BATHURST RESOURCES LIMITED

New Zealand West Coast Coal and Mining Operations

A Technical Reference

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Glossary of Terms

3D	Three Dimensional
AMD	Acid Mine Drainage
ANC	Acid Neutralisation Capacity
ARD	Acid rock drainage
ACIRL	ACIRL Quality Testing Services Pty Ltd
ASTM	American Society for Testing and Materials
bcm	Bank cubic metres
BPCP	Buller Plateaux Continuation Project
^oC	Degrees Celcius
CFSF	Coal Fines Storage Facility
CPP	Coal Handling Processing Plant
CO_2	Carbon Dioxide
CPP	Coal Processing Plant
CSN	Coal swell number
DMC	dense media cyclones circuit
DOC	Department of Conservation
EAF	Electric Arc Furnaces
ELF	Engineered Landform
ESE	Escarpment Extension
GDP	Gross Domestic Product
H_2	hydrogen
HCC	Hard coking coal
HAF	High Acid Forming
IEA	International Energy Agency
ISO	International Organization for Standardization
JORC	The Australasian Code of Reporting of Exploration Results, Mineral Resources and Ore Reserves
KPI	Key Performance Indicator
kg	Kilograms
LOMP	Life of Mine Plan
MPA	Maximum Potential Acidity (MPA)
MFS	Mt Fred South
MSR	Mussel Shell Reactor
NAF	Non-Acid Forming
NATA	National Association of Testing Authorities
NAPP	Net Acid Production Potential
NPV	Net Present Value
NZ	New Zealand
PAF	Potential Acid Forming
PHCC	Premium Hard Coking Coal
PCI	Pulverised coal for injection
PHCC	Premium hard coking coal

PVC	Polyvinyl chloride
Ro(max)	Maximum Reflectance of Vitrinite
ROM	Run of Mine
SSCC	Semi soft coking coal
SHCC	Semi-hard coking coal
SDS	Sustainable Development Scenario
TWh	Terra Watt hours
USGS	United States Geological Survey
VDT	Vegetation Direct Transfer
WWHCC	Whareatea West HCC premium product

Definitions

Aromatic Carbon	Aromatic carbon is carbon found in stable, ring-shaped molecular structures (aromatic rings), and is an important indicator of coal maturity and quality in geological and mining contexts.
Aliphatic Carbon	Aliphatic carbon is found in the molecular structure of coal, especially in lower-rank coals (such as lignite and sub-bituminous), where the proportion of aliphatic carbon is higher. The presence of aliphatic carbon affects the chemical reactivity, calorific value, and coking properties of coal.
Ash	Refers to the non-combustible mineral matter remaining after the coal has been burned
Beneficiation	A process used in the mining industry to upgrade the quality of the run of mine (or raw) coal or ore by separating out the material that degrades the overall product. The goal of the ***beneficiation*** process is to improve the economic value of the coal or ore by increasing the concentration of the desired component.
Blast Furnace	A large, vertical, tower-like smelting furnace used primarily for the extraction of metals—most notably iron—from their ores. It operates by introducing a blast of hot, compressed air from below, which enables rapid combustion and high temperatures necessary for smelting.
Carburising agent	Material used in steelmaking process that introduces carbon into iron or steel. This process increases carbon content of the metal which improves its hardness and other mechanical properties.
Calorific value	Refers to the amount of energy released when a specific amount of coal is completely burned.
Coalification	The transformation of peat into coal. The coalification process concentrates the carbon content and transforms peat into lignite (stage 1), then sub-bituminous coal (stage 2), then bituminous coal (stage 3) and then anthracite (stage 4). Lignite has the lowest carbon concentration and anthracite has the highest carbon concentration.
Coal type	Directly relates to the types of vegetation that formed the peat in the first instance and the conditions under which the coal was buried and transformed over millions of years
Coal rank	Classifies coal based on the coalification stage of the rock

Coke	Is a solid reductant made by heating bituminous coal (a special type of coal) in the absence of air to produce a hard porous material that is nearly pure carbon. Coke is an essential ingredient for steel production
Core coal seam	A cylindrical sample of coal and surrounding rock that is extracted intact from the ground.
Engineered Landform (ELF)	An Engineered Landform is a term used to describe the final landform which has been designed and constructed to be free draining and long term stable, chemically and geotechnically
Feasibility Study	A comprehensive, detailed evaluation of a proposed mining project to determine whether the resource can be mined economically within regulatory requirements.
Pre-Feasibility Study	An early-stage evaluation of a project's potential. It aims to determine whether the project is viable to justify progressing more detailed investigations and support regulatory applications.
Fixed carbon	A measure of the amount of non-volatile carbon remaining once volatile matter and moisture have been driven off during heating
Fluidity	A key property that measures how easily coal transforms into a viscous, molten, plastic state when heated; crucial for its use in making coke
Inherent moisture	The water within the microscopic structure of the coal, generally filling the pores.
JORC Code	Provides a mandatory reporting system for the classification of minerals Exploration Results, Mineral Resources and Ore Reserves according to the levels of confidence in geological knowledge and technical and economic considerations.
Lithologies	Refers to the physical and chemical characteristics of rocks including their mineral composition, grain size, texture and colour. In mining and geology, lithologies describe the different types of rock units encountered in a deposit or formation. Examples include sandstone, mudstone, conglomerate, coal and claystones.
Metamorphic processes	transforms existing rocks into new ones through heat, pressure, and chemical reactions, without melting them. This occurs deep within the Earth or at tectonic plate boundaries.
Mine subsidence	Any underground excavation will lead to a response from the overlying overburden strata (or rock). This response is called "**mine subsidence**" and it consists of downward deformation of the strata towards the underground excavation due to gravity and may involve a degree of overburden dislocation and/or rock failure
Orthophoto	an aerial image that has been geometrically corrected to remove distortions such that it creates a "map like" image which makes it possible to use the image for accurate measurements of distance, for example, and direct overlaying with other map data
Peneplain	A **peneplain** is a broad, nearly level land surface produced by long-term erosion and weathering, which reduces the landscape to a gently undulating plain with minimal relief. It represents the final stage of fluvial erosion during which the land is worn down almost to base level, leaving only isolated hills or residuals.

RoMAX	A measure of the maximum reflectance of vitrinite used as an indicator of relative rank
Rotary breaker	A large industrial machine that is used for crushing and sizing coal and/or rock, and can separate some waste material from the usable product. It consists of a large rotating cylinder that effectively breaks the rock into smaller pieces and separating softer coal from harder stone/rock.
Sankey Diagram	A tool used to represent the blending of coals from various mining pits and the spread of products that meet customers specifications.
Sedimentary Rock	Rock that forms from the accumulation and compaction of mineral and organic particle, such as sand, mud or plant material often in layers. Over time, these materials are buried and harden into rock through pressure and chemical processes.
Stockpile Stacking	The process of piling coal of a similar quality or specification into large mounds for storage, using machines called stackers. Various proportions of the stacked coal can be blended to achieve an overall coal quality required by a customer.
Sulphur	An undesirable coal constituent and its presence stems from the environment within which the coal was formed.
Vitrinite	The primary reactive component in carbonisation that acts as a binding agent enabling the creation of coke. Vitrinite is formed from altered remains of the woody parts of plant material that formed the peat
Volatile matter	A measure of the non-water gases formed and released from heating and burning coal.

Executive Summary

Background

Coal is a diverse geological material with significant variation in how it forms, what it contains and how it can be used. Some types—such as the rare coals of New Zealand's (**NZ**) West Coast—are especially valuable. This document focuses on the unique coals of the Buller Plateaux Continuation Project (**BPCP**), the mining methods used to extract them and the technical terminology needed to understand their properties. The purpose of this document is to help readers better appreciate the science, value and specific uses of coal proposed to be extracted from the BPCP.

All Coal is not created Equal

Vegetation types that formed NZs West Coast coal is approximately 200 - 170 million years younger than typical Australian coal types. The processes that formed the coal were a lot faster, being driven by geological disturbance, plate tectonics, squeezing and folding, rather than the peat being buried and squeezed over time.

The majority of the coal from BPCP will be used to make coke for iron making. Blast furnace iron making is still the dominant method of making steel (Iron becomes steel when carbon is added and the impurities are removed, making it stronger and more versatile), particularly in developing economies such as India. Whilst steel can be recycled, there is simply not enough steel available to recycle in a developing economy to meet demand. The production of "green steel" is in its infancy and whilst promising, it is facing significant challenges. Therefore, for the foreseeable future (that is the next 20-30 years as a minimum), the manufacture of steel using coal and coke will continue and Buller Plateaux coal will continue to be in high demand.

A suite of Technical Expertise

Coal resources are identified and assessed through a long exploration phase involving drilling, mapping, sampling, analysis and advanced geological modelling. Once the geology is understood, mining engineers—together with environmental specialists—design the most efficient extraction and rehabilitation plans, turning geological models into mining models. Coal processing experts then evaluate coal quality to determine processing and blending requirements, while civil engineers design the necessary supporting infrastructure. Alongside this, complex mine planning incorporates selective overburden (the material above the coal seam) removal and placement, water treatment and management, coal extraction and rehabilitation requirements.

The variety of coals available from the multiple pits proposed for the BPCP is critical to consistently meet customer blend specifications, highlighting the highly skilled, multidisciplinary nature of the entire operation. This document aims to explain the scientific, technical and highly coordinated processes and technical expertise required to find, extract, process and blend coal to meet customer specifications.

Buller Plateaux Coal – a rare commodity

The coal from the Buller Plateaux has unique properties and for this reason, the coal products and blends are highly sought after by steel manufacturers around the world. As a result of its special qualities, high carbon content and high energy rating, less coal is needed to produce a tonne of steel. Flowing on from these benefits comes reductions in greenhouse gas emissions and significant cost savings for steel producers.

The BPCP is a nationally and regionally significant project

The economic benefits from the BPCP are nationally and regionally significant. [redacted]

[redacted]

1 Introduction

Modern civilisation was built on the Industrial Age, which relied heavily on the use of natural fuels and metals. Without these natural resources, there would be no cars, rapid air travel or even many of today's renewable energy technologies. Most importantly, the current standard of living in New Zealand (**NZ**) would not be possible without the widespread use of these natural materials.

Natural fuels come in different forms, and one of the more common fuels consumed today is coal. Coal is not just a rock that can be burnt, there are different coal types that are used for very different purposes. Coal is a complex geologic material varying widely in its formation processes, its constituents and its uses. There are some coals that are quite rare and are highly prized such as NZ's West Coast coals.

The purpose of this document is to introduce the science behind different types and grades of coal focussing on those associated with the Buller Plateaux Continuation Project (**BPCP**) which are predominantly used for industrial steel making. This document will also define some of the more technical terms so that the reader can be more fully informed to understand the science behind, the value of and use of coal, specifically, the coal from the BPCP.

2 Coal – a Complex Geological Material

2.1 What is coal?

Coal is a sedimentary rock[1] comprised of predominantly carbon that is combustible, meaning that it is formed by the accumulation in a peat bog with little sedimentary input, with subsequent burial and alteration transforming it to coal. It is geologically unusual for peat to accumulate and then to be preserved to be transformed into coal.

Coal is used in a number of ways, for electrical generation or if the coal is a particular ***rank*** **(Section 2.3.1)** and ***type*** **(Section 2.3.2)**, it can be transformed into ***coke*** (**Section 2.5**), an essential ingredient for making iron and refining into steel[2] (**Section 3**). In addition to its use as a fuel, coal is a raw material from which nylon and many other plastics as well as organic chemicals can be made for use in dyes, fertilisers and clothes.

Coal tells a story unlike most sedimentary rocks. Instead of being eroded and carried far from its source, coal is formed right where lush plants once thrived millions of years ago. Those plants fell into ancient swamps, where oxygen-starved waters created the perfect setting for transformation. In these stagnant pools, oxygen was very low, and anaerobic bacteria went to work, breaking down plant matter and concentrating carbon. Over time, the microbes turned this material into peat—until acids from decaying plants wiped them out, leaving behind the raw ingredients for coal

KEY TAKEAWAY

Coal is a special type of rock that is combustible. There a different coal ranks and types that are not all the same. Coal is located only where it was laid down, so is confined to only certain locations.

[1] Sedimentary rock – Rock that forms from the accumulation and compaction of mineral and organic particle, such as sand, mud or plant material often in layers. Over time, these materials are buried and harden into rock through pressure and chemical processes.

[2] Skinner, B.J. and Porter, S.C. (1987). Physical Geology.

2.2 What is coalification?

Coalification is the transformation of peat into coal. Under geologically usual circumstances, peat is formed, then buried by other sediments in a subsiding basin. In response to burial and increase in temperature and pressure leads to chemical and physical changes in the peat. Although coalification is a continuum, the degree of coalification is termed "rank" Rank classifications within the ***coalification process*** include ***lignite*** (stage 1), then ***sub-bituminous coal*** (stage 2) then ***bituminous coal*** (stage 3) then ***anthracite*** (stage 4). Importantly, the coalification process is not just associated with physical compressional changes; there are also significant chemical changes that occur at that same time[3].

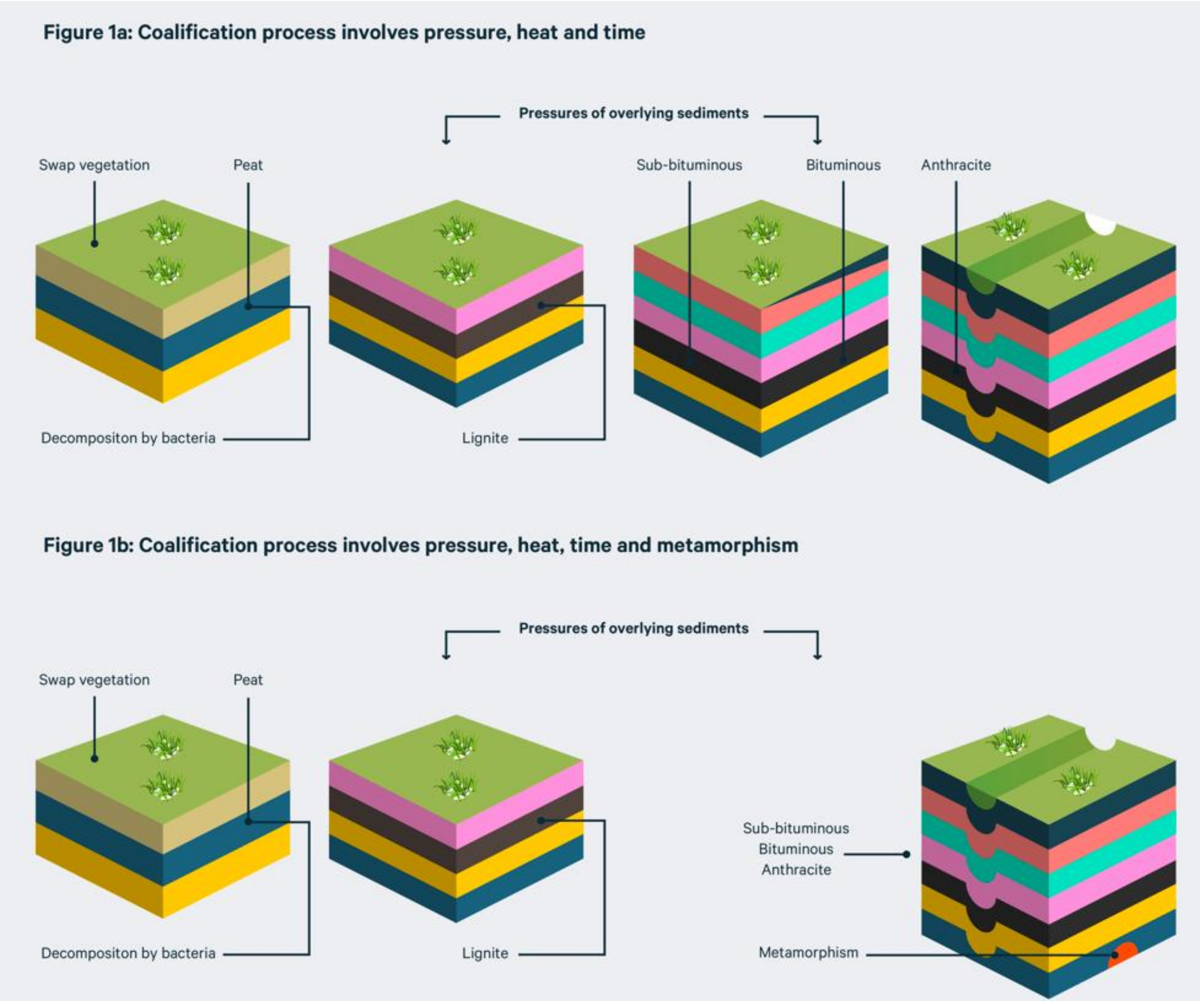

Figure 1a/b: Coalification process involves pressure, heat and time

The transformation of peat into coal can occur in a tectonically active environment where burial and uplift may be geologically "fast" or the nearby intrusion of volcanic materials (i.e. igneous dykes)[3].

Most of the world's coals were formed around 200-350 million years ago where vegetation was dominated by giant club mosses, tree ferns, horsetails and the earliest examples of seed-bearing plants such as conifers and seed ferns[4]. By comparison, Australian coal resources were formed approximately 299 – 145 million years ago.

