Report

Oceana Gold, Macraes Gold Project Greenhouse Gas Emissions Estimation - Macraes Phase III Mine Development

Prepared for Oceana Gold (New Zealand) Ltd

By Beca Infrastructure Ltd (Beca)

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Revision History

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1 Introduction

The Macraes Mine is New Zealand's largest gold mine, and is owned and operated by Oceana Gold (New Zealand) Ltd (OceanaGold). The mine consists of a large scale open cast mine, underground mine (Frasers Underground), waste rock and tailings disposal areas and supporting mine infrastructure. The mine is located close to the settlement of Macraes Flat, East Otago.

Mine development planning must take account of a wide range of parameters to ensure logical and efficient resource development. Beyond the geological, regulatory and economic parameters, work sequencing must take account of developmental sequencing to access the target gold-bearing Otago schists whilst maintaining haul road access to waste rock stacks and tailing storage facilities, and avoiding re-handling of materials. Efficiency in mine development and operation is therefore logically a consequence of geological, economic and environmental drivers.

Significant energy is expended in open cast mining associated with the excavation and transport of waste rock. Operational efficiencies are achievable in all stages between excavation to ore processing. However the most significant efficiency opportunities lie in the waste rock excavation and handling - this activity being the mine's largest energy consumer (i.e. diesel) and greenhouse gas (GHG) emitter. Whilst there are currently no practical non-petroleum fuel choices[1] there is the potential for significant variations in energy expenditure as affected by the haulage fleet (e.g. fuel consumption efficiency), waste rock volume/tonnage and haulage distance. In contrast, whilst significant energy is expended in ore handling processes, there is only limited discretion in haulage distances as dictated by the permanent location of the processing plant.

Whilst electricity and fuel consumption has traditionally been of interest for economic/financial reasons, the more recent understanding of fossil fuel derived energy's contribution to climate change via the release of GHG emissions has become an additional driver for energy efficiency.

2 Purpose of Report

The purpose of this report is to provide comment on the GHG emissions associated with the waste rock handling processes associated with the Macraes Phase III development and to ascertain whether mine sequencing is efficient from a GHG perspective.

3 Carbon Regulatory Requirements

There are no mandatory or regulatory requirements within the Resource Management Act 1991 or as otherwise required by Otago Regional Council, Waitaki District Council or central government (or its agencies) calling for OceanaGold to specifically consider the impacts of its mine energy consumption upon the release of GHG emissions, or the subsequent contribution which those emissions have upon climate change. These matters are however nationally assessed and reported by the New Zealand Government in conjunction with the country's Kyoto commitments, primarily via the coalition and reporting of a National Greenhouse Gas Inventory. Economic tools to facilitate New Zealand meeting its Kyoto obligations include an Emissions Trading Scheme, the NZ ETS.

[1] The nature and extent of heavy machinery duty in mining operations dictates a reliance on petroleum fuels.

In terms of its energy consumption (e.g. electricity and liquid fossil fuels (primarily diesel)) OceanaGold is not a direct participant in the NZ ETS. The reporting obligation for these energy sources is upstream – being the electricity generators and the country's petroleum suppliers. The effect of that reporting obligation is that the financial carbon obligations (arising from the NZ ETS) are factored into the purchase price (at the pump) of the associated fuels. In this way, OceanaGold is an indirect participant in the NZ ETS – that is, subject to the increase in energy price, but without a requirement to directly report and participate in the NZ ETS in respect of its energy consumption.

OceanaGold will be a direct participant for industrial process emissions post 2012, specifically relating to the use (via chemical reaction) of limestone (calcium carbonate, $CaCO_3$)[2]. This will ultimately see OceanaGold report the associated GHG emissions directly to the Government. This regulatory requirement is distinct to the purpose of this report and therefore is not discussed further here.

4 Waste Rock Handling

4.1 Introduction

Mine development requires the removal of vegetation, soils and waste rock to allow for the targeted excavation of the gold bearing schist. Excavations are aided by blasting, scrapers, excavators and bull dozers, with excavated material removed by haulage trucks.

