 kVA emergency diesel power unit will be installed inclusive of a fuel tank to provide power should the main supply be switched off or fail.

For the terminal, office, tower and garage building, lighting and power installations normally used in the architecture of the local commercial airports in Greenland will be included.

Telecommunication will be separate air-to-ground installation for communication with aircraft. The facilities will be connection to the site-wide communication system via a fibre optic cable.

6.11.9 Recommendations

The following recommendations have been made regarding the airport facilities:

- Further site investigations are required (particularly geotechnical) before detailed engineering commences.
- An obstacle survey for the area on the north side of Frederick E. Hyde Fjord is completed for airstrip planning and design and that updated climatic conditions including wind patterns would be beneficial.
- Due to the obstacles in the southern end of the airstrip, it is recommended to look at alternative solutions for instrumentation and maybe for using different types of aircraft over part of the year. As it usually takes up to 12 months to obtain approval of an airstrip, it is advisable to begin a preliminary (project) proposal of the airstrip as early as possible.
- In connection with the proposal, a dialogue with the authorities should be initiated for clarification of the location of the airstrip and the need for and size of air terminal facilities

SECTION 7 - TAILINGS & WATER MANAGEMENT

7. TAILINGS & WATER MANAGEMENT

7.1 Status at April 2013

Although there have been changes to and progress with project definition since February 2011, tailings and water management have not been studied further since that time (this does not present any major issues). Changes to the mining schedule since February 2011 have the potential to change the disposal method of tailings in the early project stages, which may prove to have a beneficial effect on reducing the initial capital cost requirements.

7.2 Tailings and Water Management

7.2.1 Introduction

For efficient environmental performance, the need of structural fill for mine stability and to increase underground mine ore recovery, the decision was made to use tailings as backfill underground. This is reported in further detail in Section 4 of this Report, "Mining". However, an on-ground tailings storage facility (TSF) will be required for the following operating conditions:

- when there is an imbalance between tailings produced by the mill and underground backfill requirements
- when open pit mining is conducted, with commensurate reduced tailings as mine backfill

The conceptual planning of the TSF through detailed design of each component of the operation is guided by the "design for closure" philosophy so that the overall development is consistent with an economically viable final closure plan.

Due to the complexity and variability of natural earth and rock formations and materials, significant variations may occur between or around the borings. It is possible that conditions encountered during construction may be substantially different from those indicated by the site investigation results. In these instances, design adjustments and construction modifications may be necessary.

7.2.2 Scope of Work

The scope noted below, provided the basis for the TSF design:

- field investigation and laboratory soils testing undertaken during the summer of 2010 by MT Højgaard (MTH)
- seismicity estimate based on literature review of Voss, Poulsen, Simonsen, and Gregersen (2007) for earthquake peak ground accelerations
- climatology and hydrology studies to develop storm events, recurrence periods and in-flow design floods
- feasibility level engineering analyses and design calculations for the TSF and Lake Platinova embankments, surface water management facilities around the TSF and for the tailings distribution system
- impoundment water and tailings mass balance analyses
- freshwater reclaim system from Lake Platinova
- preliminary closure and reclamation plan
- recommendations for additional work required to develop project further

7.2.3 Site description

In-situ soils at the tailings facility primarily consist of gravels (GP-GM) and silty sands (SM) according to the Unified Soil Classification System (USCS). The geologic map of Greenland shows the project area to be mainly covered by quaternary sediments from glacial and postglacial marine deposits. The sediments predominantly consist of glacial sand, gravel and boulders ranging from 0 to 60 m in thickness.

The seismicity evaluation for this study consisted of a literature review of available information.

7.2.4 Geotechnical Investigations

A geotechnical site investigation was conducted by MTH at the TSF site during the period of May to August 2010. The primary objectives of the investigation were to:

- characterise the depth and geotechnical properties of the soils beneath the dam footprint
- characterise the permafrost conditions of the site
- characterise the surficial soils in the impoundment basin
- identify possible borrow sources for dam fill materials

Investigations performed to support the design included geotechnical drilling, test pit excavation, soil sampling, and laboratory soil testing.

A total of 18 boreholes were drilled around the Citronen Fjord area, from which only three were drilled within the footprint of the tailings facility. Standard Penetration Testing (SPT) was not carried out in the field due to the permafrost in the ground.

Test pit exploration and sampling was performed in the impoundment area to characterise geology and engineering properties of surficial soils. A total of 28 test pits were excavated to investigate near surface geology and collect soil samples, six of them being located in the footprint of the dam.

Laboratory testing performed on selected samples indicates primarily gravels (GP-GM) and silty sands (SM) classification. Gravel ranges from 0% to 88% of the overall material and fines are between 3% and 100%.

7.2.5 Climatology

The climate of the Northern Greenlandic area is arctic desert, meaning it is cold with daily maximum temperatures rarely exceeding 10°C. The warmest month, July, has an approximate average daily temperature of 2.1°C (35.8°F). Citronen Fjord is also very dry, averaging less than 200 mm of precipitation per year with monthly averages of less than 30 mm during wetter months. Based on regional weather stations, most of the precipitation occurs during the months of July, August, and September, with September normally being the wettest month. February is the coldest month of the year. Citronen Fjord experiences polar night from the middle of October with twilight lasting until the end of the month, there is total darkness until the end of February with twilight commencing around the middle of the month. The sun does not set at the Citronen site from approximately the first week of April until the first week of September.

7.2.6 Design Criteria

Site-specific design criteria for the TSF study were developed based on the following agency publications:

- International Committee on Large Dams (ICOLD) – Various Bulletins

- Canadian Dam Association (CDA) – Dam Safety Guidelines, January 1999
- The Mining Association of Canada – A Guide to the Management of Tailings Facilities, September 1998

Table 7.1 summarises the design criteria and assumptions used for the Citronen Fjord TSF feasibility design.

Table 7.1 - Summary of design criteria and assumptions

1.0 Basic Data	
1.1	Total tailings is 9.0 Mt
1.2	Tailings produced at 240 t/d
1.3	580,557 m^3 tailings storage requirement for year 1; 371,000 m^3 capacity required for years 2 through 8
1.4	Tailings solids specific gravity = 3.6
1.5	Tailings slurry consists of 58% solids by weight
2.0 Dam Stability	
2.1	Minimum factors of safety – refer to Table 7.2
2.2	Maximum Design Earthquake (MDE) = Maximum Credible Earthquake (MCE)
2.3	Use pseudo-static methods of analysis
2.4	Peak Ground Acceleration (PGA) factored by 50% for pseudo-static analysis
2.5	Assume tailings fully liquefy under earthquake conditions
3.0 Storm Water	
3.1	Diversions designed for 100-year, 24-hour storm event
3.2	During operations, the impoundment will completely contain runoff resulting from the 24-h 50% PMP event in addition to the normal operating pool volume as determined from the impoundment water balance while maintaining 1 m (minimum) of residual freeboard between the dam crest and the maximum water level
3.3	Emergency spillway designed to pass the 24-hour PMP event while maintaining 1-m (minimum) of residual freeboard between the dam crest and the maximum water level
3.4	Use Soil Conservation Service (SCS) Technical Release 55 (TR-55) methods of analysis
3.5	Antecedent Moisture Condition (AMC) II assumed

Acceptable slope stability design criteria for earth and rock fill dams advocated by the ICOLD and the Canadian Mining Association were adopted for design of the Citronen Fjord tailings dam. These requirements are summarised in Table 7.2.

Table 7.2 - Minimum factors of safety for dam stability

Loading Condition	Minimum Factor of Safety	Slope
Steady state seepage with maximum storage pool	1.5	Downstream
Earthquake	1.1	Downstream

7.2.7 Tailings Embankment Design

Based upon the data available regarding available construction materials at the site, a conventional earth and rockfill dam with a geomembrane lined upstream slope was chosen for this stage of design.

The dam will be constructed in stages with locally available materials placed and compacted in lifts. In general, the tailings dam will include fine grained lower permeability materials placed in the upstream portion of the dam and coarse high strength rock materials in the downstream portion of the dam.

The location of the facility was based on the following considerations:

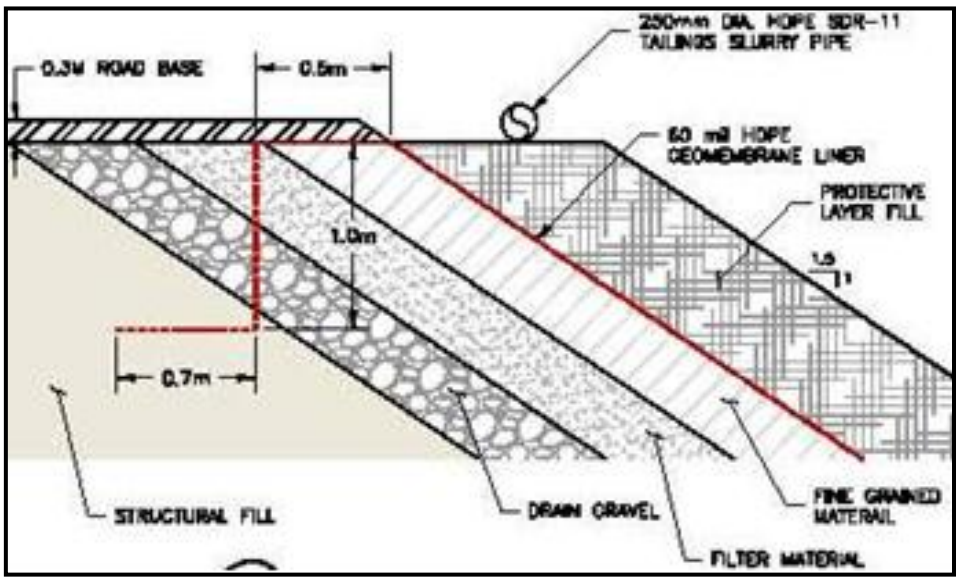
- proximity to the proposed milling facility
- impoundment storage to dam fill ratio
- water management considerations
- environmental
- geotechnical
- topography

The selected TSF location is within the tenement owned by Ironbark. Based on site investigations conducted to date, the entire impoundment area and dam foundation is covered with a thick layer of gravel interbedded with thin layers of ice. The impoundment area consists of terrain slopes ranging from 2% to 6%.

The zoned earth embankment proposed for the tailings dam is as per standard practice for tailings dam construction. It provides a cost effective, environmentally responsible and safe manner in which to store tailings.

The dam will contain five primary earth fill zones (Figure 7.1).

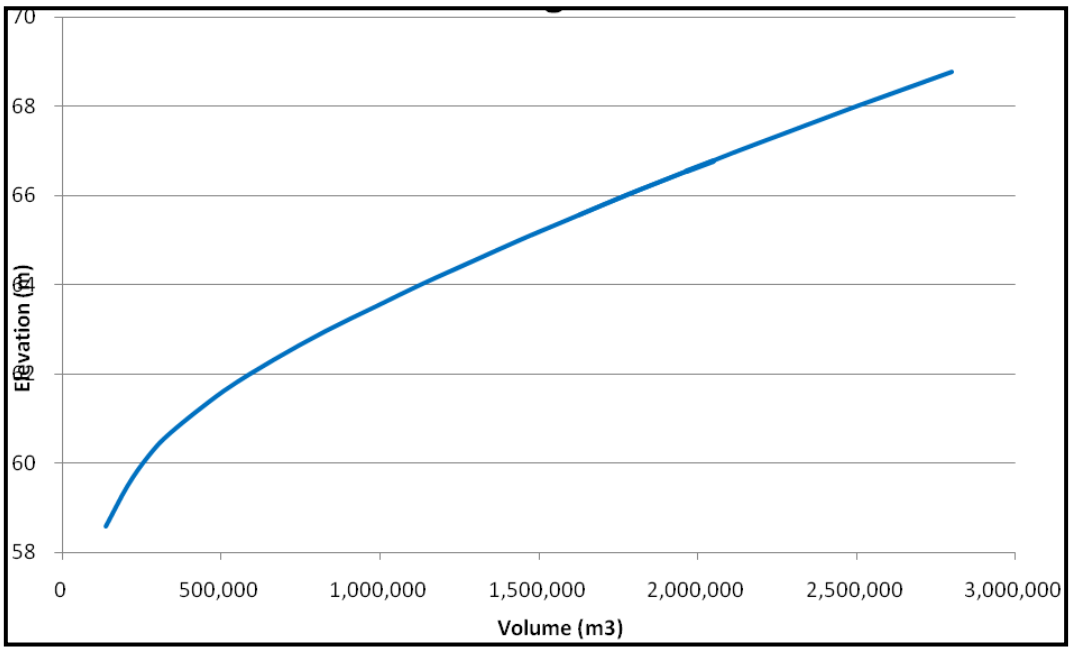
Figure 7.1 - Primary earth fill zones



7.2.8 Tailings Impoundment Design

Embankment geometry has been designed to maximise impoundment volume while maintaining a footprint that remains above the Eastern River floodplain. The layout also minimises the rate of rise of the facility to allow the tailings to freeze. Figure 7.2 presents the height-capacity relationships for the facility.

Figure 7.2 - Tailings facility storage curve



The initial starter stage embankment provides capacity for approximately 4.5 years of operations at the tailings production rate anticipated for the project. The anticipated tailings to be stored in the facility are a function of mill production and underground backfill operations. The TSF storage volumes are approximately 580,000 m^3 for Year 1, and 371,000 m^3 for Year 2 through Year 8.

A portion of the tailings in Year 2 through Year 8 are anticipated to be placed back in the underground workings. The final raise provides eight years of capacity at the current anticipated production rate.

7.2.9 Lake Platinova Embankment Design

The Lake Platinova Embankment Design type takes into consideration some of the same factors as the TSF, including earthquake resistance, relative cost, environmental performance, ease of closure and the ability to construct the embankment during the designated construction season. Based upon the data of available construction materials at the site, a conventional earth and rockfill dam with a low permeability core was chosen for this stage of design.

This embankment will be built in one stage with locally available materials placed and compacted in lifts. In general, the embankment will include fine grained lower permeability materials placed in the core of the dam and coarse high strength rock materials in the downstream and upstream portions of the dam. Intermediate filter materials will be required to transition between the fine and coarse grained materials. The advantages of this type of embankment design include:

- rockfill dams provide structural resistance to earthquake forces
- embankment construction can be performed with conventional earth moving or mining equipment
- suitable borrow sources for embankment construction are anticipated to be located in close proximity to the dam site
- clay core dams are very common in the industry and provide a cost effective method of storing water

The general location and arrangement of Lake Platinova and the location of the embankment was based on the following considerations:

- location with respect to the existing level of Lake Platinova
- water management considerations
- topography

The selected location of the embankment was chosen to allow for an overall capacity of 1.8 million cubic metres of water storage. The location of the embankment provides the most efficient use of the existing topography and most effectively stores the required volume.