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[3] Skinner, B.J. and Porter, S.C. (1987). Physical Geology

[4] www.bgs.ac.uk

NZ's West Coast coals were formed around 35 (Brunner coal measures) to 60 (Paparoa Coal Measures) million years ago, from more evolved vegetation types containing flowering plants[5]. The West Coast Paparoa coal measures were established within narrow, elongate, fault basins known as the Paparoa Trough[6]. The Brunner coal measures accumulated on a peneplain. Accumulation of the Brunner coal measures was followed by a marine incursion (inundation of land by ocean waters caused by sea level rise), approximately 34 million years ago to 23 million years ago. This resulted in up to 2,500 metres of marine sediments being deposited into the trough over the coal bearing sediments, which were later uplifted by a major change of tectonic activity – a process termed ***inversion tectonics***. Consequently, the peat material underwent a quick coalification process caused by plate tectonic activity resulting in a young bituminous coal rank at high altitudes. Another important aspect of NZ West Coast coal is that the original vegetation forming the peat was very different to other coal materials across the world with some very unusual properties, giving them high value for specialised purposes[7].

KEY TAKEAWAY

The vegetation that formed NZ's West Coast coal is approximately 275 million years younger than the majority of the worlds coal deposits and approximately 200 – 170 million years younger than Australian coals. Not only is NZ's coal a lot younger, the coalification process was a lot faster, being driven and metamorphosed by geological disturbance, plate tectonics, squeezing and folding, rather than by peat being buried and squeezed for c. 200 million years as is the case for other coals around the world. The estuarine environment within which NZ's West Coast coal was created has also resulted in the development of special properties within the coal. The coal found within the Buller Plateaux, is a very special commodity as a result of its situational and formation processes.

There are four stages of the coalification process, the transformation of peat into coal, being "lignite", "sub-bituminous", "bituminous" and änthracite" which defines the "rank" of the coal. Each stage concentrates the carbon content and modifies chemical and physical properties. As a result, each coal stage (or rank) is suitable for different uses.

2.3 Coal Rank and Types – Lignite to Anthracite

2.3.1 Coal Rank

Four main rank classifications (see Figure 2) are defined by the United States Geological Survey[8] as follows:

- **Lignite**: or brown coal, is the lowest grade of coal with the least concentration of carbon. Lignite has a low heating value and a high moisture content and is mainly used in electricity generation.
- **Sub-bituminous** : is black in colour and is mainly dull (not shiny), Sub-bituminous coal has low to moderate heating values and is mainly used in electricity generation
- **Bituminous**: is between sub-bituminous and anthracite. Bituminous coal usually has a high heating value and is used in electricity generation and steel making. It is blocky and appears

[5] www.teara.govt.nz
[6] www.solidenergy.co.nz
[7] www.teara.govt.nz
[8] www.usgs.gov

shiny and smooth, and has thin alternating shiny and dull layers. Bituminous coal has different grades as further discussed in **Section 2.5**.

- **Anthracite**: is the highest rank of coal. It is hard, brittle and black lustrous, often referred to as hard coal, containing a high percentage of fixed carbon and a low percentage of volatile matter. Typically, anthracite contains 86-98% carbon, producing more heat per weight unit and it burns cleaner due to its high carbon content and low impurity levels.

Figure 2: Coal Types or Coal Rank[9]

Rank stages are a system imposed on a continuum, with changes including:

- A decrease in air dried moisture
- An increased proportion of carbon with increased aromaticity (more aromatic carbon versus aliphatic carbon structures)
- Decreasing oxygen and then hydrogen concentrations
- Increasing calorific value (due to increased proportion of carbon)
- Development and then loss of thermoplastic properties

Figure 3 summarises the four coal ranks, relative energy and moisture properties as well as their preferred uses ("**thermal coal**" or "**metallurgical coal**") driven by the chemical changes in the coal.

[9] https://history.alberta.ca/energyheritage/coal/early-coal-history-to-1900/global-coal-formation/coal-properties.aspx#page-2

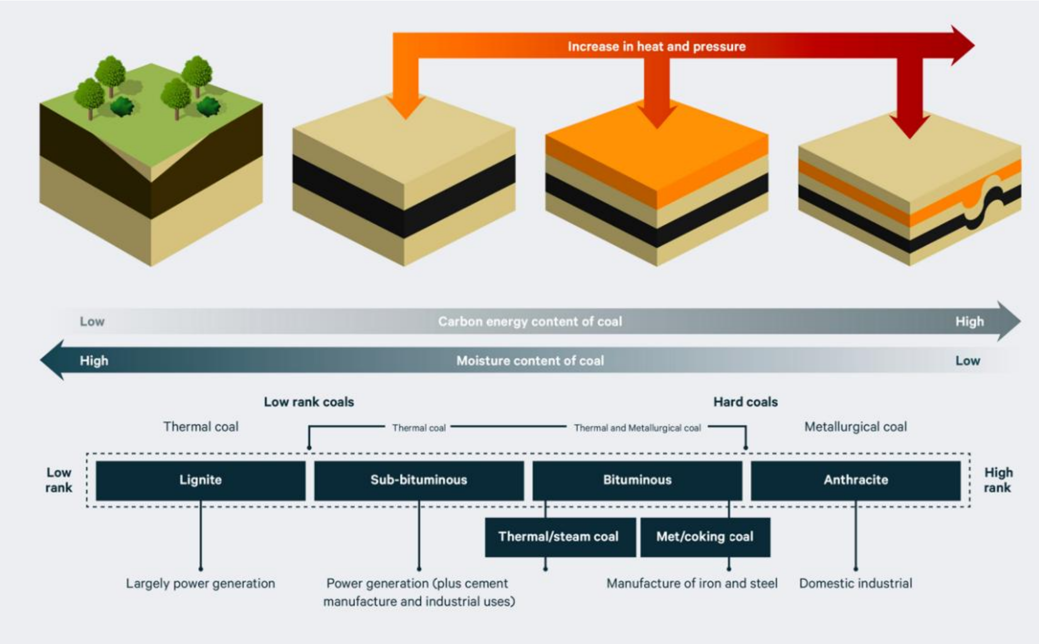

Figure 3: Coal rank and classification[10]

2.3.2 Coal Type

Coal "***type***" is directly related to the types of vegetation that formed the peat in the first instance and the conditions under which the coal was buried and transformed over millions of years. For example, different types of plants, such as woody vegetation versus algae, spores, flowering plants, lead to distinct types of coal with very different properties[11].

On the microscopic level, coal is made up of organic particles called macerals. Macerals are the altered remains and byproducts of the original plant material that formed the peat. Macerals are to coal as sediment grains and cements are to sedimentary rocks (i.e.. Sandstone) and are formed from different plant parts or different residues of bacterially, chemically or physically broken-down plant parts[12].

Coal petrographers (people who study coal under a microscope) separate macerals into three groups, each of which includes several maceral types. The groups are ***inertinite***, ***liptinite***, and ***vitrinite*** (see **Figure 4**). These groups are defined according to their greyness in reflected light under a microscope. Liptinites are dark grey, vitrinites are medium to light grey, and inertinites are white[13].

[10] Coal Rank and classification (https://whitehavencoal.com.au/wp-content/uploads/2023/06/WHC-Coal-Quality-Presentation-for-analysts.pptx.pdf

[11] teara.govt.nz/en/coal-and-coal-mining/page-1

[12] www.uky.edu

[13] www.uky.edu

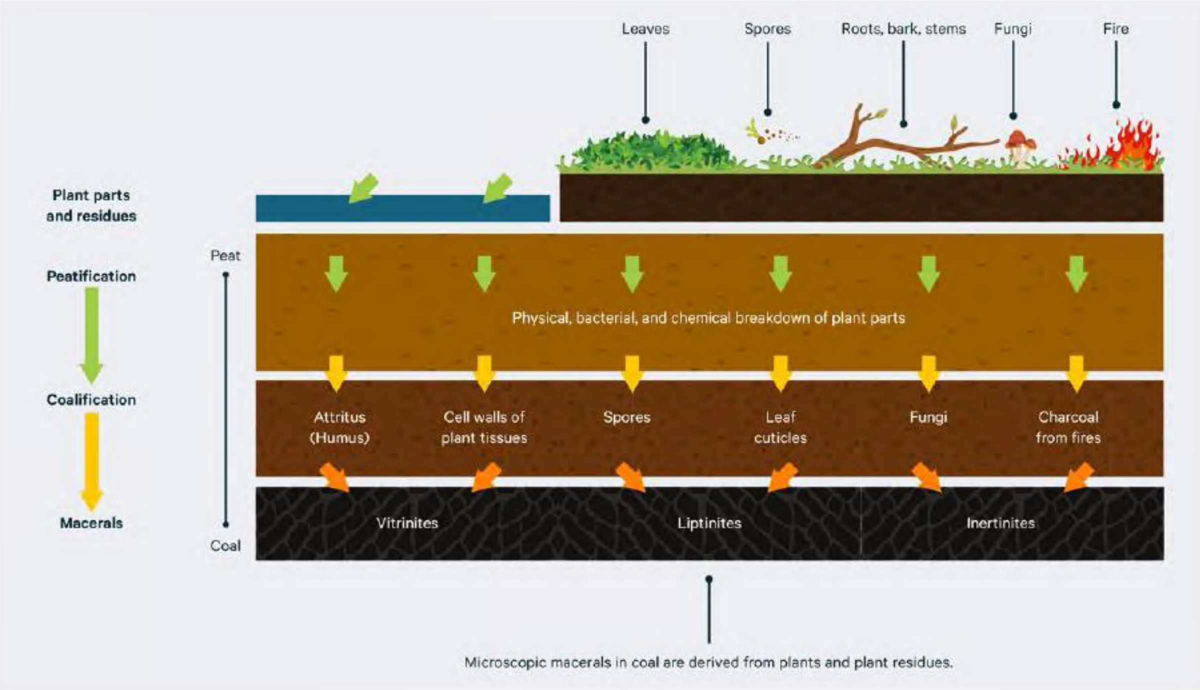

Figure 4: Development of coal[14]

Vitrinite is a very important component for steel making coal because it is the primary reactive component that acts as a binding agent enabling the creation of coke (see **Section** Error! Reference source not found.). Of relevance to metallurgical coal is the relative proportion of vitrinite. We can determine how much vitrinite is contained within coal by its vitrinite reflectance. Vitrinite reflectance is commonly used to infer coal rank and is useful as it reflects its technological properties. There are several types of vitrinite reflectance (**Ro**) measurements, the most important one being "RoMAX". RoMAX is the maximum vitrinite reflectance and is a most reliable measurement when assessing coal rank. Generally speaking, a high Ro means that the coal has a higher proportion of fixed carbon and energy value along with lower volatile matter and lower moisture – which are also necessary characteristics for coals used in the steel making process.

KEY TAKEAWAY

There are different ranks and types of coal. Most coals can contain vitrinite, however, the proportion of vitrinite varies widely. NZ's West Coast coals are characteristically higher in vitrinite (at > 86%) compared to other international equivalents such as Australia (55-65%). This makes NZ's West Coast coal highly sought after because Vitrinite-rich coal tends to have better coking properties making them valuable for industrial applications (i.e. metallurgical coal).

2.4 Important Coal quality parameters

Coal's chemical properties are crucial in steel making because they directly affect the quality and efficiency of the stell production process. Properties of interest for coal used in the steel making process can be divided into three categories, being **Chemical**, **Plastic** and **Petrographic**. Under each category there are several parameters that are crucial for steel manufactures to know before they

[14] Development of Coal (source: https://www.uky.edu/KGS/coal/coal-macerals.php)

purchase and utilise coal material. The remainder of this section defines some parameters of particular interest.

- Chemical properties[15].
  - Inherent moisture – refers to the water within the microscopic structure of the coal, generally filling the pores. Moisture absorbs heat, so high moisture content in coal reduces the relative efficiency of heating when a coal is combusted. Lower rank coals tend to have a higher moisture level. For steel manufacturing, a low moisture content is preferred because it improves efficiency in the steel plant, allows the coal to burn hotter. Lower moisture means less energy wasted on evaporating water, making the process more cost effective.
  - Ash – refers to the non-combustible mineral matter remaining after the coal has been burned. Ash content can vary widely from a low of 1% to as high as 55%. High ash coal reduces the calorific value of coal. In the steel industry, a low ash coal content is preferred and highly valuable. For steel manufacturing, a low ash content is preferred because it reduces impurities introduced into the steel.
  - Volatile matter – is a measure of the non-water gases formed and released from heating and burning coal. Volatile matter is directly related to coal rank; as rank increases, volatile matter content decreases. As volatile matter is driven from the coal material with increasing rank, the relative carbon percentage tends to increase and this is preferred for steel manufacturing because more carbon is available for iron production reduction reactions making the process more efficient and produces higher quality coke improving steel quality.
  - Sulphur – is an undesirable coal constituent and its presence stems from the environment within which the coal was formed. For example, coal with a high sulphur content is usually associated with marine influenced environments where sulphate rich sea water interacted with peat swamps. Coal with a sulphur content ranging between 3% - 6% is considered high. If steel making coal has too much sulphur it can increase sulphur content in the final steel product, leading to brittleness[16]
  - Fixed carbon – is a measure of the amount of non-volatile carbon remaining once volatile matter and moisture have been driven off during heating. Fixed carbon content increases with coal rank and is important for steel making because more carbon is available for reduction reactions making the process more efficient and producing higher quality coke improving steel quality.
- Plastic properties:
  - Fluidity – is a key property that measures how easily coal transforms into a viscous, molten, plastic state when heated; crucial for its use in making coke. It reflects the coal's ability to form a strong, coherent carbon structure. A higher fluidity typically indicates a greater ability to produce quality coke, influencing factors like particle bonding and pore structure[17]. Fluidity gives an indication as to whether a coal will bind in a coke blend.

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[15] ALS Coal Quality Course, Brisbane September 2022
Karr, C. (ed) (1979) Analytical Methods for Coal and Coal Production (3 volumes) Academic Press
Osbourne, D. (ed) (2013) The Coal Handbook. Woodhead Publishing. Particularly Volume 1: Coal Production.
Thomas, L. (2013) Coal Geology (2nd edition). Wiley-Blackwell
[16] Zhang et al (2025). Effect of volatile matter and ash composition on the migration of organic sulphur during pyrolysis of high sulphur coal. Journal of Analytical and Applied Pyrolysis. Volume 191, October 2025, 107222
[17] Kumar, P. & Barman, Sagar & Singh, S. & Ranjan, Menaka. (2008). Influence of coal fluidity on coal blend and coke quality. Ironmaking & Steelmaking. 35. 416-420. 10.1179/174328108X335113

Some fluidity is required in a coke blend, but excessive fluidity can lead to a weak frothy coke.

- Coal swell number (**CSN**) – the coal swell number is also known as the Free swelling index and it measures a coal's ability to swell when heated. It is a crucial indicator of a coal's coking properties.

- Petrographic properties.
  - Vitrinite reflectance and RoMAX have been discussed in **Section 2.3.2.** Vitrinite softens and swell in coke making (cf intertinites that exhibit lower or no thermoplastic properties), releasing volatiles, resulting in a strong porous carbon rich residue termed "metallurgical coke". The reflectance of the vitrinite is the key driver of coke strength, a critical requirement for coke in a blast furnace.

KEY TAKEAWAY

Coal is a complex geologic material and not all coals are the same. Coal used for steel manufacturing must have specific properties. The coal quality parameters listed above are just a sample of coal quality parameters that are used to classify and grade coal. There are additional coal quality parameters that individual steel manufacturers will focus on that are specific to their coke production and blast furnace design requirements. Depending on the coal rank, coal type and its formational location and processes, the qualities and properties of different coals can vary widely.

2.5 Difference between Thermal Coal and Coking Coal

Bituminous coal with the appropriate thermoplastic properties may be suitable to make coke, a key ingredient for iron production. Thermal coal is used for power and process-heat generation which uses a wide range of coals that may lack coking properties and/ or have other properties which are not suitable for steel making (low swell etc).

But Coke is not Coal – so what is Coke?

Coke is a grey, hard, porous fuel with a very high carbon content formed from bituminous coal. **Figure 5** presents a picture of pulverised bituminous coal and coke. Coke is formed by heating the coal in the absence of oxygen to temperatures of up to 1,250 degrees Celsius (ºC), resulting in a coke, which is a porous substance that is nearly all carbon[18]. The role that coke plays in the manufacture of steel is discussed further in **Section 3.**

[18] corporate.arcelormittal.com

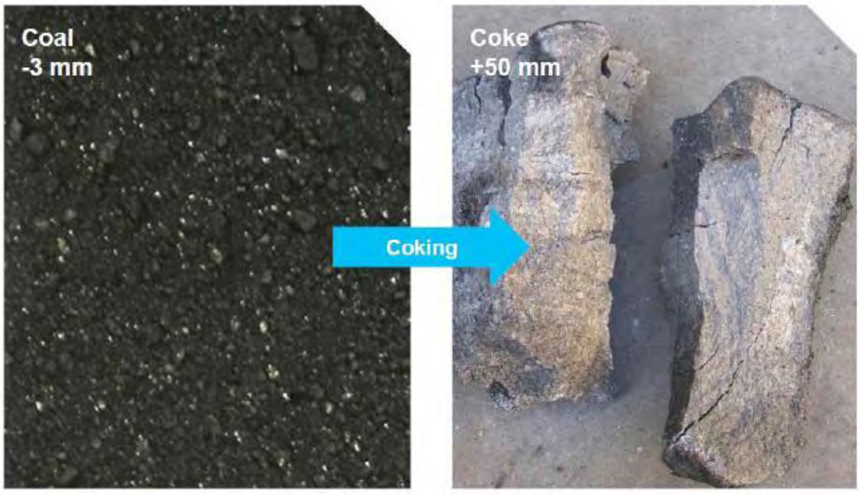

Figure 5: Representation of coal transformed into Coke[19]

The main difference between thermal coal used for power / heat generation and coking coal used for steel production is the coal's rank and quality as presented in **Table 1**.