Energy consumption (i.e. diesel) associated with the non-haulage activities (e.g. excavation) is not considered further in this report as these are planned *in-situ* activities for which there are no proposed alternative excavation/mining methods. In contrast, there are a range of disposal options for waste rock excavated from each pit. Short haulage distances are important from a fuel burn and turn-around efficiency perspective. The following sections assess the efficiency of the proposed Macraes Phase III development from a waste rock haulage perspective.

4.2 Haul truck fleet

The current and planned haul truck fleet is summarised in Table 1. Notably the proposed number of haul trucks in the OceanaGold fleet remains relatively static over the period 2011 to 2019, whilst the overall haul capacity is increased via an increased proportion of high pay load trucks as the haulage fleet is progressively replaced with a dominance of the larger Cat 789 haulage trucks. Specifically this would see a pay load increase of approximately 48 tonnes over the Cat 785C trucks. Provided the fleet is used to optimal capacity, operational efficiency will improve with less haul movements being required to move a given volume of waste rock.

[2] Note that lime (calcium oxide, CaO) is also used in the gold production process, but is not subject to NZ ETS reporting by OceanaGold.

Table 1: Haul fleet specifications

Vehicle specification	2010	2020
Cat 789C § Capacity: 154 - 195 tonnes (average payload : 193 tonnes) § Engine: Cat 3516B, V16 § Fuel: Diesel § Fuel efficiency: No manufacturer data available	11	16
Cat 785C § Capacity: 136 tonnes (average payload: 145 tonnes) § Engine: Cat 3512B, V12) § Fuel: Diesel § Fuel efficiency: No manufacturer data available	6	2
Total	17	18

Manufacturers do not specify typical fuel consumption rates for heavy machinery as it is the duty (i.e. load, gear selections, incline, operator behaviour etc) which dominates fuel consumption and efficiency. Notwithstanding this, manufacturers' marketing information communicates commitments to research, development and integration of technologies to achieve operational fuel efficiencies, and this is evident in the technical specifications of the haul trucks in use, and proposed, at Macraes. OceanaGold have determined the actual fuel burn rates of their fleet from fuel records, and these are provided in Section 4.6 below.

In conjunction with the inherent fuel consumption of the machinery and its haulage duty, non-driver factors which will have a significant influence on fuel efficiency include haul road gradient and haul road condition.

4.3 Alternate haulage systems

Electricity predominantly derived from renewable resources (e.g. wind, hydro) emits less GHG emissions than that from diesel (or other fossil fuels) combustion. Figures released by Ministry of Economic Development[3] indicate that, based upon the New Zealand grid average electricity emissions factor, electricity generation[4] produces approximately 30% less GHG emissions than diesel for the equivalent consumption of energy. An increasing proportion of renewable generation in the grid electricity mix widens that differential; in 2009 99.7% of the electricity generated in the South Island was from renewable sources, with South Island generation accounting for 42% of the New Zealand electricity generation (from all sources); 36% of the total generation was consumed in the South Island. While there is a flux of electricity between the North and South Islands, it is expected that the electricity consumed at Macraes is generated almost solely from renewable

[3] Ministry of Economic Development. 2009. "New Zealand Energy Data File". Energy Information and Modelling Group. www.med.govt.nz. Note that the 2009 rather than a more recent report has been used as it reports data from 2008, and therefore is aligned with the GHG emissions factor data reported in Ministry for the Environment 2009 "Guidance for voluntary, corporate greenhouse gas reporting. Data and Methods for the 2008 Calendar Year. Publication Number ME953.

[4] Electricity transmission and distribution losses are not taken into account.

sources. The implication of this is that estimated GHG emissions from electricity consumed at Macraes is almost certainly overstated[5]. From a GHG perspective there is therefore a clear advantage in maximising energy demand from electricity in preference to that derived from fossil fuels.