Based on the stability modelling conducted, the proposed Lake Platinova embankment adequately meets or exceeds the minimum required factors of safety for all conditions.

7.2.10 Storm Water Control

The storm water management approach for the Citronen Fjord TSF will be to limit to the maximum extent practical the volume of storm water runoff that enters the TSF. This will be accomplished by constructing a surface water diversion channel along the east side of the ultimate TSF. Due to the small quantity of runoff anticipated, the access roads in the area of the TSF will have a roadside ditch that will be used as the diversion channel. The surface water diversion is designed to convey the 100-year frequency, 24-hour duration rainfall event.

Extreme precipitation events in excess of the 100-year frequency event may result in overtopping of the surface water diversion. If a failure of the surface water diversion occurs, surface water flows will be conveyed to the TSF. During operations, adequate storage will be maintained within the TSF to completely store runoff resulting from the 50% peak maximum flow (PMF) event (assuming surface water diversion failure at the onset of the event) while maintaining one metre (minimum) of residual freeboard to the tailings dam crest. Excess water stored within the TSF during operations will be discharged through a temporary reclaim system as required during the summer months.

At closure, the tailings impoundment will be capped, isolating the tailings from the environment. Surface water flows will be conveyed to the emergency spillway, minimising the accumulation of water on the covered tailings.

7.2.11 Water and Tailings Management

A detailed water and tailings mass balance computer model was developed for the Citronen Fjord TSF. The model simulates all inflows and outflows to the system during the life of the TSF.

The mill will receive water from multiple sources including Lake Platinova, the TSF and from the underground backfill process. The source of fresh raw water is Lake Platinova. Reclaim water will be provided by the TSF in the summer months and from the underground backfill process when running and supplemented by fresh water as required.

7.2.12 Closure & Reclamation

Closure of the tailings embankment will consist primarily of vegetating the dam crest and downstream slope (if required). Progressive reclamation of the downstream slope can occur immediately following construction of the final embankment. During operations, an evaluation of the performance of the embankment with regards to erosion will be made. If unacceptable levels of erosion are noted, re-contouring of the downstream slope may be required at closure.

All diversion ditches constructed to limit inflow to the tailings facility will be left in place and allowed to naturally fill-in with eroding rock and soil from the slopes that exist above the ditches.

At closure of the facility, the Lake Platinova embankment will be breached and the lake will be allowed to return to its natural level.

More comprehensive closure plans will be developed as the project evolves during later phases of the project.

7.2.13 Emergency Spillway

As the TSF nears the end of its operating life, adequate storage of the 50% PMF event will no longer be achievable. At that time, an emergency spillway will be constructed to protect the tailings dam from overtopping during extreme precipitation events.

The spillway was designed based on the below criteria and factors:

- The spillway must handle runoff for the PMP, 24-hour duration storm event
- Rainfall from the emergency spillway design storm event was estimated to be 81 mm
- The spillway must be capable of conveying the peak flow during the spillway design storm while maintaining a minimum of 1m of residual freeboard at closure conditions
- The north and south diversion channels are assumed to fail at the onset of the spillway design storm
- The emergency spillway is assumed to be rip-rap-lined with a corresponding Manning's roughness coefficient as given in "Open Channel Hydraulics" (Chow, 1959) of n = 0.035
- The initial surface elevation in the Citronen Fjord TSF impoundment at the onset of the PMP, 24-hour duration storm event is assumed to be 68.75 m, which corresponds with the invert of the proposed emergency spillway

The emergency spillway is designed to discharge runoff from storms up to and including the full PMF event, while still maintaining a minimum of one metre of residual freeboard to the tailings dam crest throughout operations and closure. For the design of the emergency spillway, the diversion channels around the TSF are assumed to fail at the onset of the Probably Maximum Precipitation (PMP) storm and runoff from the entire 155 ha catchment area is routed through the tailings facility.

The spillway will be located at the northern end of the TSF. Discharge from the spillway will be directed away from the TSF and follow the natural topographic gradient towards the Citronen Fjord. It is not anticipated that a sedimentation basin will be required for the spillway at this stage due to the low risk of environmental contamination. The reasons for this are:

- During a PMP event, one metre freeboard allowance will remain allowing some settling of tailings solids prior to overflow.
- The majority of tailings will be frozen and will not enter the rainfall solution.
- Ecotoxicity test results concluded that concentrations of tailings decant water (including 100%) are not toxic to lower level aquatic communities.

However, during operations further testing of supernatant will be conducted to monitor the toxicity level of the supernatant and the likely solids suspension rate. Results of this monitoring will then be used to re-evaluate any risk of the supernatant to the environment in a flood situation.

7.2.14 Emergency Action Plan

A comprehensive emergency action plan (EAP) will be developed as part of the final facility design to guide the Citronen Fjord tailings facility operators in tailings and water management. The EAP will include recommendations covering both structural and environmental upset conditions. The EAP will define responsibilities and provide procedures designed to identify unusual and unlikely conditions which could endanger the Citronen Fjord tailings facility, in time to take remedial action and to notify the appropriate entities and agencies of possible, impending, or actual failure of the dam.

7.2.15 Additional Studies and Recommendations

The goal at this stage of project development is to provide the feasibility level design of a tailings facility to support financing and permitting efforts. In order to advance the facility design to final detailed design, the following activities are recommended:

- further develop site data, refine design criteria and further define plant information
- additional tailings characterisation studies
- additional evaluations regarding embankment design and geometry
- storm water and process fluid management evaluations
- additional embankment stability evaluations to include data from a detailed geotechnical investigation
- development of a tailings storage facility management master plan
- additional hydrogeochemistry analyses and modelling of tailings supernatant for water quality treatment
- update the tailings disposal plan in relation to the current mining schedule

SECTION 8 - PROJECT EXECUTION

8. PROJECT EXECUTION

8.1 Introduction

In February 2011, Wardrop Engineering Inc. (Wardrop) completed a feasibility study report that included the section titled "Citronen Fjord Feasibility Study, Greenland – Volume 7: Project Execution". It describes the requirements, timeframes and execution instructions required for the successful completion of the project, also recognising the unique challenges facing the Citronen Project (Project).

The Wardrop project plan was to initially split fabrication and erection into two main locations and organise the work as follows:

- Equipment and materials for the Project originating in Europe, Canada, North America, and Asia to be consolidated in Denmark or Iceland.
- The process plant to be erected on barges at Akureyri in Iceland and towed to the Citronen site by icebreaker tug boat.
- The main infrastructure components and primary crusher etc. to be erected at the Citronen site where the completed project will eventually be located.

For the purpose of the feasibility study report it was suggested that Wardrop Vancouver and MT Højgaard A/S Copenhagen would form an engineering, procurement and construction management (EPCM) joint venture relationship style with Metso nominated as the main vendor for all process equipment.

As part of this Report, the Wardrop project execution plan has been reviewed and amended to reflect the procurement of equipment from China. In addition, the construction philosophy has been changed to that of building the majority of the project facilities in-situ at Citronen utilising Chinese construction companies supplemented with specialists where required.

The earlier plan of nominating one supplier as the main vendor for all process equipment does not fit with the current proposed approach of procuring equipment from China. Furthermore, nominating one main vendor does not necessarily ensure that the fit-for-purpose lowest cost equipment item is selected.

This revised and updated approach to both procurement and construction has the benefit of resulting in a reduction in capital costs and this is discussed further in Section 11 of this Report.

The Project is now intended to proceed under an EPC contract with NFC. For the Project to proceed on this basis, Ironbark will need to obtain approval from the BMP for the use of foreign labour on a project of this value.

The EPCM contractor will provide all design services, procurement and contracts services, quality assurance, construction management and commissioning services. The EPCM contractor will supplement its in-house expertise with specialist sub-consultants where required.

Execution of the project will involve tasks that are common to the development of any project in the mining industry but also with the complexities of executing a project in Greenland. These include the complexities below:

- Carrying out construction in a sensitive environmental ecosystem and the need to minimise potential impacts.
- Working in harsh climatic conditions including very low temperatures and permafrost.
- Safety considerations for personnel working in these harsh climatic conditions.

- Logistics constraints arising from limited site access during a restricted shipping window from July through early September and a requirement to use ice-classed vessels.
- Schedule considerations resulting from the restricted shipping window .
- The consequential need to construct buildings early in the construction phase so that the project facilities can be erected within them on a year round basis with workers thereby protected from the elements.

The following sections discuss these issues and present the revised project execution plan in more detail.

8.2 EPCM Model of Project Delivery

The EPCM method of development for the Project by Wardrop requires that Ironbark award an EPCM services contract to a suitably qualified and experienced contractor who will develop the Project in conjunction with Ironbark as the Owner.

The role of the EPCM contractor will include the provision of personnel and expertise to:

- optimise the facility layout
- undertake detail engineering
- manage the tendering and award of purchase orders and contracts that are entered into by the Owner
- provide expediting and quality control services for the manufacture and fabrication of equipment and material supplies
- coordinate logistics and transportation globally
- coordinate and manage construction and commissioning activities
- provide project wide cost and schedule controls and reporting services

The EPCM contractor will be engaged to act as agent on behalf of Ironbark and this requires the EPCM contractor to seek Ironbark's approval for all aspects of the key decision making processes. This delivery model will enable Ironbark to maintain significant influence on the budget, schedule and quality outcomes through all stages of project development. This approach requires the Ironbark Owner's Team to be comprised of experienced personnel who are able to manage and provide an experienced overview of the EPCM contractor.

The complexities of the Project may require the EPCM contractor to utilise the services of specialist sub-consultants to incorporate cold weather expertise into the facilities design and logistics sub-consultants who are experienced in shipping in the Arctic region.

The EPCM contractor will need to demonstrate expertise in procurement in China or plan to utilise suitably qualified and experienced sub consultants for these activities to ensure tier one manufacturers are used to achieve the specified quality outcomes. Also, with the plan to engage primarily Chinese construction workers, the EPCM contractor will need to demonstrate experience working in such an environment.

8.3 Project Schedule

8.3.1 Key Activities

The Wardrop Study identified key activities of the execution plan, including the design and construction of concentrate barges. Barges will be used during the shipping window to carry concentrate to specific customers. While the new plan still includes the use of barges they will now

be hired rather than purpose built as part of the project scope. Hence the barges are no longer a key activity of the execution plan. The remaining key activities identified in the Wardrop report are as follows:

- Bureau of Minerals and Petroleum (BMP) approval of early mobilisation according to Section 702 of the Standard Terms for Exploration of Minerals (mobilisation and construction under the exploration licence).
- BMP approvals according to Sections 19 and 43 of the Act on Mineral Resources in Greenland (Exploitation Licence).
- Detailed design, planning and approval of critical items according to Section 86 of the Act on Mineral Resources in Greenland (Exploitation Licence).

With the new plan of constructing and erecting the plant on-site within a building and utilising Chinese contractors, the following items will also be critical to project execution:

- Obtaining statutory approvals to utilise foreign contractors for the majority of the work, with limited use of local contractors.
- Early design and fabrication of buildings within which the ongoing construction and erection of the project facilities can proceed on a year round basis.
- Shipping these buildings to site during the first available shipping window between July and early September to avoid delays to project completion.
- Establishment of a detailed procurement schedule which will enable equipment to be purchased and shipped to a consolidation point for transhipping to site during the annual shipping windows.

8.3.2 Schedule Development

A preliminary schedule was developed as part of the Wardrop Feasibility Study which was split into two key areas, those being on-site works at Citronen and off site pre-assembly of the process plant facilities on barges at Akureyri, Iceland, prior to towing to Citronen.

A detailed schedule will need to be produced at the commencement of the project to reflect the requirement to erect a building(s) at Citronen for subsequent process plant construction and assembly rather than pre-assembly at Akureyri and to review and finalise procurement delivery requirements to suit shipping windows based on assembly at Citronen.

The key items to be considered in revising the schedule are as follows:

- Early provision of temporary facilities to enable on-site works to commence.
- Erection of building shells including all insulated wall and roof sheeting together with all doors.
- Only the foundations for the building shell need to be constructed in the summer months.
- The other concrete works can be completed internally following erection of the buildings and the provision of temporary heating.
- A procurement strategy which ensures that equipment and materials are delivered to a staging point for subsequent transhipping on ice-classed vessels to Citronen during the shipping windows.

The basic parameters used for the schedule developed by Wardrop are:

- One working shift is 12 hours (11 working hours).
- One working week is six days.
- The site is closed for three weeks during Christmas.

- Due to the expected severe weather, the work efficiency for outdoor work will be planned as 70% efficiency for April, October, and November.
- Two shifts are planned for all outdoor activities from May to August.
- Due to the expected severe weather, no outdoor work that involves "winter sensitive" activities such as concreting is planned for December through to March.
- The shipping window is from late July to early September each year.
- The first season is "extended" through an early mobilisation using Hercules Aircraft landing on the fjord ice in April/May, and through the supply of equipment, materials, and other supplies by ice breaking tug boat in August.

The use of Chinese contractors during construction may enable a 13 day fortnight with the 14th day being taken as a day off. Closing of the site over the Christmas New Year period needs to be reconsidered as it may be appropriate to close the site over the Chinese New year period rather than as currently planned.

Concrete works can continue within the building shells provided they are adequately sealed and heating is provided.

Initial EPCM activities will include the following:

- finalisation of process design criteria, mass balance and flow sheets
- finalisation of site and plant layouts
- finalisation of discipline design criteria
- production of a detailed project execution plan
- finalisation of a contracting strategy and associated bidders list
- finalisation of the work breakdown structure (WBS)
- finalisation of the project schedule to establish critical paths and for ongoing monitoring and progress updating
- finalisation of budget allocations to procurement and contract packages
- tender and award of early works contracts for initial construction works including earthworks, concrete works, fabrication of building shell steelwork and cladding
- logistics planning
- production of standard drawings and specifications which incorporate requirements of codes and standards applicable to the works
- preparation of standard terms and conditions for contracts and purchase orders

8.4 Construction Manning

The approach of constructing the facilities on-site at Citronen rather than via pre-assembly will increase the site-manning requirements as personnel who were going to assemble the facilities off site will now be required on-site. Utilising Chinese labour will necessitate taking appropriate provision for productivity into consideration.

Actual requirements for construction manning will be finalised during development of the detailed schedule for the project. As temporary accommodation includes expansion of the existing tent facilities it is not envisioned that any increased accommodation requirements will result in delays to project execution.

8.5 Engineering

Detailed engineering will commence following the finalisation of process design criteria, mass balances, flow sheets, site layouts and discipline design criteria.

Design deliverables will be assigned to procurement and contract packages and this will enable resources to be optimised based on final schedule requirements. These deliverables will include technical specifications, data sheets, functional specifications, vendor data requirements and associated drawings.

