ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

MODIFICATION REPORT

TRONOX

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION

MODIFICATION REPORT

PREPARED BY
RESOURCE STRATEGIES PTY LTD

JULY 2019
Project No. CMA-18-07
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EXECUTIVE SUMMARY

ES.1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, New South Wales (NSW), and approximately 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km south-west of the township of Ivanhoe.

The Project operates in accordance with Development Consent (SSD_5012) issued under Part 4 of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act) in 2014. Construction activities at the Atlas-Campaspe Mine commenced in 2018.

The Project is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019.

The Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification) is sought under section 4.55(2) of the EP&A Act.

ES.2 OVERVIEW OF THE MODIFICATION

Since the preparation of the *Atlas-Campaspe Mineral Sands Project Environmental Impact Statement*, Tronox has undertaken Project optimisation planning in consideration of recent experience at its existing NSW operations.

A key outcome of the Project optimisation planning is revised mine scheduling for the Atlas deposit, which would increase the maximum mineral concentrate production rate; without increasing the approved ore mining rate. Other changes to optimise Project operations were also identified as part of the Project optimisation planning. The optimisation of the Project will increase its efficiency and economic viability.

The Modification would implement the outcomes of the optimisation planning and would include:

- increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- increased mineral concentrate transport train length (from 600 metres to 920 metres) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- increased mineral separation plant (MSP) process waste disposal from 50,000 tpa to 65,000 tpa;
- the option to use an overland conveyor to transfer overburden in addition to haul trucks;
- the relocation of the Atlas-Campaspe Mine accommodation camp;
- the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- development of an emergency airstrip at the Atlas-Campaspe Mine;
- construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- extension to the Ivanhoe Rail Facility hardstand area;
- extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- a revised alignment of the Ivanhoe Rail Facility access road and access road intersection;
- a groundwater supply bore for the Ivanhoe Rail Facility; and
- the use of local roads other than the road haulage route by Project-related light vehicles to access site.

Table ES-1 provides a comparative summary of the approved and modified Project. Based on a review of the proposed Project changes, Tronox considers that the modified Project would be substantially the same as the originally approved Project.

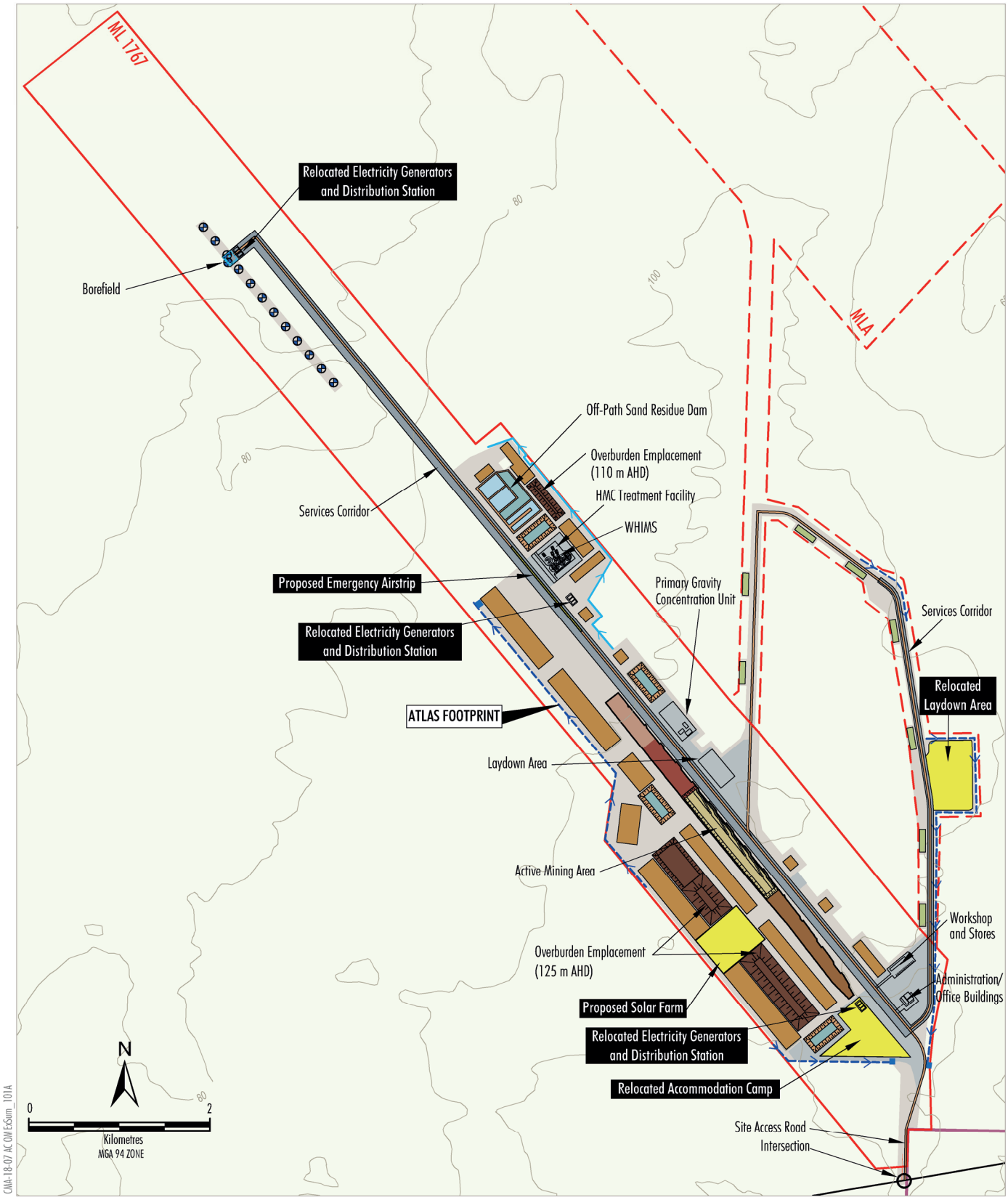
Figures ES-1 and ES-2 show the modified Atlas-Campaspe Mine and Ivanhoe Rail Facility, respectively. Figure ES-3 shows the proposed light vehicle access routes.

Table ES-1
Comparison of the Existing/Approved and Modified Project

Project Component	Approved Project	Modified Project
Atlas-Campaspe Mine		
Project Life	• Mining operations until 30 June 2034.	• No change.
Tenement	• Mining Lease 1767 and Mining Lease Application 1.	• No change.
Mining	• Dry mining (i.e. dozers and/or loaders and excavators) operation producing approximately 7.2 million tonnes per annum of ore.	• No change.
Mineral Concentration and Mineral Concentrate Transport	• Ore concentrated in the primary gravity concentration unit (comprising a screen, surge bin and wet concentrator) to produce heavy mineral concentrate. • Heavy mineral concentrate washed in the salt washing facility prior to processing in the wet high intensity magnetic separator circuit to produce ilmenite-rich, leucoxene-rich and non-magnetic (containing rutile-rich and zircon-rich) mineral concentrates. • Mineral concentrate production up to 546,000 tpa. • Mineral concentrate transport up to 450,000 tpa. • Up to 24 Roads and Maritime Services-approved haulage vehicle trips per day.	• No change to mineral concentration methods. • Increase in mineral concentrate production and transport up to 665,000 tpa. • Increase in Roads and Maritime Services -approved haulage vehicle trips up to 35 per day.
Overburden Management	• Overburden removal ahead of ore extraction areas using conventional truck and shovel methods (e.g. excavators and haul trucks). • Overburden replacement, including progressive backfilling of mine voids behind the advancing ore extraction areas or in overburden emplacements adjacent to the mine path using haul trucks.	• Option to use an overland conveyor to transfer overburden in addition to haul trucks.
Sand Residue and Coarse Reject Management	• Sand residues and coarse rejects placed in either overburden emplacement cells behind the advancing ore extraction area or in off-path sand residue dams.	• No change.
MSP Process Waste Management	• MSP process waste placed behind the advancing ore extraction areas at either the Ginkgo Mine, Snapper Mine or Atlas-Campaspe Mine. • MSP process waste production of up to 50,000 tpa.	• No change to MSP process waste management. • Increase in MSP process waste production up to 65,000 tpa.
Water Supply	• Water requirements will be supplied by the Atlas-Campaspe Mine borefield.	• No change.
Electricity Supply	• Electricity supplied by diesel generator sets.	• Option to develop on-site solar power generation infrastructure to supplement diesel power generation.
Supporting Infrastructure	• Construction of supporting infrastructure within the approved surface development area.	• Relocation of the accommodation camp. • Development of an emergency airstrip. • Construction and operation of a telecommunications tower.
Site Access	• Access to the Atlas-Campaspe Mine is via the road haulage route.	• The use of other local roads other than the haulage route by Project-related light vehicles to access site.

Table ES-1 (Continued)
Comparison of the Existing/Approved and Modified Project

Project Component	Approved Project	Modified Project
Atlas-Campaspe Mine (Cont.)		
Employment	• Approximately 300 personnel during peak construction. • Approximately 200 personnel during operations.	• No change.
Rehabilitation Works	• Progressive rehabilitation undertaken as mining advances.	• No change.
Biodiversity Offset Area	• Approximately 16,540 hectares will be established to offset native vegetation communities cleared for the Project.	• No change.
Ivanhoe Rail Facility		
Infrastructure	• Construction of infrastructure within the approved surface development area, including access road, rail siding, hardstand area, site office, parking, fencing, lighting and water management infrastructure.	• Extension to the hardstand area. • Extension of the rail siding and addition of a passing siding. • Revised alignment of the access road and access road intersection.
Unloading and Stockpiling	• Mineral concentrate emptied directly onto a mineral concentrate stockpile for reclaim by a front-end loader to load directly into train wagon containers.	• No change.
Train Movements	• Up to three trains per week. • Up to one train trip in any 24-hour period.	• Increase in train frequency to four per week. • No change to number of trains in any 24-hour period.
Water Supply	• Waters collected onsite and potable water trucked from the Atlas-Campaspe Mine or the Ivanhoe town water supply.	• Addition of a groundwater supply bore. • No change to the potable water supply.
Electricity Supply and Distribution	• Electricity supplied via the local network.	• No change.



Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012) and Tronox (2019)

LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Exploration Licence Boundary (EL)
- Up-catchment Diversions
- Collection Drains
- Bore
- Approximate Extent of Surface Development - Year 2
- Fixed Infrastructure Areas
- Soil Stockpile
- Process Water Storage
- Overburden Emplacement
- Stage 1 Rehabilitation - Stabilised Landform with Seed/Cover Crop Application

Active Mining Area

- Vegetation Clearance/Soil Stripping
- Overburden Removal
- Ore Zone/Extraction Area
- Overburden Replacement/Process Waste Emplacement/Soil Replacement
- Sediment Basin

ACMSP Modification

- Modification Surface Development Area

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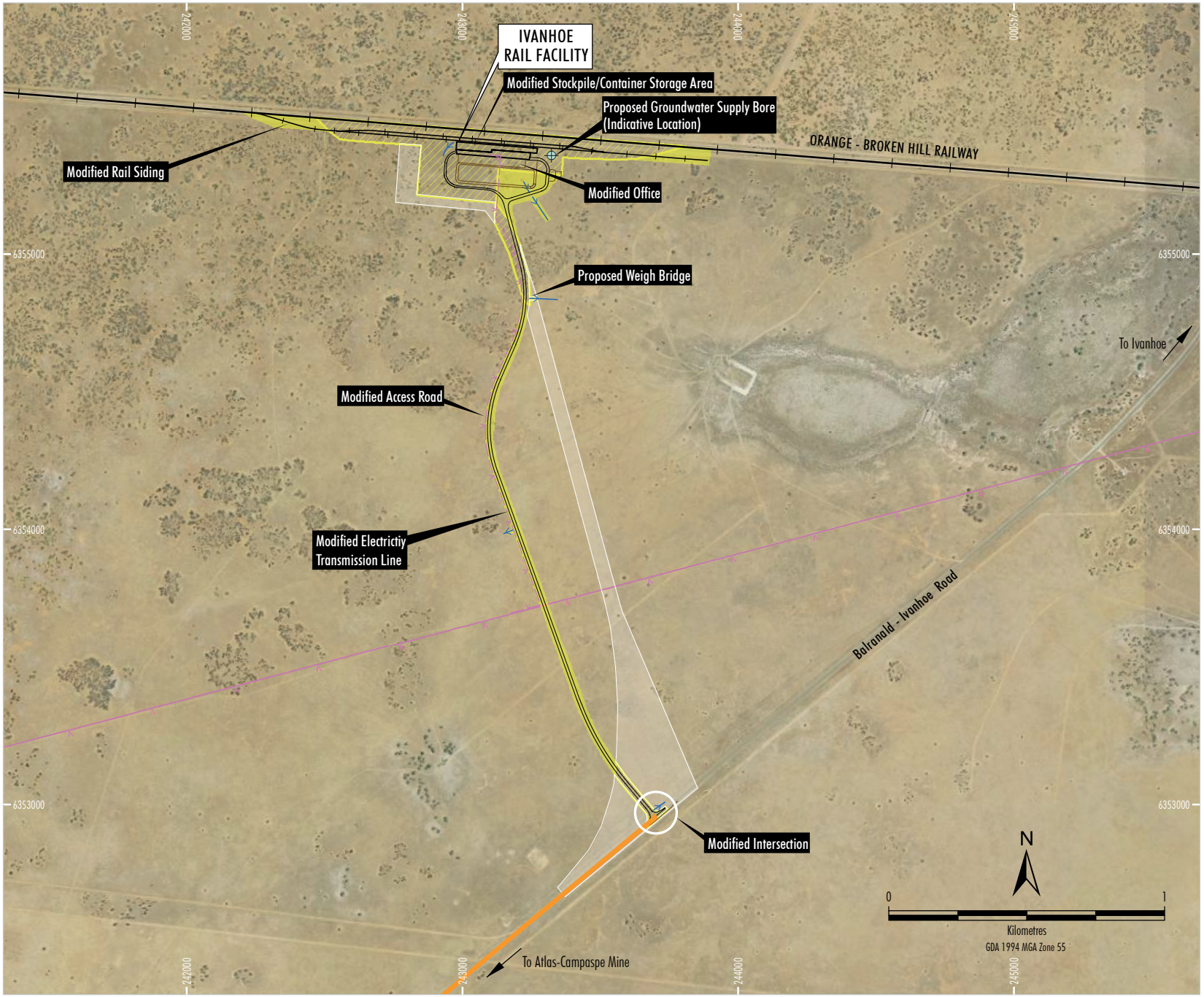
OPTIMISATION MODIFICATION