Table 1: Main Differences between Thermal Coal and Coking Coal

Thermal Coal	Coking Coal
generally lower fixed carbon, higher ash and moisture, lower vitrinite content	higher fixed carbon content, lower ash and a high vitrinite content
does not swell very well	ability to swell, with a high "coal swell number" and indicates strong gluing properties in the coke blend
cannot transform into a viscous, molten, plastic state when heated. cannot physically transform into coke, the necessary ingredient for making steel.	ability to become molten and viscous and then resolidify to a strong porous material ability to form coke

KEY TAKEAWAY

Coking coal and thermal coal are very different materials. The properties of thermal coal cannot produce coke. Coking coal is used to produce coke which is an important ingredient for the steel making process.

2.6 Grades of Coking Coal

2.6.1 Coking Coal Grades

There are several "**grades**[20]" of metallurgical (coking) coal as presented in **Table 2**.

Table 2: The FIve Grades of Metallurgical (Coking Coal)

[19] Whitehaven Coal, Coal Quality Workshop 2023: https://whitehavencoal.com.au/wp-content/uploads/2023/06/WHC-Coal-Quality-Presentation-for-analysts.pptx.pdf
[20] https://www.bhp.com/what-we-do/products/metallurgical-coal#

Premium hard coking coal	Hard coking coal	Semi-hard coking coal	Semi soft coking coal	Pulverised coal for injection
PHCC	HCC	SHCC	SSCC	PCI
excellent coke strength a critical requirement for coking coal more expensive due to limited international resources	generally lower coke strength than a PHCC coking coal	generally commands a lower price due to its lower rank sought after to reduce ash in coking coal blends and as a binding agent	lower rank a cheaper source of carbon in the coking coal blend	required for producing blast furnace heat, carbon monoxide (as a reducing agent) as a cheaper replacement for some of the metallurgical coke requirement in a blast furnace

A mixture of coal grades are required in coke-making to make a strong coke. A single coking coal grade/type generally cannot produce the coke required for steel manufacturing. A coking coal blend is like a cake recipe: a specific mixture ratio of ingredients is required or the cake (coke) will not bake. It is not possible to make a cake with just flour; other ingredients are needed such as sugar (for sweetness), eggs (for binding, moisture and overall cake structure), baking powder (to make the cake rise and for an airy texture), butter (for flavour, mouthfeel and an airy texture). Just like the cake, different grades of coking coal are required to produce the optimal coke blend in the steel manufacturing process. However, the terminology for the "coke recipe" is called a "**coking coal blend**".

KEY *TAKEAWAY*

Coke ***is produced*** from a blend of different coals that have special properties and it is a specialised process. Coal blends are heated and must be able to melt and then reform into a strong, porous, high energy product. Coke is considered a nearly pure form of carbon.

Table 3: Baking a cake and coal blend recipe analogy

Cake v's Coke blend recipe

Cake Ingredient	Coking Coal Type	Purpose in Coal Blend
Sugar – for sweetness	Semi Soft Coking Coal (SSCC)	Adds balance and reduces cost; may improve plasticity and gas release[21]
Flour – for structure and texture	Semi Hard Coking coal (SHCC)	Provides structure; generally better thermoplastic properties to improve binding in the blend; may be lower in ash than HCC's
Butter – for airiness, flavour	Hard Coking Coal (HCC)	Essential for strong coke; high quality, supports blast furnace operations. Other, less expensive coking coals are also added

[21] Seiji Nomura, 2019, 12 - The development of coke making technology based on the utilization of semisoft coking coals; New Trends in Coal Conversion

		to the blend to meet cost and energy requirements, as hard coking coal is a scarce and high-cost resource
Eggs – for airiness, and structure	Premium Low-Volatile Coal	Enhances coke strength; low volatile matter (higher coke yield), improves steelmaking efficiency

Companies that make coke and steel purchase different coals to make up the required blend for their specific processes. **Buller Plateaux coking coals are sought after by steel producers because of the high rank (CSN** – coals ability to swell when heated**, Vitrinite and RoMAX** – see **Section 2.3.2) and low ash properties.**

KEY TAKEAWAY

There are five grades of coking coal based on various coal quality parameters. A single coking coal grade/type cannot produce the coke required for steel manufacturing. Steel manufacturers prefer certain blends of coking coal grades to suit their bespoke processes and they tend to have their own recipes. As an analogy, a cake cannot be baked with only flour.

2.6.2 Importance of Coke in the blast furnace

A blend of different coal types and grades are transformed into coke. Producing coke is a specialised process as it is important that the coke produced is able to do the following in a blast furnace[22]:

1. Provide a permeable medium to allow liquid metal to drip down to the tap holes and reducing gasses to migrate upward. A blast furnace operates at ~1600°C in the lower regions, by which stage coke is the only solid material. As a result, coke needs to be very strong.
2. Burn in the lower part of the furnace to provide heat to drive the steel making process.
3. Provide carbon monoxide from combustion in Point 2 to undertake the chemical reduction reactions with the iron ore. The more carbon available in the coke to undertake the reduction reactions the better, so lower ash coke is an advantage.

The role of coke in the blast furnace is further detailed in **Section 3.**

There are a number of coke blend design schemes that tend to all have a rank factor and a caking (thermoplastic; gluing) factor. Vitrinite reflectance (a rank indicator) is the primary driver of coke strength (**Figure 6**) and a caking index is used to assure sufficient binding in the blend.

[22]ALS Coal Quality Course, Brisbane September 2022
Chatterjee, A. & Krishnan, S.H. (2024) Insight into Coal and Coke for Ironmaking. University Science Press
Diez, M, Alvarez, R. and Barriocanal, C. (2002) Coal for Metallurgical Coke Production: Predictions of Coke Quality and Future Requirements for Coke making. Int Jnl of Coal Geology V50, p389-412
Loison, R., Foch, P. and Boyer, A. (1989) Coke Quality and Production. 2nd Edition. Butterworths & Co

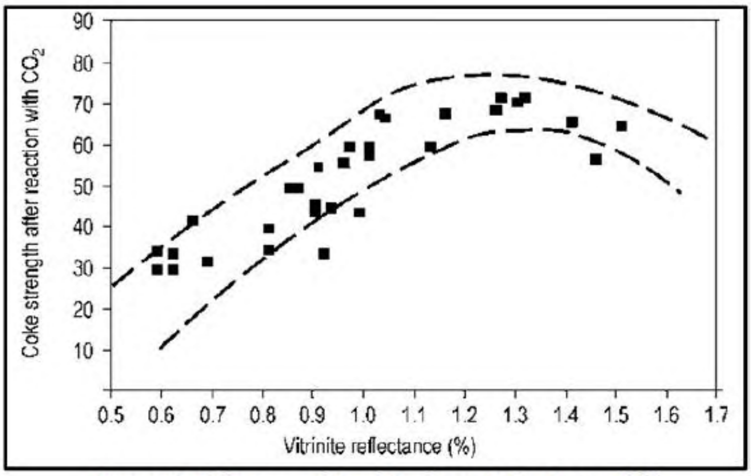

Figure 6: Influence of Coal Rank on Coke Strength[23]

KEY TAKEAWAY

Coke is produced from a blend of different coals that have special properties and it is a specialised process. Coal blends are heated and must be able to melt and then reform into a strong, porous, high energy product. Coke is considered a nearly pure form of carbon.

2.7 NZ West Coast Coking Coal – why is it sought after?

NZ's deposits of coking coals[24] are found only on the West Coast of the South Island, are relatively young[25] in age and are high in vitrinite.

The major Buller (and Greymouth) coalfields on the West Coast show rapid lateral variation in coal rank[26], reflecting the unique geological conditions during the coalification process. This has resulted in seams where coal quality changes rapidly both laterally and vertically across a deposit.

Overall, the combination of low ash, high vitrinite (rank) and extremely low phosphorus makes the NZ coking coals unique in the global market[27]. **Table 4** presents the typical Buller Plateaux coal quality parameters[28] that coking coal buyers repeatedly and specifically seek.

Table 4: Buller Plateaux Coking Coals – Typical Coke strength and coal rank

Parameter	Typical Buller Coal	Typical Australian Coal	Coking Purpose
Coke strength	55-60	55-70	Lower coke strength increases the coke rate of the furnace per tonne of hot metal (examples: +1% M25 (cold coke strength index) reduces coke rate by 3kg coke/t of hot metal; +1 unit of CRI (coke more reactive so CSR lower) increases coke rate by 1.5kg/t hot metal)

[23] 2002, Diez, Alvarez & Barriocanal
[24] Sherwood, A. (2019) The Geology & Resource of New Zealand Coalfields. Monograph 33. NZP&M/ AusIMM publication
[25] Approximately 35 million years old for the Brunner coals located on the Buller Plateaux
[26] Suggate, R.P & Boyd, R.J. (2010) Greymouth Coalfield, New Zealand: Coal Ranks in the Context of Basin Development. MBIE Unpublished Coal Report CR3388

Coal rank	0.9-1.3 RoMax	0.95-1.47 RoMax	Essential for strong coke; high quality, supports blast furnace operations. High rank coking coal allows the coke producer the opportunity to blend in lower rank coals providing a cost advantage for steel production.
Low ash	3.5% -5.5% Currently	7.5% -10.6%	Slag is a by-product of steel production and consumes some of the coking coal within a blast furnace. A low ash coking coal produces lower amounts of slag. Low ash means less heat is wasted on melting impurities, less flux (to assist melting the ash) is required, and the slag rate is lower. Reduced ash also generally improves coking coal strength by reducing impurities.
Low phosphorus	.005%	0.015%	High phosphorus content in coal is undesirable for steel production because it can make the resulting metal fragile NZ coals are very low in phosphorus (0.005%) due to their unique depositional environment.

As a result of the high vitrinite and low ash, quality is improved and the amount of fuel (coking coal and PCI) required to produce a tonne of steel is reduced. Reducing the amount of fuel required gives BPCP customers an immediate commercial benefit by reducing their coal purchases.

KEY TAKEAWAY

NZ's West Coast Coals contain very special properties for making coke and are highly sought after by the steel manufacturing industry.

3 Coking Coal essential for Making Steel

3.1 The Steel Making Process[29]

The process to generate steel, presented in **Figure 7**, commonly consists of the following basic steps:

1. The coking coal blend is fed into ovens and "coked" at ~1000-1250°C in the absence of oxygen to prevent combustion. This step produces coke (left hand image of **Figure 7)**.
2. The coking process removes volatile compounds leaving pure carbon (coke).
3. Coke is sized and fed into a ***blast furnace*** (middle image of **Figure 7** and **Figure 8**) in alternating layers with iron ore and limestone[37]. A ***blast furnace*** is a large counter-current reactor that smelts the iron ore to create pig iron that is tapped out the bottom of the furnace at ~1600°C in liquid form.
4. Pig Iron is further refined in a basic oxygen furnace to make steel where impurities are removed and alloys are added (right hand image of **Figure 7)**.

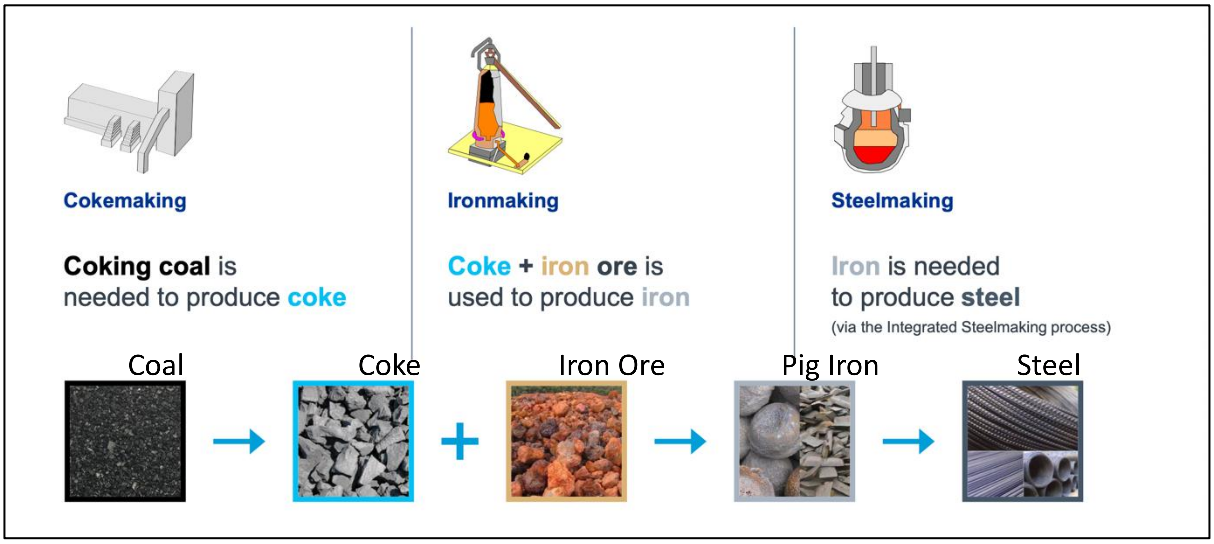

Figure 7: The Steel Making Process [30]

Figure 8 is a simple representation of a blast furnace depicting the physical and chemical roles of coke as discussed above in points 1 – 4, during the iron making process.

[29] Selected references:
ALS Coal Quality Course, Brisbane September 2022
Chatterjee, A. & Krishnan, S.H. (2024) Insight into Coal and Coke for Ironmaking. University Science Press
Diez, M, Alvarez, R. and Barriocanal, C. (2002) Coal for Metallurgical Coke Production: Predictions of Coke Quality and Future Requirements for Coke making. Int Jnl of Coal Geology V50, p389-412
Loison, R., Foch, P. and Boyer, A. (1989) Coke Quality and Production. 2nd Edition. Butterworths & Co

[30] Whitehaven Coal, Coal Quality Workshop 2023: https://whitehavencoal.com.au/wp-content/uploads/2023/06/WHC-Coal-Quality-Presentation-for-analysts.pptx.pdf

[37] Limestone is added to a blast furnace to remove impurities from the iron ore.

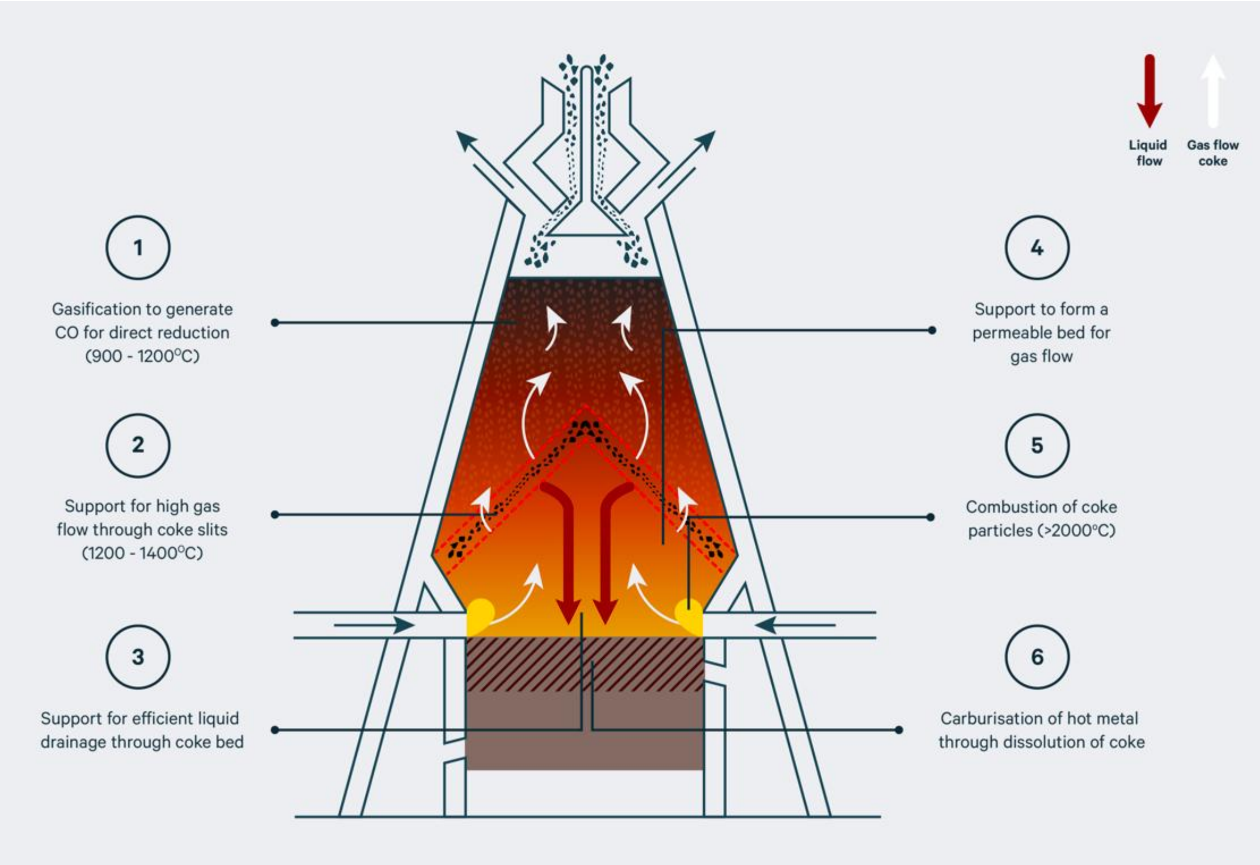

Figure 8: The Role of Coke in a Blast Furnace

In a blast furnace, coke quality is more important than ferrous material quality. The coke has three main roles including:

1. Providing a heat source.
2. Providing reductant source to aid chemical reactions occurring in the blast furnace – introduces carbon monoxide which strips the iron ore of oxygen to produce metallic iron. This process is a key step in converting iron ore into steel.
3. Creating a permeable bed during the iron making process - maintaining good permeability to allow gases to flow through, crucial for efficient heat transfer, chemical reaction and overall process performance. Good permeability reduces the pressure drop across the bed within the furnace, meaning less energy is needed to push the gases through reducing consumptive coal required.