Engineering progress will be monitored to ensure activities are undertaken in the correct sequence and are delivered on time.

8.6 Procurement and Contracts

Procurement and contract packages will be prepared and issued to the pre-qualified and approved bidders. The procurement and contracts group will monitor the tender process and, in conjunction with the relevant discipline engineering leads, evaluate tenders received and prepare recommendations for award.

Following award of the purchase orders, expeditors and inspectors will be assigned to the packages to monitor progress and quality of the work being carried out.

Contrast and orders will be entered into between Ironbark on the one part and the successful approved bidder on the other part. Management of orders and contracts will be undertaken by the EPCM contractor.

Expeditors will liaise with logistics personnel to ensure that shipping activities are arranged in a timely manner.

8.7 Project Controls

The EPCM project controls group will carry out the functions described in the following sections associated with schedule and budget monitoring, control and reporting.

8.7.1 Cost Control

Cost control personnel will:

- monitor commitments with respect to budget
- monitor actual costs
- forecast cost at completion in conjunction with the project manager
- prepare trend notices, which may have both a cost and schedule impact, so that mitigation strategies and actions can be put in place
- prepare scope changes where approved
- estimate cost and schedule implications of trends and scope changes
- provide input into monthly reporting including cost reports, scope and trend registers

8.7.2 Schedule

The project schedule group will update the master schedule for the project based on information received from:

- expeditors with respect to equipment and materials supply

- the construction manager for all site activities being undertaken by contractors
- design progress by deliverables
- procurement and contract award
- the commissioning manager for all commissioning activities

Updated progress information will be provided for inclusion in monthly reports which will include planned and actual progress and an updated schedule.

8.8 Construction Infrastructure

To initiate construction works on-site, the construction camp, fuel storage facility and communications will need to be in place prior to mobilisation of the initial construction workers. This will also include the need to mobilise construction equipment and materials including explosives, cement, reinforcing steel, building shell materials and process plant building shell materials during the initial shipping window.

The existing communications system comprising of Iridium units will be expanded to meet construction requirements because Citronen's location precludes other systems from working.

To support the initial construction effort a number of service contracts must be put in place, including:

- fuel supply
- geotechnical laboratory
- fixed wing air transport
- helicopter transport
- icebreaker transport
- camp management

8.9 Labour Relations and Manpower Training

Good labour relations are essential for the efficient and safe execution of the Project. It is planned to execute the Project on an 'open-shop' basis which permits both union and non-union contractors to execute work at the Citronen Fjord site.

The preassembly activities at Akureyri are undertaken by qualified subcontractors. The availability of these qualified resources is regarded as being high and is therefore not deemed to be a major issue for the project. Hence, the following considerations are for the Greenlandic site only.

The following items have been reviewed:

- Construction Employer Organisation- Grønlands Arbejdsgiverforening (Greenlandic Employer's Association "GA") coordinates and represents employers in Greenland within all business areas including transport, electrics, plumbing, building and general contracting
- Collective Agreements in Greenland- Collective Agreements applying to the construction industry in Greenland are negotiated by GA and the Sulinermik Inuussutissarsiuteqartut Kattuffiat (SIK) union in Greenland
- Government Labour Codes: The Greenlandic and Danish working environment is regarded as being very free and unregulated (the so called "Danish Model" or "Flexicurity Model"). The most important rules and regulations are the Employer's and Salaried Employees' Act, the Working Environment Act, the Holly Day Act and the Leave and Maternity Act

- Labour Strategies, Communications and Support including employee orientation and site indoctrination program and procedures for controlling and resolving labour disputes or disruptions
- Manpower Training: To assist construction contractors in securing qualified and trained Greenlandic local workers on the Project, it is recommended to enter early discussions with the Greenlandic authorities to encourage and support them in their work with training programs for the local work force. At this stage it is difficult to give any number on potential local employees. The number of persons living on the east coast of Greenland is limited and therefore the available workforce also
- Training Programs during Construction: During the construction phase, the possibility for on-the-job training will be evaluated as the project develops. This will also include the possibilities of having more formal training like apprenticeship programs on-site. Apprenticeship programs are best planned together with the local educational institutions
- Orientation Training: During the construction phase, orientation or site induction programs will be required for all first time employees. The orientation program will be completed in 4 hours and will be conducted by the Camp Manager, Safety and Environmental Coordinator.
- Operations Build-Up: The turnover will be coordinated with Ironbark to ensure proper staffing levels are available from the operations workforce to assume responsibility for the facilities

The handover of completed facilities and systems will be coordinated by the EPCM contractor with Ironbark to ensure operations staffing levels are pre-emptively built-up so the operations workforce will be available to assume the required responsibilities.

8.10 Pre-Operational Testing and Start-Up

The EPCM Project Team will provide commissioning management services which will include the provision of:

- commissioning manager and commissioning engineers
- coordination of commissioning activities between all parties involved in the commissioning process
- co-ordination and management of safety issues between operations, construction and commissioning groups
- production, implementation and management of the commissioning procedures
- liaison with the design consultants to ensure that the engineering requirements of commissioning are met
- review of activities leading up to commissioning and subsequently auditing site compliance with procedures, standards and site and statutory regulations and the design drawings and specifications
- authorisation of commissioning work permits
- ensuring that all data collected during commissioning is provided for review and inclusion as necessary in operating and maintenance manuals
- co-ordination of an overall commissioning report detailing all on-site activities relating to commissioning and including copies of all test and check forms completed with data relating to physical checks, settings, clearances, temperatures, etc. plus manufacturers' reports and certificates
- ensuring documented and formal approval of facilities handed over to operations for care, custody and control

Design consultants, where required, together with the EPCM design team will provide the following:

- technical support during the commissioning process
- commissioning detailed procedures and checklists
- provision of commissioning engineers where required
- updating of all engineering documents to as built status

Construction contractors will provide personnel, materials and equipment to support the commissioning team and under the direction of the commissioning manager will rectify/modify any items identified during the commissioning process. The quantity and mix of personnel will be agreed with the commissioning manager.

A list of vendors recommended for inclusion in the commissioning process will be developed during the detailed design phase of the project. The list will include vendors whose contractual requirements to accept warranty obligations requires them to be present for pre-commissioning checks and commissioning supervision.

The Ironbark operations group will provide suitably trained personnel to operate the various systems and equipment during commissioning and ramp up phase. Operations personnel will be under the direction of the Ironbark operations manager who will report to the commissioning manager until the Project is formally handed over to the operations group.

8.11 Logistics

Due to the isolated location of the site and the limited shipping windows available, logistics management is a critical activity that will need to be closely monitored. Expediting of materials and equipment is a critical activity for the success of the Project.

Access to the Project by sea requires the use of icebreaker tugs and ice-classed barges and is only available from late July to beginning of August in the Citronen Fjord area. A permanent airstrip will also be established in the project area.

Factors such as the remote location of the Project site, the limited shipping window, environmental and safety concerns, together with the high cost to transport materials, equipment, fuel and personnel to the site, will require detailed planning and close co-ordination of activities throughout the design and construction phases of the Project.

The scope of the logistics plan will encompass the services necessary for the efficient expediting, transport, traffic, warehousing and marshalling of personnel, materials and equipment, including living quarters, food, fuel and cement required to construct the facilities. It is imperative that materials and equipment transported during the shipping window arrive at the site according to the planned window sequences to enable all work to be completed on schedule.

The Project will require one main marshalling point close to the site to take advantage of the limited shipping window. This will be a location suited to the transfer of equipment and materials from normal ocean-going ships onto ice-classed vessels. The Wardrop Feasibility study identified this location as being Akureyri in Iceland. Pre-assembly of the process plant at Akureyri made this an attractive location for a marshalling point, however other alternatives can be considered.

It is estimated the project will have approximately 30,000 t of process and mobile equipment, structural steel and other architectural materials, pipe, valves, fittings, cement, ammonium nitrate

and other equipment, materials and consumables together with process plant equipment for its construction and development.

The majority of the process plant equipment and steelwork will come from China and other goods will originate from Europe, North America, Asia and Australia.

The shipping season can vary from year to year depending on actual weather and ice conditions transiting to and from Cap Nordøstrungen and Citronen Fjord. The average shipping window is from late July to early September for ice-class PC 1 icebreaker/tugboats together with ice-classed PC 5 barges.

During the first mobilisation to site, a barge will be equipped with a 200 t capacity crawler crane to discharge equipment and materials to site. This machine will later form part of the port mobile equipment. During the operations phase all loading of concentrate and unloading of barges will be done by the crawler crane and shiploader.

Load plans will be established based on the priority cargo to be shipped and the configuration of the nominated vessel prior to vessel loading.

The port facilities will not be constructed during the first shipping season and special allowance will be made to handle offloading at Citronen Fjord. A smaller temporary pier head will be constructed prior to the landing by equipment brought to site by Hercules flights landing on the ice.

SECTION 9 - ENVIRONMENTAL & SOCIAL ASSESSMENT

9. ENVIRONMENTAL & SOCIAL ASSESSMENT

9.1 Status at February 2013

9.1.1 Environmental Assessment

A draft Environmental Impact Assessment (EIA) Revision 1 was submitted to the BMP in February 2011. Version 3 is an update to address comments received from BMP which was submitted to the BMP in August 2012. The EIA is in two volumes comprising the EIA and its appendices and is summarised in Section 10.2 of this report.

9.1.2 Social Impact Assessment

A draft Social Impact Assessment (SIA) has been prepared. It is in line with the BMP guidelines "*Social Impact Assessments for Mining Projects in Greenland, Nov 2009*". This document is designed to meet the BMP's guidelines and forms the basis of public circulation and discussion. The SIA includes records of meetings with potential stakeholders including the BMP, the association of local governments and municipalities, local business groups, employer associations and trade unions and a number of other potential stakeholders. The SIA is summarised in Section 9.3 of this report.

9.2 Environmental Assessment

9.2.1 Regional Context

Citronen Fjord is located in Peary Land and is an appendage of the much larger Frederick E. Hyde Fjord (FEHF). Citronen Fjord is approximately 2,000 km north-northeast from Greenland's capital, Nuuk and 940 km from Qaanaaq – the nearest Greenlandic settlement. The Project lies at the head and east shore of Citronen Fjord, in the junction of two glacial valleys in which the Esrum and Eastern Rivers run, and is surrounded by bare mountains up to 1,000 m high. Access to the site is currently via aircraft, with ocean access possible during the summer months via FEHF.

The Citronen Fjord area is in the High Arctic Region with continuous permafrost (whereby the ground stays frozen all year long) across cold winters and short, cool summers. Mean daily temperatures above freezing occur from June until September. Precipitation is very low (in the order of 200 mm/a) and mainly falls as snow. The FEHF and Citronen Fjord are ice-locked most of the year.

9.2.2 Legislative Framework Affecting the Project

Greenland is part of the Kingdom of Denmark. Autonomous local governance was introduced to Greenland in 1979. On June 21, 2009, a new *Act on Greenland Self Government* came into force, stating Greenland could take over the administration of natural resources from Denmark. Consequently, the Naalakkersuisut (Government of Greenland) immediately took control of the mineral resource sector. The BMP (under the Greenland Self Government) is responsible for the management of mineral resource activities in Greenland.

The 2009 Mineral Resources Act (the Act) came into force on January 1, 2010 (*Greenland Parliament Act* no. 7 - 7 December 2009 on mineral resources and mineral resource activities). This law regulates all matters concerning mineral resource activities, including environmental matters (such as pollution) and nature protection.

Nature conservation and environmental regulation are administrated in accordance with the *Nature Protection Act* (Landsting Act no 29 of December 18, 2003 on Protection of Nature) and the Lov nr. 850 af December 21, 1988, for Grønlandommiljøforholdm.v (Act number 850 of December 21, 1988, for Greenland regarding environmental matters). The relevant paragraphs of the Act are in general agreement with these two Acts.

The 2009 Mineral Resources Act specifically stipulates that an Environmental Impact Assessment (EIA) must be prepared before permission to exploit minerals can be granted. Of particular relevance to the EIA is the regulation of environmental protection. This is included in Chapter 13 of the Act, which is divided into three sections on environmental protection, climate protection, and nature conservation.

Under *Environmental Protection*, the following provisions are of particular importance for the Project:

- The use of best available techniques should be applied, including less polluting facilities, machinery, equipment, processes, and technologies.
- When selecting measurements to prevent and mitigate pollution, attention should be paid to the environment of the site and how metals and other pollutions can have an influence on specific species and the ecosystem.
- When selecting a site, a place should be chosen where the pollution has least impact on the environment. Furthermore, when choosing machinery and working processes, the best available techniques should be selected that generate least pollution, emissions and waste.

In the section on *Climate Protection,* the Act states that when the Greenland Government makes a decision on approving the establishment and operation of a facility, it attaches importance to the considerations taken for avoiding a negative impact on the climate.

In the *Nature Conservation* section, the Act states that when granting a license for approval of an activity, the Greenland Government attaches importance to the consideration of avoiding impairment of nature and the habitats of species in designated national and international nature conservation areas and disturbance of the species for which the areas have been designated.

In order to advance its exploration licence into an exploitation licence, Ironbark must apply to the BMP for the exploitation licence pursuant to the provisions given in S.16 of the Act. The application for an exploitation licence must be accompanied by a number of documents, including:

- A declaration that the deposit at Citronen Fjord is commercially viable and that Ironbark intends to exploit the deposit.
- A Definitive Feasibility Study of the Citronen Fjord deposit on which the declaration is based
- An EIA.
- A Social Impact Assessment, including an Impact Benefit Agreement with the public authorities.

9.2.3 Public Hearing

Following preliminary approval by the BMP, the EIA will be made available for public comment. The report will be posted on the BMP website and will be made available as per the guidelines provided by the BMP.

The exploitation licence and approvals can only be issued by BMP after a thorough evaluation of the EIA is undertaken by BMP and the Danish Centre of Environment and Energy (DCE). In addition, any affected organisations and authorities, as well as the general public, have the opportunity to express

their opinion on the assessment. Comments will be evaluated and considered for inclusion in the decision-making process and will be included in the final version of the EIA report.

9.2.4 National Park of North and East Greenland

Citronen Fjord is situated in the northern part of the National Park of North and East Greenland. With an area of 972,000 km^2, of which 200,000 km^2 is snow and ice-free during summer, it is the largest national park in the world.

The national park was created in 1974 and has no permanent human population. During winter, the personnel of three small military bases, a civilian weather station and a research station (numbering around 30 personnel) are the only inhabitants in the national park. This number increases in summer when many scientists work in the national park.

The proposed Citronen Project would be located outside any species specific core areas and fauna protection areas.

Applications for prospecting, exploration, and exploitation of minerals in the national park are administrated according to the Mineral Resources Act.