Modified Atlas-Campaspe Mine General Arrangement - Year 2

Figure ES-1



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure ES-2

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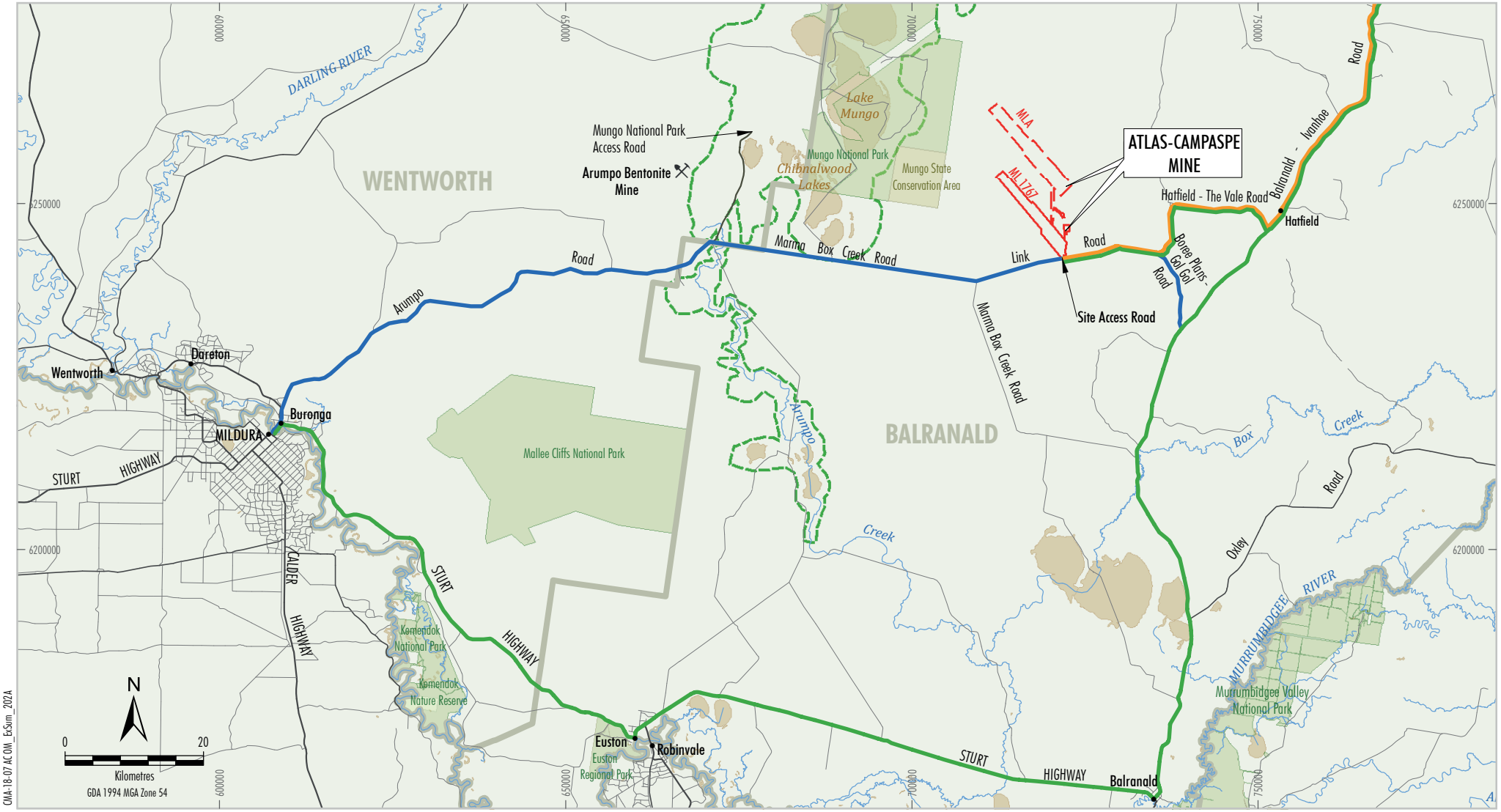

LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- National Park
- Nature Reserve
- Regional Park
- State Conservation Area
- Approved Light Vehicle Access Route
- Approved Mineral Concentrate Transport Route
- Proposed Light Vehicle Access Routes

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012); Tronox (2019) and TTPP (2019)

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OPTIMISATION MODIFICATION

Project Transport Routes

Figure ES-3

ES.3 ENVIRONMENTAL REVIEW

The key potential impacts of the Modification are related to the proposed changes to the approved Atlas-Campaspe Mine, Ivanhoe Rail Facility and Project transport activities described in Table ES-1.

In order to assess the potential environmental impacts of the Modification, an environmental review of the key potential impacts of the Modification was undertaken. The key outcomes of the environmental review are summarised in Table ES-2.

Table ES-2
Key Outcomes of Environmental Review

Environmental Aspect	Summary of Key Environmental Review Conclusions	
	Atlas-Campaspe Mine	**Ivanhoe Rail Facility**
Road Transport	• The increased heavy vehicle trips on the approved road haulage route would be well within the day-to-day variation in traffic volumes and would not have a perceivable impact on the level of service experienced by drivers along the route. • The proposed local roads routes would satisfactorily accommodate the Project-generated traffic, subject to the implementation of road improvements. • Portions of Link Road and Boree Plains-Gol Gol Road would be upgraded for the Modification. • The Modification would have road safety benefits for the Project workforce and other road users.	
Air Quality	• Potential air quality impacts associated with the modified Atlas-Campaspe Mine would not contribute to any exceedances of the relevant air quality criteria at the closest privately-owned sensitive receptors. • Dust emissions from the modified Atlas-Campaspe Mine would decrease if the overland conveyor is adopted to transfer overburden.	• Potential air quality impacts associated with the modified Ivanhoe Rail Facility would not contribute to any exceedances of the relevant air quality criteria at the closest privately-owned sensitive receptors. • The Modification would result in an overall reduction in emissions from the Ivanhoe Rail Facility.
Noise	• Noise emissions from the modified Atlas-Campaspe Mine would be unchanged and therefore comply with the relevant noise criteria for all modelled receivers under neutral and adverse meteorological conditions. • Noise emissions from the modified Atlas-Campaspe Mine would decrease if the overland conveyor is adopted to transfer overburden.	• Noise emissions due to the modified Ivanhoe Rail Facility would not result in any material increase in noise levels, and relevant noise criteria are predicted to be achieved for all modelled receivers under neutral and adverse meteorological conditions.
Biodiversity	• As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on biodiversity are expected.	• No increase in impacts on biodiversity values would occur as a result of the Modification, as there would be a reduction in native vegetation/habitat clearance for the modified Ivanhoe Rail Facility. • A Biodiversity Development Assessment Report is not required to be prepared for the Modification as the Modification would not increase impacts on biodiversity values, with reference to the *Biodiversity Conservation Act, 2016* and the Department of Planning and Environment's *Biodiversity Development Assessment Report Waiver Determinations for SSD and SSI Applications.*

Table ES-2 (Continued)
Key Outcomes of Environmental Review

Environmental Aspect	Summary of Key Environmental Review Conclusions	
	Atlas-Campaspe Mine	**Ivanhoe Rail Facility**
Aboriginal Cultural Heritage	• As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on Aboriginal cultural heritage are expected.	• Five Aboriginal cultural heritage sites were identified in the modified Ivanhoe Rail Facility surface development area. • Tronox would arrange collection of the objects prior to the commencement of disturbance activities and engage a suitably qualified archaeologist and representatives of the Registered Aboriginal Parties to record and collect the artefacts.
Historic Heritage	• As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on historic heritage are expected.	• No historic heritage sites were recorded during the field survey of the modified Ivanhoe Rail Facility surface development area.
Land and Agricultural Resources	• As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on land and agricultural resources are expected.	• The Modification would result in a net reduction in surface development area at the Ivanhoe Rail Facility, therefore there is expected to be an overall reduction in potential land and agricultural resource impacts as a result of the Modification.
Surface Water Resources	• As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on surface water resources are expected.	• The Modification would not significantly change the general arrangement and/or water management at the Ivanhoe Rail Facility, therefore no material change to potential surface water impacts are expected.
Groundwater Resources	• As the Modification would not change the approved mine path, mine life or mining rate, or the water demand at the Atlas-Campaspe Mine, no changes to the approved groundwater impacts are expected.	• The maximum predicted drawdown due to the proposed Ivanhoe Rail Facility groundwater supply bore is not predicted to be significant beyond 100 metres. • Drawdown at the closest bore (approximately 2 km away) is predicted to be negligible. • The proposed Ivanhoe Rail Facility groundwater supply bore would have “minimal impact” as defined in the NSW Aquifer Interference Policy. • Tronox holds sufficient entitlements (100 share components or ML) under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Ivanhoe Rail Facility groundwater supply bore.
Greenhouse Gases	• It is expected that although annual greenhouse gas emissions may increase during certain years, the total greenhouse gas emissions due to the modified Project (over the whole Project life) would not change significantly as a result of the Modification.	

Table ES-2 (Continued)
Key Outcomes of Environmental Review

Environmental Aspect	Summary of Key Environmental Review Conclusions	
	Atlas-Campaspe Mine	Ivanhoe Rail Facility
Economic	• The estimated NSW Government royalties over the life of the Project (i.e. $95 million) would not significantly change as a result of the Modification as the total amount of mineral concentrates produced would not significantly change. • The Modification would not change the approved Project workforce, and therefore the economic benefits associated with these employment opportunities would be unchanged.	
Hazards and Risks	• The Modification would not significantly change the existing potential risks or hazard consequences identified in the Preliminary Hazard Analysis for the approved Project, as the proposed activities associated with the Modification are consistent with those for the approved Project.	
Visual	• As the Modification would not significantly change the design or arrangement of the approved Project, no significant changes to the approved potential visual impacts are expected.	
Social and Community Infrastructure	• As the Modification would not result in any additional demand for employees or change the expected employee residential distribution, no material alteration to the approved social and community infrastructure impacts is expected.	

ES.5 MODIFICATION JUSTIFICATION

Approval of the Modification is considered to be justified given:

- The Modification would promote the more efficient and economic recovery of mineral sands resources at the Atlas-Campaspe Mine (i.e. through increasing the mineral concentrate production rate without having to increase the mineral sands ore extraction rate).
- The proposed use of local roads would improve the safety of the Project workforce and the road network.
- The proposed increases in the rate of mineral concentrate production and transport could be achieved with no exceedances of the relevant noise and air quality criteria.
- The proposed telecommunications tower would provide mobile coverage/reception to the Atlas-Campaspe Mine area that would also be able to be used by community members.
- The proposed emergency air strip would improve safety of the Project workforce.
- The proposed changes to the Ivanhoe Rail Facility layout would reduce potential biodiversity and land resource impacts.
- The Modification would improve the productivity of the Project, improving the security of the continued employment of the workforce and ongoing expenditure in the State and local economies.

It is therefore considered that the Modification is justified on environmental, economic and social grounds.

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1 INTRODUCTION

This document is a Modification Report for a proposed modification to the Atlas-Campaspe Mineral Sands Project (the Project).

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Project operates in accordance with Development Consent (SSD_5012) (Attachment 1) issued under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act, 1979* (EP&A Act) in 2014. Construction activities at the Atlas-Campaspe Mine commenced in 2018.

The Project is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019.

The Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification) is sought under section 4.55(2) of the EP&A Act.

1.1 OVERVIEW OF THE APPROVED PROJECT

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW, and approximately 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km south-west of the township of Ivanhoe (Figure 1).

The Project will integrate with currently existing/approved Tronox operations in western NSW, including (Figure 1):

- the Broken Hill Mineral Separation Plant (MSP) – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine;
- Snapper Mine – located approximately 105 km west of the Atlas-Campaspe Mine; and
- Ginkgo Mine – located approximately 100 km west of the Atlas-Campaspe Mine.

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the MSP for processing (Figure 1).

At the MSP, the mineral concentrates from the Atlas-Campaspe Mine will be separated and treated to produce valuable minerals. Process wastes generated as a result of processing mineral concentrates at the MSP will be backloaded to the Snapper and Ginkgo Mines until operations at these existing mines cease. At that time, the MSP process waste generated from the processing of mineral concentrates from the Atlas-Campaspe Mine will be railed to the Ivanhoe Rail Facility for subsequent road transport to the Atlas-Campaspe Mine for unloading, stockpiling and placement behind the advancing ore extraction areas.

The Project is approved to extract up to 7.2 million tonnes per annum (Mtpa) of mineral sands ore from the Atlas and Campaspe deposits, and transport a maximum of 450,000 tonnes per annum (tpa) of mineral concentrate to the MSP.

The approved Atlas-Campaspe Mine and Ivanhoe Rail Facility general arrangements are shown on Figures 2 and 3, respectively.