The use of electric drive equipment technology in mining requires significant capital investment and is typically employed in very large, long life operations where the electricity distribution infrastructure (i.e overhead power lines, power transformers) remains fixed in place for long periods of time. The Macraes open pit operation is dynamic in that there are numerous short-life haulage roads and a high rate of vertical advance in the open pits. Accordingly electricity infrastructure would require frequent and expensive relocations in response to the mine development. OceanaGold do not consider electric drive equipment in their open casting operations as productive or practical. In contrast, in the underground mine, it is cost effective to use electrically operated drills to develop roadways and there are three electric-hydraulic twin boom jumbos which are used. The underground mine has an extensive electrical distribution network and the drills connect into this system with electric trailing cables. The remaining underground equipment (loaders, haulage trucks) are highly mobile and it is not practical to operate these electrically.

4.4 Mine Development

The total tonnage of material to be mined from all open pits for the Macraes Phase III from 1 January 2011 is planned to be in the order of 490 Mt. The proposed Macraes Phase III mine development is planned based upon an interconnected and complex array of requirements, opportunities and constraints, including: existing resource consents, sought resource consents, site geology, ore location, waste rock stack development and haul road access, continuity in public roads and staged site rehabilitation.

The likely mine development sequencing considered in this report is as per advice of Macraes Gold Project production engineers, and summarised in Table 2 below.

[5] Note however that best practice methods (e.g. GHG Protocol, Ministry for the Environment guidance) for reporting of GHG emissions associated with grid sourced electricity assumes a published national or regional grid emissions factor, and not site specific emissions factor based upon estimated generation characteristics.

Table 2 : Macraes Stage III pit development plan

PITS	2011\Qtr1\Jan	2011\Qtr1\Feb	2011\Qtr1\Mar	2011\Qtr2\Apr	2011\Qtr2\May	2011\Qtr2\Jun	2011\Qtr3\Jul	2011\Qtr3\Aug	2011\Qtr3\Sep	2011\Qtr4\Oct	2011\Qtr4\Nov	2011\Qtr4\Dec	2012\Qtr1\Jan	2012\Qtr1\Feb	2012\Qtr1\Mar	2012\Qtr2\Apr	2012\Qtr2\May	2012\Qtr2\Jun
	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt
FRASERS STAGE 4	400	249	300	384														
FRASERS STAGE 5	4247	3875	4931	4419	4700	4486	4777	4490	4654	5304	5139	5172	4790	4088	4208	2524	2680	2099
FRASERS STAGE 6															322	2,276	2,212	2,599
ROUND HILL STAGE 1																		
ROUND HILL STAGE 2													600	600	600	600	600	600
ROUND HILL STAGE 3																		
INNES MILLS																		
TOTAL MOVEMENT	**4,647**	**4,123**	**5,231**	**4,802**	**4,700**	**4,486**	**4,777**	**4,490**	**4,654**	**5,304**	**5,139**	**5,172**	**5,390**	**4,688**	**5,130**	**5,400**	**5,492**	**5,298**

PITS	2012\Qtr3\Jul	2012\Qtr3\Aug	2012\Qtr3\Sep	2012\Qtr4\Oct	2012\Qtr4\Nov	2012\Qtr4\Dec	2013\Qtr1	2013\Qtr2	2013\Qtr3	2013\Qtr4	2014\Qtr1	2014\Qtr2	2014\Qtr3	2014\Qtr4	2015	2016	2017	2018	2019
	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt	kt
FRASERS STAGE 4																			
FRASERS STAGE 5	2343	1668	1473	1176	1361	972	2405	3400	1613										
FRASERS STAGE 6	2,191	3,133	3,340	3,794	3,268	3,764	12,078	9,852	12,169	13,589	11,755	12,187	12,834	10,976	7,563				
ROUND HILL STAGE 1														2,249	24,621				
ROUND HILL STAGE 2	600	600	600	600	600	600	1,800	1,800	1,800	1,800	1,800	1,800	369						
ROUND HILL STAGE 3															29,682	52,005	26,000	3,841	
INNES MILLS																11,327	38,808	54,472	5,414
TOTAL MOVEMENT	**5,134**	**5,402**	**5,413**	**5,570**	**5,229**	**5,336**	**16,284**	**15,052**	**15,582**	**15,389**	**13,555**	**13,987**	**13,204**	**13,225**	**61,866**	**63,332**	**64,808**	**58,312**	**5,414**

4.5 Emissions Factors

In order to report GHG emissions, an 'emissions factor' is typically used to convert activity data (e.g. diesel or electricity consumed) into greenhouse gases. There are numerous gases which impact upon the global warming (ie. greenhouse gas) effect, however the gases of prime interest are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFC), perfluorocarbons (PFC) and sulphur hexafluoride (SF_6)). In terms of this study, it is specifically GHGs arising from fuel combustion which are of interest, being carbon dioxide, methane and nitrous oxide. The combined concentration of GHGs is expressed as carbon dioxide equivalents, and typically in tonnes i.e. tCO_2-e).