It has been proposed to divide the national park into three levels of management:

- Level 1: species specific core areas (i.e. “biodiversity hot spots”), which are often of small size and with vaguely defined borders.
- Level 2: fauna and flora protection areas, which are larger areas often with many specific core areas or special nature types.
- Level 3: the national park outside the specific core areas and the fauna and flora areas.

According to these anticipated management levels, the proposed Project would be managed within Level 3 as it is located outside any species specific core areas and fauna protection areas.

9.2.5 Baseline Studies

BMP requires two to three years of environmental baseline studies to adequately characterise an area prior to project start. Prior to 2010, two years of detailed baseline studies were completed in the Citronen Fjord area, in 1994 and 1997, as well as a reconnaissance study in 1993 and marine water sampling in Citronen Fjord in the winter of 1995.

In 2010, Ironbark and Orbicon A/S (Orbicon) conducted another baseline study of the Project during the summer months of July to September.

The results of the 2010 environmental baseline study are comparable to the previous baseline studies undertaken in 1994 and 1997, with much of the same flora and fauna species identified in the Citronen Fjord area, as well as similar spatial and temporal variations in heavy metal concentrations measured in the Eastern River and Citronen Fjord.

All marine and fresh water samples were analysed for a full suite of metals and major ions. All other samples are currently stored at DCE prior to analysis. Sample collection is summarised in Table 9.1.

Table 9.1 - Summary of sample collection for all baseline studies at Citronen Fjord

Sample Type	1994	1995	1997	2010
Eastern River Water	X	X	X	X
Esrum River Water	X		X	X
Lake Platinova Water				X
Lake Platinova Sediment				X
Eastern River Sediment	X		X	X
Esrum River Sediment	X		X	X
Marine Water (CF)	X	X	X	X
Marine Sediment (CF)	X			
Higher Plants	X		X	X
Animal Scats	X		X	X
Seaweed	X		X	X
Fish	X		X	X
Soil	X		X	X
Reference Marine Water Column				X
Reference Sediment (Marine)				X
Reference Seaweed				X
Reference Plants				X
Reference Animal Scats				X
Reference Soil				X
Fauna Observations	X		X	X

9.2.6 Fresh Water

The Eastern and Esrum rivers cross through a large alluvial floodplain prior to entering the Citronen Fjord. While the Eastern River drains precipitation and groundwater following melting of the upper active layer, the main water source is from melting of snow and ablation from local glaciers. Due to the rare rain events in the area, it is apparent the direct runoff is mainly controlled by air temperature and solar radiation.

Elevated metal concentrations in Eastern and Esrum rivers are affected by natural processes related to the geological background and vegetation coverage in the catchment areas of these rivers. There are exposed areas of intensely oxidised sulphide minerals located within the catchment area of Eastern River. Considerable amounts of metals (zinc, lead, iron, cadmium, aluminium and nickel) are naturally washed into the Eastern River via runoff following precipitation, melting of permafrost and, in particular, melting of snow and erosion of local glaciers. High concentrations of some metals such as iron, cadmium and particularly aluminium are also found in Esrum River water.

Lake Platinova is the only lake in the immediate vicinity of the Project. It is a small, rounded depression fed by precipitation and melting of the active layer surrounding the lake. The maximum depth is approximately 11 m and the lake is ice free in summer. An interconnecting flood channel received by the Eastern River receives inflows from the outlet of Lake Platinova during flood periods, however, the passage of water in the channel is limited due to the low annual precipitation, and the channel typically remains dry for most of the season. The lake has a sedentary population of arctic char.

9.2.7 Marine Water

Citronen Fjord is a relatively small fjord that extends about four kilometres southwards from the FEHF. Concentrations of zinc, copper, and lead in the water column of Citronen Fjord vary considerably over depth, with other metals showing similar trends in concentration.

Measurements in August 2010 found the highest concentrations of zinc, copper, and lead in the lower part of the fjord, in proximity to the mouth of Eastern and Esrum Rivers. These high metal concentrations were recorded several weeks after the peak concentrations of zinc were recorded in Eastern River.

There is thermal stratification evident in the water column of Citronen Fjord, with the fresher surface waters showing higher temperatures than the lower denser waters which appear to correlate with the fluctuations in metal concentrations over depth.

Concentrations of zinc, copper and lead in Citronen Fjord were found to exceed the proposed DCE guidelines at some depths. Metal concentrations above BMP guideline (2011) levels were recorded in a few cases in FEHF.

9.2.8 Sea Ice

Fast ice is a form of sea ice which is fastened to a shore. Fast ice covers all the fjords and a shelf along the outer coast of north Greenland most of the year. This includes Citronen Fjord and FEHF. In recent years, the sea ice in Citronen Fjord has thawed during late July and the fjord has been free of fast ice during much of August. Occasionally FEHF becomes more or less ice free, as was observed in 2010.

Drift ice is unattached sea ice that floats on the surface of the water. When the drift ice is driven together into a large single mass, it is called pack ice. Off the east coast of Peary Land, a long wide stretch of open water (a lead) usually develops during summer in the shear zone between the shore fast ice and the drift ice. To the northeast of this lead, multi-year polar drift ice covers the ocean. The drift ice consists of a mixture of multi-year and first-year ice with scattered icebergs from the glaciers on the coast. The drift ice is transported south along the coast by the East Greenland Current.

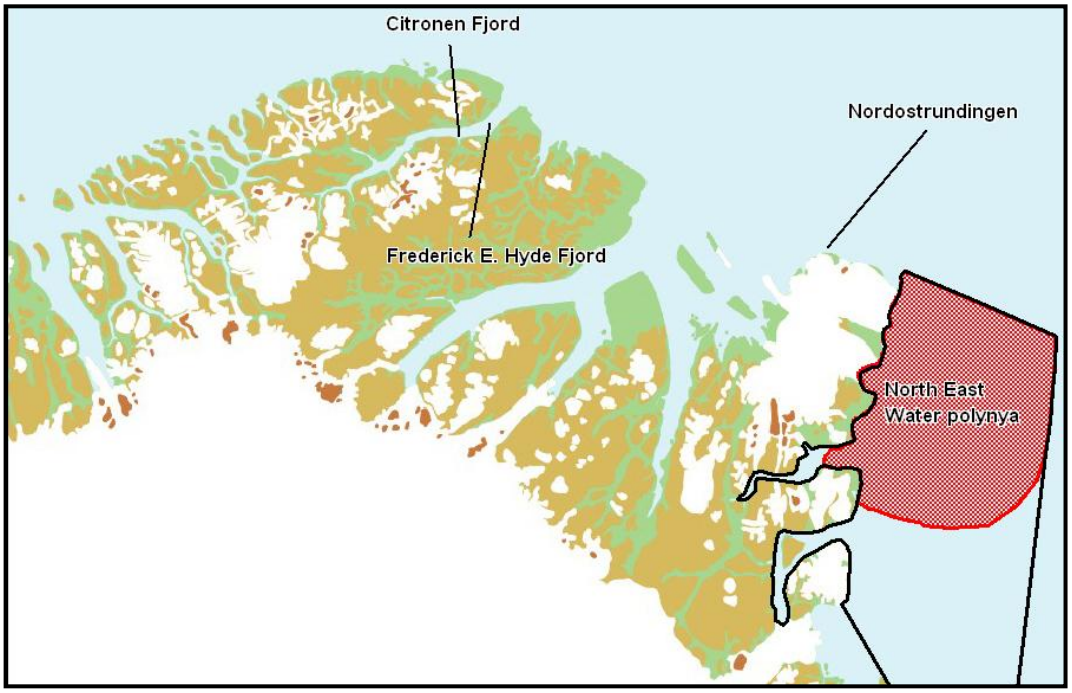
Polynyas are open waters in otherwise ice-covered waters which occur seasonally at the same time and place each year. The most significant polynya off northeast Greenland is the North East Water (NEW) off Kronprins Christian Land (Figure 9.1). The NEW typically begins to open in April and closes in September, however, fractures and leads of open water are present during winter months. The predictability of the NEW makes it an important habitat for birds and mammals.

There are several breeding and non-breeding seabird colonies that occur throughout the open water parts of the NEW and on the cliffs along the shore close to the NEW. During the shipping period in summer (July-August), breeding and non-breeding fulmars are the seabirds most susceptible to disturbance, as they have been recorded in low densities throughout the NEW in summer and leave the NEW shortly before it freezes over again in September. The fulmar is not listed on the Greenland Red List of threatened species.

Walruses, ringed seals, and small numbers of polar bear are present in the NEW throughout the year. From May to June, when larger areas of open water appear, other marine mammals migrate into the NEW. Bearded seals and narwhals are common and widespread throughout the NEW in August and large numbers of bowhead whales have been recorded from the NEW and the sea just off the NEW in recent years. There are a number of marine mammals that are listed on the

Greenland Red List of threatened species that occur in the NEW. The bowhead whale is listed as Critically Threatened, the polar bear as Vulnerable and the walrus as Near Threatened. The narwhal and bearded seal are both listed as Data Deficient.

Figure 9.1 - Location of the NEW off the East Coast of Greenland



Note: The area of NEW open water varies considerably during the year but also between years. The black line marks the protection zone for marine mammals (narwhals, bowhead whales, and walruses) in the northern part of East Greenland.

9.2.9 Flora and Fauna

Citronen Fjord is situated in the High Arctic Region, defined as an area with very low precipitation, four months of semi-darkness during winter and a very short and cold growing season. As such, the Citronen Fjord region is an extremely harsh environment supporting only a small number of plant and animal species which have adapted to these extreme conditions.

For the purpose of the EIA, higher plants, seaweed, and vertebrates have been used as a guide to the overall biodiversity of the area. Within Greenland, these flora and fauna elements are best known in terms of habitat requirements, diet and sensitivity to disturbance and pollution. An annotated list of all species of higher plants, birds, mammals and fish recorded from the area is included in the 2010 baseline survey.

Flora

The vegetative cover in Peary Land, including the Citronen Fjord region, is sparse and discontinuous. A study in 1988 of the vegetation cover in North Greenland using satellite images showed the vegetation cover exceed 8% in only a few areas. The amount of vegetation cover in Peary Land in August 2004 monitored from multispectral satellite data show that the Citronen Fjord region has particularly sporadic plant cover, indicating low amounts of green vegetation.

Field observations in the Citronen Fjord area in August 2010 confirmed the overall vegetation cover is very low and that large expanses have virtually no vegetation at all. With less than two months of summer-vegetative growth and very low precipitation, only the most cold-hardy plant species grow in the Citronen Fjord area. This is most likely why only approximately 50 species of higher plant species have so far been recorded in this area.

The higher plant species known from the Citronen Fjord area consist of widespread and common species in Greenland that reach their most northern distribution at Citronen, as well as specific high-arctic plants with their distribution limited to North Greenland.

Fauna

Sixteen species of birds have been recorded in the Citronen Fjord area. Of these, eight species are believed to breed occasionally in the area. Most notably among the non-breeding bird species are large numbers of geese that spend the summer in Peary Land. In winter (October to February), no birds occur at Citronen Fjord. All birds that occur regularly in the area during summer occur throughout large parts of the National Park.

Six terrestrial and one marine mammal occur throughout the year in the Citronen Fjord region. The polar bear is an uncommon visitor to the FEHF, but has so far never been officially recorded from Citronen Fjord.

Only two fish species are known with certainty to occur in Citronen Fjord area: arctic char and four-horned sculpins. It must be assumed that at least some of the additional nine species of fish recorded in Jørgen Brønlund Fjord in South Peary Land also occur in Citronen Fjord.

Four animal species occurring in the Citronen Fjord area are listed on the regional Greenland Red List of threatened species:

1. Wolf: listed as *Vulnerable* because of its small (<1,000 animals) population in Greenland
2. Polar bear: listed as *Vulnerable* because its small population is declining
3. Ivory gull: listed as *Vulnerable* because of its very small and declining population (approximately 2,000 adults) in Greenland
4. Arctic tern: listed as *Near Threatened* because of its large decline in Greenland

The polar bear and ivory gull are also on the International Union for Conservation of Nature Red List of threatened species.

Except for the wolf, the red-listed species recorded from the Citronen Fjord area are uncommon or rare visitors with no known breeding grounds in or near the fjord. Small numbers of wolves have been observed in the Citronen area, however, the Citronen area is not known to be of particular importance for wolves or any of the other red-listed species.

The Greenland Red List also recognises a number of national responsibility species. These are species where more than 20% of the global population occurs in Greenland and for which Greenland therefore has a special responsibility to protect. Four national responsibility species have been recorded from the Citronen Fjord area (Table 9.2).

Table 9.2 - National responsibility species occuring in the Citronen Fjord Region

Species	Percentage of Total World Population in Greenland	Status in Citronen Fjord Area
Polar Bear (*Ursus maritimus*)	>20%	Uncommon visitor to FEHF
Pink-footed Goose (*Anser brachyrhynchus*)	>30%	Common summer visitor
Knot (*Calidriscanutus*)	>50%	Uncommon breeding bird
Arctic Redpoll (*Cardueli shornemannii*)	>50%	Occasional visitor

9.2.10 Archaeology and Cultural Heritage

In July of 1994, the Greenland National Museum and Archives conducted an archaeological survey of the Citronen Fjord area to ensure no protected sites or other archaeological interests would be affected by exploration activities undertaken by Platinova A/S at the time.

The archaeological survey covered an area of 6.5 km², including the river delta, investigating the eastern side of Citronen Fjord to FEHF and the Eastern and Esrum River valleys to a distance of four to five kilometres from Citronen Fjord.

No evidence of former Eskimo settlements were found within the area, with the only sign of potential pre-historical activities being a site on the eastern shore of Citronen Fjord, marked as "A2". This site comprises of three stones arranged in a row, and may have been placed by members of the Thule culture to support an "umiak" – an eight to ten metre-long open boat used in summer to move people and possessions to seasonal hunting grounds.

Subsequent discussions with the Greenland National Museum and Archives expressed the report sufficiently characterises the archaeology of the Citronen Fjord area. However, prior to works, there is a need for an archaeological registration and documentation of the probable anthropology structure (A2) and near surroundings.

In the 2010 field season, the A2 site was located during the environmental baseline studies. The structures were photographed, measured and a GPS location of the site was recorded. Prior to any disturbance of the area, a staff member of the Greenland National Museum and Archives will further photograph and measure the A2 structure and 10 m to 15 m around the site as part of the archaeological registration and documentation of the site.

The site will be appropriately marked and all Ironbark staff and contractors will be made aware of the site. No disturbance of the site will take place prior to archaeological registration and documentation, and approval to disturb the site is granted.

9.2.11 Key Environmental Issues

The EIA has identified the following environmental issues as being the key areas requiring detailed assessment and management for the Citronen Project.