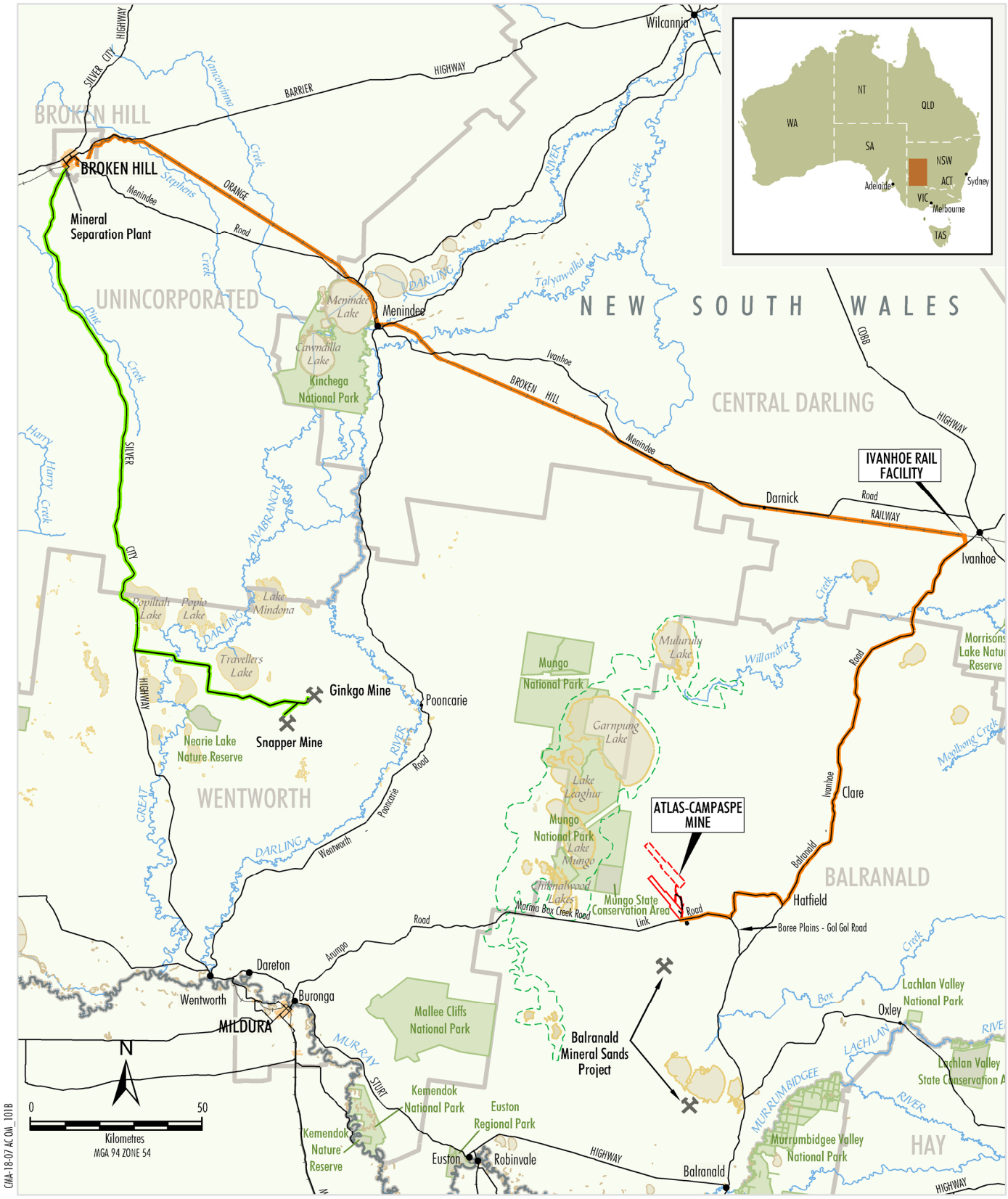
1.2 OVERVIEW OF THE MODIFICATION

Since the preparation of the *Atlas-Campaspe Mineral Sands Project Environmental Impact Statement* (the Project EIS) (Cristal Mining Australia [CMA], 2013), Tronox has undertaken Project optimisation planning in consideration of recent experience at its existing NSW operations.

A key outcome of the Project optimisation planning is revised mine scheduling for the Atlas deposit, which would increase the maximum mineral concentrate production rate; without increasing the approved ore mining rate. Other changes to optimise Project operations were also identified as part of the Project optimisation planning. The optimisation of the Project will increase its efficiency and economic viability.

The Modification would implement the outcomes of the optimisation planning and would include:

- increased mineral concentrate production from 546,000 tpa to 665,000 tpa;
- increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);



LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

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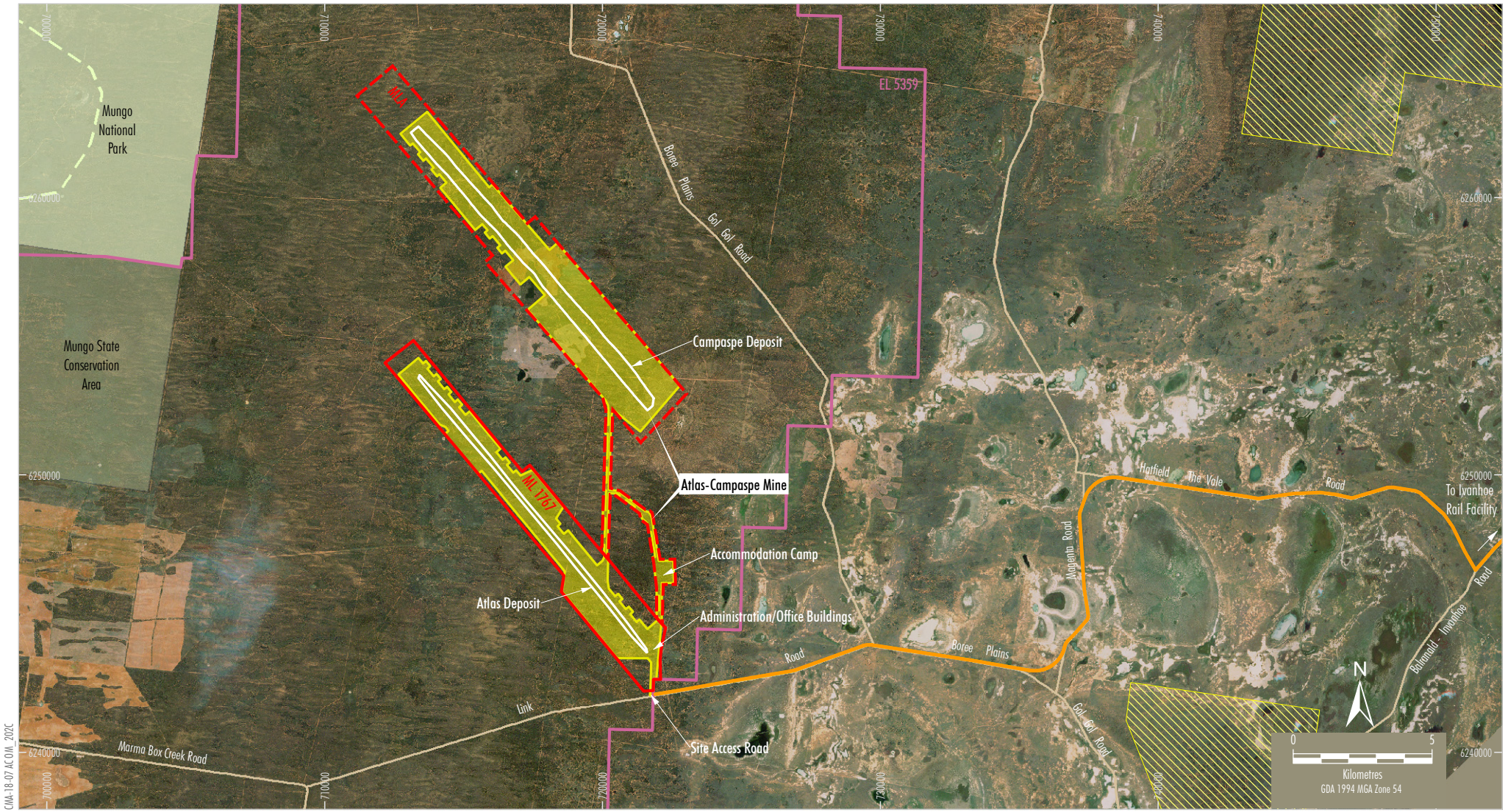
Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1



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LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Exploration Licence Boundary (EL5359)
- National Park/State Conservation Area
- Willandra Lakes World Heritage Area
- Timber Reserve
- Extent of Approved Mine Path
- Approximate Extent of Surface Disturbance
- Mineral Concentrate Transport Route

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)
Orthophoto: AAM Pty Ltd (2011)

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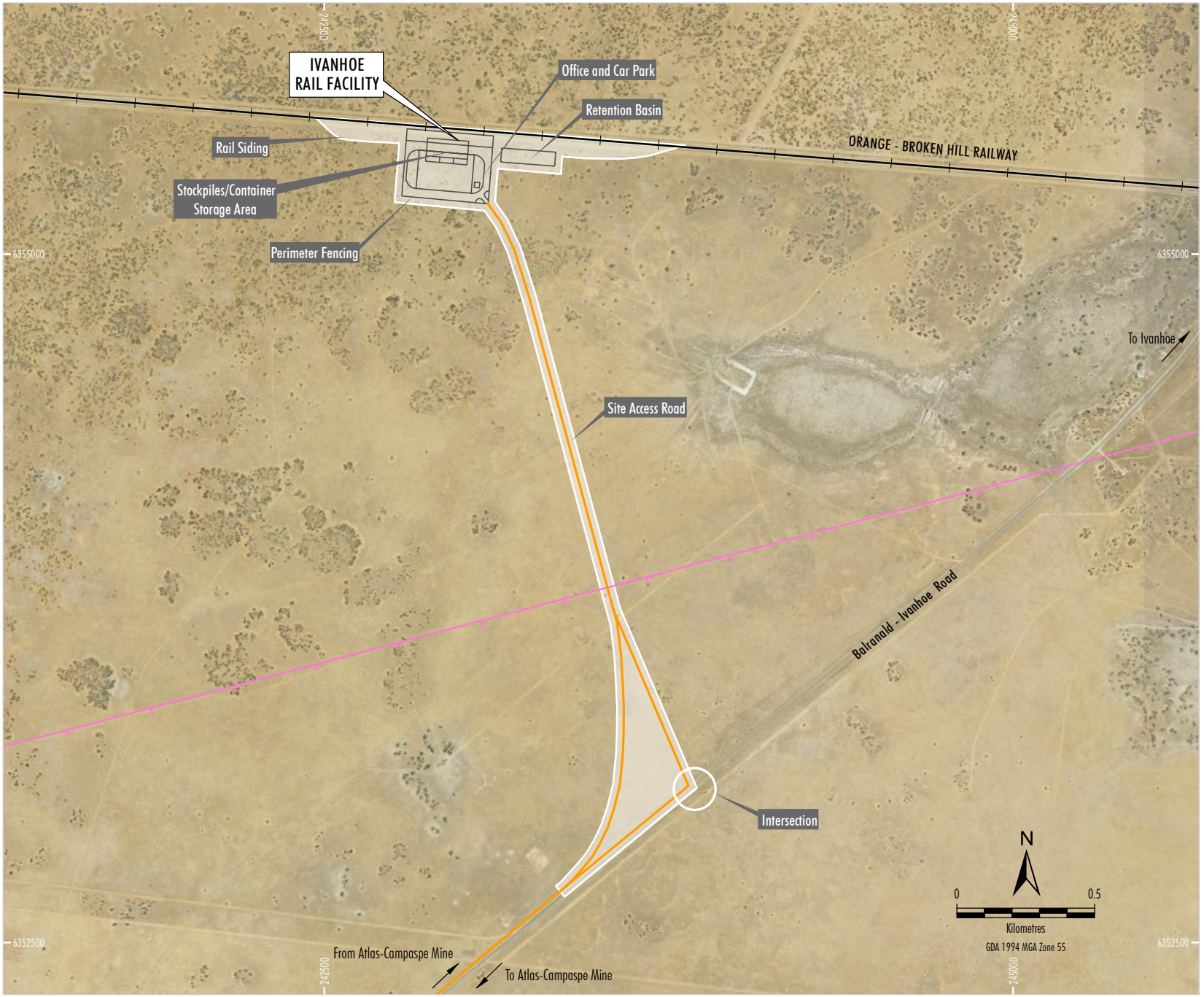
OPTIMISATION MODIFICATION

Approved Atlas-Campaspe Mine General Arrangement

Figure 2



LEGEND

Extent of Approved Surface Development - Ivanhoe Rail Facility

Mineral Concentrate Transport Route*

Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Approved Ivanhoe Rail Facility General Arrangement

Figure 3

CMA-18-07 AC OM_203C

- increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- the option to use an overland conveyor to transfer overburden in addition to haul trucks;
- the relocation of the Atlas-Campaspe Mine accommodation camp;
- the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- development of an emergency airstrip at the Atlas-Campaspe Mine;
- construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- extension to the Ivanhoe Rail Facility hardstand area;
- extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- a revised alignment of the Ivanhoe Rail Facility access road and access road intersection;
- a groundwater supply bore for the Ivanhoe Rail Facility; and
- the use of local roads other than the road haulage route by Project-related light vehicles to access site.

Table 1 provides a comparative summary of the approved and modified Project. Based on a review of the proposed Project changes, Tronox considers that the modified Project would be substantially the same as the originally approved Project (Section 4.1.1).

The modified Atlas-Campaspe Mine and Ivanhoe Rail Facility general arrangements are shown on Figures 4 and 5, respectively.

1.3 CONSULTATION

Consultation has been conducted with relevant leaseholders, Aboriginal stakeholders, key NSW Government agencies, relevant local councils and relevant service providers during the preparation of this Modification Report. A summary of this consultation is provided below.

It is anticipated that consultation will continue during the public exhibition of this Modification Report and the assessment of the Modification by the NSW Government.

Relevant Leaseholders

Tronox provided the leaseholder surrounding the Ivanhoe Rail Facility a briefing that provided information on the Modification (particularly the proposed changes to the Ivanhoe Rail Facility), the environmental approval process and the scope of the Modification Report in May 2019.

Furthermore, Tronox consulted with leaseholders surrounding the Ivanhoe Rail Facility during the preparation of the Bore Census (provided as Attachment A of Appendix F). Tronox also provided the relevant leaseholders surrounding the Ivanhoe Rail Facility a copy of the finalised Ivanhoe Rail Facility Bore Census (included as Attachment A of Appendix F) in July 2019.

Aboriginal Stakeholders

Aboriginal stakeholders were consulted throughout the preparation of the Aboriginal Cultural Heritage Assessment (ACHA) for the Modification (Appendix E). Consultation was conducted in accordance with the NSW Office of Environment and Heritage (OEH) policy *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water [DECCW], 2010a).

Further detail on consultation with Aboriginal stakeholders for the Modification is provided in Section 3.6.