Ministry for the Environment (MfE) publishes a schedule of greenhouse gas emissions factors specifically for use in New Zealand. These emissions factors are derived from technical information published by New Zealand government agencies, and primarily the Ministry of Economic Development (MED). The most recent emissions factors were published in September 2009, and pertained to fuel data in the market place during 2008. These emissions factors are the best emissions factors currently available for this assessment, albeit there can be expected to be slight variations in subsequently published emissions factors. For instance, an approximate 1.5% variation exists between diesel (transport fuel) emissions factor reported for the 2006 and 2008 calendar years. Beca understands that MfE are not publishing emissions factors in 2010.

The scope of this report solely requires the consideration of GHG emissions associated with diesel combustion. In this respect, the emissions factors detailed in Table 3 are relevant to the study.

Table 3: Greenhouse gas emissions factor for transportation diesel

Emission Source	Source	Unit	Emission Factor (kg/unit)			
			CO_2-e	CO_2	CH_4	N_2O
Diesel transport fuel (2008)	Ministry for the Environment "Guidance for Voluntary, Corporate Greenhouse Gas Reporting: Data Methods for the 2008 Calendar Year". September 2009.	litre	2.69	2.64	0.00306	0.0441

4.6 Fuel burn and Greenhouse gas estimate

The Macraes Gold Project production engineer has modelled the haul route options associated with the proposed Macraes Phase III development. Cycle times and haul distances were calculated using Talpac[6] haulage software, with the haul routes measured from the centres of mass of the pit to each destination. Having determined cycle times, the fuel burn associated with haulage operations has been estimated. Fuel burn rates have been estimated by calibrating to the observed average fuel consumption rates from the existing OceanaGold fleet of CAT 789C haulage trucks (being the larger of the haul trucks). This average fuel consumption is considered the best available information for the purposes of this study, and it is assumed that this would remain representative for the life of the mine, and of the intended fleet purchased up until 2020.

[6] Talpac is an independent haulage fleet evaluation system. It has been designed to determine productivity and economics of truck and loader hauling systems, and is accepted as the global mining industry standard. Talpac is designed to calculate fleet productivity for long and short term planning and equipment evaluation.

Fuel burn associated with disposal site haulage options from each pit is presented in Table 4, along with the associated estimate of GHG emissions (as derived from the emissions factors discussed above). The results are presented on a 'per kilo-tonne of material' basis. Shaded in 'green' are the proposed Macraes Phase III haulage origin/destination journeys. Note that as the mine development advances, waste rock stacks will be filled to completion and therefore are unavailable for use in the future – this is denoted in Table 4 as 'Full'. A schematic of the existing and proposed pit, waste rock stack and tailing stack and storage developments is provided in Figure 1.