Uses and Users of Steel

Across the world, steel is made and used for other applications including building wind turbines, solar cells, nails, fencing wire, rock bolts (to keep road cutting safe), components, boats, aeroplanes, cars and so on (see **Figure 9**).

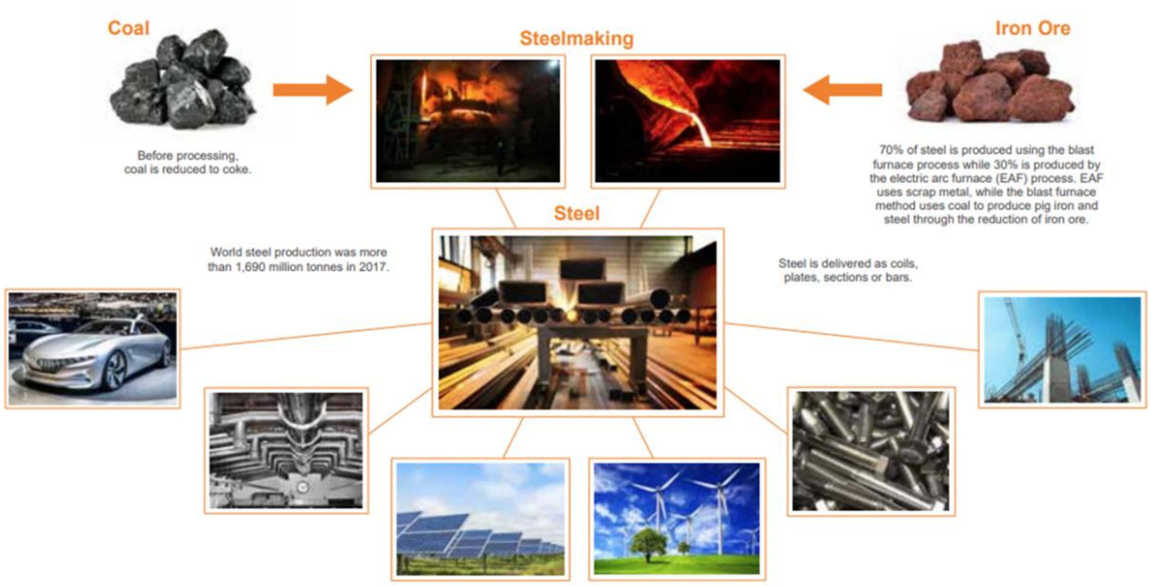

Figure 9: Steel: Raw Ingredients to Final Products

On their website, New Zealand Steel[31] produces steel for a range of industries including for the:

- Construction industry – steel framing, colorsteel® for roofing, guttering, cladding, zincalume®, galvsteel®, etc.
- Infrastructure – steltech® for bridges, hot rolled steel for beams, tanks, flanges, welded pipes.
- Farming – steel for milking sheds, equipment storage, fencing, fasteners.
- Storage – insulated panels, flooring, beams.
- Manufacturing – high strength structural applications.

The above example is from one manufacturer in NZ.

Scale of Steel Consumption – An example

To consider the scale of steel consumption, let us turn to cars in NZ alone, as an example. CEIC data report that the number of registered vehicles in NZ was 4,712,629 as at December 2024[32]. A typical NZ imported car contains approximately 800 kilograms[33] (**kg**) of steel. To make 800 kg of steel, it requires approximately 600kg of coking coal[34]. Calculating the volume of steel required to build all of NZs cars (registered as at December 2024) equates to approximately 3.8 million tonnes of steel, which would have required 2.8 million tonnes of coking coal to manufacture the steel. This is just one example of scale where steel is used for just <u>one</u> purpose.

Coal from the Buller Plateaux ranges from HCC (best coke strength) to SSCC, (lower rank of coal, see **Table** 2) with much of the coal being low ash. Bathurst Resources exports its coking coal to a range of international customers [redacted] The

[31] https://www.nzsteel.co.nz
[32] www.ceicdata.com/en/indicator/new-zealand/number-of-registered-vehicles
[33] noting that the volume of steel required for a single car can range between 650kg – 1, 200 kg
[34] www.bhp.com

coking coal from NZs West Coast is highly prized sought after because it improves coke strength (using HCC) and decreases coke ash to reduce the amount of coke required to make a tonne of pig iron.

Steel can also be infinitely recycled. Iron ore is the source of approximately 70% of the metallic raw material inputs to steelmaking globally; the rest is supplied in the form of recycled steel scrap. Steel production from scrap requires approximately one-eighth of the energy of that produced from iron ore – mainly in the form of electricity, rather than coal for production from iron ore. This benefit results in high recycling rates (around 80-90% globally). However, scrap cannot fulfil the sector's raw material input requirements alone because steel demand and production today is much higher than in the past. This means that recycling alone cannot be relied upon to supply global demand[35].

3.2 Sources of Steel Production

Steel production comes from two key sources: Blast furnaces and Electric Arc Furnaces (**EAF**). **Blast Furnaces** produce what is called virgin iron from iron ore and requires coke as a reducing agent to convert the iron ore oxide into iron. **EAF's** recycle existing iron and steel (scrap steel) into new steel products. The EAF process requires very large quantities of electricity, preferably from a renewable energy source.

There needs to be sufficient quantities of scrap steel within the country's economy before it is economical to have an EAF. New Zealand Steel is currently building an EAF with commissioning due towards middle of 2026.[36] This will provide a means for recycling more domestic scrap steel in NZ, rather than the bulk of it being exported overseas to be recycled.

When a country has reached a level of steel intensity within its economy (~220kg/capita/annum in the developed world), the requirement for virgin iron decreases[37] and EAFs are used to recycle steel as it becomes available. **Figure 10** describes the steel production profile for Japan which reached a steady state of production from 1975.

Developing economies like India are below the typical steel intensity hence India and other developing countries have a growing high demand for virgin iron based on blast furnace technology that requires coking coal. Large EAF facilities for recycling of steel will come much later.

[35] https://www.iea.org/reports/iron-and-steel-technology-roadmap

[36] www.nzsteel.co.nz

[37] Poveromo, JJ, 2021, "Prospects for EAF Steel Making in Europe", Eurocoke 2021

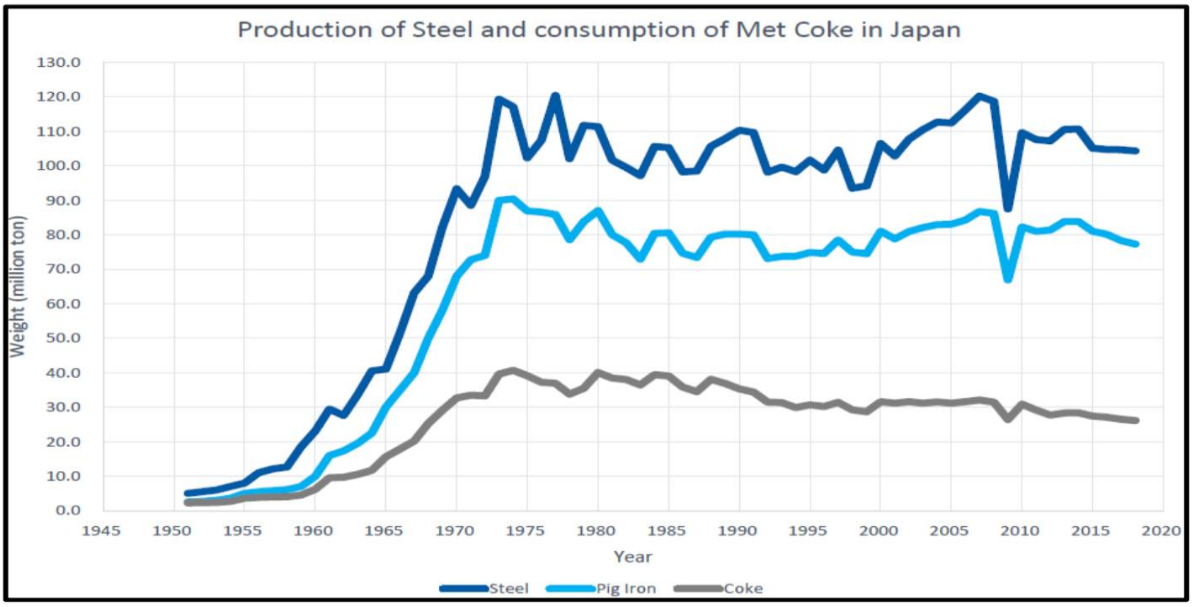

Figure 10: Demand for virgin iron does not increase indefinitely (Japanese experience)

3.3 Green Steel as an Alternative

Green steel refers to steel produced using environmentally friendly and sustainable methods. This usually involves using renewable energy sources. This can be achieved through various means such as reducing the use of carbon-based reducing agents and fuels, moving from blast furnace processes to electric arc furnaces fed with steel scrap and powered by renewable energy, converting from fossil based fuels to hydrogen (**H_2)** or electricity in downstream processing[38]**.**

Blast furnaces require coke to be used as a reducing agent (among other things) for iron production. Noting that coking coal and coke produce approximately 7% of human-induced CO_2 emissions[39] worldwide.

Hydrogen H_2 has been identified as a potential reducing agent replacement for coke in the production of iron ore (termed "green steel"). However, the production of 99% of the world's consumed H_2 is produced using predominately fossil fuels: 76% from natural gas and 23% from coal.

Another way of producing H_2 is via electrolysis. To meet the current H_2 world-wide demand would require 3,600 Terra Watt hours (**TWh**) of renewable electricity. This is more than the annual renewable energy generation capacity of the European Union. If H_2 was used across the world to make steel, then a further 2,500 TWh of clean electricity would be required to meet current global demand.

According to the IEA Sustainable Development Scenario (**SDS**) 2023, the transition to a direct reduction ironmaking coupled with EAF will take decades. Therefore, the global transition period to "green steel" is considered beyond the time scale of the BPCP.

[38] https://afry.com/en/competence/green-steel#:~:text=What%20is%20green%20steel?,or%20electricity%20in%20downstream%20processing.

[39] European Commission (2020). Emissions database for global atmospheric research (EDGAR). http://edgar.jrc.ec.europa.eu/overview.php?v=431.

Despite these hurdles, there is growing research and development into assessing viable techniques to produce green steel, using innovative processes and technologies to significantly reduce or eliminate carbon emissions associated with traditional steelmaking.

Technical challenges in producing green steel include:

- H_2 embrittles iron leading to cracks and fractures transporting pipework. Special alloys may mitigate this problem.
- H_2 does not burn as hot as carbon and so needs heating; highly risky given the gas is explosive.
- Iron ore feedstock requires a higher grade of iron ore, 67% iron to avoid slag issues. Only 3-4% of world iron ore product meet this specification. A typical high grade Western Australian iron ore[40] is 56-62% iron and is currently only suitable for incumbent, highly carbon-intensive blast furnace technology.
- Requires a large source(s) of renewal electricity for electrolysis.

A recent Swedish steel plant conversion to "green steel" has proven some success and was aided by abundant hydroelectricity, modifications to the existing blast furnace technology requiring large capital reinvestment, available high quality ores and a large amount of European Union investment.

This single "green steel" blast furnace project resulted in approximately 25% of Sweden's output and0.06% global steel production.

4 How West Coast Coal for Steel Making is Found and Mined

Coal resources on the West Coast of NZ are identified and categorised by resource geologists with the aim of determining:

- The thickness and lateral extent of the coal seam;
- The geological structure, e.g. flat lying or dipping, location of folding of faulting (the latter ubiquitous in West Coast coal resources); and
- A range of coal quality parameters relevant to utilisation.

This process strictly adheres to an Australasian Code, known as the "**JORC Code**". Therefore, all analysis is undertaken by fully independent laboratories to comply with analytical standards and JORC[41] Code requirements.

Coal quality variations within the seam/ resource are determined by drilling and testing of cored coal seams[42]. The data is then modelled using the geological modelling package such as Vulcan[43] that employs sophisticated algorithms to extrapolate between drillholes. Outputs from Vulcan provide information on the overall coal resource, including depth of coal, coal thickness, coal quality and

[40] Nicholas, S, Basirat, S, 2023, Australia faces growing green iron competition from overseas, Institute of Energy Economics and Financial Analysis

[41] Australasian Joint Ore Reserves Committee, the JORC Code provides a mandatory reporting system for the classification of minerals Exploration Results, Mineral Resources and Ore Reserves according to the levels of confidence in geological knowledge and technical and economic considerations

[42] Cored coal seam – A cylindrical sample of the coal and surrounding rock is extracted intact from the ground.

[43] Maptek Vulcan - 3D mine planning & geological modelling

mining recovery, which then allows mining engineers to assess how the coal can be extracted economically.

This section describes the steps and processes of how coal is identified and analysed and then, how the data is used to develop a mining model.

4.1 Exploration

Exploration is an important activity to allow geologists to determine the location, depth, thickness and quality of coal deposits. Understanding the geology helps assess potential environmental risks like ground subsidence and acid mine drainage.

The objective of coal exploration is to assess:

- Prospective deposits.
- Economic coal seams within deposits.
- Nature of best reserves for mining.
- Geological and geotechnical hazards for seam development and extraction.
- Coal quality characteristics and their variation.

As each stage of exploration is completed, the reliability of site information increases. Areas of insufficient or unreliable data become more obvious, and requirements for further exploration can be described more accurately in terms of programming, timing and cost. Exploration generally includes the following activities:

- Surface mapping.
- Sub-surface mapping, (if underground mine workings are accessible).
- Drilling.
- Geophysical surveys.

These methods are summarised below.

4.2 Surface Mapping

On-ground geological mapping in promising terrain is usually the first coal exploration field activity. Outcrops are located, and their lithologies[44] and structural features described and recorded (**Figure 11**). Coal seams found are measured and sampled. Surface mapping is also very important for optimising exploration drill site selection.

[44] Lithologies – Refers to physical characteristics of rock or a rock unit such as mineral content, grain size, texture and color.

Figure 11: Geological Mapping in Rockies West Mine area

Mapping requires surveyed base topography maps of the area, or at least good aerial photograph control. Searching for old data and plans is a worthwhile exercise in areas previously mined, particularly where underground mining has occurred and old workings are likely to be encountered.

Trenching (**Figure 12**) is often required to expose near-surface coal seams and is carried out by hand digging, backhoe excavation or blasting, depending on the terrain and the sample volume requirements.

Figure 12: Trench digging

4.3 Sub-surface Mapping

Where access is available to underground exposures of rocks and coal seams, typically in stone drives and underground coal mine workings, valuable geological data can be gained by mapping the walls and roof of "roadways", (i.e. tunnels, as referred to the coal industry) if safe and practicable to do so. The principles are the same as for surface mapping, but special difficulties likely to be encountered include:

- No light.
- Obscuring of geological features by stone dust, mine infrastructure, weathered/slumped strata, lagging, water, bacterial slime, etc.
- Hazards to personal safety including poor ventilation and noxious gasses in underground workings, unstable roof and sides associated with the underground workings, potential entrapment caused by uncontrolled collapse of underground roadways, remote work, dangerous access, extreme weather.

4.4 Drilling

Drilling is the most frequent method of exploration and sampling, using either non-cored or partially/fully cored holes (**Figure 13**). Non-cored holes provide the most basic structural data and give indicative coal seam thicknesses and quality information. Extra data can be gleaned if these holes are geophysically logged by inserting an array of geophysical tools to "map" and measure various properties of the walls of the drillhole. Coring, though more expensive, gives more reliable data on coal and rocks encountered. Coring consists of cutting and maintaining in a long column, a cross sectional sample of the rock that lies above and below the coal seam (referred to as the "core"). It allows geologists and geotechnical engineers to determine rock types, thicknesses, structure and also allows geologists to carry out tests on the physical rock and coal samples (see **Section 4.5**).

Drill rigs are normally truck-transported or skid-mounted, while tracked carriers are becoming more common. In terrain which is inaccessible to tyred/tracked vehicles, skid-mounted rigs are broken down and flown to and from specially prepared sites by helicopter.