Contamination of Fresh Water or Marine Water Resources

To assess and describe potential transport and exposure pathways from contaminant sources (i.e. waste rock dumps and tailings storage facility) to potential ecological receptors, a Screening-Level Ecological Risk Assessment (SLERA) including toxicity testing was conducted. The SLERA identified parameters within surface water, sediment and surface soils as potentially affecting receptors at the site. Fish, aquatic invertebrates and aquatic plants in the Citronen Fjord at the mouth of the Eastern

River were identified as the main community receptors. Toxicity testing indicated there is no toxicity associated with the tailings supernatant to either marine invertebrates or fish.

The SLERA study concluded that mine wastes will not significantly increase the levels of metals in the aquatic or terrestrial environment of the Citronen Fjord area. There is no anticipated impact to the upper trophic aquatic life (including birds, fish and mammals) or lower trophic level communities (including benthic macro-invertebrates and aquatic communities).

Seepage and Release of Leachates from Mine Waste Facilities

Geochemical characterisation was conducted on various mine wastes (waste rock, tailings and DMS rejects) to assess the potential for release of contaminants to the environment. The main focus was on the potential leaching of metals and the generation of acid which could release metals from the surroundings.

The geochemical testing studies indicate the potential for acid rock drainage and metal leaching from waste rock is low and will lead to no or very limited contamination of the localised terrestrial ecosystem at the dump. The acid-based-accounting shows waste rock samples with low total sulphur are likely to be classified as non-acid-generating due to the presence of excess neutralisation potential in the form of calcite and/or dolomite. The total sulphur content of the waste rock can assist with waste rock management during operations.

The testing indicated tailings will most likely generate acid after long-term exposure to oxygen and water and as such will require an additional level of containment normally accepted in conventional tailings facilities. Accordingly, the dam area will be lined with a geomembrane to contain seepage.

Dust Emissions

Air dispersion modelling was conducted to assess the potential dispersal of dust at the proposed Project site. Dust emissions were developed and ground level particulate matter concentrations and deposition estimates were predicted for the mining operations based upon meteorological data and air emission sources.

The dust modelling showed the highest dust concentrations will occur along the haul roads; however, this is mainly caused by vehicle turbulent wake and contains little dust from the loads containing metals such as zinc and lead. Contamination with dust containing zinc and lead mainly occurs at the pit and the crusher with local dust dispersal from the underground vent raises. Except for small areas close to the pit, crusher and underground vent raises, the maximum annual zinc and lead dust deposition in and outside the mine area is predicted to be less than 0.5 g/m^3 and 0.016 g/m^3, respectively.

Disturbance to Fauna

The construction and operation of a mine at Citronen has the potential to impact local fauna of the region. It is considered the fauna in the region will not be significantly impacted by the Project for the following reasons:

- No fish occur in Eastern River; therefore, it is anticipated that the Project will not impact on the fauna of the river.
- The construction of the port facility only relates to a minor loss in habitat for marine fauna. Any change in water quality from suspended material during construction will be temporary.
- Shipping will be limited to 10 return trips in the summer in the fjords and open water.
- Fauna that normally inhabit areas at the Project are likely to move to areas outside the mine once disturbance and construction begin.

- Limited vegetation within the Project area will not attract fauna for feeding purposes.
- Hunting is forbidden on the mine site, as is regulation in National Parks.

There is potential for some adverse impacts to the Lake Platinova arctic char population due to the fluctuations in water quantity and quality within the lake as a result of the pumping of water from Eastern River.

Loss of Vegetation and Terrestrial Habitat

On average, the vegetation cover in the Citronen area is about 5% including some areas characterised by almost bare ground with loose rubble and broken slopes with very little or no vegetation cover. Continuous vegetation is mostly found in depressions and along streams. This vegetation is dominated by a few plant species that are common and widespread in North Greenland; therefore, clearing within the Project will not impact representative flora of the area. Among the flora species known to occur in the Citronen area, none are rare or endangered.

The vegetation in the Citronen area provides food for a number of mammals and birds (and invertebrates), in particular muskoxen, arctic hare and collared lemming as well as ptarmigan and staging geese. The loss of fauna habitat is considered very small in relation to the surrounding available vegetation given that:

- plants cover only a small percentage of the ground in the Citronen area
- the overall footprint of the Project is relatively small
- some of the major facilities are proposed in areas with almost no vegetation (e.g. pit and airstrip)

Alteration to Surface Water Regimes

The Eastern River flows during the summer and, as required by the Project, it is planned to pump 1.3 million m^3 of water from the river into Lake Platinova for use on-site (corresponding to 1,000 m^3/h of water). Removal of this volume of water has the potential to alter the flow dynamics of the Eastern River. Pumping the required volume of water to Lake Platinova from Eastern River equates to 8.8% of the total runoff.

In order to contain this increase in volume as required by the Project, an embankment will be constructed along the northeast shore of the lake. The use of lake water for production will cause the water level to vary between a low level in spring (May) and a high level in July/August after water has been pumped into the lake from Eastern River.

The change in water volume of Lake Platinova will have little impact on the overall surface water regime in the Project area. Some negative impacts are anticipated for the lake ecosystem, including the arctic char population, due to fluctuations in water quantity and quality within the lake due to pumping. No impact to the Eastern River is anticipated because the river is already experiencing varied water levels from melting snow and ice.

Diversion drains will be constructed around the underground decline, tailings storage facility, pit crest and waste rock dumps to prevent water from entering these facilities, particularly melting water in spring and summer. The water will be diverted to Eastern River and/or Citronen Fjord. A few small temporary streams may also be diverted around the mine facilities at the shore of the fjord. The diversion drains at the pit, decline, tailings storage facility and waste rock dumps will remain on closure while the other diversions (not required for long term stability) will be removed during the rehabilitation of the mine.

Precipitation in the Project area is very limited and the annual runoff of the local catchment area is small and limited to June to September. The diversions around the mine facilities will therefore only be diverting small amounts of water during a short time of the year. The diverted water will be directed to its original outflow destination.

Unplanned Release of Hazardous Materials to Land or Water

Unplanned releases in connection with transport, storage and handling of hazardous materials such as fuel, grease, paint and chemicals could potentially cause contamination of soil or water resources at the Project.

Fuel, cargo and concentrate will be shipped to and from the Project each summer. An icebreaker tug towing a barge will enter the port at Citronen Fjord approximately 10 times each year between July and early September. Sailing in more or less ice-covered waters poses an increased risk of shipping accidents. The icebreaker tugs that will be used will be of the highest "ice class" suitable for conditions off the coast of Greenland. The barges will be purpose-built for the Project and reinforced to sustain ice conditions. The barges will be twin-hulled to reduce the risk of sinking. Diesel (for use on-site) will be pumped into purpose-built sealed tanks within the barges and scantling is increased where the fuel tanks sit. Dangerous goods (explosives) and controlled substance will be shipped in suitable, approved containers (as per established shipping arrangements).

The risk of potential contamination of the marine environment due to accidental release of concentrate or fuel during shipping is considered moderate. This is due to the potential severity of this event if it occurs, even though the probability is very low.

Hydrocarbons (such as oil, petrol and diesel) can also cause localised contamination on-site. Appropriate storage (consistent with Greenland government regulations and guidelines) and handling of hazardous materials will reduce the risk of contamination from these materials. Bulk hydrocarbons will be stored within bunded tanks and pipelines carrying such materials will also be bunded to capture leaks or spills.

It is considered the risk of contamination from hazardous surface soil or water resources in and around the mine area is low. None of the planned mine activities would lead to more than very limited and localised contamination.

Greenhouse Gas Emissions

Carbon dioxide and other greenhouse gases will be generated by the diesel power plant and vehicles. Visiting aircraft and ships will also generate greenhouse gases. Approximately 50 million litres of diesel will be consumed annually by the Project (80% power generation and 20% mobile equipment). Emissions have been calculated as approximately 132,700 t of carbon dioxide (assuming one litre of diesel generates 2,654 g of carbon dioxide).

By adopting the Best Available Technique (BAT) principle, Ironbark will ensure emissions from the power plant, trucks and other sources are kept at a minimum and these emissions are not considered to have a significant impact on the air quality in the area.

Rehabilitation and Closure

Once the end of mine life has been reached, it is Ironbark's goal to restore the land to an environmentally acceptable state, managing the environment through a program of post-closure care and maintenance. Ironbark plans to develop a rehabilitation and closure strategy that allows life-of-mine closure planning that is responsive to Project planning decisions and changing regulatory framework.

The closure planning process Ironbark proposes to adopt for Citronen is a phased approach permitting the development of a Conceptual Closure Plan which will be updated and refined throughout the life of the mine. A Final Closure Plan will be developed near the end of the mine life that takes into consideration the results of the testing and monitoring as well as any changes to the environmental, regulatory and social environment that may have occurred over the life of the mine.

9.2.12 Conclusions

Overall, the risk analyses conclude that most mine activities have a low risk level of disturbing or contaminating the environment at Citronen Fjord. This generally low level of risk is consistent with the nature and scale of the Project, which includes the below factors:

- The Project is located in a remote area of Greenland with the nearest permanent habitation being the Danish army base at Station Nord, 240 km southwest of the Project.
- The Project is located in an arctic environment with limited rainfall, as well as permafrost, and sub-zero temperatures most of the year resulting in reduced weathering/oxidisation of materials, freezing of mine wastes, limited runoff during a short period of the year, and small numbers of plant and animal species that are able to adapt to these extreme conditions.
- Tailings waste will be contained within a fully-lined facility or underground.
- Waste rock is characterised as being non-acid generating.
- There is a relatively small scale of disturbance, with only limited clearing of vegetation in a sparsely vegetated region.
- No populations of flora or fauna are unique to the Project area.
- Most potential impacts only have a localised affect, which can be readily managed or remediated.

9.3 Social Impact Assessment

During the exploration and planning phases, Ironbark has used MT Højgaard, a Danish company with a Greenland office, as a consultant on substantial aspects of the planning related to establishing the mine. The draft Social Impact Assessment (SIA) report has also been prepared by a Greenland company on behalf of Ironbark.

The following areas have been the primary focus of the social impact assessment:

- recruitment of Greenland labour
- engaging Greenland enterprises
- transfer of knowledge (e.g. education programmes) to ensure long-term capacity-building of local competence within the mining industry and mining support industries
- preservation of socio-cultural values and traditions

The guidelines issued by the Bureau of Minerals and Petroleum outline five major goals of conducting the SIA process:

1. To engage all relevant stakeholders in consultations and public hearings.
2. To provide a detailed description and analysis of the social pre-project baseline situation as a basis for development planning, sustainability initiatives and future monitoring.
3. To provide an assessment based on collected baseline data to identify both positive and negative social impacts at both the local and national level.
4. To optimise positive impacts and minimise negative impacts from the mining activities

throughout the project lifetime.

5. To develop a Benefit and Impact Plan for implementation of the Impact Benefit Agreement.

The SIA report meets the above criteria.

9.3.1 Social Impacts Summary

The following overall impact areas were selected for analysis in the SIA process:

- impact on population trends
- impact on financial factors
- impact on the development of the workforce and employment
- impact on business development
- impact on land
- other factors

9.3.2 Impact on Population Trends

As a new industrial activity, the scope and content of the Citronen Zinc Project could result in a very small increase in the size of the population. This is because due to the Project's remote location and the projected use of any foreign labour not being permanent residents of Greenland.

Foreign workers, if used, pay income tax to Greenland, but are not otherwise part of the society. They are unlikely to use public services in the healthcare, social or educational sectors, due to the distance of the mine from public services and because Ironbark will provide emergency health services on-site. Foreign workers at the mine would not have the right to vote in parliamentary or municipal elections because they would not be registered as Greenland citizens.

In regards to the Greenland workforce, if the jobs at Citronen are filled by unemployed Greenlandic people, the population will remain the same. However, if currently employed individuals were hired, their previous roles might be filled by foreign workers who may settle in Greenland for a short or long period of time.

Workers brought to Greenland would not necessarily be Danish or of another nationality. They could potentially be Greenlanders currently residing in Denmark. Today, some 18,000 Greenlanders or descendants of Greenlanders reside in Denmark.

Increasing economic activity tends to increase population (often by reducing population loss through people seeking employment opportunities overseas) and mining companies operating in Greenland are expected to purchase a portion of their products and services in Greenland, thus increasing economic activity.

9.3.3 Impact on Financial Factors

New mine development will have the following effects for the Greenland economy:

- increased tax revenues
- increased revenues and increased consumer spending
- increased expenditure for public services
- increased public expenditure for housing and infrastructure

A new mine would increase Greenland's income (both Homerule and private). This income growth is classified in terms of direct and indirect income. Direct income would be through company tax and

income tax. Indirect income would be through increased consumption and government revenues through the multiplier effect.

Direct

Ironbark has calculated the total annual wage costs for the mine to be approximately DKK 280 million. Of this, about 35% of these wages will be paid to the Greenland Self Rule as tax each year. This equates to income taxes of approximately DKK 100 million a year.

Foreign investors building a mining project in Greenland would potentially offer a very large input into the economic cycle in Greenland. A substantial portion of the capital expenditure and special equipment obtained for the mine will be imported directly, because there are no suppliers of these items in Greenland. However, there will be flow-on effects to Greenlandic companies which increase the economic activity of Greenland.

It should be recognised there is a limited experienced mining base of this scale in Greenland. Best endeavours have been made to utilise as much Greenlandic labour during the feasibility stage as possible and foreign companies with local Greenlandic offices have been engaged wherever possible.

The purchasing pattern will differ depending on the phase of the mining project. During the construction phase, purchasing will differ from the operating phase in the long term. At present, detailed information is unavailable as regards which suppliers would be selected in both the construction and operating phases.

Ironbark is familiar with and wishes to fully meet the requirements of the Mineral Resources Act's provisions concerning the preferential selection of Greenland companies. It is important to note these requirements will also apply to companies to which Ironbark outsources tasks.

The direct income from the Citronen Zinc Project would have an overall major positive impact on Greenland's economy. The predominant impact on financial factors will be tax revenues and personal income resulting from direct employment at the mine, which the Citronen Zinc Project is expected to bring in. The tax revenues include corporate taxes and income taxes from employees.

Corporate tax includes corporate and dividends tax. The corporate tax is currently 30% for companies with a licence under the Mineral Resources Act. Any dividends paid by Ironbark will be subject to a 37% withholding tax.

Greenland society will, from the outset, receive appreciable tax revenues from the direct, indirect and induced income from mine employees.

In addition to taxes generated by these direct incomes, the mining activities are expected to result in relatively large indirect and induced incomes and thus in the tax revenues associated with them. Currently it is not possible to assess the dimensions of this portion of the tax revenues.

Indirect

The induced income impact includes wage increases and increases in other revenues for businesses whose sale of goods and services would increase as a result of increases in direct and indirect income. The induced income from the Project is not expected to have a major impact on the Greenland economy.