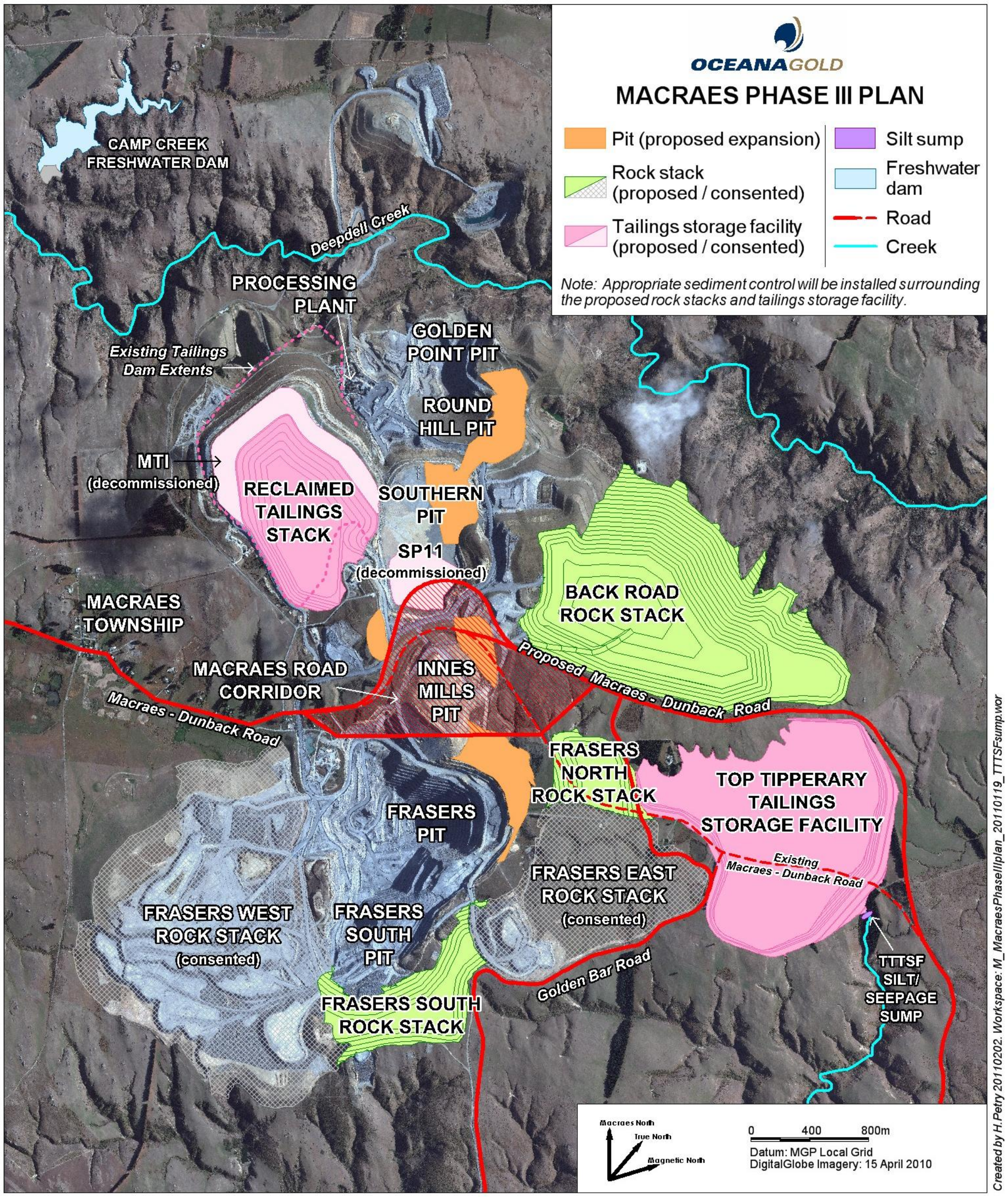

Figure 1: Macraes Phase III – Proposed mine configuration.

Note that the Talpac software predicts haulage cycle times (and hence fuel consumption) by computer simulation, and therefore there are inherent inaccuracies which will see some deviation from actual observed cycle times. Similarly, the emissions factors used have been applied to forecast data, and it is expected that there will be slight variations in the diesel emissions factor from year to year. For these reasons, the GHG estimates should be considered as 'indicative', but reliable for the purposes of comparisons.