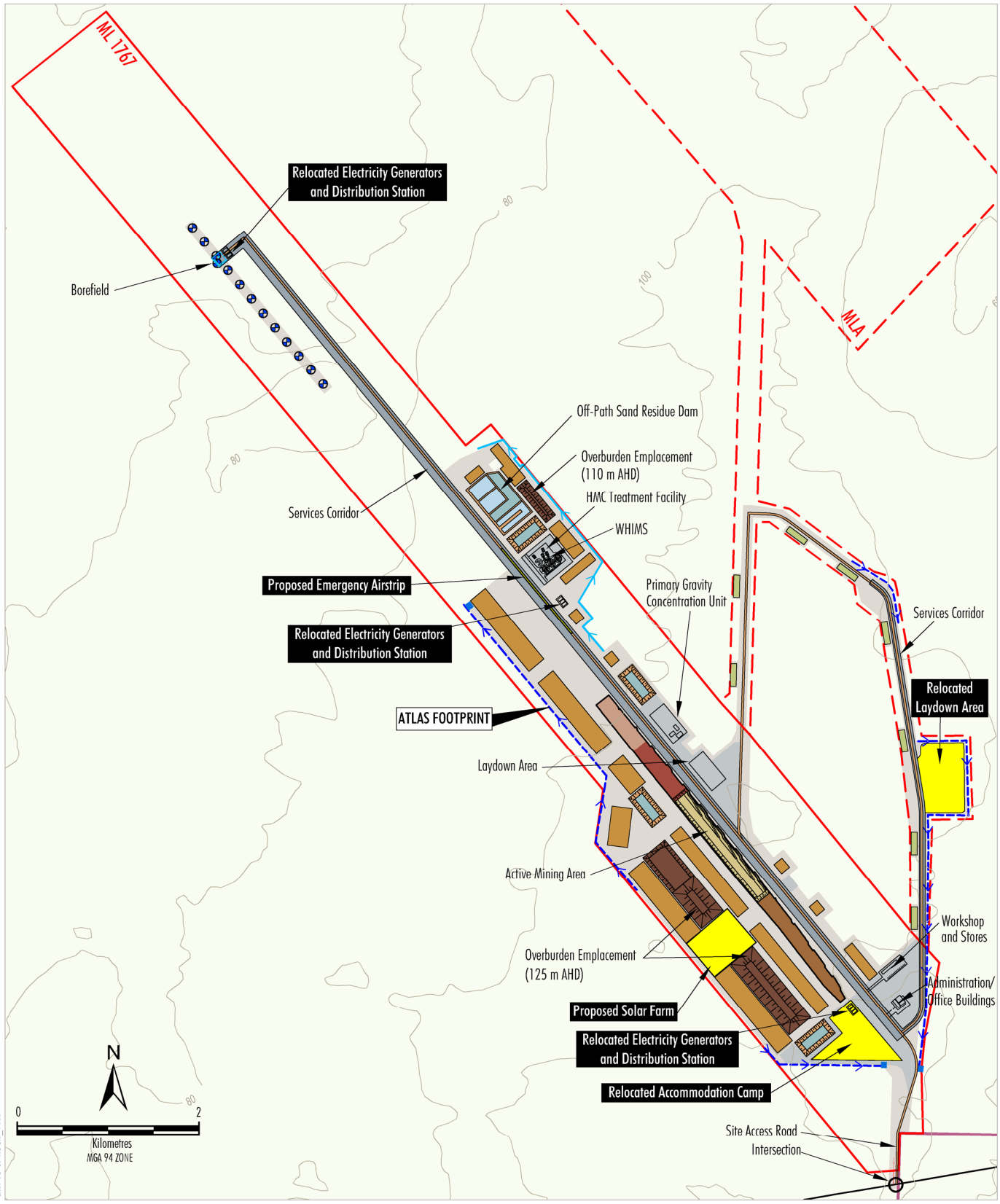
NSW Government Agencies

Tronox continues to consult with relevant NSW Government agencies on a regular basis in relation to the current activities at the Project.

Department of Planning, Industry and Environment

Tronox met with the NSW Department of Planning and Environment (DP&E) (now the Department of Planning, Industry and Environment [DPIE]) on 29 April 2019 to provide an overview of the Modification, proposed approval pathway and the proposed scope of the environmental assessment.

Following the meeting, Tronox wrote to the DP&E regarding the Modification, the proposed approval pathway and the proposed scope of the environmental assessment. The DP&E subsequently wrote to Tronox on 30 May 2019 confirming it agreed with the proposed approval pathway and outlining additional environmental assessment aspects to be considered as part of the Modification application. These environmental assessment aspects have been considered in this Modification Report.



Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012) and Tronox (2019)

LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Exploration Licence Boundary (EL)
- Up-catchment Diversions
- Collection Drains
- Bore
- Approximate Extent of Surface Development - Year 2
- Fixed Infrastructure Areas
- Soil Stockpile
- Process Water Storage
- Overburden Emplacement
- Stage 1 Rehabilitation - Stabilised Landform with Seed/Cover Crop Application

Active Mining Area

- Vegetation Clearance/Soil Stripping
- Overburden Removal
- Ore Zone/Extraction Area
- Overburden Replacement/Process Waste Emplacement/Soil Replacement
- Sediment Basin

ACMSP Modification

- Modification Surface Development Area

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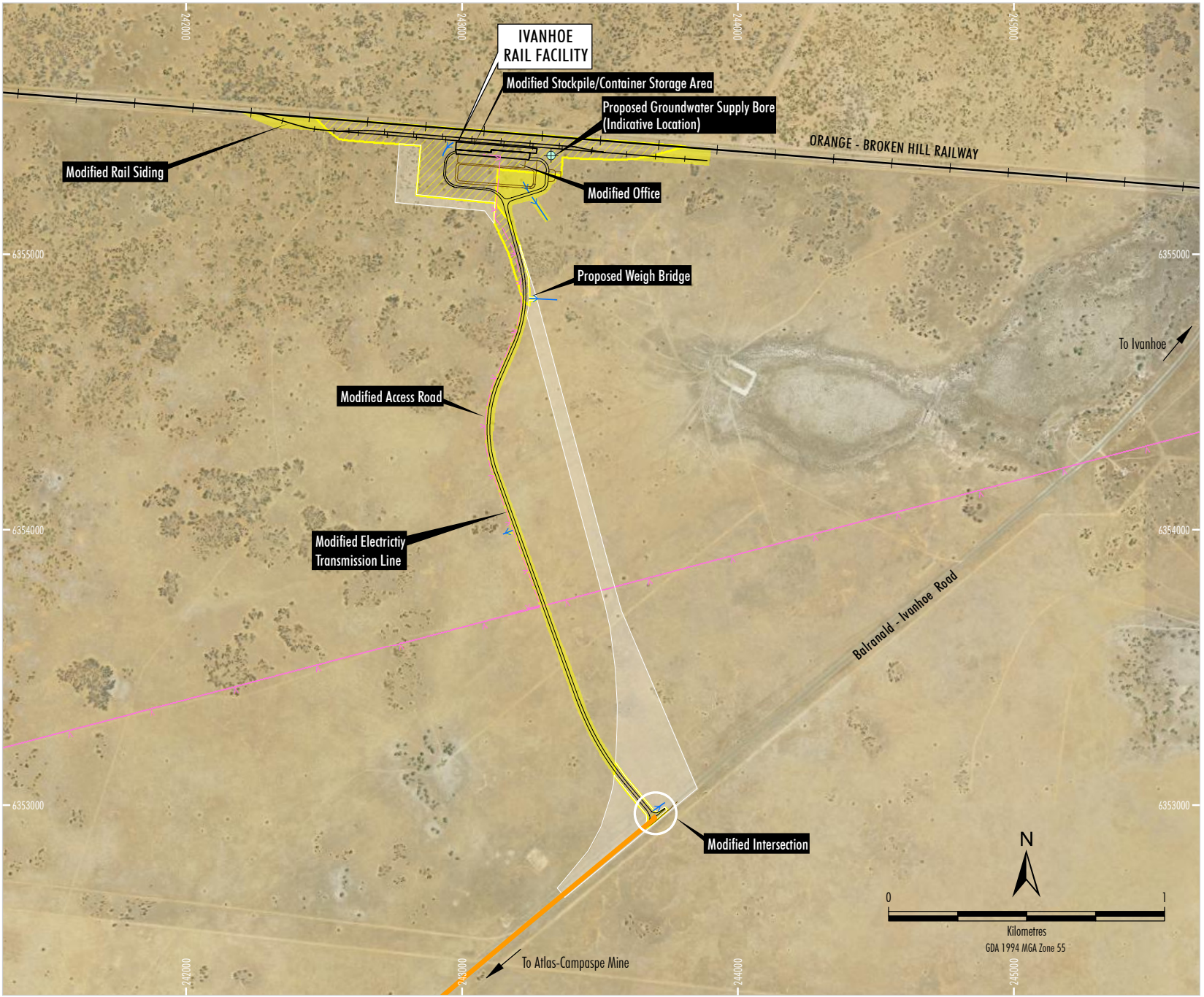
OPTIMISATION MODIFICATION

Modified Atlas-Campaspe Mine
General Arrangement - Year 2

Figure 4



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 5

CMA-18-07 AC OM_204F

Table 1
Comparison of the Existing/Approved and Modified Project

Project Component	Approved Project	Modified Project
Atlas-Campaspe Mine		
Project Life	• Mining operations until 30 June 2034.	• No change.
Tenement	• Mining Lease (ML) 1767 and Mining Lease Application (MLA) 1.	• No change.
Mining	• Dry mining (i.e. dozers and/or loaders and excavators) operation producing approximately 7.2 Mtpa of ore.	• No change.
Mineral Concentration and Mineral Concentrate Transport	• Ore concentrated in the primary gravity concentration unit (comprising a screen, surge bin and wet concentrator) to produce heavy mineral concentrate (HMC). • HMC washed in the salt washing facility prior to processing in the wet high intensity magnetic separator (WHIMS) circuit to produce ilmenite-rich, leucoxene-rich and non-magnetic (containing rutile-rich and zircon-rich) mineral concentrates. • Mineral concentrate production up to 546,000 tpa. • Mineral concentrate transport up to 450,000 tpa. • Up to 24 Roads and Maritime Services (RMS)-approved haulage vehicle trips per day.	• No change to mineral concentration methods. • Increase in mineral concentrate production and transport up to 665,000 tpa. • Increase in RMS-approved haulage vehicle trips up to 35 per day.
Overburden Management	• Overburden removal ahead of ore extraction areas using conventional truck and shovel methods (e.g. excavators and haul trucks). • Overburden replacement, including progressive backfilling of mine voids behind the advancing ore extraction areas or in overburden emplacements adjacent to the mine path using haul trucks.	• Option to use an overland conveyor to transfer overburden in addition to haul trucks.
Sand Residue and Coarse Reject Management	• Sand residues and coarse rejects placed in either overburden emplacement cells behind the advancing ore extraction area or in off-path sand residue dams.	• No change.
MSP Process Waste Management	• MSP process waste placed behind the advancing ore extraction areas at either the Ginkgo Mine, Snapper Mine or Atlas-Campaspe Mine. • MSP process waste production of up to 50,000 tpa.	• No change to MSP process waste management. • Increase in MSP process waste production up to 65,000 tpa.
Water Supply	• Water requirements will be supplied by the Atlas-Campaspe Mine borefield.	• No change.
Electricity Supply	• Electricity supplied by diesel generator sets.	• Option to develop on-site solar power generation infrastructure to supplement diesel power generation.
Supporting Infrastructure	• Construction of supporting infrastructure within the approved surface development area.	• Relocation of the accommodation camp. • Development of an emergency airstrip. • Construction and operation of a telecommunications tower.
Site Access	• Access to the Atlas-Campaspe Mine is via the road haulage route.	• The use of other local roads other than the haulage route by Project-related light vehicles to access site.
Employment	• Approximately 300 personnel during peak construction. • Approximately 200 personnel during operations.	• No change.

Table 1 (Continued)
Comparison of the Existing/Approved and Modified Project

Project Component	Approved Project	Modified Project
Atlas-Campaspe Mine (Cont.)		
Rehabilitation Works	• Progressive rehabilitation undertaken as mining advances.	• No change.
Biodiversity Offset Area	• Approximately 16,540 hectares (ha) will be established to offset native vegetation communities cleared for the Project.	• No change.
Ivanhoe Rail Facility		
Infrastructure	• Construction of infrastructure within the approved surface development area, including access road, rail siding, hardstand area, site office, parking, fencing, lighting and water management infrastructure.	• Extension to the hardstand area. • Extension of the rail siding and addition of a passing siding. • Revised alignment of the access road and access road intersection.
Unloading and Stockpiling	• Mineral concentrate emptied directly onto a mineral concentrate stockpile for reclaim by a front-end loader to load directly into train wagon containers.	• No change.
Train Movements	• Up to three trains per week. • Up to one train trip in any 24-hour period.	• Increase in train frequency to four per week. • No change to number of trains in any 24-hour period.
Water Supply	• Waters collected onsite and potable water trucked from the Atlas-Campaspe Mine or the Ivanhoe town water supply.	• Addition of a groundwater supply bore. • No change to the potable water supply.
Electricity Supply and Distribution	• Electricity supplied via the local network.	• No change.

Roads and Maritime Services

Tronox provided a briefing package to the RMS in April 2019 that provided an overview of the proposed Modification and the approach to assessing the potential road transport impacts associated with the Modification.

Tronox held a teleconference with RMS on 28 June 2019, where the RMS environmental assessment requirements were discussed. These environmental assessment aspects have been considered in this Modification Report.

Office of Environment and Heritage

Tronox provided a briefing package and held a teleconference with the OEH on 25 March 2019 to provide an overview of the Modification and discuss the approach to assessing potential biodiversity and Aboriginal cultural heritage impacts associated with the Modification.

Tronox further consulted with the OEH regarding the approach to assessing potential biodiversity impacts in April and May 2019; the OEH confirmed the approach adopted in this Modification Report was appropriate.

Natural Resources Access Regulator

Tronox provided a briefing package and held a teleconference with the NSW Natural Resources Access Regulator (NRAR) on 26 March 2019 to provide an overview of the Modification and discuss the approach to assessing potential water resource impacts associated with the Modification.

The NRAR indicated that the *NSW Aquifer Interference Policy* (AIP) (NSW Department of Primary Industries [DPI], 2012) did not apply to the proposed Ivanhoe Rail Facility groundwater supply bore, and confirmed the proposed analytical methods would be appropriate to predict groundwater drawdown associated with the groundwater supply bore at the Ivanhoe Rail Facility.