9.3.4 Impact on the Development of the Workforce and Employment

Ironbark's initial calculation of the size of the workforce required to operate the mine at Citronen Fjord indicates the total employment in the mining project to be approximately 300 full-time

employees. In the long term, the entire Greenland workforce is expected to increase in connection with the establishment of this mine and other jobs in the mineral resource sector.

During construction it is expected that up to approximately 930,000 man-hours will be required on-site for the construction of the Project, at a total cost of approximately USD 43.5 million dollars. Due to the remote location of the Project, considerable fabrication and construction will be conducted off-site.

A potential impact may be increased competition among companies and sectors to recruit labour in Greenland. This may lead to increased living standards through increased wages and demand for skills and labour. Improvement of skills for Greenlandic people as a result of exposure to training and employment opportunities will improve productivity in Greenland and the attractiveness of foreign capital for investment.

Greenlandic workers for the Citronen Zinc Project could be recruited from every region of Greenland. The normal practice is for a mining company in Greenland to pay the employee's costs relating to travelling to and from the mine from designated central points or 'hubs' such as major towns.

9.3.5 Impact on Business Development

There will be a positive impact on business development in Greenland through the successful construction and operation of the Citronen project. Greenland will be viewed as a more favourable country as a destination for international capital.

9.3.6 Impact on Land

The exploration area is located within a National Park in the most remote part of Greenland. The only human activity within a radius of hundreds of kilometres is at Station Nord, a military outpost. Hunters and fishermen from Illoqqortoormiut do not travel as far as Peary Land. Hunters from Qaanaaq and neighbouring settlements do not travel further than Inglefield Land to the east.

Ironbark is acutely aware the proposed mining activities are located in a very important area in terms of its natural value. Additionally, Ironbark is aware of zinc and lead mines which have previously operated in Greenland resulting in contamination of the environment. Lead contamination continues to be an ongoing consequence of previous mining in Marmorilik and Mestersvig. Ironbark is committed to ensuring all reasonable measures are taken to protect these assets for future generations. Significant environmental aspects relating to the National Park and land use for mineral extraction are discussed in the Environmental Impact Assessment.

9.3.7 Other factors

The mine will be a characteristic enclave mine. As all infrastructure and supporting services will have to be established by Ironbark, the direct impact on existing planning in Greenland is limited.

It is noted that due to the remote location, employees are away from their families for up to six weeks at a time and it is important for each employee to have access to telecommunications via a telephone or the Internet. This is a common situation for many mining operations in remote locations.

Effective verbal and written communication is essential for the operation of a productive and safe mine. As previously described, initially, a significant portion of labour will be sourced internationally and with this several different languages may be spoken. There is considerable focus on promoting the Greenlandic language in every respect, however, a uniform language is essential for conveying

important information. Therefore, it is proposed that the main language spoken at large new workplaces will be English. Greenlandic workers will have the added benefit of improving and learning the English language which will provide greater employment opportunities globally.

SECTION 10 - CAPITAL COST ESTIMATE

10. CAPITAL COST ESTIMATE

10.1 Introduction

In February 2011, Wardrop completed a feasibility study report that included a Capital Cost Estimate. The Wardrop estimate is a Class 3 estimate with an accuracy range of ±15% prepared in accordance with the AACE International estimate classification system. It was prepared with a base date of Q4-2010 and did not include any escalation beyond that date. The various quotations on which the estimate was based were obtained in Q4-2010 and had a validity period of 90 days.

The Wardrop cost estimate responsibility matrix was as follows:

- Wardrop Engineering Inc.: mining, layout and general arrangements, plant infrastructure, dust control, building services such as heating, ventilation, air conditioning (HVAC) (heat recovery) and fire protection, instrumentation and controls, piping, process plant electrical distribution, mechanical equipment (excluding Metso supplied equipment).
- Wardrop/Tetra Tech: tailings and water management.
- Metso: process mechanical equipment (Metso supplied)
- MT Højgaard: site layout, site civil works, site infrastructure and services, construction costs
- Ironbark Zinc Limited: Owner's costs

Wardrop was responsible for the development of the overall capital cost estimate with inputs from the aforementioned companies.

The estimate has been reviewed at a high level and modified to encompass the following changes to align with the current project execution strategy:

- supply of mechanical equipment from China
- supply of electrical equipment from China
- supply of electrical materials and piping materials from China
- supply of steelwork and platework from China
- building the process plant on-site rather than on barges at Akureyri
- renting process barges for concentrate haulage in lieu of fabricating them
- allowance for increased plant throughput to 3.3 Mtpa (excluding minor items)
- commencing the project with full capacity from the underground mine and deferring commencement of the open pit mine until the underground resources are depleted
- utilising Chinese installation contractors

The cost changes within this section are based on the Q4 2010 estimate presented by Wardrop and do not attempt to update the information upon which the Wardrop estimate is based or to verify the costs used in the estimate. There is no provision for escalation, changes to currency exchange rates or other variable factors that might apply in the intervening period to date (Q1 2013). The financial model however escalates these costs at 2.5% per annum and modified elements have been factored accordingly.

The overall capital cost estimate, based on the project execution strategy listed above, is presented in Table 10.1.

Table 10.1 - Capital cost estimate: overall summary

Area/Description	Cost (US$)
Direct Works Total	274,418,410
Indirect Works Total	124,561,247
First Fills	55,562,866
Contingency	30,306,396
Total Project Capital Costs	**484,848,919**

A summary for the major areas for the cost estimate can be found in Table 10.2.

Table 10.2 - Summary of Akureyri cost estimate by major area

Area	Description	Cost (US$)
	Direct Works	
1000	Mining - Surface Infrastructure	481,285
1100	Mining - Open Pit Pre-production	-
1500	Mining - Underground Pre-production	53,157,206
2000	Crushing Plant & Fine Ore Feed	11,382,242
2400	Process Plant	98,272,656
2800	Concentrate Storage/Reclaim	8,338,780
3000	Tailings and Water Management	11,642,480
4000	Plant Site	19,422,439
4500	Site Power and Heating	32,136,513
5000	Port Facilities & Storage	15,818,228
6000	Infrastructure	9,165,922
6500	Site Services & Utilities	4,399,419
8500	Temporary Services	10,201,241
	Direct Works Total	**274,418,410**
	Indirect Works	
9000	Construction Indirects	22,068,569
9100	Project Indirects	87,711,178
9200	Owners Costs	14,781,500
9900	Contingencies	30,306,396
	First Fills	55,562,866
	Indirect Works Total	**210,430,509**
	Total	**484,848,866**

10.2 Project Currency and Foreign Exchange

All project capital costs in the Wardrop estimate were expressed in United States dollars (US$) with the following provisions:

- The capital cost estimate was prepared in US dollars based on the exchange rates shown below.

- For the purposes of developing the capital cost estimate, any costs submitted in other currencies were converted to US dollars.
- No provision was made for fluctuations in the currency exchange rates.

The currency exchange rates used in the Wardrop estimate to convert all costs to US dollars are shown in Table 10.3.

Table 10.3 - Exchange rates

Currency/Country	Exchange Rate (Note 1)
Denmark Kroner	DKK 5.43
Euro	EUR 1.37
Canada Dollar	CAD 0.9921
United Kingdom Pounds	GBP 1.591
Sweden Kronor	SEK 0.1492
South Africa Rand	ZAR 0.1459
Australia Dollar	AUD 0.9781

Note 1: Exchange rate as of 1st October 2010.

10.3 Quantities

Quantities used in the Wardrop estimate were based on the following:

- Bulk earthworks quantities were based on rough grading designs completed using Autodesk Land Development Desktop and Civil Design.
  - Excavation of overburdens and allowance for rock excavation were based on any geotechnical information available at the time of the study.
  - In general, the cost of structural fill was based on material used directly from borrow pits without crushing and screening.
  - Earthwork quantities did not include an allowance for bulking or compaction of materials, these allowances are included in the unit prices
- Underground services (firewater and sewage) quantities were based on engineering designs, sketches and the piping diagrams, which identify pipe sizes and routing
- Concrete quantity material take-offs (MTOs) were based on "neat" line quantities from engineering designs and sketches with any appropriate allowances by the Estimator.

The current execution plan is to erect the process plant on-site within an enclosed building rather than as per the Wardrop plan of erection on barges which would subsequently be towed to site and secured in-situ. Consequently, additional foundation concrete is included in this estimate and has been factored as 25% of the mechanical equipment costs for the purposes of the update.

Similarly, the overall plant buildings will require additional space to be available around the process equipment to allow the use of cranes, etc. during construction and erection within the buildings. The cost of the buildings which were to be erected on the barges in the Wardrop plan has been increased by 20%. The same appropriate allowances have been made for the insulated roof and wall sheeting due to the increased building size.

The Wardrop steel quantity material take-offs (MTOs) were based on quantities developed from engineering design and sketches and allowances were included for cut-offs, bolts and connections.

In the Wardrop estimate, quantities for all platework and metal liners for tanks and chutes were calculated on detailed quantity take-offs developed from design drawings and sketches and provided in kilograms of steel. Wear plate liners (abrasion resistant plates) for the chutes are calculated from the design sketches based on layout and included as appropriate.

As part of this Report, fuel tank storage facilities were factored to take into account the increased plant throughput from 3.0 Mtpa to 3.3 Mtpa.

Mechanical equipment requirements were based on process flow diagrams and equipment lists developed during the study.

Piping and valve allowances were based on drawings supplied by Metso. Fittings quantities were based on detailed quantity take-offs for pipe three inches (75 mm) and above in diameter and small bore components, with the exception of valves, were calculated on a percentage basis, based on Wardrop's in-house experience.

Quantities for electrical and instrumentation major cable runs for motor and power distribution were estimated based on cable lists provided by Metso. Instrumentation quantities were as specified by Metso and based on the Piping and Instrumentation Diagrams (P&ID) developed during the study. Other materials and allowances included are based on Wardrop's experience with items such as electrical room cable tray systems, indoor lighting, etc.

10.4 Direct Costs

10.4.1 Quantities

Quantities used in the Wardrop estimate were based on the following:

- Earthworks for the access dike and pier were based on quantity take off; quantities for civil works, concrete and sheet piling were included in the estimate based on MTH quantity take offs.
- Container storage earthworks were estimated for costing purposes.
- Tailings facility quantities were generated from Civil3D AutoCAD for embankments, spillway and access roads; pipeline lengths were estimated measuring the length of the different pipelines.
- Underground services (firewater and sewage) quantities were based on engineering designs, sketches and the piping diagrams, which identify pipe sizes and routing.
- Concrete quantity material take-offs (MTO's) were based on "neat" line quantities from engineering designs and sketches with any appropriate allowances by the estimator.

Steel quantity MTO's were based on quantities developed from engineering design and sketches and allowances were included for cut-offs, bolts and connections.

Quantities for all platework and metal liners for tanks and chutes were calculated on detailed quantity take-offs developed from design drawings and sketches and provided in kilograms of steel. Wear plate liners (abrasion resistant plates) for the chutes are calculated from the design sketches based on layout and included as appropriate.

Piping and valve allowances were based on drawings supplied by Metso. Fittings quantities were based on detailed quantity take-offs for pipe three inches (75 mm) and above in diameter and small bore components, with the exception of valves, were calculated on a percentage basis, based on Wardrop's in-house experience.

Quantities for electrical and instrumentation major cable runs for motor and power distribution were estimated based on cable lists provided by Metso. Instrumentation quantities were as specified by Metso and were based on the P&IDs developed during the study. Other materials and allowances based on Wardrop experience for items such as electrical room cable tray systems, indoor lighting, etc. were included.

10.4.2 Labour Rate and Productivity Factor

The current project execution plan is based on utilising Chinese construction contractors. Consequently, the estimate has been revised to utilise Chinese labour rates, rather than the blended labour rate used by Wardrop. The productivity factor on labour hours for the capital cost by Wardrop was 1.0 for direct costs. The estimate has been amended to reflect a productivity factor of 2.0 using Chinese contractors for installation man-hours.

10.4.3 Pricing and Labour

The below has been incorporated with regards to pricing and labour within the current project execution plan:

- Based on advice from NFC, all equipment and materials pricing has been reduced by 15% for Chinese supplied materials.
- Wardrop obtained budget quotations for modular buildings including administration facilities and the accomodation camp.
- Pre-engineered buildings (the mill building, main warehouse, truck shop and power plant) were estimated using a combination of material takes offs and supplier quotations.
- Wardrop estimated arctic corridor costs based on the overall layout of the plant site and supplier quotations.
- The potable water treatment plant was quoted by supplier and included in the Wardrop estimate. Civil works, piping, electrical, pumps and tanks were estimated by Wardrop based on MTH estimated quantities.
- The sewage treatment plant was quoted by a supplier and included civil works, piping and heat tracing; pumps and associated electrical were estimated by Wardrop based on MTH quantities.
- The waste incinerator including commissioning was quoted by a supplier and included in the Wardrop estimate.
- Generating sets, instrumentation, piping, HVAC, waste oil system, exhaust system, lube oil system, water systems, coolant system, pumps, hoists and lube oil storage were included in the estimate by Wardrop based on supplier quotes.
- Wardrop included costs for external site communications using the Iridium OpenPort system based on quotation by a supplier and additional equipment including applications, instrumentation and electrical were also included based on a quotation by a supplier.
- For the airstrip, Wardrop included the de-icer, jet fuel trailer, surface friction trailer, trolley trailer and meteorological equipment based on supplier quotes.
- Port equipment was estimated by Wardrop based on a crawler crane and container handlers which were quoted by a supplier; shiploader and link conveyors were also quoted by a supplier.