Table 4: Fuel burn rates for a range ofhaul options

			SOURCE (PIT)					
		units	Frasers 5	Frasers 6	Round Hill	Round Hill (Tailings)	Innes Mills
DESTINATION	Frasers West Waste Rock Stack	litres/kt	319.6	352.7	Full	N/A	Full
		tCO2-e/kt	0.85972	0.94876			
	Frasers East Waste Rock Stack	litres/kt	248.9	222.9	Full	N/A	Full
		tCO2-e/kt	0.669541	0.599601			
	Frasers (In-pit) Backfill	litres/kt	236.5	Unavailable	462.8	N/A	274.5
		tCO2-e/kt	0.63619		1.24493		0.73841
	Back Road Waste Rock Stack	litres/kt	401.8	266.1	341.2	N/A	221.5
		tCO2-e/kt	1.08084	0.71581	0.91783		0.59584
	South of Frasers West Waste Rock Stack (example only)	litres/kt	359.6	392.7	421.6	N/A	331.3
		tCO2-e/kt	0.96732	1.05636	1.13410		0.89120
	Top Tipperary Waste Rock Stack (example only)	litres/kt	448.8	362.7	395.5	N/A	316.8
		tCO2-e/kt	1.20727	0.97566	1.06390		0.85219
	Reclaimed Tailings Stack (Mixed Tailings Dam)	litres/kt	N/A	N/A	N/A	168.8	N/A
		tCO2-e/kt				0.45407	
	Top Tipperary Tailings Storage Facility	litres/kt	N/A	N/A	N/A	233.1	N/A
		tCO2-e/kt				0.62704	
KEY	Haul route proposed (green)	Haul route not proposed (grey)	Haul route unavailable. (white)				

From Table 4 it is evident that waste rock sourced from each pit development is being disposed of, without exception, in waste rock stacks necessitating the least fuel burn (and therefore least GHG emissions) of the proposed options. Expansion of existing waste rock stacks in the vicinity of the pit developments (e.g. extensions of the Back Road Rock Stack, Fraser East Rock Stack (proposed Frasers North Rock Stack), Fraser West Rock Stack (proposed Frasers South Rock Stack)) are logical from the perspective of minimising haulage distances.

An analysis has been undertaken to estimate the haulage GHG emissions contribution per pit development. This is graphically shown in Figure 2. Note the trend in GHG emissions directly reflects the intensity of mine development, being relatively constant from year to year, with the exception of the ramp down of activity towards 2019. Total GHG emissions arising from haulage is estimated at 353,415 tCO_2-e.

The proposed mine development incorporates the deconstruction of the SP11 Wall (Qtr 1 2012 to Qtr 3 2014) and tailings removal in conjunction with development of the Round Hill Pit. GHG emissions associated with re-haulage of these materials will be significant, and possibly up to about 75,000 tCO_2-e. Where the tailings are excavated and disposed of via scrapers, these emissions would be additional to the above estimates, as are the emissions associated with pumping of tailings to the Top Tipperary Tailings Storage Facility.

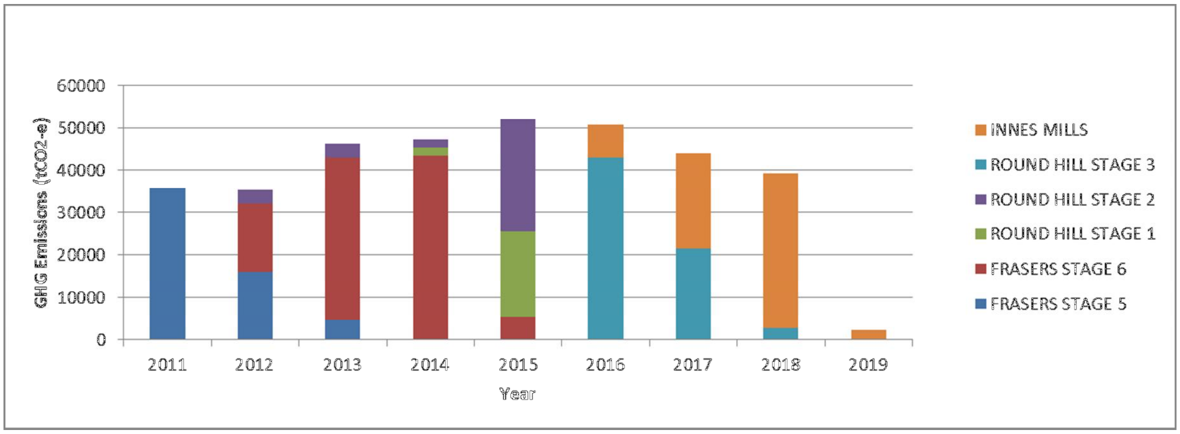

Figure 2: Macraes Phase III – GHG emissions from waste rock haulage from each pit.