Notwithstanding the NRAR advice, the minimal impact considerations in the AIP (DPI, 2012) have been addressed in Sections 3.9 and 4.4, and Appendix F.

Environment Protection Authority

Tronox provided a briefing package and held a teleconference with the NSW Environment Protection Authority (EPA) in May 2019 to provide an overview of the Modification and discuss the approach to assessing potential noise, air quality and water resources impacts associated with the Modification.

Tronox held a teleconference with the EPA on 27 May 2019, where the EPA confirmed it was satisfied with the proposed approach to assessing potential noise, air quality and water resources impacts associated with the Modification.

Other NSW Government Agencies

In May 2019, Tronox provided a briefing package that included information on the Modification and offered further information if requested to the following NSW Government agencies:

- NSW Division of Resources and Geosciences (DRG);
- NSW Resources Regulator; and
- NSW Department of Industry – Crown Lands.

No request for further information was received from these NSW Government agencies.

Local Councils

The Project is located within the Balranald Shire Council (BSC) and Central Darling Shire Council (CDSC) local government areas (LGAs) (Figure 1).

In addition, a portion of the light vehicle access routes proposed as part of the Modification would be located within the Wentworth Shire Council (WSC) LGA.

Tronox consulted with the BSC, CDSC and WSC throughout May to July 2019 regarding potential road transport impacts associated with the Modification.

A copy of the draft Road Transport Assessment was provided to the BSC, CDSC and WSC in June 2019.

The BSC confirmed on 24 June 2019 that Tronox's existing road maintenance contributions made to the BSC (as outlined in Appendix 7 of Development Consent [SSD_5012]) (Section 2.2.3) would address the road maintenance requirements associated with the proposed increase in mineral concentrate transport truck trips.

Tronox is continuing to consult with the BSC regarding contributions toward local road upgrades, improvements and maintenance.

On 3 July 2019, the CDSC confirmed that Tronox's existing road maintenance contributions made to the CDSC (as outlined in Appendix 8 of Development Consent [SSD_5012]) (Section 2.2.3) would address the road maintenance requirements associated with the proposed increase in mineral concentrate transport truck trips.

The WSC confirmed on 13 June 2019 that it was satisfied with Tronox's proposed use of local roads in the WSC LGA for the modified Project.

Further details on the road upgrades and maintenance required are provided in Sections 2.1.7 and 2.2.3.

Service Providers

Australian Rail Track Corporation

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be railed from the Ivanhoe Rail Facility to the MSP on the Orange – Broken Hill Railway (Figure 1). The Orange – Broken Hill Railway is owned by the Australian Rail Track Corporation (ARTC).

Tronox has consulted with the ARTC regarding the design of the proposed rail siding extension and passing siding. The outcomes of this consultation have been incorporated into the design of the proposed rail siding extension and passing siding.

Tronox has also consulted the ARTC regarding the proposed increase in train length (from 600 m to 920 m) and frequency (from six to eight train movements per week).

Tronox will continue to consult with the ARTC regarding the construction and operation of the Ivanhoe Rail Facility.

Royal Flying Doctor Service

Tronox has consulted with the Royal Flying Doctor Service regarding the design requirements for the proposed emergency airstrip at the Atlas-Campaspe Mine.

Telstra

Tronox has consulted with Telstra regarding the proposed telecommunications tower at the Atlas-Campaspe Mine (Section 2.1.8).

Tronox would continue to consult with Telstra regarding the construction and operation of the telecommunications tower.

1.4 STRUCTURE OF THE DOCUMENT

This Modification Report comprises a main text component and supporting studies. An overview of the main text sections is presented below:

Section 1	Provides an overview of the approved Project, the Modification and the consultation undertaken in relation to the Modification.
Section 2	Provides a description of the Modification.
Section 3	Provides an environmental assessment of the Modification, and describes the existing environmental management systems and measures available to manage and monitor any potential impacts.
Section 4	Describes the general statutory context of the Modification and describes how the Modification meets relevant statutory requirements.
Section 5	Provides a conclusion and justification for the Modification.
Section 6	Lists the references cited in this report.

Attachment 1 and Appendices A to F provide supporting information as follows:

Attachment 1	Development Consent (SSD_5012)
Appendix A	Road Transport Assessment
Appendix B	Air Quality Review
Appendix C	Noise Review
Appendix D	Vegetation Condition Assessment
Appendix E	Aboriginal Cultural Heritage Assessment
Appendix F	Groundwater Review

2 MODIFICATION OVERVIEW

A description of the Modification is provided in this section, including a comparison of the modified Project with the approved Project.

As only minor changes are proposed to the approved Project as part of the Modification (Table 1), this section focuses on the components of the Project that would change as a result of the Modification.

2.1 ATLAS-CAMPASPE MINE

2.1.1 Mining Operations

Mining operations using dry mining methods (i.e. dozers and/or loaders and excavators) are approved to be undertaken up to 24 hours per day, seven days per week at the Atlas-Campaspe Mine.

Mining will commence at the south-eastern end of the Atlas deposit and then progress in a north-westerly direction.

Mining of the Campaspe deposit will commence once mining within the Atlas footprint is complete. Initial development will commence at the south-eastern end of the Campaspe deposit and mining would progress in a north-westerly direction.

The general sequence of the approved mining operations is as follows (Figure 6):

1. Vegetation clearance and soil stripping.
2. Overburden removal ahead of ore extraction areas using conventional truck and shovel methods (e.g. excavators and haul trucks).
3. Mineral sands ore extraction and placement in a dry mining unit (DMU) using conventional dry mining equipment (e.g. dozers and loaders) at up to 7.2 Mtpa.
4. Overburden replacement using haul trucks, including progressive backfilling of mine voids behind the advancing ore extraction areas or in overburden emplacements adjacent to the mine path.
5. Placement of process wastes (i.e. sand residues, coarse rejects and MSP process waste) following mineral processing to either the active mining area (behind the advancing ore extraction area) or in sand residue dams.
6. Overburden and soil replacement, including profiling of the final landform in preparation for rehabilitation activities.
7. Progressive rehabilitation behind the advancing mining operation.

The Modification would involve revised mine scheduling for the Atlas deposit, which would increase the maximum mineral concentrate production rate.

The Modification would also include the option to use an overland conveyor to transfer overburden in addition to haul trucks.

If the overland conveyor is adopted, overburden would be placed directly into a hopper, which would feed onto the overland conveyor. The overburden would then be transported behind the advancing ore extraction areas to backfill mine voids consistent with the approved Project (Figure 6). The overland conveyor system would comprise approximately 1 to 3 km of overland conveyor and a mobile stacker conveyor. The conveyor feed hopper would be periodically relocated to follow the stripping operation.

Changes to the operational mobile and fixed equipment after Year 1 would also be included in the Modification. Further details of the modified operational mobile and fixed equipment are provided in Appendix C.

The Modification would not change the approved mine path, mining method, operational hours, maximum mining rate or rehabilitation strategy.

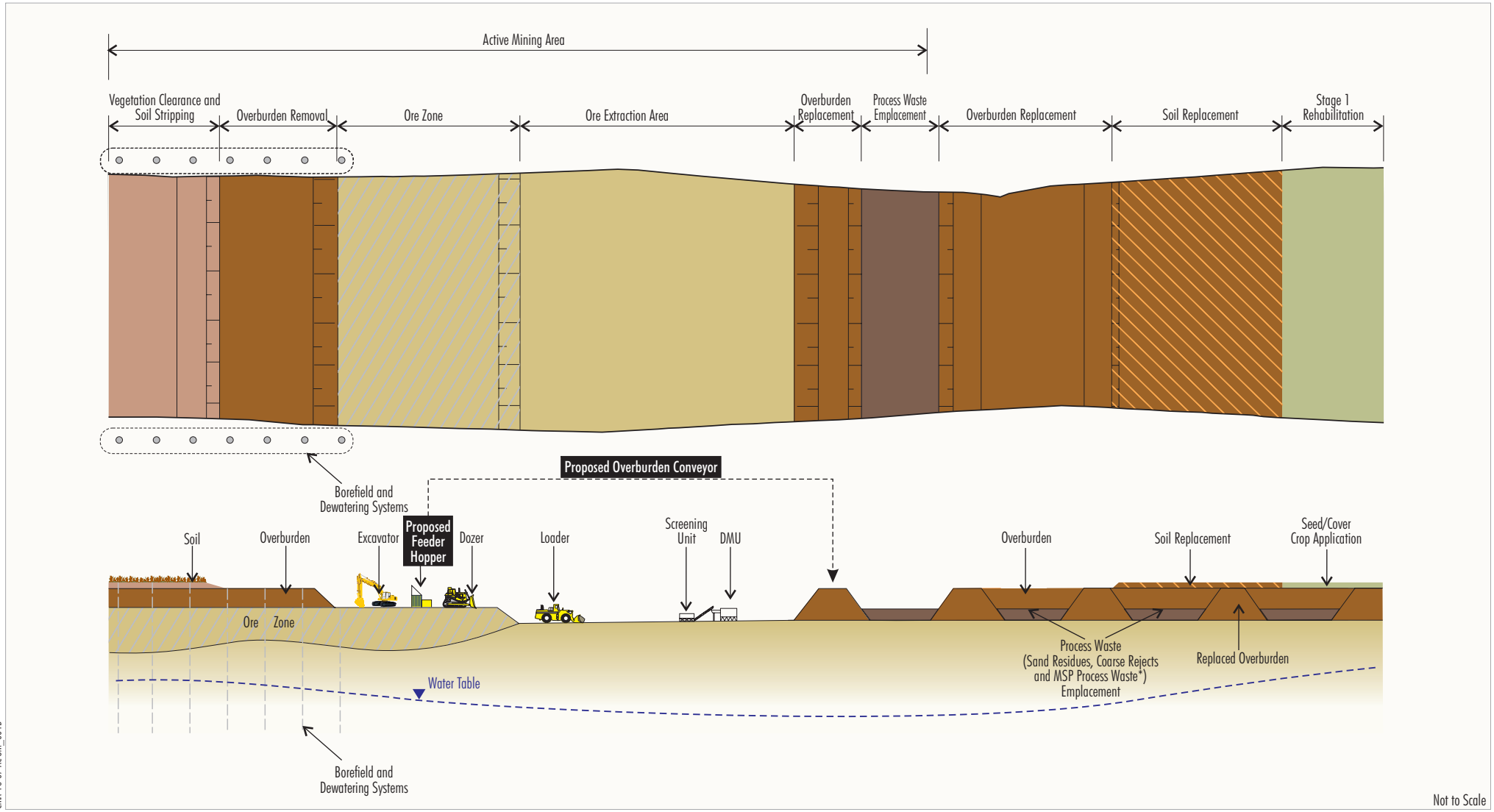
2.1.2 Mineral Processing

Processing of mineral sands ore is approved to occur at the Atlas-Campaspe Mine up to 24 hours per day, seven days per week.

Primary separation of HMC from ore will occur in the primary gravity concentration unit. The HMC recovered by the primary gravity concentration unit will be processed further at the HMC treatment facility. The HMC treatment facility includes a salt washing facility and the WHIMS circuit. The HMC will be washed with desalinated water in the salt washing facility prior to processing in the WHIMS circuit.

The WHIMS circuit is a preliminary treatment stage that separates the HMC into ilmenite-rich, leucoxene-rich and non-magnetic (containing rutile-rich and zircon-rich) mineral concentrates. Up to 546,000 tpa of mineral concentrates are approved to be produced.

The mineral concentrates from the WHIMS circuit will be stockpiled in the mineral concentrate stockpile areas by product stackers before they are loaded onto trucks for transport to the Ivanhoe Rail Facility.



CMA-18-07 AC OM_001B

* Following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012) and Tronox (2019)

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OPTIMISATION MODIFICATION

Modified Mining Operations Conceptual Plan and Section

Figure 6

In consideration of the MSP processing schedule (including Ginkgo and Snapper Mines), the total mineral concentrate transported from the Atlas-Campaspe Mine to the MSP was expected to be 450,000 tpa. Given the approved maximum mineral concentrate production rate is greater than 450,000 tpa, mineral concentrate will need to be stockpiled at the Atlas-Campaspe Mine during years where the mineral concentrate production rate exceeds 450,000 tpa.

The Modification would include an increase in the maximum mineral concentrate production rate to 665,000 tpa.

In addition, a review of the MSP processing schedule conducted as part of the optimisation planning identified that 665,000 tpa of mineral concentrate could be transported from the Atlas-Campaspe Mine to the MSP. All mineral concentrates produced would therefore be transported to the MSP shortly after processing for the modified Project, rather than be stockpiled at the Atlas-Campaspe Mine.

No other changes to the approved mineral processing operations are proposed as part of the Modification.

2.1.3 Process Waste Management

Approved process wastes comprise sand residues (including a small proportion of clays) and coarse reject materials from on-site processing and MSP process waste.

Sand residues (and coarse materials) will be pumped from the primary gravity concentration unit to either the overburden emplacement cells behind the advancing ore extraction area or in off-path sand residue dams.

Up to approximately 50,000 tpa of MSP process waste is approved to be produced by the Project. The MSP process wastes produced by the Project will be combined with the existing/approved MSP process wastes produced from the Ginkgo and Snapper Mines and continue to be transported to the Ginkgo and Snapper Mines in accordance with existing/approved operations up until cessation of those operations.

Following the cessation of the Ginkgo and Snapper Mines, MSP process waste in sealed containers (transported via the Orange – Broken Hill railway) will be unloaded from trains at the Ivanhoe Rail Facility, and temporarily held in a designated area prior to loading onto haulage vehicles for transportation to the Atlas-Campaspe Mine.

MSP process waste will be transported via road in sealed storage containers from the Ivanhoe Rail Facility to the Atlas-Campaspe Mine for unloading, stockpiling and placement behind the advancing ore extraction areas. No MSP process waste will be placed in off-path sand residue dams at the Atlas-Campaspe Mine.

The Modification would increase the rate of MSP process waste production to up to 65,000 tpa. This increase is due to the proposed increase in mineral concentrate production (i.e. increased mineral concentrate production results in an increase in MSP process waste production at the MSP).

No changes to the approved process waste management are proposed as part of the Modification.