Figure 13: Helicopter supported Diamond Drilling at Mount Frederick South

4.5 Coal Quality Sampling

The sampling and analysis of coal encountered in exploration is performed in a systematic way. Sampling techniques must be statistically valid and must avoid contamination by sandstones and other non- coal materials. Coal samples are analysed to determine coal quality properties like ash, sulphur content, moisture and calorific value (see **Table 5**). Analysis standards are required to ensure appropriate controls are adhered to during analysis ensuring good governance. The coal quality parameters measured depend on the rank of the coal.

Table 5: Analytical Tests on Coal Samples

Test	Metallurgical	Thermal	Analysis Standard
Visual Description	**X**	**X**	
Chemical			
Proximate	X	X	
Moisture*	X	X	ASTM D5142-02A mod
Volatile Matter*	X	X	ASTM D5142-02A mod
Fixed Carbon* (by difference)	X	X	ASTM D5142-02A mod
Ash*	X	X	ASTM D5142-02A mod
Air-dried Moisture**		X	ASTM D5142-02A mod
Sulphur*	X	X	ASTM D4239-04A
Ultimate	X	X	ACIRL in-house/NATA
Carbon	X	X	
Hydrogen	X	X	
Nitrogen	X	X	
Oxygen (by difference)	X	X	
Sulphur	X	X	
Forms of Sulphur	X	X	AS 1038 Part 11
Chlorine	X	X	ISO 587
Ash Composition	X	X	ASTM D4326-01
Ash Fusion Temperature*	X	X	ISO 540:1955€

Trace Elements	X	X	
Calorific Value*	X	X	ISO 1928-1995
Rheological and Physical			
Gieseler Fluidity*	X***		ASTM D2639-90
Dilatation Tests (Audibert-Arnu)	X***		
Free-Swelling Index*	X***		ISO 501:2003(E)
Hardgrove Grindability Index*	X	X	ISO 5074
Petrographic			
Maceral Analysis*	X***		ISO 7404
Vitrinite Reflectance*	X***	X	ISO 7404
Notes: * Minimum test required to characterise coal properly ** Important for low rank coal samples *** Bituminous coals only			
Adapted from Table 5 in Luppens et al., (1992).			

The analysis results are crucial for deciding the best use and economics of the coal deposit, whether for power generation, steel production or other industrial applications.

4.6 Acid Mine Drainage Sampling

Acid Mine Drainage (**AMD**) is a general term used to describe waters impacted chemically by mining activities. . AMD is typically generated by the excavation of rocks that contain sulphide minerals, such as Pyrite. When these rocks are exposed to oxygen and water, they undergo weathering processes and oxidise, generating acidity and releasing toxic metals. Rock and coal analysis, modelling and prediction is critical to understanding the potential for AMD as well as the severity and longevity of AMD.

Rocks above and below coal seams (ie. waste rock) are sampled and analysed for the following tests including but not limited to :

- Maximum Potential Acidity (**MPA**): MPA measures the highest possible acidity that could be generated.
- Acid Neutralisation Capacity (**ANC**): ANC accesses the ability of the rock or coal to neutralize acids.
- Net Acid Production Potential (**NAPP**): NAPP calculates the balance between acid generating and acid neutralising components to estimate overall acid risk from the material.
- Paste Ph[45]: Paste Ph Determines the acidity or alkalinity of a paste made from rock or coal, indicating the immediate potential for acid generation.
- Rinse Ph: Rinse Ph measures the Ph of the water rinsed through rock or coal samples to assess how quickly and strongly acidity may be released to the environment.
- Stored acidity: Stored acidity evaluates the amount of acid stored in rocks or coal that could be released over time.

[45] Potential of Hydrogen": Scientific term used to describe the concentration of hydrogen in a solution, which determines how acidic or basic (alkaline) that solution is

These chemical components are estimated into the overlying and underlying rock horizons in the geological model to determine the nature and extent of acid forming rock throughout the coal deposit. The rock horizons are then characterised into the following categories:

- Non- Acid Forming (**NAF**)
- Potential Acid Forming (**PAF**)
- High Acid Forming (**HAF**)

A waste rock block model facilitates the development of a materials schedule for NAF, PAF and HAF materials which are used for mine planning. Site specific classifications are created as recommended by internationally accepted metal accounting code principles (AMIRA and price (2009) Guidelines and Mine Environment Neutral Drainage (MEND)guidelines). AMD classifications enable the modelling and preferential management for NAF, PAF and HAF materials.

4.7 Rock Strength Testing

In opencast mining, rock strength testing is crucial for highwall safety and design efficiency. Strong rocks can support steep pit walls and require more durable machinery. Weak rocks may require gentler slopes or reinforcement to prevent landslides and allow for faster excavation with lighter equipment. Knowing rock strength also helps engineers choose the right amount of explosives to improve excavation practice. It ensures effective fragmentation without over-blasting or damaging nearby structures. For example, strong and competent rock will require more explosives to break up compared to soft, highly weathered rock material.

Rock strength testing measures how much force or pressure a rock can withstand before it breaks or deforms. It helps geologists and engineers understand the mechanical properties of rocks. Strength testing is undertaken using the core (see **Section 4.4**).

Common types of tests completed are the following;

- Uniaxial Compressive Strength – Measure how much pressure a rock can take when squeezed.
- Point Load Test – A quick test to estimate strength using a small sample.
- Triaxial Test – Simulates underground conditions with pressure from multiple directions.
- Tensile Strength Test - Measure how much pulling force a rock can resist.

4.8 Ground Water Monitoring

Groundwater monitoring is the process of checking the quality, quantity, flow direction and levels of water stored in underground water bearing rocks or fissures referred to as ***aquifers***. It involves collecting data from boreholes over time.

Commonly, Bathurst will install standpipes in selected boreholes. A standpipe is a vertical Polyvinyl Chloride (**PVC**) pipe installed into the borehole to monitor groundwater (**Figure 14**). It allows water to rise inside the pipe to the same level as the surrounding groundwater body.

Figure 14: Standpipe installed at Mount Frederick South

Groundwater monitoring is especially important in opencast mining because mining activities have the potential to significantly affect underground water systems and groundwater can impact upon highwall stability.

4.9 Geological Modelling

Three dimensional (**3D**) geological modelling is like creating a digital map of the layers of rocks and coal seams below the surface. Instead of just looking at the surface of the Earth, resource geologists generate a 3D picture of the rocks, layers, and structures hidden below ground level. It helps geologists, mining engineers, and decision-makers visualise and understand the structure, composition, and distribution of rocks and minerals underground.

The data collected during the phases of exploration is collated into a digital format, validated and used to systematically construct a geological structural model. Structural models represent the geometry and spatial arrangement of geological structures. It shows how rock and coal layers are tilted, folded, broken or displaced (**Figure 15**).

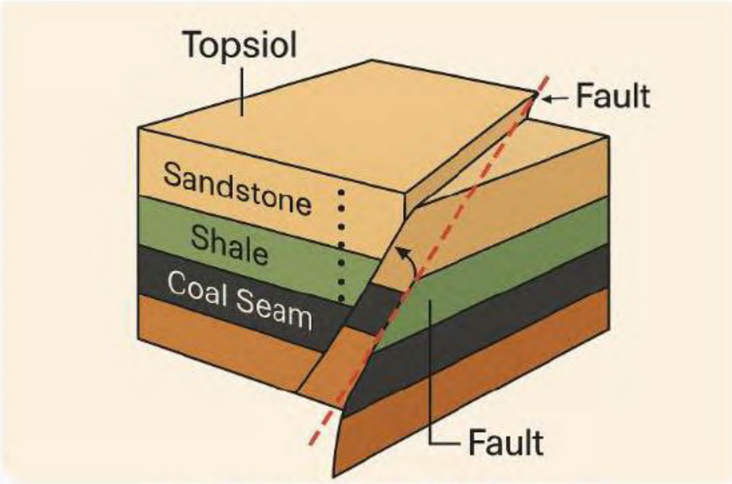

Figure 15: Structural model schematic

These models are crucial for understanding the history of an area, predicting the location of the resource, and assessing project viability and risk. Using specialised software like Maptek Vulcan three-dimensional mining software, surfaces are created to represent the different layers of rock and coal. (**Figure 16**).

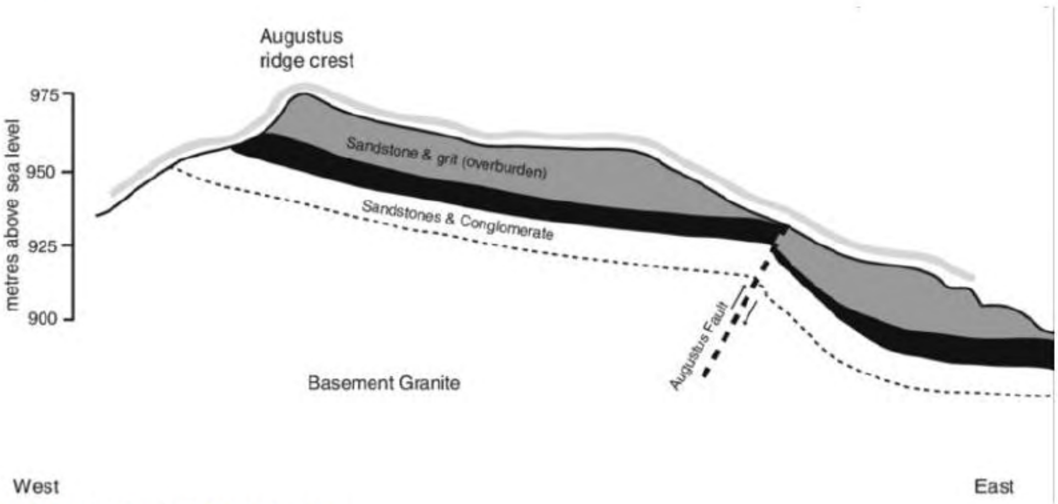

Figure 16: Typical Cross Section

Cross sections provide the resource geologist the ability to ensure coal seams are correlated between data points like drillholes and outcrop points and enable understanding of the local geology to be built into the model.

Bathurst's modelling process makes use of Vulcan Stratigraphic modelling process which converts the data and the resource geologist's knowledge into structural grids. It is like a 3D mesh or net representing the surface of rock and coal layers. Resource geologists run several iterations prior to finalising the grid surface, often refining the wide range of informing data and cross sections.

A block model provides the resource geologist the opportunity to add several fields to allow estimation of a range of attributes such as coal quality attributes, density, historical coal extraction, calculated fields to estimate remaining coal etc. The block model is then populated in the first instance by estimating coal quality and AMD attributes using advanced best practice estimation methods.

The objective is to create a model that best represents the coal seam's location, depth, thickness, coal quality properties, rock strength and AMD classifications. If the model is being used in an active mining environment, resource geologists constantly refine the model using new and actual data to produce reliable outputs that can be used by project and mining teams to evaluate and develop mine plans and mine schedules.

4.10 Converting the Geological Model into a Mining Model

The objective of converting a geological model to a mining model is to add relevant mining data to allow mining engineers to be able to use the mining model to plan the mine layout and schedule extraction.

Mining engineers develop a number of mining factors based on historical performance for the preferred mining method. For a new resource area, equivalent operational knowledge is considered and applied to the mining model.

Typical mining factors that may be considered include:

- **Coal Dilution**: the unwanted material like rock, shale or low-quality coal that gets mixed in with the coal during mining. This reduces the quality of the coal that is extracted. Think of it like getting pebbles mixed in with a scoop of clean sand. The clean sand being what is required.
- **Loss of coal due to historical mining** – underground mining may have historically occurred in the area of the proposed open cast pit, noting that some coal remains as supporting pillars. If mining engineers overestimate how much coal was left behind in these underground workings, there will be a reduced recovery compared to that modelled. Similarly, if mining engineers underestimate how much coal was left behind in these underground workings, there will be a much higher recovery compared to that modelled.
- **Loss of coal due to historical fires in old coal workings -** underground mining may have historically occurred in the area of the proposed open cast pit, noting that some coal remains as supporting pillars. This coal may have been subject to historical fires which may have completely burnt the coal or affected the in situ quality, reducing modelled recovery.
- **Mining Loss**: The portion of coal that is left behind or not recovered during the mining process.
- **Mining Recovery**: Mining recovery is the proportion of coal that is successfully extracted from the ground
- **Beneficiation Coal yields**: Refers to the amount, expressed as a percentage, of clean coal that is recovered from the raw (or run-of-mine) coal during the ***beneficiation*** process. For clarity, ***beneficiation*** means, a process used in the mining industry to upgrade the quality of the run of mine (or raw) coal or ore by separating out the material that degrades the overall product. The goal of the ***beneficiation*** process is to improve the economic value of the coal or ore by increasing the concentration of the desired component.

The final model helps mining teams make informed decisions about where to mine, how much coal to extract, and how to manage resources efficiently. It also supports financial forecasting, equipment planning, and environmental management. The model is updated regularly as new data is collected during mining.

5 Mine Planning Process

5.1 Mining Method Selection: surface or underground mining

The technical and economic feasibility of a coal resource area needs to be evaluated for a suitable mining method. There are many factors that are considered to determine the best method to extract the identified coal resource including:

- Regional geological conditions i.e. depth of coal seam, geological anomalies.
- Overburden characteristics i.e. competency of overlying rock materials.
- Coal seam characteristics i.e. Seam splitting, seam thickness, coal quality and continuity.
- Coal recovery i.e. Restrictions / opportunities associated with historic underground workings (see **Section 8**).
- Land ownership and surface environmental conditions.
- Groundwater conditions.
- Gas generation i.e. levels of methane within the seam.
- Labour and workforce availability.
- Market demand and coal price.
- Capital investment and cashflow.

Appendix 1 contains a more comprehensive description of the factors that go into selecting the most applicable mining method depending on the factors discussed above.

5.2 Mine Planning Process

The mine planning process encompasses an integrated planning process (**Figure 17**), working in a hierarchy from long term to short term. Longer-term plans set the overall strategic direction. Progressively shorter-term plans provide more operational detail and accuracy at the front end of the longer-term plans. The mine planning process consists of several steps that are often iterative and consecutive. **Figure 17** below summarises the mine planning process. Further details of each step are summarised below.

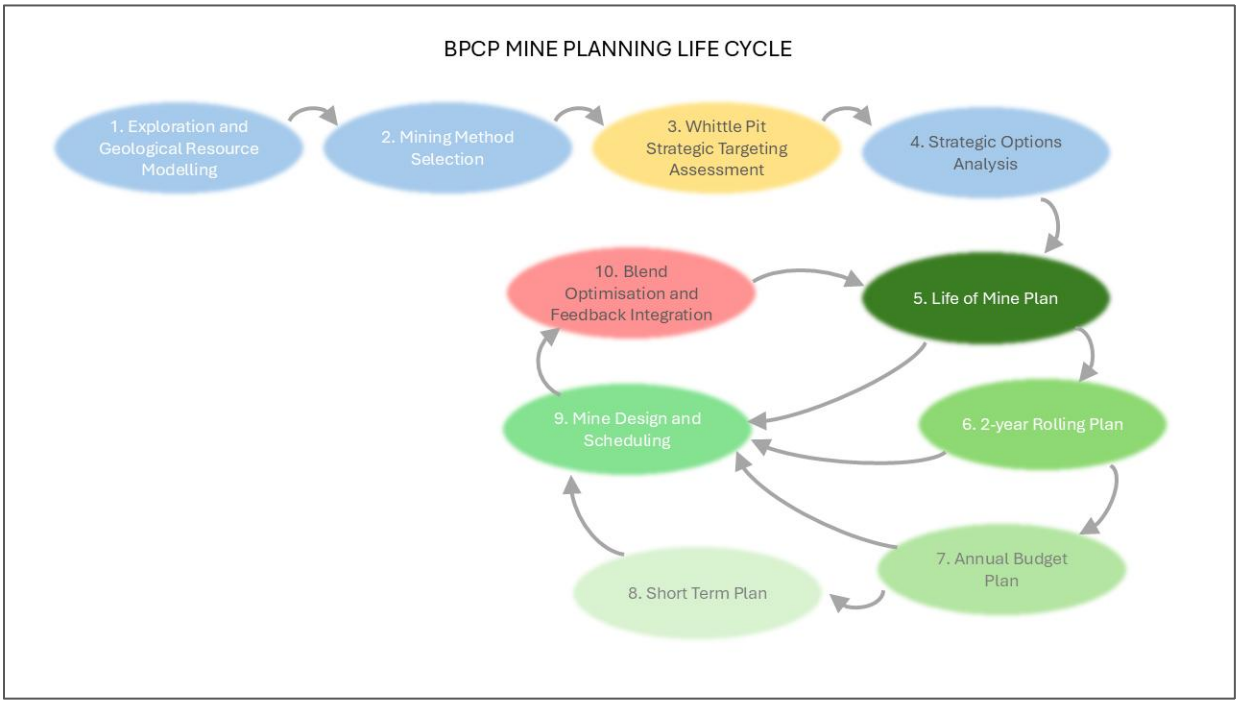

Figure 17: Mining Planning Process

Step 1 – Exploration and Geological Resource Modelling
The mine planning process starts with exploration and geological resource modelling as discussed in **Section 4**. The outputs from this process enable a determination of how much coal is likely to be available. In accordance with the JORC Code[46], a resource is estimated that meets the reporting requirements of the JORC Code[47] which has three categories based on the level of confidence (typically as a result of known data) that the resource exists and can be mined economically. The three categories include:

- **Inferred** (least certain)
- Indicated
- **Measured** (most certain)

Step 2 – Mine method selection (see **Section 5.1**)

Step 3 – Pit Optimisation Strategic Targeting Assessment

Pit optimisation software like Vulcan Pit Optimiser or software marketed by Geovia Software (Whittle optimise) are used to optimise a pit shell and mining phases to maximise the value of the coal asset using a combination of:

- economic parameters of mine costs and product revenues from sales,
- coal processing yield factors,
- geotechnical slope stability of open-pit walls

[46] The reporting of resources and reserves is controlled by an external governance body: the Australasian Joint Ore Reserves Committee (JORC) and reporting is specified and controlled by the **JORC Code. The Code** sets the rules for how mining companies publicly report **Exploration Results, Mineral Resource**s, and **Ore Reserves** in Australasia. Only a **Competent Person** can prepare and sign off on reports.
[47] Australasian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves, The JORC Code 2012 Editon, www.jorc.org/docs/JORC_code_2012.pdf

- land disturbance and rehabilitation costs

It is effectively a "first pass" design which is followed by more detailed planning and scheduling (Steps 4 and 5). Scheduling refers to the order in which materials are worked to access the coal, extract the coal and then rehabilitate the land. Scheduling activities incorporate the selective management of PAF, NAF and HAF materials.