A sensitivity analysis has been conducted to ascertain the increase in estimated GHG emissions arising from haulage to alternate, rather than proposed, waste rock stacks from the Frasers Stage 5 and 6, Round Hill and Innes Mill pit developments. The analysis has been performed by estimating the emissions increase associated with the next best available option (being the waste rock stack with the next best haulage fuel consumption) and for waste rock stacks with a corresponding highest haulage fuel consumption. These are depicted in Figure 3 as 'Scenario – low' and 'Scenario – high' respectively. The analysis estimates the range in which the actual emissions estimate would lie (that is, the true value would lie between the low and high scenario values), and the results are presented in Figure 3. It is evident that the proposed (optimised) approach of placing waste rock in stacks in immediate vicinity of the pit developments would facilitate a significant reduction in GHG emissions than would otherwise occur from use of alternate and more distant waste rock stacks. Note that the high emissions estimates for Frasers Stage 5 and 6 are associated with the use of the Top Tipperary Tailings Storage Facility for waste rock disposal, and use of the area south of Frasers West Waste Rock Stack (being a southern extension to the existing Frasers West Waste Rock Stack) respectively. The use of these two areas is not planned and these have been included in the assessment as examples of other waste rock disposal options and why they are not being pursued.

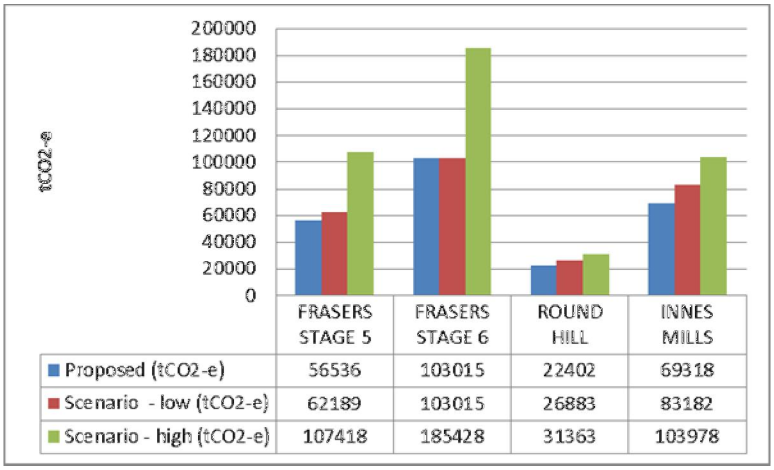

Figure 3: Macraes Phase III – GHG emissions from haulage to other waste rock stacks.

5 Conclusions

The proposed Macraes Phase III mine development planning has been developed to take account of existing and proposed resource consents, site geology, mining requirements, land tenure and access requirements, rehabilitation programmes, financial constraints and other drivers.

Energy consumption associated with waste rock haulage has been analysed. This activity is a significant consumer of energy and generator of GHG emissions. There is typically significant energy efficiency opportunities afforded in waste rock haulage – from both sequencing and operational perspectives. An assessment of the haulage associated with the proposed pit developments and associated waste rock stacks has been undertaken and found to represent an energy and GHG emissions efficient configuration. Overall GHG emissions from waste rock haulage operations between 2011 and 2019 are significant at an estimated 353,415 tCO_2-e. Maximum waste rock haulage emissions occur in 2015 at 52,153 tCO_2-e. Alternative waste rock haulage options could be used however their deployment would lead to an increase in GHG emissions; for the Frasers 5 and 6 developments that increase could be as much as 80-90%.

6 Limitations

This report has been prepared by Beca for OceanaGold. Beca has relied upon the information provided by OceanaGold in completing this document, including details of proposed Macraes Phase III sequencing, waste rock volumes and fuel burn data. Unless otherwise stated, Beca has not sought to independently verify this information as provided. This report is, therefore, based upon the accuracy and completeness of the information provided at the time of the review, and Beca cannot be held responsible for any misrepresentations, incompleteness, or inaccuracies provided within that information. Should any other information become available, this report will need to be reviewed accordingly.