2.1.4 Accommodation Camp

The accommodation camp is approved to accommodate the peak construction workforce (up to approximately 300 people) before being reduced in size to accommodate approximately 200 people for operations.

The approved accommodation camp is located to the east of the Atlas deposit and immediately north of the site access road (Figure 2).

Facilities at the accommodation will include:

- up to 300 single quarters/rooms;
- mess area (including stores, kitchen and wet mess);
- office building;
- laundry facilities;
- ablution facilities;
- garden/recreation area; and
- sewage treatment plant.

The Modification includes the relocation of the accommodation camp to the south-eastern end of the Atlas deposit inside the existing surface development area (Figure 4). The relocation is proposed based on the outcomes of optimisation planning undertaken for the Project.

The modified accommodation camp would be located in the footprint of an approved laydown area. The approved accommodation camp footprint may be used as a laydown area if required (Figure 4).

The Modification would not change the approved accommodation camp capacity or facilities.

2.1.5 Electricity Supply

Electricity for the Atlas-Campaspe Mine is approved to be supplied by diesel generator sets.

The Modification would include the option to develop on site solar power generation infrastructure to supplement the diesel generator sets. If developed, the on-site solar power generation infrastructure would have an installed capacity of up to 1 megawatt and would provide approximately 2,000 megawatt hours of power to the Atlas-Campaspe Mine each year.

The on-site solar power generation infrastructure would include the following:

- photovoltaic (PV) solar modules;
- inverters and transformers;
- electrical conduits and cabling connecting PV solar modules with inverters;
- internal access tracks; and
- perimeter fencing.

The on-site solar power generation infrastructure would be located on the southern side of the Atlas deposit inside the approved surface development area (Figure 4).

Tronox is separately considering importing electricity to the Atlas-Campaspe Mine via an electricity transmission line. The electricity transmission line would be subject to separate environmental assessment and approval.

2.1.6 Emergency Airstrip

The Modification includes the development of an emergency airstrip at the Atlas-Campaspe Mine to allow for the evacuation of Project personnel in the event of an emergency.

The emergency airstrip would be approximately 1,200 m long and located on an approved haul road inside the approved surface development area (Figure 4).

The emergency airstrip would be designed and constructed in accordance with the requirements of the Royal Flying Doctor Service.

The emergency airstrip would not be used to transport Project workforce to and from the Atlas-Campaspe Mine.

2.1.7 Site Access

Condition 6, Schedule 3 of Development Consent (SSD_5012) states:

> *The Applicant shall ensure that no project-related traffic (including employees and contractors) uses local roads to access the site, other than those local roads that form part of the haulage route shown in Appendix 3, except in an emergency to avoid the loss of life, property and/or to prevent environmental harm.*
>
> *Note: This condition does not apply to any employees that may reside on a local road that does not form part of the haulage route (in the vicinity of the development), or the infrequent use of the roads for consultation, environmental monitoring and inspection and maintenance of nearby infrastructure.*

The Modification would include the use of local roads other than the road haulage route by Project-related light vehicles to access the site, including (Figures 7a and 7b):

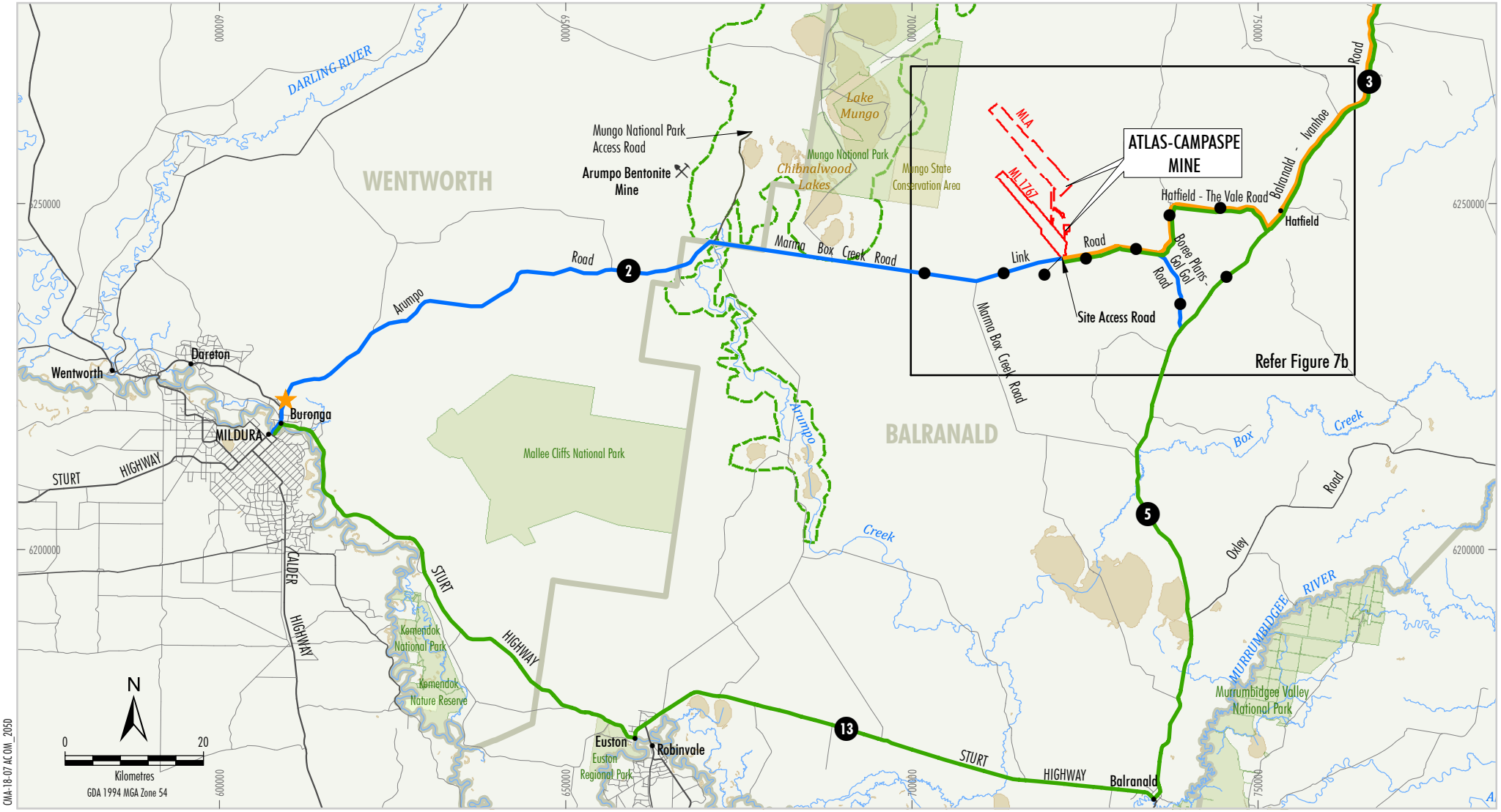
- to/from Mildura/Buronga via Arumpo Road, Marma Box Creek Road and Link Road; and
- to/from Balranald via Balranald-Ivanhoe Road, Boree Plains-Gol Gol Road and Link Road.

The proposed local road routes would reduce the travel distances to Mildura/Buronga and Balranald from the Atlas-Campaspe Mine relative to the approved routes by approximately 150 km and 32 km, respectively (Appendix A).

Tronox is currently reviewing the feasibility of operating shuttle buses between the Atlas-Campaspe Mine and Buronga/Mildura or Balranald for Project workers. If a Project worker shuttle bus was to operate, it would also travel along these local roads.

Tronox has consulted with the BSC, WSC and RMS regarding the proposed light vehicle use of these local roads and the following road upgrades are proposed (Appendix A):

- Link Road (between Marma Box Creek Road and the Atlas-Campaspe Mine) would be upgraded to meet the minimum carriageway and formation width requirements for a Class 4B unsealed road (Australian Road Research Board [RRB], 2009); and
- the surface of Boree Plains-Gol Gol Road would be sealed on its approach to its intersection with Balranald-Ivanhoe Road.



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- National Park
- Nature Reserve
- Regional Park
- State Conservation Area
- Approved Light Vehicle Access Route
- Approved Mineral Concentrate Transport Route
- Proposed Light Vehicle Access Routes
- Traffic Forecast Location
- Traffic Survey Location

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012); Tronox (2019) and TTPP (2019)

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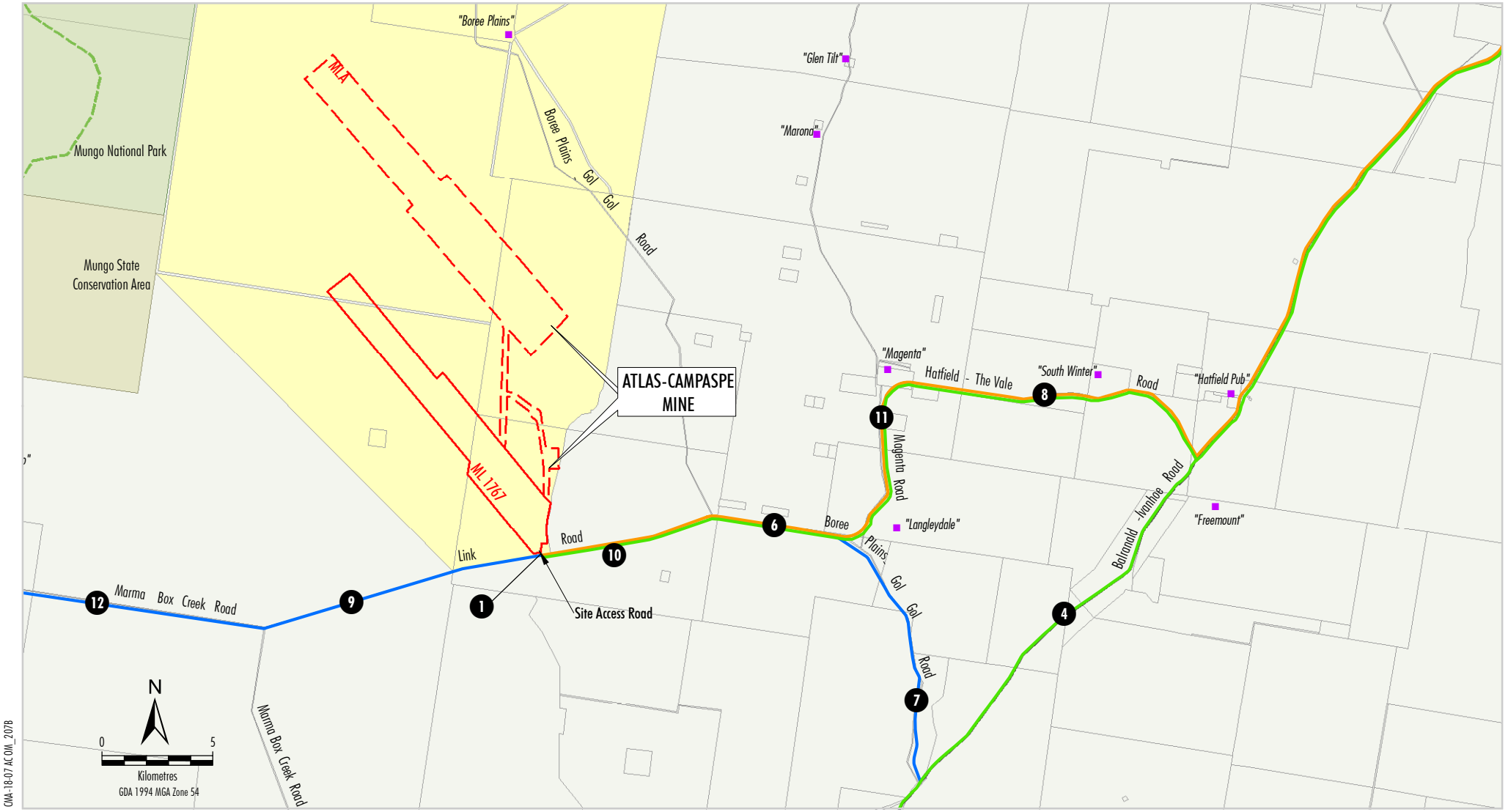
OPTIMISATION MODIFICATION

Project Light Vehicle Access Routes

Figure 7a



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Proposed Light Vehicle Access Routes
- Approved Light Vehicle Access Route
- Traffic Forecast Location

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012); Tronox (2019) and TTPP (2019)

TRONOX

OPTIMISATION MODIFICATION

Project Light Vehicle Access Routes - Inset

Figure 7b

In addition, the following road improvements would progressively be made as part of ongoing maintenance activities (Appendix A):

- the road surface of relevant sections of the local road routes would be improved to establish a good riding surface with reduced dust emissions; and
- appropriate traffic control signs would be installed along the local road routes.

Tronox is continuing to consult with the BSC regarding contributions toward local road upgrades, improvements and maintenance.

The WSC has stated that no ongoing financial contributions to the maintenance of Arumpo Road is required at this stage.

2.1.8 Telecommunications Tower

The Modification includes the construction of a telecommunications tower at the Atlas-Campaspe Mine to provide mobile reception to the Project area and surrounds.

The telecommunications tower would be constructed adjacent to approved infrastructure, within the approved surface development area of the Atlas-Campaspe Mine. The exact location of the tower would be determined in consultation with Telstra.

The tower would be constructed in accordance with relevant Telstra requirements.

2.1.9 Other Atlas-Campaspe Mine Components

There would be no change to the following key components of the approved Atlas-Campaspe Mine due to the Modification:

- mine life and hours of operation;
- mining tenement;
- water demand and supply;
- water management;
- dangerous goods management;
- workforce; and
- rehabilitation strategy.

2.2 MINERAL CONCENTRATE AND MSP PROCESS WASTE ROAD TRANSPORT

2.2.1 Road Haulage Route and Vehicles

Mineral concentrates generated at the Atlas-Campaspe Mine (Section 2.1.2) are approved to be trucked to the Ivanhoe Rail Facility for unloading, stockpiling and subsequent loading to trains for rail transportation to the MSP.

RMS-approved vehicles will be used to transport the mineral concentrates and MSP process waste.

The approved road haulage route consists of (Figures 1 and 3):

- the Atlas-Campaspe Mine access road;
- Link Road;
- Boree Plains-Gol Gol Road;
- Magenta Road;
- Hatfield-The Vale Road;
- Balranald-Ivanhoe Road; and
- Ivanhoe Rail Facility access road.