- Offshore mooring buoys, anchor chain and sea bed anchors were quoted by a supplier.
- Wardrop included the port area fuel storage including fuel oil and jet fuel together with distribution systems, two 25,000m^3 non-insulated steel tanks, two jet fuel non-insulated steel tanks together with all required pumps, motors, associated electrical, hose station, pipelines and hoses and containerised fuel station complete with pumps based on supplier quotations.
- Wardrop included the fresh water supply system based on two submersible pumps, HDPE transfer pipeline inclusive of heat tracing, two sets of diesel driven pumps and a fresh water tank.
- Process water costs were included in the estimate by Wardrop based on quoted costs and installation hours from Metso for all mechanical equipment.
- Mining surface infrastructure including ANFO mobile mixing unit and explosive magazines were included in the estimate based on supplier quotations.
- Labour and haulage for the pre-stripping of the open pit were capitalised in the Wardrop estimate based on the unit costs developed for operations. However all open pit mining costs have been deleted from the capital cost estimate as part of this update as the open pit development will now take place towards the end of the life of the underground mine and consequently will be considered as either a separate project or as deferred capital in financial modelling.
- Wardrop utilised quotations for costing all mobile equipment required at site including the equipment required for the underground mine. The current execution strategy is to develop the underground mine to enable full 3.3 Mtpa feed to the process facilities without development of the open pit mine until a later stage of the project. As part of the estimate review, the cost of additional equipment which was in the deferred category for the underground mine has now been included to enable the 3.3 Mtpa plant feed to be produced from the underground development.
- Dewatering infrastructure was estimated based on prior project experience and was included in the estimate by Wardrop.
- Equipment and electrical requirements specific to the underground operations were included in the estimate by Wardrop based on estimates and quoted by suppliers.
- Design was completed for the underground ventilation requirements and vendor quotes were received for inclusion in the estimate by Wardrop.
- Development costs for the underground mine were capitalised and included in the estimate by Wardrop and were based on the unit costs developed for operations.
- The system to deliver tailings underground was designed and pipeline costs were provided from a budget quotation which was included in the estimate by Wardrop. Additional ancillary equipment was estimated by Wardrop.
- Wardrop estimated the boiler system, pumping and piping requirements for the glycol storage and distribuion system with all equipment pricing obtained as vendor quotations.
- Wardrop obtained budget quotations for all major mechanical equipment from either Metso or Wardrop-obtained pricing from other suppliers. For non-major equipment (i.e. equipment

less than $100,000), costing was based on in-house Wardrop data or quotes from Wardrop recent similar projects.

- Wardrop utilised quoted prices for major electrical equipment equipment and quoted prices for power cables and historical prices for other all materials necessary together with allowances based on their experience for items such as electrical room cable tray systems, indoor lighting, etc.
- Temporary facilities and services including additional 50-person camp for the first year of construction (including building services, electrical and inventory) together with camp managing, check-in, catering, laundry, cleaning and technical maintenance were estimated based on MTH in-house data for inclusion in the estimate by Wardrop.
- The quotations provided to Wardrop were budgetary and non-binding.

10.5 Project Indirects

As with project direct costs, project indirect costs are based on advice from NFC and all equipment and materials pricing has been reduced by 15% for Chinese supplied materials; a productivity factor of two has been applied to installation man-hours. Labour rates have also been adjusted to reflect utilisation of Chinese installation contractors.

The Wardrop estimates included the following:

- Two generators for temporary power which were priced based on MTH in-house data as well as supplier information.
- Temporary fuel storage facilities comprising of bladder tanks complete with containment berms based on MTH in-house data and by a supplier.
- Temporary warehousing and workshops in the estimate comprising of a carpenter workshop, reinforcement workshop, mechanical workshop, electrical workshop, as well as general storage facilities (including inventory) based on MTH in-house data and on supplier information.
- A nominal allowance for the supply and treatment for any water requirements not captured under the MTH scope.
- Temporary sanitation services, piping and collection estimates based on MTH in-house data.
- The Iridium-based communication system and handheld radio communication system were quoted by a supplier.
- Estimates for office running, health and safety, storage facilities, workshop facilities, general site labour, general transport, travel staff, travel freight, travel management, site running, purchase and running of light vehicles, general equipment, earthworks, concrete, small tools, structural steel, survey equipment, standby costs for earthworks equipment, site installations, storage containers, computers and accessories based on MTH in-house data and from supplier information.
- Spare parts for all mechanical equipment were specified and costed by Metso. Wardrop's estimate was based on past project experience for spare parts on equipment and materials within the MTH and Wardrop scope. Additionally, Metso provided costs for commissioning spares and these were also included in the estimate by Wardrop.
- Cost of all reagents and consumables required for one year of operation based on quantity estimates and budget quotations.
- Freight and logistics inclusions in the Wardrop estimate were inclusive of, loading at country of origin, overland freight country of origin, marshalling areas, unloading and loading at port

of origin, shipping to Akureyri and Citronen, ship unloading, air freight charges and customs/duty fees.

- Costs for power plant training and technical assistance which were quoted by a supplier.
- Port commissioning and start-up which was estimated based on MTH in-house data.
- Airport test flight and airstrip commissioning estimated based on MTH in-house data and from supplier information.
- MTH, Wardrop and Metso all provided engineering and procurement estimates for their respective scopes of work and MTH, in conjunction with Wardrop and Metso, estimated construction management costs.
- Owners costs were inclusive of, home office staffing and travel, field staffing and travel, legal costs, product marketing, land taxes, reclamation bonds, project funding or financing costs, environmental programs and permitting, licenses, import duties and tariffs, miscellaneous allowances for deductible claims, geotechnical work and drilling programs, metallurgical testwork programs, commissions and royalties, good will and local infrastructure contributions, training program development – systems training, general training and orientation, safety equipment and supplies, site orientation and security.
- Wardrop included overall construction cost insurance together with marine and ocean insurances in the estimate.

10.6 Contingency

The contingencies allowance included by Wardrop in the estimate were intended for undefined items of work that are incurred within the defined scope of work covered by the estimate and cannot be explicitly foreseen or described at the time the estimate is completed due to a lack of complete, accurate and detailed information.

The contingency allowance in the Wardrop estimate was not considered a compensating factor for estimating inaccuracy nor was it intended to cover items such as any potential labour disputes, currency fluctuations, escalation, force majeure, or other uncontrolled risk factors.

Wardrop considered it should be assumed that the contingency amount will be spent over the engineering and construction period. Contingency was estimated as a percentage for each line item. There has been no attempt to review contingency for this estimate.

10.7 Qualifications and Exclusions

10.7.1 Qualifications

For the capital cost estimate Wardrop assumed the below:

- concrete aggregate and suitable backfill material will be locally available
- soil conditions will be adequate for foundation bearing pressures
- construction activities will be continuous, except with respect to the TSFs
- bulk materials such as cement, reinforcing steel, structural steel and plate, cable, cable tray and piping will be available when they are required
- capital equipment will be available when it is required

10.7.2 Exclusions

The following were excluded from the estimate by Wardrop:

- cost escalation during construction
- major scope changes
- interest during construction
- schedule delays and associated costs, such as those caused by the following:
  - scope changes
  - unexpected ground conditions
  - extraordinary climate events
  - labour disputes
  - receipt of information beyond the control of EPCM contractors
  - schedule recovery or acceleration
- financing costs
- taxes and duties
- overtime
- cost outside battery limits
- sunk costs
- research and exploration drilling costs
- permitting costs
- project risks
- pipe supports (supports quantities will be confirmed at a later date with equipment location and final pipe routing); for this study, a percentage of the total piping material cost was assumed for pipe supports (both large and small diameter)
- any last minute scope changes to the process and layout
- receipt of information beyond the control of Wardrop
- cost outside battery limits
- pipe insulation is not included as all piping is assumed to be indoors or in heated corridors; the only exception is the tailings line, which is specified as a pre-insulated pipe
- all pricing of the piping and fittings for raw water, tailings and surplus water are in the mechanical scope of work

The following items were excluded from the capital cost estimate by Wardrop, but were included in the financial model at that time:

- sustaining capital
- working capital
- closure costs (sustaining capital)
- salvage values (sustaining capital)

SECTION 11 - OPERATING COST ESTIMATE

11.OPERATING COST ESTIMATE

11.1 Introduction

In February 2011 Wardrop completed a feasibility study report that included an Operating Cost Estimate. The operating cost estimate for this Report is based on Ironbark's review and update of the Wardrop Report as summarised in this chapter.

The main points of difference between the current Ironbark and Wardrop estimates are that underground mining is now scheduled to commence first and the process plant throughput is now 3.3 Mtpa compared to 3.0 Mtpa in the Wardrop estimate.

The operating cost estimate for the life-of-mine (LOM) operations for the Citronen Project is presented in Table 11.1 in total dollars, dollars per tonne ore and dollars per tonne of zinc concentrate produced. Relative proportions of overall operating costs can be seen in Figure 11.1 for mining, process, shipping and logistics costs and general and administration (G&A).

All costs are in US dollars (US$) unless otherwise noted. The projected LOM average operating cost for the Citronen Project is calculated to be US$ 63.90/t ore mined.

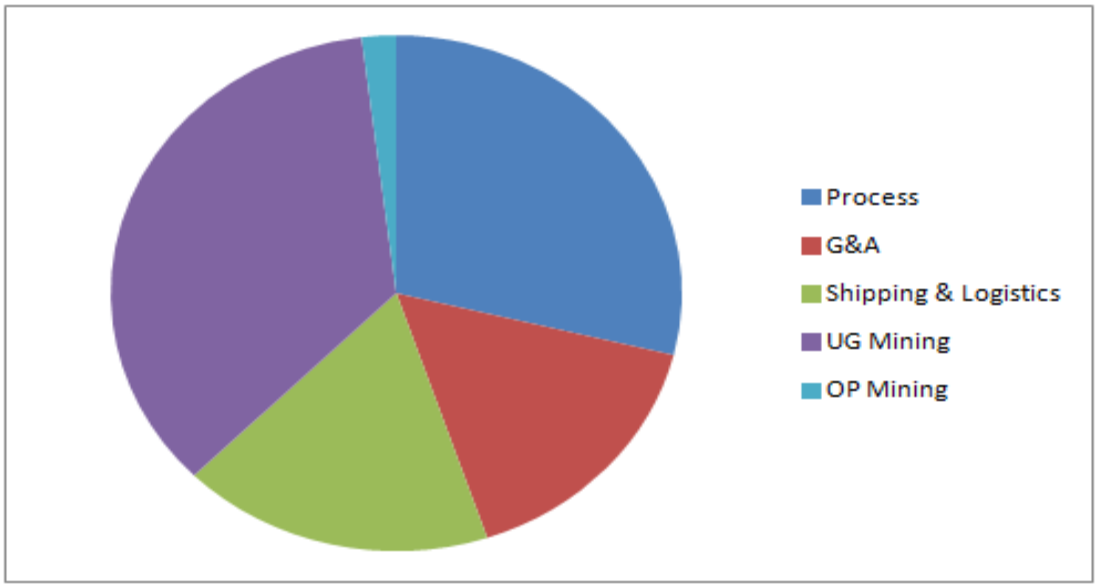
All costs are exclusive of taxes, permitting costs, or other government imposed costs unless otherwise noted. All costs are based on the Wardrop Feasibility Study and are escalated at 2.5% per annum.

Table 11.1 - Citronen Project operating costs summary

Description	Annual Cost (US$X1,000)	Unit Costs (US$/t Ore)	Unit Costs (US$/t Zn Conc)
Underground Mining	87,327	26.12	293.41
Open Pit Mining	15,926	5.49	103.16
Process	47,135	14.69	205.07
Shipping & Logistics	31,062	9.58	122.21
General & Administration (G&A)	25,696	8.01	103.69
Total Operating Costs	207,146	63.90	827.56

Note: large first fill (Year 1 consumables) have been capitalised.

Figure 11.1 - Overall operating costs distribution



Note the unit costs are based on LOM total ore and therefore the costs for the underground and open pit mine are lower than per cost of ore specific to the ore body.

11.2 Mining Operating Costs

11.2.1 Underground mining operating costs

Operating costs for the underground mine were divided into two categories: direct costs and indirect costs. Operating costs were calculated on a yearly basis and then divided by the expected production tonnage to arrive at a cost per tonne.

Direct Costs

Direct costs were generated based on the mining schedule. The amount of drifting required was taken into consideration along with production from room and pillar stopes. Direct costs were based on the following major components:

- drilling and blasting
- roof control
- utility
- labour
- load-haul-dump (LHD)
- haulage
- miscellaneous equipment and support

Each component was the result of specific unit cost breakdown based on production rates and unit cost. The unit used in the cost model included time and meters and varied depending on the requirements of the cost component. For example, LHD costs were based on the time required to muck a stope or drift, while utility costs were based on the metres of drift that require utility installation.

Indirect Costs

Indirect costs comprise indirect labour (typically hourly miners) along with various surface support costs associated with operating the underground mine. Indirect costs were applied in the same manner as direct costs. There is a slight decrease in indirect costs in the final production year of the underground mine caused by the decrease in production due to the closure of the underground operation in Year 11 and the subsequent shift in the labour force requirements to those of the open pit operation.

Total Operating Costs

The overall weighted average operating cost for the underground mine was determined to be US$ 26.51/t ore mined..

Table 11.2 - Total underground mine operating costs

Underground Operating Costs on a Yearly Basis		
Production Year	**US$/t Mined**	**US$/t Ore**
Yr 2	26.61	26.80
Yr 3	26.63	26.73
Yr 4	26.24	27.01
Yr 5	26.16	26.93
Yr 6	26.67	26.76
Yr 7	26.47	26.56
Yr 8	26.51	26.79
Yr 9	26.65	26.80
Yr 10	26.58	26.75
Average	26.50	26.79

Year 1 is not included as the reagent costs are included in the first fill costs.

Year 11 is not included in the above table as it is a transitional year combining completion of underground mining and commencement of open pit operations.

Operating Costs by Area

The underground operating costs fall into four main areas: consumables, labour, mobile equipment and power (associated with the underground mining operations).

Table 12.3 shows the breakdown of the costs for each area over the life of the underground operation.

Table 11.3 - Underground operating costs by area

Underground Operating Costs by Area			
Area	LOM Cost (US$X1,000)	US$/t Mined	US$/t ore
Consumables	24,339	7.30	7.38
Labour	33,125	9.93	10.04
Mobile Equipment	23,069	6.92	6.99
UG Power	7,877	2.36	2.39
Total	88,411	26.50	26.79

11.2.2 Open Pit Mining Operating Costs

Total Operating Costs

Expected maintenance, spare parts, fuel consumption and lube unit rates were provided by equipment vendors. These rates were applied to the calculated number of operating hours for each piece of equipment to determine yearly costs. A breakdown of the yearly operating costs for the open pit can be found in Table 11.4.

Table 11.4 - Open pit total operating costs

Open Pit Operating Costs on a Yearly Basis		
Production Year	US$/t Mined	US$/t ore
Yr 12	2.97	6.48
Yr 13	2.29	7.10
Yr 14	1.90	7.03
Average	2.39	6.99

Year 11 is not included in the above table as it is a transitional year combining completion of underground mining and commencement of open pit operations.

Operating Costs by Area

The underground operating costs fall into three main areas: consumables, labour and mobile equipment.

Table 11.5 shows the breakdown of the costs for each area over the life of the underground operation.

Table 11.5 - Open pit costs by area

Open Pit Operating Costs by Area			
Area	LOM Cost (US$X1,000)	US$/t Mined	US$/t ore
Consumables	2,499	0.29	0.86
Labour	12,940	1.54	4.50
Mobile Equipment	4,676	0.56	1.62
Total	20,115	2.39	6.99

11.3 Process Operating Costs

11.3.1 Total Operating Costs

Table 11.6 shows a summary of the projected LOM process operating costs for the project, both as yearly total costs and per tonne of ore crushed.