Outputs from Step 3 enable the initial determination of the JORC Code requirement, a **JORC Ore Reserve** which is the part of a **JORC Resource** that can be mined economically and profitably. It comes from the Measured and/or Indicated Resource categories and includes extra material that might mix in during mining, i.e. dilution material; as well as expected losses during mining, processing and blending. The **JORC Ore Reserve** is continually reviewed and evaluated as the mine planning process matures. As information and data is updated the **JORC Ore Reserve** matures from **Probable** to **Proven,** noting that to report a JORC compliant **Ore Reserve,** a Pre-Feasibility Study or a Feasibility Study showing mining is economically viable is required. As a minimum a pre-feasibility study is required to report reserves to international stock exchanges. This is required to provide confidence to investors that a reserve is based on a substantial mining study.

Step 4 - Strategic options analysis: relates to high-level decisions on how the mine will be constructed, operated, rehabilitated and closed.

Step 5 - Life of Mine Plan or **"**LOMP" has increasing detail on the mine plan from inception to mine closure, surface and ground water management and final landform design for rehabilitation.

Step 6 – Two Year Rolling Plan: provides a higher level of detail, supported by more detailed engineering work. It is updated half yearly with activities reported against it on a monthly basis. It is a regular ongoing part of the short-term planning process.

Step 7 – Annual budget Plan: provides an outline of the organisations expected income and expenses for a 12-month period. Serves as a guide for resource allocation, operational planning and financial control.

Step 8 – Three month Short Term Plan including tactical updated plans with the most accurate data and information for Operations.

Step 9 – Mine Design and Scheduling: is an iterative process using the outputs from the Whittle Pit Strategic Targeting Assessment and the Strategic Options Analysis.

Several different mine sequences and mining schedules are assessed to test blend optimisation techniques to maximise value of the different coal quality types present in the BPCP (see **Section 6.2**).

Once the blending strategy has been reached, further analysis and planning is carried out considering the following aspects:

1. Water management considering surface water, ground water and historic flooded underground workings water flow paths.
2. Mine access ramps.
3. Initial expit overburden storage areas and Engineered Land Forms (**ELF**[48]) .

[48] ELF – an Engineered Landform is a term used to describe the final landform which has been designed and constructed to be free draining and long term stable, chemically and geotechnically.

4. Haulage routes for overburden movement.
5. Haulage for coal movement.
6. Removal and placement of vegetation and topsoils.
7. Final landform design and rehabilitation including surface water controls.

Steps 1) to 7) are an iterative process with the aim of maximising the value of the coal resource through maximising the coal blended value while meeting the mine design constraints of water management, rehabilitation requirements, material movement and haulage paths.

Step 10 – Blend Optimisation and Feedback Integration: maximises mined material value by strategically blending coal from different pit sources with varying grades to meet market specifications. This process becomes a **Dynamic Feedback Loop** whereby there is continuous feedback of operational data into mine scheduling and the mine plan. This allows for adjustments of production targets and quality specifications to be continuously refined. Integrating blending and coal quality constraints into the dynamic feedback look improves mine plan responsiveness to operational and market changes.

6 Coal Extraction – Open Cut at BPCP

The BPCP proposes to extract bituminous coking coal of various grades using open cut mining techniques. **Figure 18** shows the general steps of open cut mining and generally reflects the mining processes used at the existing Stockton mine .

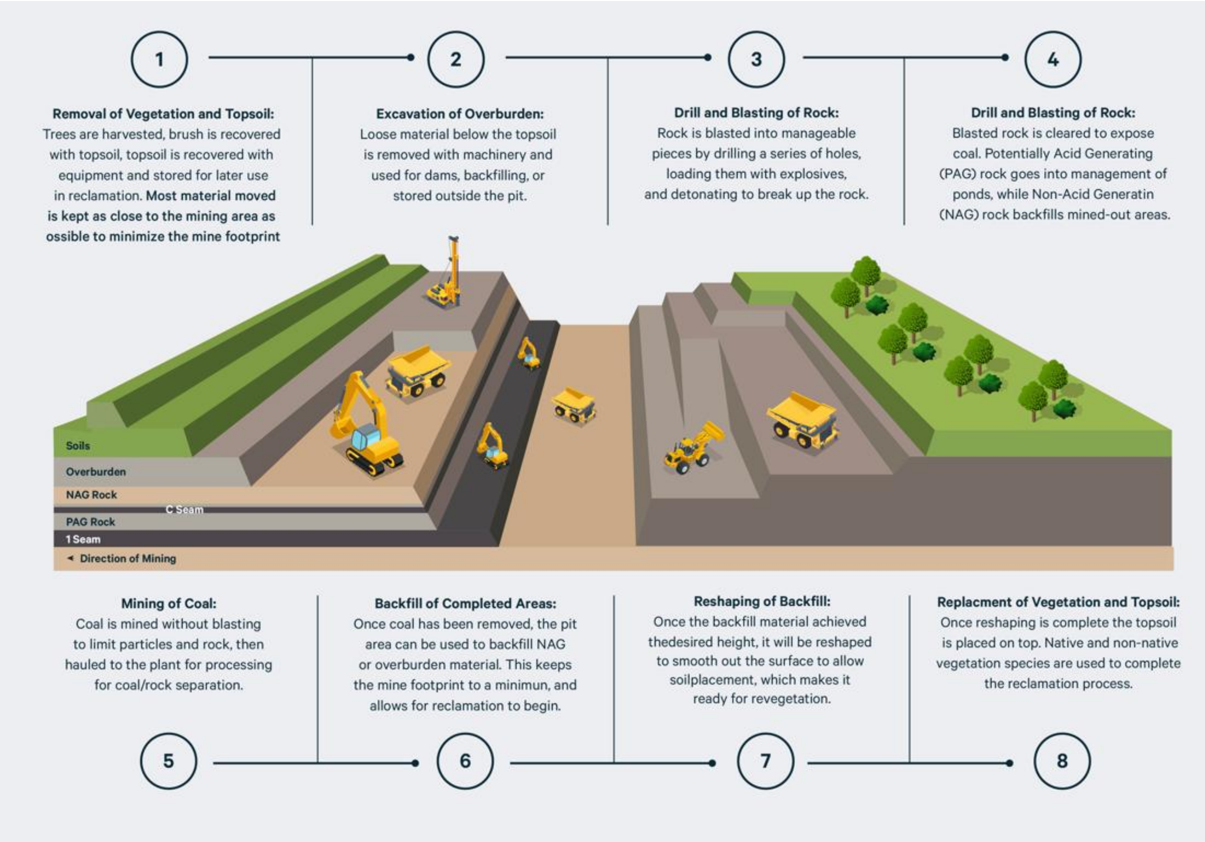

Figure 18: General Open Cut Mining Process

<u>Step 1</u> is to remove and salvage the existing vegetation and topsoils. This material can be stored in low level stockpiles or can be directly placed in areas that are ready for revegetation. The Stockton mine practises Vegetation Direct Transfer (**VDT**). VDT is the term for the process where the vegetation and the immediate soil substrate within which it survives is scraped off and then transported and placed on an area ready for revegetation (see **Figure 19**). This practice will be replicated by the BPCP where possible. This practice has proven to be successful at the Stockton mine and is carried out where possible, noting that it cannot be implemented everywhere due to scheduling constraints from the mining sequence and suitable land available and the time of Step 1: removal of vegetation and top soil.

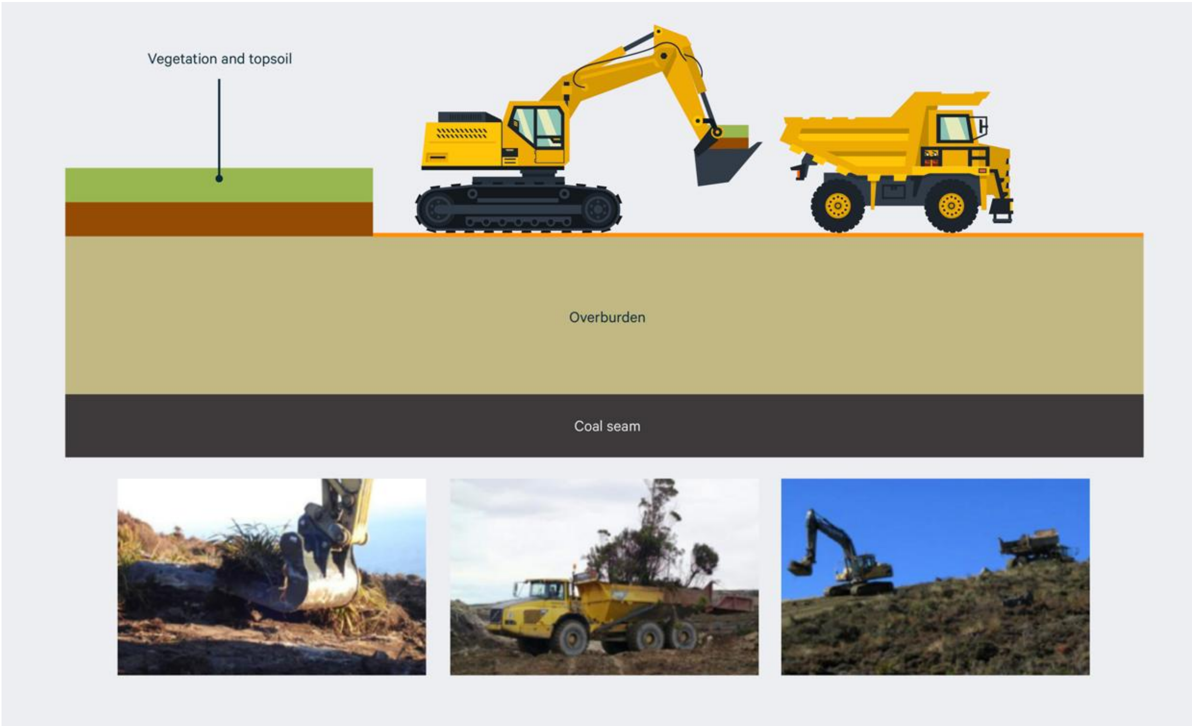

Figure 19: Vegetation Direct transfer at the Stockton Mine

Where VDT is not possible, vegetation is removed and stored - to be used as brush material and seed banks on rehabilitated lands - and topsoil is salvaged and stored in low rise stockpiles - to be used on rehabilitated lands as a vegetation growth medium.

Steps 2 - 4 is to remove the overburden to access the coal seam. Overburden is a term used to represent the layers of rock in between the surface and the coal seam. Mining operators refer to the quantities of overburden to be moved in "**bcm**" or bank cubic metres rather than tonnes. This is because the removal of the material becomes an exercise of three-dimensional size and capacity rather than weight. Removal of the rock can be done by ripping of the material using excavators, dozers and trucks to haul the material to areas where the coal seam has been removed. Ripping the rock can only be carried out where it is soft enough to do so. When the overburden rock is too strong/hard, blasting of the rock material is carried out to loosen and break up the rock in situ so that dozers and excavators are able to load the material into haul trucks for placement elsewhere **(Figure 20)**. Typical equipment size is 120-400 tonne excavators, loading into 55, 90 and 180 tonne trucks supported by 50-70 tonne sized dozers. The different sized equipment is selected based on the intended application.

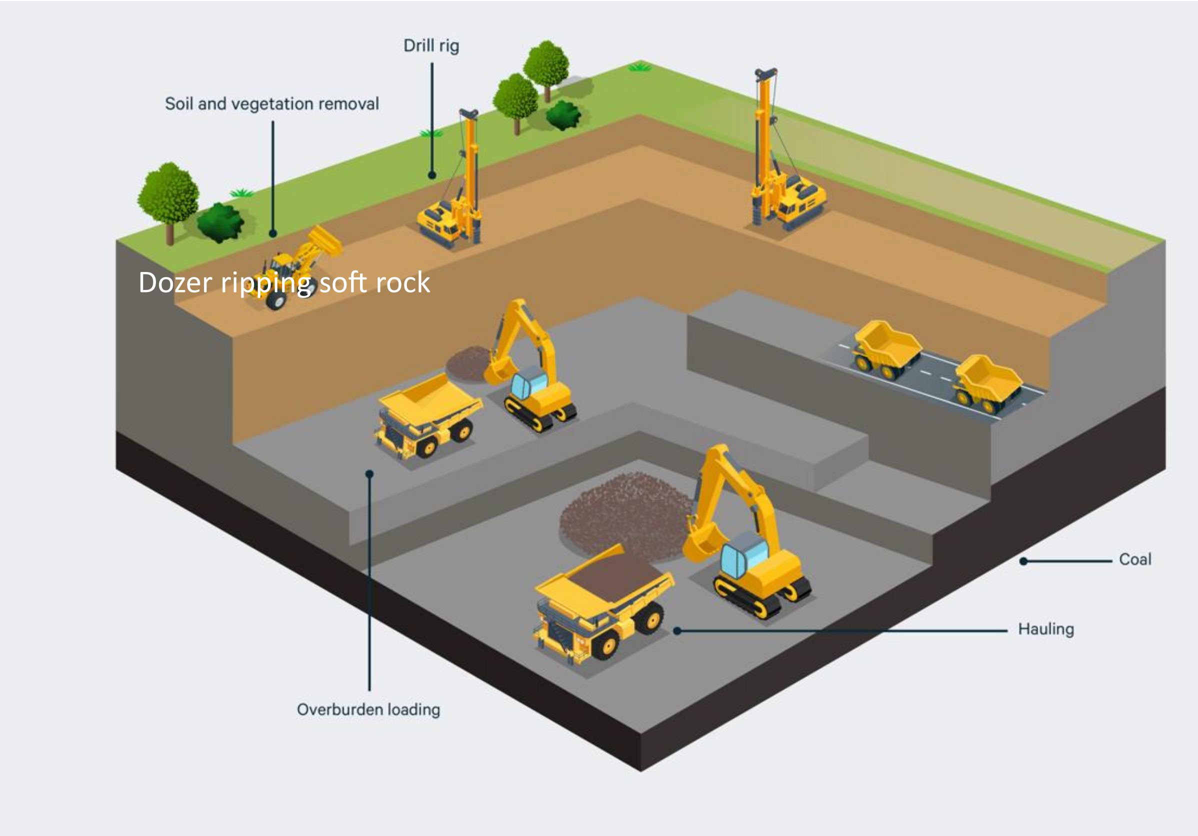

Figure 20: Removal of Overburden to access the Coal Seam:

For blasting, drill rigs drill a hole to a specific depth, explosives are loaded into the hole and when all clear, the explosives are detonated.

Removal of overburden, whether ripped or blasted, is a very precise activity as sometimes layers of rock need to be specially managed and separated. Potentially acid forming (**PAF**) rock must be kept separate from non-acid forming (**NAF**) rock. PAF rock needs to be buried and compacted at depth, often below the water table, so that it is protected from oxygen and free draining water to the greatest extent possible[49]. NAF rock is used to encapsulate the PAF rock and is used at the surface interface as it will be exposed to more oxygen.

Step 5 is the removal of the exposed coal. Coal is typically mined using smaller excavators (50 – 90 tonne excavator to load 55 and 100 tonne trucks). Coal excavated from the open pit is called "Run-of-Mine" (**ROM**) coal and it is directed to either the Coal Handling and Processing Plant (**CPP**) stockpiles for processing based on coal quality and coal types and grades or, it is directly loaded out for dispatch, by-passing the CPP. The latter ROM coal is called "**by-pass coal**" because it by-passes and is not processed by the CPP. Different coal qualities, grades and by-pass coal are stockpiled separately, managed individually and are not mixed, unless they form a specific coal blend.