The Modification would not change the approved road haulage route or vehicles.

2.2.2 Road Haulage Frequency

Up to 450,000 tpa of mineral concentrate is approved to be transported from the Atlas-Campaspe Mine to the Ivanhoe Rail Facility.

In addition, up to 50,000 tpa of MSP process waste is approved to be transported from the Ivanhoe Rail Facility to the Atlas-Campaspe Mine via the road haulage route in sealed storage containers.

Up to 24 heavy vehicle trips in any 24-hour period are approved.

The Modification would increase heavy vehicle trips from 24 per day to 35 per day to allow for the transport of increased mineral concentrate production and MSP process waste proposed as part of the Modification (Sections 2.1.2 and 2.1.3).

2.2.3 Road Upgrades

Condition 1, Schedule 3 of Development Consent (SSD_5012) requires Tronox to implement road haulage route upgrades to an acceptable standard for Type 1 road trains and to the satisfaction of the RMS, BSC and CDSC prior to the haulage of mineral concentrate.

In addition, Tronox will make financial contributions to the BSC and CDSC to rectify the "high risk" road safety deficiencies along Balranald-Ivanhoe Road in accordance with Condition 5, Schedule 3 of Development Consent (SSD_5012).

The BSC and CDSC have confirmed that the above road upgrades along the road haulage route are appropriate for the Modification.

The Modification would not change the approved road haulage route upgrades (Appendix A).

2.2.4 Road Maintenance Contributions

Tronox will make financial contributions to the BSC and CDSC for the maintenance of Balranald-Ivanhoe Road and other local roads along the road haulage route in accordance with Conditions 4 and 5, Schedule 3 of Development Consent (SSD_5012).

The Modification would not change the approved methodology for determining road haulage route maintenance contributions (Section 1.3).

2.3 IVANHOE RAIL FACILITY

2.3.1 General Arrangement

The approved Ivanhoe Rail Facility comprises:

- a rail siding;
- hardstand areas, including stockpiles/sealed container storage areas;
- access road and internal haul roads/pavements;
- a retention basin, drains, pumps, pipelines and other water management equipment and structures;
- site office, ablutions and car parking facilities;
- perimeter fencing;
- extension to existing powerline;
- night-lighting; and
- vegetation management area.

The approved Ivanhoe Rail Facility general arrangement is shown on Figure 3.

The Modification includes the following changes to the approved general arrangement to allow for longer trains proposed as part of the Modification (Section 2.3.2) (Figure 5):

- extension to the hardstand area; and
- extension of the rail siding and addition of a passing siding.

The design and construction of the modified rail siding would be undertaken in accordance with the requirements of the ARTC.

In addition, the approved access road and intersection would be realigned (Figure 5). The realignment of the access road and intersection is proposed to address the outcomes of consultation with the underlying leaseholder.

The realigned intersection would be designed and constructed in accordance with Austroads requirements in consultation with the RMS and CDSC (Appendix A).

Other components of the approved Ivanhoe Rail Facility general arrangement would not be significantly changed.

The modified Ivanhoe Rail Facility components would require an additional 10 ha of surface development area (herein referred to as the additional surface development area). The modified Ivanhoe Rail Facility general arrangement would however not require the use of approximately 24 ha of currently approved surface development area. The Modification would therefore result in a net reduction in surface development area of approximately 14 ha.

2.3.2 Operations

Operations at the Ivanhoe Rail Facility are approved to be undertaken up to 24 hours per day, seven days per week.

A turn-around loop at Ivanhoe Rail Facility will enable the haulage vehicles to turn-around, unload and exit using the access road. Mineral concentrate emptied from the haulage vehicles will be stockpiled within the hardstand area.

A front-end loader will be used to reclaim mineral concentrate from the stockpile and load containers on the hardstand area. A forklift will be used to remove and replace container covers and to load the containers onto the train wagons.

Once operations at the Ginkgo and Snapper Mines cease, MSP process waste in sealed containers will be unloaded from trains at the Ivanhoe Rail Facility prior to returning to the Atlas-Campaspe Mine.

The Modification would include changes to the operational mobile equipment at the Ivanhoe Rail Facility. Further details of the modified operational mobile equipment are provided in Appendix C.

Based on train lengths of up to 600 m, the approved Project will require a maximum of three trains per week with no more than one train in any 24-hour period.

The Modification would include an increase in the train length to 920 m and frequency to four trains per week. The increased train length and frequency would be required to allow for the transport of the increased mineral concentrate production proposed as part of the Modification (Section 2.1.2).

There would be no change to the maximum number of trains in any 24-hour period (i.e. one train per day).

Tronox has also consulted the ARTC regarding the proposed increase in train length and frequency.

2.3.3 Water Supply

The approved water supply at the Ivanhoe Rail Facility includes:

- waters collected in the retention basin will be utilised for dust suppression; and
- potable water will be provided from the Atlas-Campaspe Mine or Ivanhoe town water supply and delivered by truck for use at the site office buildings.

The Modification includes the addition of a groundwater supply bore at the Ivanhoe Rail Facility (Figure 5). Up to 60 million litres per year (ML/year) would be extracted from the groundwater supply bore to be utilised for wash-down purposes and dust suppression on the access road and mineral concentrate stockpiles.

The groundwater supply bore would be located inside the approved surface development area (Figure 5).

3 ENVIRONMENTAL ASSESSMENT

3.1 IDENTIFICATION OF KEY ISSUES

The key potential impacts of the Modification are related to the proposed changes to the approved Atlas-Campaspe Mine, Ivanhoe Rail Facility and Project transport activities described in Table 1 and Section 2.

Tronox has undertaken a review of the potential environmental impacts of the Modification to identify key potential environmental issues requiring assessment. The key environmental issues identified are summarised in Table 2 and addressed in Sections 3.2 to 3.13 and the relevant appendices.

Table 2
Summary of Key Potential Environmental Issues/Impacts

Environmental Aspect	Key Potential Environmental Issues/Impacts		Report Section/Appendix
	Atlas-Campaspe Mine	Ivanhoe Rail Facility	
Road Transport	Potential road transport impacts associated with increased mineral concentrate transport and the use of local roads by Project-related light vehicles.	Potential road transport impacts associated with increased mineral concentrate transport and the modified Ivanhoe Rail Facility access road intersection.	Section 3.2 and Appendix A
Air Quality	Potential air quality impacts due to increased mineral concentrate production and the potential use of conveyors to transfer overburden.	Potential air quality impacts due to increased mineral concentrate transport rate and handling (e.g. additional mobile fleet).	Section 3.3 and Appendix B
Noise	Potential noise impacts due to operational mobile and fixed equipment changes, and potential road noise impacts associated with increased mineral concentrate transport.	Potential noise impacts due to increased mineral concentrate transport rate and handling (e.g. additional mobile fleet, trains), and operational mobile equipment changes.	Section 3.4 and Appendix C
Biodiversity	As the Modification would not change the extent of the approved surface development area associated with the Atlas-Campaspe Mine, no changes to the approved impacts on biodiversity, Aboriginal and historic heritage, land and agricultural resources or surface water resources are expected.	Potential impacts on biodiversity, Aboriginal and historic heritage, land and agricultural resources and surface water resources associated with the modified Ivanhoe Rail Facility surface development area.	Section 3.5 and Appendix D
Aboriginal Cultural Heritage			Section 3.6 and Appendix E
Historic Heritage			Section 3.7 and Appendix E
Land and Agricultural Resources			Section 3.8
Surface Water Resources			Section 3.10
Groundwater Resources	As the Modification would not change the approved mine path, mine life or mining rate, or the water demand at the Atlas-Campaspe Mine, no changes to the approved groundwater impacts are expected.	Potential groundwater impacts associated with the addition of a groundwater supply bore.	Section 3.9 and Appendix F
Greenhouse Gas	Potential greenhouse gas emission changes due to increased mineral concentrate production, the potential use of conveyors to transfer overburden and potential addition of on-site solar power generation infrastructure.	Potential greenhouse gas emission changes due to increased mineral concentrate transport rate (e.g. additional fleet, trains etc.).	Section 3.11
Economic	Potential economic impacts associated with the increased maximum mineral concentrate production rate as part of the Modification.		Section 3.12

Table 2 (Continued)
Summary of Key Potential Environmental Issues/Impacts

Environmental Aspect	Key Potential Environmental Issue/Impact		Report Section/Appendix
	Atlas-Campaspe Mine	Ivanhoe Rail Facility	
Hazards and Risks	As the Modification would not change the existing potential risks or hazard consequences identified in the Preliminary Hazard Analysis for the approved Project, no significant changes to the approved potential hazards and/or risks are expected.		Section 3.13
Visual	As the Modification would not significantly change the design or arrangement of the approved Project, no significant changes to the approved potential visual impacts are expected.		N/A
Social and Community Infrastructure	As the Modification would not result in any additional demand for employees or change the expected employee residential distribution, no material alteration to the approved social and community infrastructure impacts is expected.		N/A

3.2 ROAD TRANSPORT

A Road Transport Assessment was undertaken for the Modification by The Transport Planning Partnership Pty Ltd (TTPP) (2019) and is presented in Appendix A.

3.2.1 Background

Previous Assessment

GTA Consultants (2012) prepared a Road Transport Assessment for the approved Project in accordance with the *Guide to Traffic Generating Developments* (Roads and Traffic Authority, 2002). GTA Consultants (2012) concluded:

> *The proposal … to develop the Project in the south-west of NSW would have acceptable impacts on the operation of the surrounding road system.*
>
> *No significant impacts on the performance, capacity, efficiency and safety of the road network are expected to arise as a result of the Project.*

Road Hierarchy and Conditions

Road Haulage Route

The approved road haulage route consists of (Figures 1 and 3):

- the Atlas-Campaspe Mine access road;
- Link Road;
- Boree Plains-Gol Gol Road;
- Magenta Road;
- Hatfield-The Vale Road;
- Balranald-Ivanhoe Road; and
- Ivanhoe Rail Facility access road.

Link Road is an unsealed local road that provides a link from Marma Box Creek Road to Boree Plains-Gol Gol Road. The Atlas-Campaspe Mine access road is located off Link Road (Appendix A).

Boree Plains-Gol Gol Road is an unsealed local road that extends from Balranald-Ivanhoe Road to Gol Gol Road on the eastern side of Garnpung Lake. Between Link Road and Magenta Road, Boree Plains-Gol Gol Road forms part of the road haulage route. The intersection of Boree Plains-Gol Gol Road and Link Road is aligned such that Boree Plains-Gol Gol Road has priority. At its intersection with Balranald-Ivanhoe Road, Boree Plains-Gol Gol Road is the minor road (Appendix A).

Magenta Road is an unsealed local road that provides a north-south link between Boree Plains-Gol Gol Road and Hatfield-The Vale Road. The intersections of Magenta Road with Hatfield-The Vale Road and Boree Plains-Gol Gol Road are T-intersections, with Magenta Road as the minor road (Appendix A).

Hatfield-The Vale Road is an unsealed local road that provides an east-west link between Balranald-Ivanhoe Road and Magenta Road, then turns northwards west of Magenta Road. Hatfield-The Vale Road is the minor road at the T-intersection formed with Balranald-Ivanhoe Road, and is the major road at the T-intersection formed with Magenta Road (Appendix A).

Balranald-Ivanhoe Road is a Regional Road that links the Sturt Highway at Balranald, generally north-south to the Cobb Highway at Ivanhoe. North of Hatfield-The Vale Road, it forms part of the road haulage route. Balranald-Ivanhoe Road is a two-lane road, and has a sealed surface between Balranald and a point 71 km north of its intersection with Hatfield-The Vale Road. North of this point, the road is generally unsealed, with short sections of sealed road (Appendix A).

As described in Section 2.2.3, Tronox will upgrade the road haulage route to an acceptable standard for Type 1 road trains to the satisfaction of the RMS, BSC and CDSC in accordance with Condition 1, Schedule 3 of Development Consent (SSD_5012).

In addition, Tronox will make financial contributions to the BSC and CDSC to rectify the "high risk" road safety deficiencies along Balranald-Ivanhoe Road in accordance with Condition 5, Schedule 3 of Development Consent (SSD_5012).

Other Local Roads

Marma Box Creek Road is an unsealed local road that provides an east-west link between Link Road and Arumpo Road (Figure 7a). The intersection of Marma Box Creek Road with Link Road is a T-intersection, with Link Road being the minor road and Marma Box Creek Road the major road, which bends through 90 degrees at the intersection (Appendix A).

Arumpo Road is a Regional Road that links the Silver City Highway north of Buronga to the western side of Lake Mungo at the Mungo National Park (Figure 7a). Access to the Mungo National Park is available via Arumpo Road. Its intersection with Marma Box Creek Road is a T-intersection and is aligned such that Arumpo Road has priority. Arumpo Road is a two-lane road, and has a sealed surface between the Silver City Highway and a point approximately 18 km north-east of its intersection with the Silver City Highway. North-east of this point, it has a good quality unsealed road surface (Appendix A).

Traffic Volumes

Background Traffic Volumes

Traffic volumes on Balranald-Ivanhoe Road are an average of 35 vehicles per day in the vicinity of the Ivanhoe Rail Facility, and an average of 32 vehicles per day north of Hatfield-The Vale Road (Appendix A).

Traffic volumes on Boree Plains-Gol Gol Road, Marma Box Creek Road and Link Road are expected to be lower than those recorded on Balranald-Ivanhoe Road (Appendix A).

The south-western end of Arumpo Road in the vicinity of Buronga (Figure 7a) carries approximately 400 vehicles per day. Traffic volumes at the north-eastern end of Arumpo Road (further away from Buronga) however are expected to be lower (Appendix A).

Project Traffic Generation

Table 3 summarises the approved Project peak daily vehicle movements (traffic in both directions) for the construction and operations phases.

Table 3
Approved Project Peak Traffic Volumes
(Vehicles/Day)

Vehicle Type	Construction	Operations
Light Vehicles	244	162
Heavy Vehicles	10	10
Mineral Concentrate Transport	0	48
Total Vehicles	254	220

Source: After GTA Consultants (2012).