Table 11.6 - Total process operating costs

Process Operating Costs on a Yearly Basis		
Production Year	Total (US$X1,000)	US$/t ore
Yr 2	52,433	15.89
Yr 3	54,019	16.37
Yr 4	54,312	16.46
Yr 5	56,090	17.00
Yr 6	55,040	16.68
Yr 7	56,903	17.24
Yr 8	55,023	16.67
Yr 9	52,056	15.77
Yr 10	56,131	17.01
Yr 11	56,034	16.98
Yr 12	57,843	17.53
Yr 13	57,067	17.29
LOM Average	55,246	16.74

11.3.2 Operating Costs By Area

The process operating costs comprise fixed costs (mobile equipment, process labour, spares/ wear parts and power) and variable costs (reagents and consumables). The fixed costs are based on total tonnes of ore delivered to the crushing plant whereas the variable costs are based on the DMS sinks. The correlation for determining the ratio of DMS sinks to the overall feed is built into the operating cost calculations and applied to the variable costs as required. This variable cost is the reason for the variation in operating costs by year in Table 11.6.

Table 11.7 shows a breakdown of LOM costs by area.

Table 11.7 - Process operating costs by area

Process Operating Costs by Area		
Area	**Total (US$X1,000)**	**US$/t ore**
Reagents	25,670	7.78
Spares/Wear Parts	5,824	1.76
Power	17,894	5.42
Labour	5,143	1.56
Mobile Equipment	715	0.22
Total Process Operating Costs	55,246	16.74

11.3.3 Reagents and Consumables

A summary of the estimated reagents and consumables for the Citronen Project are shown in Table 11.8.

Table 11.8 - Reagents and consumables costs summary

Process Reagent and Consumables Costs			
Description	**Total (US$X1,000)**	**US$/t ore**	**US$/t milled**
Ferrosilicon	876	0.27	0.49
Dextrin	447	0.14	0.25
CaLigno	1,555	0.47	0.87
D200	89	0.03	0.05
SEX	625	0.19	0.35
9323	576	0.17	0.32
CuSO4.5H2O	3,546	1.07	1.98
Interfroth 6-3N	89	0.03	0.05
Magnafloc M10	217	0.07	0.12
CaO	7,764	2.35	4.33
Ball Consumption	1,559	0.48	0.89
VTM Hi Chrome Cyclo-Peb	2,646	0.80	1.48
Pb Regrind Media (Cer Bead)	3,662	1.11	2.04
Zn Regrind Media (Cer Bead)	1,980	0.60	1.10
Sub-total reagents	25,670	7.78	14.33

11.3.4 Wear Parts

Metso provided an estimate for process plant consumables (i.e. wear parts, liners, etc.) by area based on a process plant throughput of 3.0 Mtpa. The yearly costs by area are outlined in Table 11.9.

Table 11.9 - Wear parts costs by area

Description	Total/Year (US$X1,000)
2030 - Primary Crushing	124.55
2031 - Secondary Crushing	394.98
2033 - Fine Ore Conveyor	0.00
2410 - DMS	579.51
2411 - Grinding	1,953.18
2412 - Preflotation	28.83
2413 - Lead Flotation/ Regrind	394.23
2414 - Zinc Flotation/ Regrind	1,264.87
2415 - Concentrate Dewatering	322.82
2420 - Tailings Dewatering	21.79
2425 - On Stream Analyser & Ancillaries	99.22
2430 - Reagents & Consumables	80.13
2440 - Plant & Instrument Air	25.22
2450 - Gland Water	0.00
2455 - Process Water	4.90
Sub Total	5,294

11.4 General and Administration Costs

Ironbark provided the G&A operating costs, which are calculated to be US$8.08/t ore. These costs include management and administration support functions for both Akureyri and site operations, as follows:

- Akureyri yearly operating expenses
- building maintenance
- camp accommodation
- communication systems (external)
- consultants
- environmental permits
- external assays/ testing
- government affairs & public relations
- head office expenses
- insurance
- land leases/ right of way

- legal services
- light vehicles
- marketing
- medical supplies
- property taxes
- recruitment
- regulatory compliance
- road maintenance
- safety and training supplies
- security supplies
- site environmental management
- training programs
- waste management

The G&A operating costs comprise fixed costs associated with general operation of the overall project. These items include those listed above and are grouped generally into power, labour, mobile equipment, regulatory compliance and miscellaneous.

Table 11.10 shows a breakdown of LOM costs by area.

Table 11.10 - G&A operating costs by area

G&A Operating Costs by Area		
Area	**LOM (US$X1,000)**	**US$/t ore**
Power Costs	3,127	0.95
Total G&A Labour	18,956	5.74
Total G&A Mobile Equipment	1,463	0.44
G&A Regulatory Compliance	2,628	0.80
G&A Operating Misc.	500	0.15
Total	26,675	8.08

11.5 Shipping and Logistics Costs

Shipping and logistics costs were provided by MTH. The information contained costs for leasing the barges, shipping concentrate and supplies from and to Citronen Fjord respectively including yearly mobilisation and demobilisation costs, storage in Akureyri and onward shipping to the smelter.

Table 11.11 shows the breakdown of these costs.

Table 11.11 - Shipping and logistics operating costs by area

Shipping and Logistics Operating Costs by Area		
Area	**LOM (US$X1,000)**	**US$/t concentrate**
Barge Leasing	7,415	26.55
Barge Towing	16,157	55.32
Handling	1,443	4.92
Onward Shipping	4,909	16.73
Container Handling	521	1.87
Akureyri FOP	3,283	11.75
Total	33,728	117.13

11.5.1 Shipping

Shipping costs include mobilisation and demobilisation of the icebreaker tugs and non-ice class tugs to Akureyri at the beginning and end of each season. The shipping route from Akureyri to Citronen and preliminary operating procedures are described in detail in the Shipping Logistics sub-section of Section 6 - Infrastructure and Ancillary Facilities of this Report. Non-ice class tugs are used in the first portion from Akureyri to the meeting point and ice-class tugs thereafter. The use and costs with the tugs are outlined below.

Each barge can transport 32,000 dry tonnes of concentrate. At an assumed concentrate moisture content of 8% this translates into 29,630 dry tonnes per trip.

Non-Ice Class tug Operation

Non-ice class tugs are mobilised and demobilised to Akureyri once per year. Throughout the shipping season they are then used to transfer the barges from Akureyri to the meeting point as this is the portion of the shipping leg where no icebreaker assistance is required. The barges will then be transferred to an ice-class tug at the meeting point.

Time has been included for loading and transferring of the tugs at both Akureyri (AKU) and the meeting point. Table 11.12 shows the breakdown of costs for the non-ice class tugs for one journey.

Table 11.12 - Shipping costs for non-ice class tugs

Shipping Costs for Non-Ice Class Tug				
Leg	**Days**	**Chartering Cost ($/d)**	**Total US$**	**Fixed/ Variable**
Tug Mobilisation to AKU	4.0	30,000	120,000	Fixed
Tug AKU to meeting point	3.7	30,000	111,000	Variable
Tug meeting point to AKU	1.1	30,000	33,000	Variable
Support time at AKU and Leg 1	1.9	30,000	57,000	Variable
Tug Demobilisation	4.0	30,000	120,000	Fixed

Note that the fixed costs relate to a one-time cost for the shipping season whereas the variable costs refer to each barge trip, dependant on the total tonnes of concentrate produced each year.

Fuel costs for the non-ice class tugs are included in the daily chartering rates.

Ice Class Tug Operation

Ice class tugs are mobilised and demobilised to Akureyri and then further on to the meeting point once per year. Throughout the shipping season they are also used to transfer the barges from the meeting point to the Citronen site through three varying degrees of ice. The costs are broken down into the three varying ice thicknesses because the tug speed varies for each.

Table 11.13 shows the breakdown of costs for the ice-class tugs for one journey.

Table 11.13 - Shipping costs for ice class tug

Shipping Costs for Ice Class Tug						
Leg	Days	Fuel (tonnes)	Fuel Cost ($/d)	Chartering Cost/day ($)	Total US$	Fixed/ Variable
PC-IB Mobilisation to AKU	4.0	42	25,200	60,000	340,800	Fixed
PC-IB AKU - meeting point	3.7	65	39,000	60,000	366,300	Fixed
PC-IB Icy waters - Leg 1 (to site)	1.1	70	42,000	60,000	112,200	Variable
PC-IB Icy waters - Leg 2 (to site)	3.7	70	42,000	60,000	377,400	Variable
PC-IB Icy waters - Leg 3 (to site)	0.3	70	42,000	60,000	30,600	Variable
PC-IB Icy waters - Leg 1 (to meeting point)	0.3	70	42,000	60,000	30,600	Variable
PC-IB Icy waters - Leg 2 (to meeting point)	3.7	70	42,000	60,000	377,400	Variable
PC-IB Icy waters - Leg 3 (to meeting point)	1.1	70	42,000	60,000	112,200	Variable
PC-IB meeting point - AKU	3.7	65	39,000	60,000	366,300	Fixed
PC-IB Demobilisation	4.0	42	25,200	60,000	340,800	Fixed

Note: the fixed costs relate to a one-time cost for the shipping season whereas the variable costs refer to each barge trip, dependant on the total tonnes of concentrate produced each year. Cost per tonne of marine grade oil (MGO) fuel is US$753.

11.5.2 Logistics

A subcontractor has expressed interest in handling all works for bulk operations in Akureyri for the concentrate handling, unloading of the barges and loading the onward vessels for shipping supplies to Citronen Fjord. This contract would potentially include all container handling and stevedoring of consumables to site and includes the below cost estimates:

- bulk handling of concentrate in Akureyri: US$ 4.92/ tonne concentrate
- container handling (1000 TEUs): US$ 520.99/ annum
- onward transport of concentrate to Antwerp (assumed): US$ 16.73/ tonne concentrate
- fixed yearly operating expenses in Akureyri: US$ 3.28 million

11.6 Labour Costs

Labour costs have been developed for the Citronen project with information provided by MTH. Costs have been built up from annual salaries per job description and include flights per rotation, associated travel costs and food allowances. Unit salaries include all payroll burdens.

Roster rotations and annual salaries by job description are outlined in Table 11.14.

Table 11.14 - Salaries

Yearly Salaries based on Job Description			
Job Description	**Scale**	**Roster**	**Salary (000 $)**
Site Manager	1	6	270
Senior Management	2	6	210
Middle Management	3	6	170
Senior Technical	4	6	150
Technical	5	6	120
Junior Technical	6	6	90
Assistant	7	6	70
Senior Supervisory	8	9	200
Supervisory	9	9	170
Operator Class 1	10	9	150
Operator Class 2	11	9	135
Operator Class 3	12	9	120
Operator Class 4	13	9	105
Operator Class 5	14	9	90
Trainee Operator	15	9	75
Trade Class 1	16	9	135
Trade Class 2	17	9	120
Process Class 1	18	9	105
Process Class 2	19	9	90
Trainee Process	20	9	70
Surface Class 1	21	9	80
Surface Class 2	22	9	70

Roster '6' refers to a 3 week on/3 week off rotation whereas Roster '9' refers to a 6 week on/3 week off roster. Flights and travel are calculated to both respectively and added into the yearly costs per person.

SECTION 12 - RISKS & OPPORTUNITIES

12. RISKS & OPPORTUNITIES

12.1 Introduction

The Citronen Project (Project) has a range of associated risks common to many mining operations and some specific to the Project. The focal risk is on potential challenges associated with the geographical location of the project and sensitivity to the zinc price. Numerous opportunities exist, as identified below, to increase the profitability of the Citronen Project.

12.2 Risks

12.2.1 Market Risk

This Project is sensitive to the zinc price. The various market forecasts for future zinc price are very favourable; however, the current zinc prices and equity market are challenging factors.

The operation of the Citronen Project involves several currencies (including the Australian, US & Canadian Dollars, Danish Kroner, and Chinese Yuan) and is therefore sensitive to the fluctuation in foreign rates.

12.2.2 Geographical Location & Access

The mine site is located at latitude 83 degrees north and is 940 km from the nearest Greenlandic settlement. The project location comes with inherent weather and access difficulties. While year round access to site may be obtained via aircraft, ocean access is possible only during the summer months; this is due to sea ice and requires the use of special ice class of vessels. This circumstance influences on the import to site of bulk supplies and the export of concentrate products.

12.2.3 Project Execution

The above mentioned geographical difficulties could result in delayed project completion due to the missing of weather windows required for shipping access. Such a delay would have a negative effect on financial indicators.

12.2.4 Regulatory Risks

The Project is currently held within an Exploration Licence which must be converted to an Exploitation Licence before construction can commence. The Greenland BMP have indicated this process may take up to six months after all necessary project information is submitted. A delay in this conversion may push back the start date for construction. Ironbark is militating against this risk by following all BMP guidelines in regards to project document content and submission and is in regular negotiations with the BMP.

12.2.5 Mining Risks

There is a low risk associated with the mining and extraction of ore at Citronen. The ore body's nature and orientation is well understood and the room and pillar mining method has been selected as the most appropriate for this style of deposit. Ironbark is confident this understanding will achieve the maximum possible head grade for the mine.

Ironbark has completed extensive metallurgical testing and testwork has returned zinc recoveries over 90%. Ironbark is confident that the recoveries achieved during mining will reflect the testwork completed to date and the risk of poor recoveries is very low.

12.3 Opportunities

12.3.1 Resource

The resource estimate as shown in Section 3 has taken into consideration only a small area of the existing lease. There are several areas with the potential to increase resources and convert them into reserves. Further drilling is required to confirm this potential. However, the prospects for delineating further resources and reserve is considered very good as the current resource is open to further mineralisation in every direction.

Recent metallurgical testwork has shown zinc recoveries exceed 90%. Further engineering work is required before this could be raised to the level of engineering confidence required for inclusion in the Feasibility Study.

12.3.2 Plant Throughput

The study performed by Metso in 2012 indicates it is possible to increase the plant throughput beyond 3.3 Mtpa without major changes to the process equipment or capital cost increases.

Competent Person Statement

The information in this Document that relates to Exploration Results and Mineral Resources is based on information compiled by Mr. Adrian Byass, B.Sc Hons (Geol), B.Econ, FSEG, MAIG an employee of Ironbark Zinc Limited. Mr. Byass has sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2004 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves.

The information in this Document that relates to Ore Reserves is based on information compiled by Mr. Greg Campbell, B.E (Chem) Hons, MAusIMM and Mr. J Downes, B.Sc (Geol), MAIG who are both employees of Ironbark Zinc Limited. Mr Campbell and Mr. Downes have sufficient experience that is relevant to the style of mineralisation and type of deposit under consideration and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2004 Edition of the Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves. Mr. Byass, Mr. Campbell and Mr. Downes consent to the inclusion in this Document of the matters based on this information in the form and context in which it appears.

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