Step 6 is the backfilling of the open cut pit. The backfilling is carried out to a specified design called an Engineered Landform (**ELF**). ELFs are carefully designed with input from a range of technical experts (i.e. geotechnical, hydrologists, hydrogeologists, environmental engineers etc). They are landforms that need to be stable over the long-term and free draining, so extreme care is taken in their design

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[49] PAF rock exposed to oxygen will generate acid mine drainage, resulting in, if not contained and treated, acidic water drainage. Acidic water can be hazardous because it leaches and dissolves metals from surrounding rocks which can reach levels that are toxic to the environment.

and construction. Backfilling the open cut pit is not a matter of "*just dumping the rock back into the pit*".

Consideration is given to water drainage and collection from rainwater percolating through the ELF. Key ELF design elements include:

- Established construction methodology with construction in 3-5m high sections for each open pit working area. Individual ELF lift construction heights are limited to provide for increased compaction of the placed rock by haul trucks and dozers limiting permeability of the ELF to minimise surface water and oxygen ingress into the rock to limit AMD potential (see **Section 5.3**).
- Overburden rock that has been defined as PAF (see step 2) is stored in the base of the ELF.
- Overburden NAF rock is either placed on final surface layers of ELF construction or stored in designated NAF ELF locations.
- Drainage channels are designed and constructed for the surface of the ELF to allow water to freely and safely drain from the newly created topography for erosion and sediment control.
- Final ELF surface topography is designed to blend into the surrounding topography and where possible, is designed to mimic the original landscape.
- ELF construction follows the advancing coal mining face as coal is extracted.

Step 7 is final landform shaping, finessed by highly skilled dozers and excavators operators who follow the engineered design of the ELF. The landform construction is controlled using GPS control on individual earth moving machinery.

Step 8 is the placement of topsoil and vegetation. Preference is given for VDT (step 1) if available, or soil stockpiles are used to place topsoil on top of the final landform. Where VDT is not possible, planting of vegetation is carried out. **Figure 21** presents some rehabilitation activities at the Stockton mine, Photo 1 showing a replanted final landform, Photo 2 showing vegetation plantings and Photo 3 showing VDT placement.

Photo 1

Photo 2

Photo 3

Figure 21: Rehabilitation at the Stockton Mine

6.1 Coal Dilution

Coal dilution happens when unwanted material like rock, shale or low-quality coal gets mixed in with the coal during mining. This reduces the quality of the coal that is extracted. Think of it like getting pebbles mixed in with a scoop of clean sand. The clean sand being what is required.

ROM coal with dilution requires further processing in the CPP to separate out the dilution material from the product coal.

6.2 The Perfect Mix – Coal Blending

Coal blending is the process of mixing coals together after it has been extracted from the mining pit and/or processed through the CPP to achieve quality attributes (i.e. customer specification) required for the coal's intended application. The CPP carries out the beneficiation process. As a very simple example, a customer may require a low sulphur, low ash, high vitrinite coal that has minimal impurities which requires:

- a quantity of low sulphur coal (which has a higher ash level) from Pit A;

- a quantity of low ash coal (which has a higher sulphur) from Pit B;
- a quantity of high RoMAX (rank) coal from Pit C;

noting that, each of the different coals come from different mining pits.

The blending of the coals becomes a delicate balance so blending represents a challenging and complex problem with numerous possibilities, multiple constraints and competing objectives. The extraction of coal from the BPCP will occur from three different mining areas, each with varying coal qualities. This provides Bathurst with the opportunity to mix/blend coal from the different areas to meet bespoke specifications required by customers. No single mining area will be able to achieve this, so blending of the coal is fundamental to the overall BPCP's success and not without its challenges.

Blending can take place in several locations across the mining, processing, dispatch and receival chain with the location of blending sometimes being important depending on the customer's specifications (**Figure 22**). For example, blending before the CPP is sometimes needed to improve washability and increase CPP production rates and yields. The act of blending typically occurs through stockpile stacking[50] however it may also take place within a vessel's hatch during ship loading.

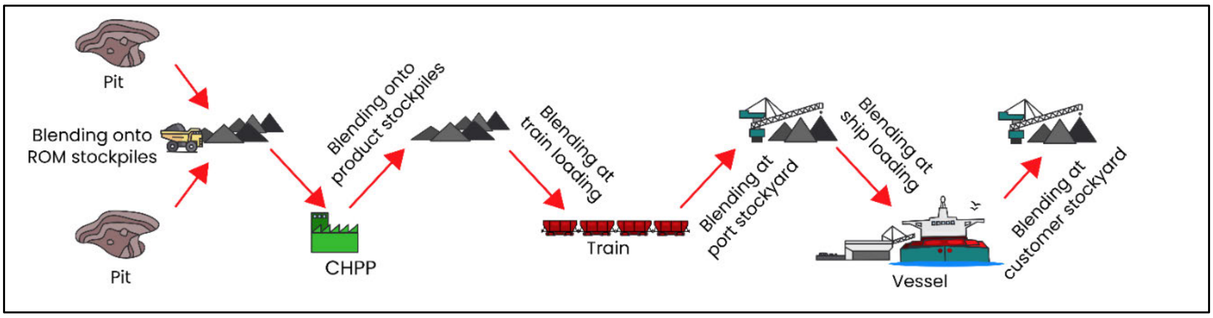

Figure 22: Coal Blending Opportunities - Mining, Processing, Dispatch and Receival Chains

Blending is a complex challenge often involving multiple coal quality parameter where the objective is typically to meet customer specifications, maximise revenue and Net Present Value (**NPV**), or monthly product tonnage targets. Important and closely related Key Performance Indicators (**KPIs**) include mining productivity, product quality consistency, and product reliability (e.g. product consistency from month to month).

Coking coal blending optimisation at BPCP considers several trade-offs:

- Costs and value generation.
- Timing of mined coal delivery available for blending and sale.
- Desired qualities for different coal products including (see **Section 2.4**):
  - Ash.
  - Sulphur.
  - Crucible Swelling Index.
  - Volatile matter.
  - Inherent Moisture.
  - Total Moisture.

[50] Stockpile stacking is the process of piling coal of a similar quality or specification into large mounds for storage, using machines called stackers. Various proportions of the stacked coal can be blended to achieve an overall coal quality required by a customer.

    - Coal rank, measured by reflectivity (RoMAX).
- CPP yield performance where high ash material and dilution sandstone rock is separated from coal.
- Market and customer specific demand.
- Maximising value generation by the differing coking coal categorisation products.

Incorrect blending will lead to the incorrect products being produced, resulting in negative coking performance outcomes for technical reasons for the customer. Customers can refuse a $40 Million shipment if the Stockton coal blend specification is not met. Incorrect blending will lead to not achieving the highest value coal products and overall diminishing the value of the Buller Plateaux resource value.

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

[redacted]

7 Coal Processing

7.1 Existing Infrastructure

The Stockton Coal Processing Plant (CPP, see **Figure 24**), operational since 2010, will continue to be used for Stockton, Cypress and both Mount Frederick South and Escarpment Extended coals. The plant consists of three major process circuits:

- [redacted]
- [redacted]
- [redacted]

Coal is transported from the CPP using 90 tonne trucks via a 7.3 km haul road to the aerial ropeway. The aerial ropeway conveys coal to the Ngakawau rail loadout facility.

[redacted]

[51] A rotary breaker is a large industrial machine that is used for crushing and sizing coal and/or rock, and can separate some waste material from the usable product. It consists of a large rotating cylinder that effectively breaks the rock into smaller pieces and separating softer coal from harder stone/rock.

[redacted]

[redacted] [redacted]

[redacted] [redacted]

[redacted]

[redacted]

[redacted] [redacted]

[redacted]

- [redacted]

- [redacted]

[redacted]

- [redacted]
- [redacted]
- [redacted]
- [redacted]

[redacted]

7.4 Coal Rejects Management

Coal rejects are separated waste material from the coal products. Typically, coal rejects contain high ash coal, mudstone partings from within the mined coal seam and sandstone dilution from the mining process. Higher dilution occurs where underground workings are present.

[redacted]

For the BPCP, future CFSF storage is planned at A-Drive (**Figure 27**). The proposed A Drive Sumps/Borrow Pit stages 2 and 3 are estimated to have a combined excavation volume of approximately 1.9 million bank cubic metres (MBCM) dominated by granite resource. The excavated pits will be repurposed for coal fines storage and will have a combined storage capacity of approximately 950,000 m^3 assuming a freeboard of 4 metres. All A Drive CFSF's will be excavated below ground level and will not have engineered embankments and thus do not qualify as dams.

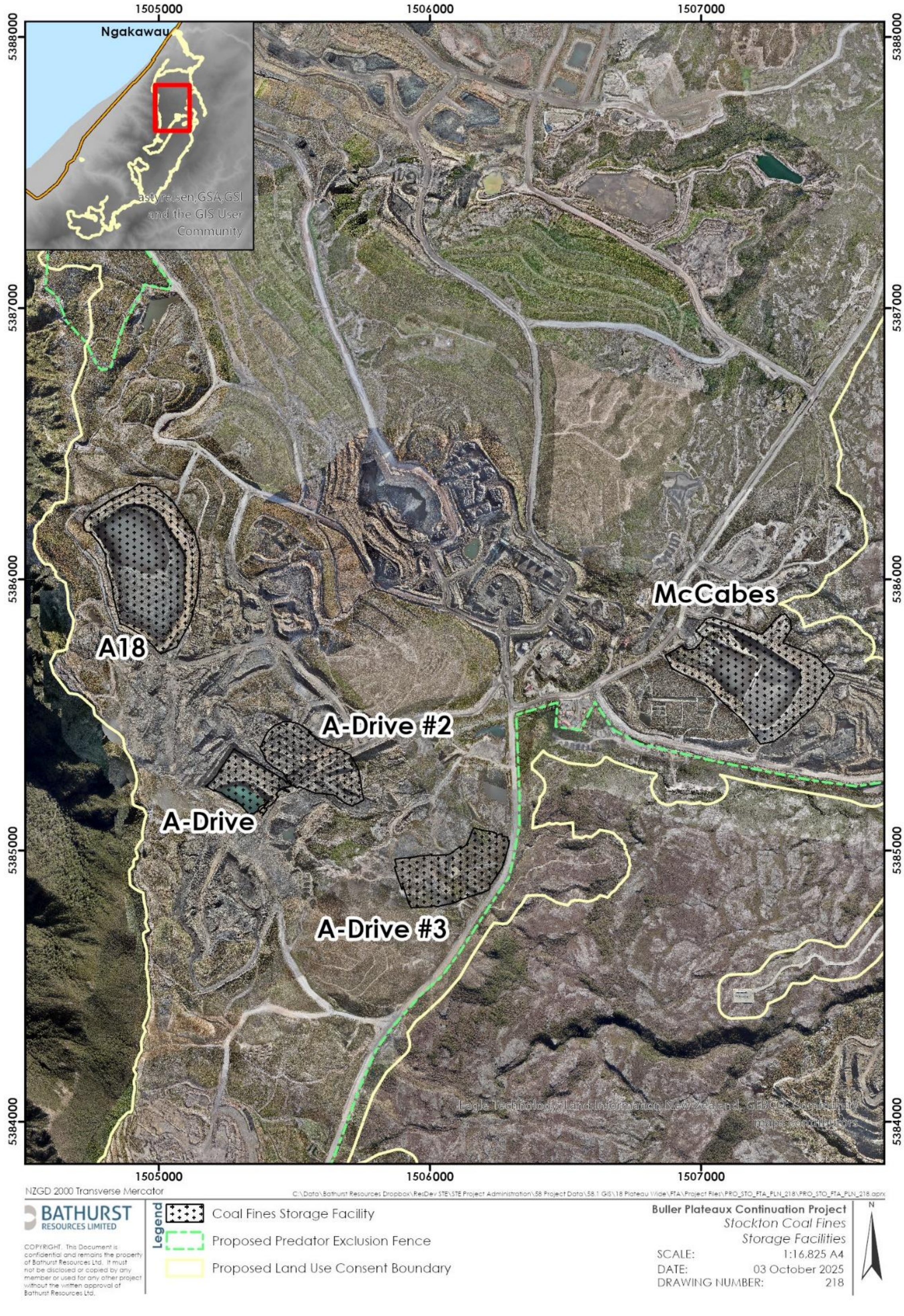

Figure 27: A-Drive Coal Fines Storage

8 The Challenges of Mining on the West Coast

8.1 Brief History of Mining on the Plateaux

Coal mining has a long history in the Buller District, dating back to the opening of the first mine there in 1864. Prior to World War II, all coal was produced by underground methods, but since 1975, opencast mining has accounted for 95% of production.

Coal mining and its associated infrastructure developments – roads, railways and the port – were the foundations of the town of Westport. Gold was worked in the Cedar Creek saddle area in the 1860's and coal mining began at Burnett's Face near Denniston in 1882. The coal field now covered by the Stockton mine has been mined since 1890.

The Crown, through State Coal Mines, first acquired mines on the Stockton Plateau in 1944 and immediately commenced a large-scale development programme, which included a shift from underground mining to opencast mining. This enabled the Crown to increase the rate of coal removal, a trend which would continue through the 1990's and 2000's. **Figure 28** presents a photograph of open cut mining, under the control of the Crown at Stockton from May 1948.

Figure 28: Open cut mining at Stockton, May 1948

By 1985, it is estimated that around 1 million tonnes of coal had been excavated from Stockton mine by opencast methods. By 1990, this had grown to half a million tonnes of coal mined per year, and by the mid 2000's, coal extractions reached a peak of two million tonnes per year. To date, approximately 28.5 million tonnes of coal has been extracted from the Buller Plateaux.

Figure 29 presents existing known underground workings across the Buller Plateaux in the Stockton Mine area shown by the black hatching. **Figure 30** presents underground workings across the Denniston Plateau. The location of these historic workings is important because the BPCP open cut mining activities will interact with them.

[redacted]

[redacted]

The historic underground workings only extracted part of the coal resource. There are still pillars of coal in-situ that remain and can be extracted. Many of these old underground workings are flooded as water has flowed into the voids created by the mining process. The BPCP will be open cut mining in and around these historical workings. This will present its own set of challenges as explained in the following section.

8.2 Underground Workings

As presented in **Figure 29** and **Figure 30**, there are underground workings present within the BPCP mining areas, so whilst this presents an opportunity to extract the remaining pillars that were left behind, it also presents significant operational challenges that need to be managed**.** Principal challenges relate to[52] :

- Lack of information on the old workings – there could be a paucity of information regarding the state of the old pillars and the general conditions of the workings.
- Spontaneous combustion.
- Sinkholes and surface subsidence in the old workings.
- Incompetent roof beam and highwall.
- Excessive dilution.
- Fire affected coal impacting on coal quality.
- Pit flooding.
- Acid Mine Drainage (**AMD**) where the relevant conditions exist.

Bathurst and BT Mining are experienced in managing these challenges as we have been working in and around historic underground workings for decades at Stockton as well as at other mining operations around NZ. To this end, and in addition to site specific risk assessments and hazard identification, existing operational controls in place will be employed at the BPCP to manage the challenges noted above.

8.3 Existing Acid Mine Drainage

The oxidation of PAF and HAF rocks and the consequent release of acid drainage is a natural process, referred to as "acid rock drainage" (ARD), which normally occurs slowly as the surface of the earth erodes and the underlying rock oxidises[53]. The term (**ARD**) includes all processes whereby sulphide rich (ie. PAF and HAF) rocks are exposed to oxygen and water and can occur without mining as part of normal geological weathering. Bedrock buried in the Earth is chemically stable as it is not exposed to air, but when it becomes exposed to air and water the rock becomes destabilised through chemical and physical changes. Mining operations can accelerate the oxidation process by providing flow paths (Department of the Environment, 2021) that accelerate the process of acid rock drainage which is referred to as "acid mine drainage" (AMD).

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[52] Ngwenyama, P.L. and Graaf, W.W (2021). Risks and Challenges affecting opencast pillar mining in previously mined underground bord and pillar workings. Journal of the South African Institute of Mining and Metallurgy. Vol.121, No. 12, pp.623-633

[53] Department of the Environment (2021). Acid mine drainage in Australia: Its extent and potential future liability. https://www.dcceew.gov.au/science-research/supervising-scientist/publications/ssr/acid-mine-drainage-australia-its-extent-and-potential-future-liability accessed 10 August 2025.

For both ARD and AMD, sulphide minerals can break down, producing acid which reacts with rocks, dissolving other metals into solution and being transported away in the water. This process is known as "metal leaching". ARD and metal leaching are complex processes which involve several chemical, biological and electrochemical reactions with the rate of reaction dependent upon many factors including:

- the morphology of the sulphide rich rock.
- presence of oxygen.
- presence of bacteria.
- presence of acid-consuming materials – materials with the capacity to neutralise acid.
- presence of water.

Identifying PAF, HAF and NAF rocks is critical to mine planning and the following activities are carried out to understand the potential for these rocks to exist within the proposed mining area:

- A geochemical baseline programme focuses on understanding the chemical composition of materials to be mined (e.g., waste rock, see **Section 4**). This information determines the potential of these materials to release acid and metals into the environment.
- The results of the geochemical characterisation will provide input into overburden rock placement and water management planning, as well as to inform closure and rehabilitation planning.
- A robust geochemical characterisation programme is used to build a model of the different geochemical rock types.
- The geochemical characterisation programme is ongoing with the mining operations to validate, maintain the database of PAF and NAF rock and its location and update the geochemical model
- The geochemical model is used to determine where the differing overburden rock types will be placed when mined and emplaced during rehabilitation.
- Historic underground mining on the Buller Plateaux has a strong influence on ground water flow paths. The historic underground workings are considered in the mine planning and design process.
- The hydrogeological baseline programme focuses on the quality, distribution and movement of groundwater, which will provide input into the mine design, including site layout, overburden rock placement, water management and rehabilitation.

Controls and mitigation measures typically implemented to manage PAF rock may include (**Figure** 31):

- Segregation of PAF rocks and NAF rocks once exposed.
- Placement of PAF rock under groundwater levels to minimize exposure to air and oxygen.
- Sealing of underground workings (if present) to restrict the escape of acidic water and/or restrict the ingress of oxygen.
- Encapsulation and compaction of PAF rocks at depth within ELFs.
- Encapsulating compacted PAF rocks by a cover of compacted NAF rocks.

- Neutralising PAF rocks via the addition of acid-consuming materials such as lime, mixed in and compacted within the rock matrix.
- Directing water drainage from PAF rock areas to containment ponds with water treatment to neutralise acidic water and collect sludges (i.e. metals and materials that precipitate out of the formerly acidic waters). Water treatment options may be "active" or "passive".

The potential for AMD is considered at every stage of mine development, operation and reclamation (rehabilitation) by ensuring mined materials are characterised and proactive measures such as those listed above (see also **Figure 31**), to minimise AMD are included in the design.

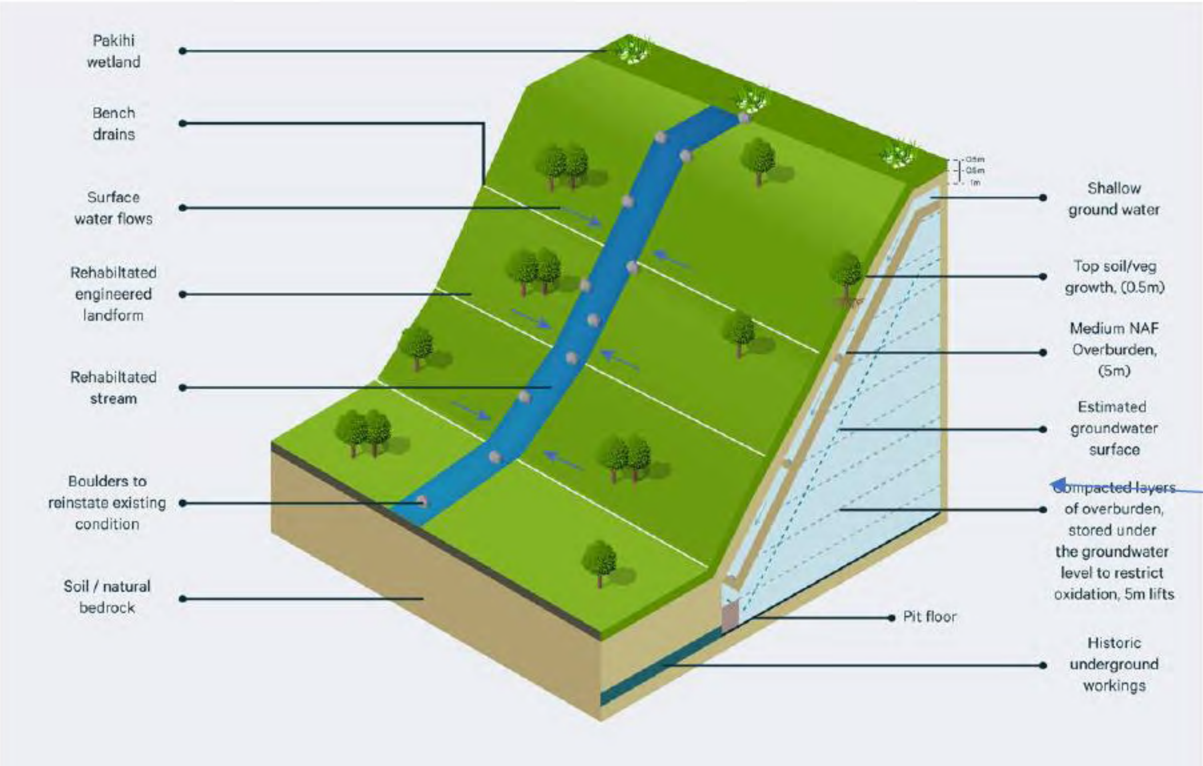

Figure 31: Conceptual ELF Design - Segregation and Management of PAF and NAF rocks

Bathurst and BT Mining are experienced in treating and managing AMD where it exists. Management ranges from "Active Treatment" processes to "Passive Treatment" processes. "Active Treatment" includes physically dosing neutralising chemical followed by physical and chemical mixing and settling processes. "Passive Treatment" includes allowing the water to filter through a medium such as Mussel Shell Reactors[54] (**MSR**) which neutralises the water, allowing solid precipitates to settle out, generally without the need for continual intervention. Both "Active and Passive Treatment" facilities are operated and monitored by experienced personnel.

[54] Weber et al, 2016, Novel cost effective full scale mussel shell bioreactors for metal removal and acid neutralization

9 Buller Plateaux Continuation Project – Meeting the Challenge

9.1 Meeting Customer Specifications – BPCP Interdependencies

[redacted]

As discussed in **Section 2.6**, steel manufacturers all have their own recipe for making coke (i.e. coal blend) required to make their steel. Buller Plateaux coals vary in coking properties and coal quality across the Stockton and Denniston plateaux. This requires careful blending strategies that govern the mine plan, and mining sequencing, coal processing requirements and timing of extraction to ensure customer blends can be delivered.

Coal from the Buller Plateaux is mined from seams using open pit mining methods. Excavated coal is separated (processed) from overburden rock material to prepare it for commercial use. Coal quality, ash, sulphur, volatiles and coal rank, are all key considerations (amongst others) to make a suitable blend for steel producers. For this reason, coal quality parameters are sampled, analysed, interpreted, modelled, interpolated and mapped across the differing mining areas based on coal testing results obtained from exploratory drilling and in pit testing. **Figure 32** and **Figure 33** show the variation in just two coal quality parameters from the Denniston Plateau; **Figure 32** presents the variability in RoMAX and **Figure 33** presents the variations in volatile matter. Similar variations exist for other coal quality parameters. The different colours presented in both figures depicts the varying qualities.

[redacted]

[redacted]

The coal to be extracted from the BPCP mining sub-areas all have varying qualities and need to be blended to meet customer specifications. The blending of coals from the various BPCP mining pits are depicted in the Sankey Diagram presented in **Figure 23** of **Section 6.2**. Plans and schedules are prepared on how, where and when the coals from the various mining pits can be extracted and blended to meet customer specifications and requirements. This requires multiple working pits to be in operation at any one time.

Getting the product blends right requires meticulous planning and timing using experienced personnel to make sure the required proportions of the various coals are extracted at the right time and at the required volumes with minimal dilution. Coupled with ELF design, pit backfill, segregation and management of PAF and NAF rocks, rehabilitation, VDT; these mining processes require a skilled multi-disciplinary team. Importantly, without the variety of coals on offer at any time from each of the mining pits (Escarpment Extended, Mount Frederick South, Cypress and Stockton), product blends required by customers will not be able to be met. [redacted]

9.2 Greenhouse Gas Benefits

Bituminous coal from the Buller Plateaux has unique properties and for this reason, the coal products and blends are highly sought after by steel manufacturers around the world. The purpose of this section is to provide examples of why coal from Buller Plateaux is a sought after commodity.

Minimises Greenhouse Gas Emissions

An independently verified analysis of coal from the Buller Plateaux[55], has validated that overseas steelmakers avoid emitting 195,000 tonnes of CO_2 per year because of its unique properties. It is well established that the high vitrinite and low ash properties in coal from the Stockton mine (specifically the "Alpine Blend") offer fuel savings to customers when compared with other seaborne coking coals, and therefore lower carbon dioxide emissions per unit of steel they produce.

[55] SGS unpublished report, 2012, Calculation of New Zealand Export Coking Coal Carbon Dioxide Emission Savings.

A study carried out in 2021-2022, quantified the emission savings by using one of Bathurst's iron and steel manufacturing customers in India as a case study. They opt to blend the "Alpine Blend" product with Australian and Indian coals, precisely because Stockton's low ash and high vitrinite content coal:

- Reduces their fuel use,
- Reduces the rate of slag formation in the furnace,
- It also improves the coke strength in the furnace; and
- Reduces their overall fuel use, saving on costs.

Bathurst's analysis confirmed that at this single steel manufacturing plant alone, the benefits of using the "Alpine Blend" product amounts to an annual reduction in CO_2 emissions of 145,000 tonnes ("t CO_2"). This reflects a reduction in the blast furnace fuel rate of 14.24 kilograms of coal per tonne of hot metal produced, at an annual plant production of 3.6 million tonnes ("Mt") of hot metal.

[redacted]

In the early years of the BPCP plan, the emissions reduction delivered by continued sales of low ash coal (dominated by Stockton area production) remains substantial at ~270,000t/annum emissions.

Once the Alpine product is removed from the product mix the annual estimated emissions reduction drops to ~200,000t/annum. In the final 5 years of production, that focus on a specific premium coking product mix proposed for the BPCP project (Whareatea Hard Coking Coal product) emission savings are further reduced to ~120,000t per annum.

Independent verification of these results has been obtained from SGS Laboratories Limited. The report states "*the derived emissions reductions are fairly calculated for the Alpine blend*", which refers to Stockton's export coal specification.

At present, bituminous coal remains an essential input into the steel industry. The International Energy Agency projects demand for steel to increase by a third by 2050[56]. To this end, Bathurst Resources plays a role in supplying coal required for steel manufacturing to customers, who can now quantify their emissions reductions from using the "Alpine Blend" product. The BPCP will extend this benefit out to 2029 through the ongoing supply of the "Alpine Blend" and beyond 2029 with its other coal blends.

[56] https://www.iea.org/reports/iron-and-steel-technology-roadmap

10 Conclusion

The Buller Plateaux Continuation Project represents a uniquely valuable opportunity for New Zealand's mining sector and for the global steel industry. The geology of the West Coast has produced rare, high-quality bituminous coals with exceptional coking properties, characterised by high vitrinite content, low ash levels and favourable rank profiles. These qualities make Buller Plateaux coals highly sought after by international steel manufacturers, who rely on consistent, high-performance blends to maintain efficient and economic blast furnace operations. The scientific, technical and operational processes described in this report clearly demonstrate the depth of expertise required to identify, extract, process and blend these coals to meet stringent customer specifications.

As outlined, the BPCP can only realise its potential when all mining sub-areas—Escarpment Extended, Mount Frederick South, Cypress and Stockton—operate in an integrated manner. Each contributes essential coal qualities needed for the complex blending requirements that underpin customer contracts and product value. Without this multi-pit approach, the premium blends that underpin economic viability cannot be produced.

Mining on the West Coast presents significant technical and environmental challenges, including complex geology, historic underground workings, rock strength variability, and the need for robust acid mine drainage management. Through the application of disciplined geological modelling, advanced mine planning, structured waste rock management, engineered landforms, and ongoing environmental monitoring, Bathurst and BT Mining have demonstrated the capability to manage these challenges responsibly and effectively.

The project also delivers wider benefits beyond the mine gate. High-rank, low-ash West Coast coal directly reduces emissions for global steelmakers by improving coke strength, reducing slag volumes, and lowering total fuel consumption. Independent analysis confirms that the premium "Alpine Blend" alone enables hundreds of thousands of tonnes of CO_2-equivalent emissions to be avoided each year—a meaningful contribution during a decades-long global transition toward lower-carbon steelmaking.

Ultimately, the BPCP continues a long legacy of coal extraction on the Buller Plateaux while applying modern science, engineering and environmental stewardship. The project supports regional employment, contributes to national economic growth, and plays a critical role in supplying high-quality coking coal essential for global steel production—a material central to infrastructure, technology, manufacturing and modern life. The combination of rare resource characteristics, disciplined planning, and responsible operations ensures that the BPCP can meet both economic and environmental expectations while delivering a product integral to global development.

Appendix 1

Mining Method Selection: Surface or Underground Mining

The technical and economic feasibility of a coal resource area needs to be evaluated for a suitable mining method. There are many factors that are considered to determine the best method to extract the identified coal resource including:

- Regional geological conditions ie. depth of coal seam, geological anomalies
- Overburden characteristics ie. competency of overlying rock materials
- Coal seam characteristics ie. Seam splitting, seam thickness, coal quality and continuity
- Coal recovery ie. Restrictions / opportunities associated with historic underground workings
- Land ownership and surface environmental conditions
- Groundwater conditions
- Gas generation ie. Is methane inherently high within the seam
- Labour and workforce availability
- Market demand
- Capital investment and cashflow
- Health and safety issues

Table 6 describes the high-level ranking assessment for considering the application of surface and underground mining methods.

Table 6: Mining Method Selection Criteria

Mining Method Selection Criteria	Surface Mining	Underground Mining
Regional geological conditions;	Improved ability to sequence mining around variable geological conditions and work around or mine through fault zones. Coal seams are relatively shallow that preclude.	Less flexible to mining sequence around geological conditions, standoff distances from adverse underground features and loss of coal reserves around faults.
Overburden characteristics;	Competent rock amenable to stable walls for opencast mining; Bathurst holds many years of mining in similar conditions.	Relative competent rock for underground mining.
Coal seam characteristics including seam continuity, thickness, structure, coal quality, coal quality continuity and depth;	Opencast mining flexible to coal seam spatial variability and coal quality variability.	Not flexible to changing conditions. Underground mining in NZ has always struggled with coal seam physical and spatial variability. Overseas mining jurisdictions, e.g. Australia, do not have the same level of structural variability.
Coal mining recovery differences across surface and	High level of coal seam recovery using opencast	Lower coal seam recovery with underground mining.

differing underground mining methods	mining techniques. Bathurst has proven record of coal seam recovery of previous underground mind areas and managing hot zones and active open fires in underground worked areas.	Loss of coal on the coal seam roof and floor that is left for underground opening support Lack of ability to respond to hot ground and open fires in previous underground worked areas Nil ability to mine in and adjacent to previously worked underground mined areas. Previous underground workings are dangerous in the confined spaces of underground mining.
Strength of materials above and below the seam for roof and floor conditions;	Amenable to opencast mining techniques.	
Topography, especially altitude and slope;	Amenable to opencast mining techniques.	
Surface environmental conditions from surface and underground mining.	Large impact caused by opencast mining that is mitigated by proven Stockton rehabilitation practices on surface mining I timeframes of years to decades. Able to correct poor outcomes for surface water discharge and surface disturbance in previous underground worked areas.	Lower impact to surface effects from underground mining. However previous studies indicate the economics do not stack up. Not able to mitigate the surface water discharge and surface disturbance in previous underground worked areas.
Climate;	Proven ability to work in the subalpine environment.	Proven ability to work in the subalpine environment.
Land ownership and land access as it affects the availability of land for mining and access;	Land access has been granted in prior cases for surface mining on Crown land managed by Toitū Te Whenua Land Information New Zealand (LINZ) and Department of Conservation Te Papa Atawhai (DOC) subject to suitable bonding and access fees.	
Surface drainage patterns;	Surface drainage patterns require reinstatement following opencast mining and for a key part of final landform design and rehabilitation.	Surface drainage patterns are likely to be disturbed from subsidence caused by underground mining, especially so given the shallow nature of the coal seams of interest. Surface water features require reinstatement following underground mining.
Groundwater conditions;	The ground water conditions within the area of interest on the Buller Plateaux has been impacted by previously	Underground mining presents limited capability and opportunity to control and capture underground water for

	underground worked areas and causing AMD waters to leach from the uncontrolled underground drainage flow into surface streams. Opencast mining will take control of the underground drainage flows and provide opportunity to either block off the drainage paths or intercept the AMD groundwater for active and passive treatment. This is practiced at the Stockton Mine.	active and passive water treatment.
Availability of skilled labour and materials;	Skill operating workforce present drawing from the Stockton Workforce, practices and experience gained over many years.	Very limited skills in New Zealand for underground coal mining. Many people have left the NZ coal mining industry after the closing of the underground coal mines of Spring Creek, Roa and Pike River. It would be difficult to reintroduce the skills and work culture required for underground coal mining in New Zealand The NZ mining conditions are different to typical mining conditions experienced in Australia and South Africa.
Coal purchaser specification requirements in terms of tonnage, quality, and destination.	Experienced techniques and flexibility with opencast mining to match the variable coal quality on Buller Plateaux coals to market requirements.	Blending techniques would be similar however underground mining is much less flexible to coal quality variation experienced within th e seam from roof to floor as well spatial extents of variability.
Capital investment requirements and timing of cashflows during mine development and mine production.	Lower capital investment required, higher operating cos when strip ratio of waste: coal gets high	Larger upfront capital investment required to establish an underground mine's infrastructure and initial development requirements. Lower production costs come from pillar extraction activity
Health and Safety Issues	All the normal H&S issues around extractive activities but without the added risks of explosions in a mine	Issues around gassy mines and dealing with methane. Previous coal mining disasters have related to underground

		coal mines e.g. Strongman mine and Pike River Mine

For the BPCP area, there are significant areas of underground workings within the coal resource area. The presence of the underground working precludes the ability to safely mine these areas using underground mining methods. The areas that do not have underground workings have been left for either coal seam structural reasons (faulting, narrow seams) or coal quality reasons.