As the workforce will reside at the Atlas-Campaspe Mine accommodation camp during their roster, the Project workforce will travel to and from the accommodation camp at the start and end of their roster periods (which vary for different types of employees). The predicted peak light vehicle movements presented in Table 3 are maximum case and will only occur when rosters start and/or finish on the same day which would only occur occasionally (i.e. estimated to be 10 to 11 days per year) (GTA Consultants, 2012).

Road Safety

The Road Transport Assessment did not identify any inherent safety concerns on the Project routes (Appendix A).

School Bus Operations

No commercial school buses currently operate on the road haulage route. There are, however, informal carpooling arrangements along the road haulage route (Appendix A).

Road Maintenance

Tronox will make financial contributions to the BSC and CDSC for the maintenance of Balranald-Ivanhoe Road and other local roads along the road haulage route in accordance Conditions 4 and 5, Schedule 3 of Development Consent (SSD_5012).

Management Regime

In accordance with Condition 9, Schedule 3 of Development Consent SSD_5012, a Transport Management Plan (CMA, 2018a) has been prepared for the construction phase of the Project. Prior to the commencement of operations, the Transport Management Plan will be updated to include:

- a program to monitor and report on the amount of mineral concentrate and MSP process waste transported;
- the measures to be implemented to address the relevant requirements in the *Code of Practice for the Safe Transport of Radioactive Materials* (Australian Radiation Protection and Nuclear Safety Agency, 2008, or its latest version);
- a Road Transport Protocol for all drivers transporting materials to and from the site with measures to ensure:
  - heavy vehicles adhere to the designated road haulage route;
  - all vehicles transporting mineral concentrate are completely covered whilst in transit;
  - the staggering of heavy vehicle departures to minimise impacts on the road network, where practicable;
  - no disruption to school bus timetables;
  - the management of worker fatigue during trips to and from the site (including a fatigue management plan;
  - appropriate driver behaviour (i.e. a Driver Code of Conduct);
  - adherence to drug and alcohol policies;
  - appropriate vehicle maintenance;
  - contingency plans when the road haulage route is disrupted due to low visibility or closed due to wet weather;
  - emergency response plans;
  - the safe transportation of MSP process wastes; and
  - compliance with, and enforcement of, the protocol.

During the 2018 Annual Review reporting period, Tronox received no road transport-related complaints (Appendix A).

3.2.2 Potential Impacts

Modified Project Traffic Generation

A summary of the predicted distribution of the approved and modified Project maximum case traffic during the construction and operations phases is provided in Table 4.

Mineral Concentrate Transport

The Modification would increase heavy vehicle trips from 24 per day to 35 per day (or 48 to 70 movements per day) on the approved road haulage route to allow for the transport of the increased mineral concentrate production proposed as part of the Modification (Table 4).

The approved road haulage route or vehicle types would not change as a result of the Modification (Section 2.2.1).

The increased heavy vehicle trips on the approved road haulage route are well within the day-to-day variation in traffic volumes and would not have a perceivable impact on the level of service experienced by drivers along the route (Appendix A).

Light Vehicles

The number of light vehicle trips during the construction and operations phases would not change as a result of the Modification.

Project-related light vehicles would however use local roads in addition to the road haulage route to access the site, including (Figures 7a and 7b):

- to/from Mildura/Buronga via Arumpo Road, Marma Box Creek Road and Link Road; and
- to/from Balranald via Balranald-Ivanhoe Road, Boree Plains-Gol Gol Road and Link Road.

Table 4
Predicted Peak Approved and Modified Project Traffic Volumes (Vehicles/Day) on the Road Network

	Location[1]	Construction Phase		Operations Phase	
		Approved Project (LV/HV)[2]	Modified Project (LV/HV)[2]	Approved Project (LV/HV)[2]	Modified Project (LV/HV)[2]
1	Atlas-Campaspe Mine Access Road	228/10	228/10	156/58	156/80
2	Arumpo Road between Marma Box Creek Road and Silver City Highway	0/0	110/0	0/0	58/0
3	Balranald-Ivanhoe Road between Ivanhoe Rail Facility and Hatfield-The Vale Road	68/2	68/2	42/50	42/72
4	Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road	160/8	0/8	114/8	0/8
5	Balranald-Ivanhoe Road between Boree Plains-Gol Gol Road and Sturt Highway	160/8	50/8	114/8	56/8
6	Boree Plains-Gol Gol Road between Link Road and Magenta Road	228/10	118/10	156/58	98/80
7	Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road	0/0	50/0	0/0	56/0
8	Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road	228/10	68/10	156/58	42/80
9	Link Road between Atlas-Campaspe Mine access and Marma Box Creek Road	0/0	110/0	0/0	58/0
10	Link Road between Atlas-Campaspe Mine access and Boree Plains-Gol Gol Road	228/10	118/10	156/58	98/80
11	Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road	228/10	68/10	156/58	42/80
12	Marma Box Creek Road between Link Road and Arumpo Road	0/0	110/0	0/0	58/0
13	Sturt Highway between Balranald and Mildura	110/2	0/2	58/2	0/2

[1] Refer to Figures 7a and 7b.

[2] Light Vehicles/Heavy Vehicles

Source: Appendix A.

As the workforce would reside at the Atlas-Campaspe Mine accommodation camp during their roster, modified Project light vehicle movements would vary each day depending on when rosters start and/or finish.

During peak construction, the modified Project would generate up to 56 to 110 light vehicles movements per day on Arumpo Road, Marma Creek Box Creek Road and Link Road on three days of the week (Table 4). On the remaining four days of the week, the modified Project would generate negligible traffic on these local roads.

Once operational, the modified Project would generate up to 58 light vehicle movements per day on Arumpo Road, Marma Creek Box Creek Road and Link Road on the busiest 10 to 11 days of the year (Table 4). On an average day, this would fall to fewer than 20 light vehicle movements per day.

The modified Project would generate up to 54 and 56 light vehicle movements per day on Boree Plains-Gol Gol Road during the operation and construction phases, respectively (Table 4).

It is noted that these light vehicle movements would decrease if Tronox implements a shuttle bus service between the Atlas-Campaspe Mine and Mildura/Buronga or Balranald (Section 2.1.7).

The local roads proposed to be used by Project-related light vehicles would satisfactorily accommodate the Project-generated traffic (subject to the implementation of road upgrades and improvements).

Other Heavy Vehicles

The Modification would not change the number or routes of other heavy vehicles during the construction and operations phases of the Project.

Road Upgrades and Improvements

In addition to the approved road upgrade requirements (Section 2.2.3), Tronox has consulted with the BSC, WSC and RMS regarding the proposed light vehicle use of local roads, and the following additional road upgrades are proposed (Appendix A):

- Link Road (between Marma Box Creek Road and the Atlas-Campaspe Mine) would be upgraded to meet the minimum carriageway and formation width requirements for a Class 4B unsealed road (ARRB, 2009); and
- the surface of Boree Plains-Gol Gol Road would be sealed on its approach to its intersection with Balranald-Ivanhoe Road.

In addition, the following road improvements would progressively be made as part of ongoing maintenance activities (Appendix A):

- the road surface of relevant sections of the local road routes would be improved to establish a good riding surface with reduced dust emissions; and
- appropriate traffic control signs would be installed along the local road routes.

Tronox is continuing to consult with the BSC regarding contributions toward local road upgrades, improvements and maintenance (Section 1.3).

The WSC confirmed on 13 June 2019 that it was satisfied with Tronox's proposed use of local roads in the WSC LGA for the modified Project (Section 1.3).

Modified Ivanhoe Rail Facility Access Road Intersection

The approved Ivanhoe Rail Facility access road and intersection would be realigned (Figure 5).

The realigned intersection would be designed and constructed in accordance with Austroads requirements in consultation with the RMS and CDSC (Appendix A).

Road Safety

The Modification (including road upgrades and improvements) is expected to have positive impacts on the safety of the Project workforce and the road network (Appendix A).

The Modification would result in improved road conditions along Link Road, Marma Box Creek Road and Arumpo Road with the implementation of the proposed road upgrades and improvements (e.g. road surface improvements). This would improve the safety of all road users (Appendix A).

The use of local roads other than the road haulage route by Project-related light vehicles would reduce the travel distance for trips from the Atlas-Campaspe Mine to Mildura/Buronga and Balranald by approximately 150 km and 32 km, respectively. Over one year of Project operations, this represents a saving of over 2.1 million vehicle kilometres travelled. The reduction in Project vehicle kilometres travelled would reduce exposure to road accidents (Appendix A).

In addition, the use of local roads other than the road haulage route by Project-related light vehicles would reduce travel times for Project workers travelling from the Atlas-Campaspe Mine to Mildura/Buronga and Balranald, which would reduce the risk of drivers driving or working while fatigued (Appendix A).

School Bus Operations

No school buses currently operate on the road haulage route. There are, however, informal carpooling arrangements along the road haulage route (Appendix A).

In the event school bus operations commence on the road haulage route, Tronox would consult with school bus operators to develop measures to minimise potential disruption to school bus operations. These measures would be incorporated in the Transport Management Plan (CMA, 2018a) (Section 3.2.3).

Mungo National Park Traffic

Access to the Mungo National Park is available via Arumpo Road. As described above, the Modification is expected to have positive impacts on the safety of other road users on the road network (including Arumpo Road) as it would include proposed road improvements (e.g. road surface improvements) (Appendix A).

In addition, it is noted that the increased use of these roads would improve safety in the event of an accident, as the time before a vehicle would pass (and be able to render assistance) would be reduced.

Level Crossings

GTA Consultants (2012) considered the incremental risk of road and rail traffic interaction due to the increase in Project road movements (i.e. employees and other traffic) at the Orange – Broken Hill railway crossing south of Ivanhoe and concluded the risk would be low.

As the Modification would not change Project-generated road or rail movements at this road level crossing, there would be no change to the risk of road and rail traffic interaction associated with the modified Project at this road level crossing and no upgrades to the road level crossing are therefore required (Appendix A).

Cumulative Impacts

EMM (2015) examined the likely routes used by traffic generated during the construction and operational stages of Iluka Resources Limited's Balranald Mineral Sands Project (Figure 1). The Balranald Mineral Sands Project is approved but has not commenced.

No Balranald Mineral Sands Project traffic is expected to use the road haulage route or the local roads proposed to be used by modified Project traffic. Given the above, no cumulative road transport impacts are expected on these routes as a result of the Modification (Appendix A).

3.2.3 Mitigation Measures, Management and Monitoring

The existing road system, with the implementation of the proposed road upgrades and improvements, would satisfactorily accommodate the expected future traffic generated by the modified Project (Appendix A). Tronox would implement the following management measures:

- Implement road haulage route upgrades to an acceptable standard for Type 1 road trains and to the satisfaction of the RMS, BSC and CDSC prior to the haulage of mineral concentrate in accordance with Condition 1, Schedule 3 of Development Consent (SSD_5012).
- Make financial contributions to the BSC and CDSC to rectify the "high risk" road safety deficiencies along Balranald-Ivanhoe Road in accordance with Condition 5, Schedule 3 of Development Consent (SSD_5012).
- Make financial contributions to the BSC and CDSC for the maintenance of Balranald-Ivanhoe Road and other local roads along the road haulage route in accordance with Conditions 4 and 5, Schedule 3 of Development Consent (SSD_5012).
- Implement the proposed road upgrades and improvements to the local roads proposed to be used by Project light vehicles (Section 2.1.7).
- Complete a review into the feasibility of operating shuttle buses between the Atlas-Campaspe Mine and Buronga/Mildura or Balranald for Project workers.

The Transport Management Plan (CMA, 2018a), and its relevant mitigation and management measures, would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

The revised Transport Management Plan (CMA, 2018a) would include a revised Fatigue Management Plan prepared in consideration of the Fatigue Management Guide (NSW Resources Regulator, 2018) and incorporates specific measures for the Project workforce. It is expected that the Fatigue Management Plan would include:

- consultation with the workforce;
- identification of factors that contribute to fatigue (e.g. roster and shift arrangements, unplanned work requirements, non-work-related factors);

- fatigue risk assessment that considers:
  - how likely is it that workers could become fatigued; and
  - the severity of the consequences that may be expected because of fatigue impairment;
- control measures (identified through a risk assessment) that will be implemented so that hazards that pose risk to workers or to others are properly controlled.

3.3 AIR QUALITY

An Air Quality Review was undertaken for the Modification by Katestone Environmental Pty Ltd (Katestone) (2019) and is presented in Appendix B.

3.3.1 Background

Sensitive Receptors

The Project components are located at significant distances from sensitive receptors. The closest privately-owned sensitive receptors to the Project components are:

- Atlas-Campaspe Mine – Marona is located approximately 14 km to the north-east (Figure 8).
- Road haulage route – Magenta is located approximately 800 m to the north (Figure 8).
- Ivanhoe Rail Facility – the Ivanhoe Township is located approximately 4.5 km to the north-east (Figure 9).

Previous Assessment

Katestone (2013) prepared an Air Quality and Greenhouse Gas (AQGHG) Assessment for the approved Project. The AQGHG Assessment was prepared in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Approved Methods) (NSW Department of Environment and Conservation [DEC], 2005).

The results of the AQGHG Assessment for the approved Project are outlined below.

Atlas-Campaspe Mine and Ivanhoe Rail Facility

Potential air quality impacts at the Atlas-Campaspe Mine and the Ivanhoe Rail Facility were modelled and the assessment indicated (Katestone, 2013):

- compliance with annual average impact assessment criteria for total suspended particles (TSP), particulate matter 10 micrometres or less in diameter (PM_{10}) and dust deposition at all sensitive receptors for the Project in isolation;
- compliance with 24-hour average impact assessment criteria for TSP, PM_{10} and dust deposition at all sensitive receptors for the Project in isolation;
- compliance with annual average impact assessment criteria for TSP, PM_{10} and dust deposition for the Project with the inclusion of conservative background levels;
- compliance with the relevant annual average National Environment Protection (Ambient Air Quality) Measure (Air-NEPM) advisory standard for $PM_{2.5}$ for the Project in isolation and with the inclusion of conservative background levels; and
- compliance with the relevant 24-hour average Air-NEPM advisory standard for $PM_{2.5}$ for the Project in isolation and with the inclusion of conservative background levels.

No cumulative air quality impacts were predicted from the coincident construction and operation of the approved Project and the Balranald Mineral Sands Project (Katestone, 2013).

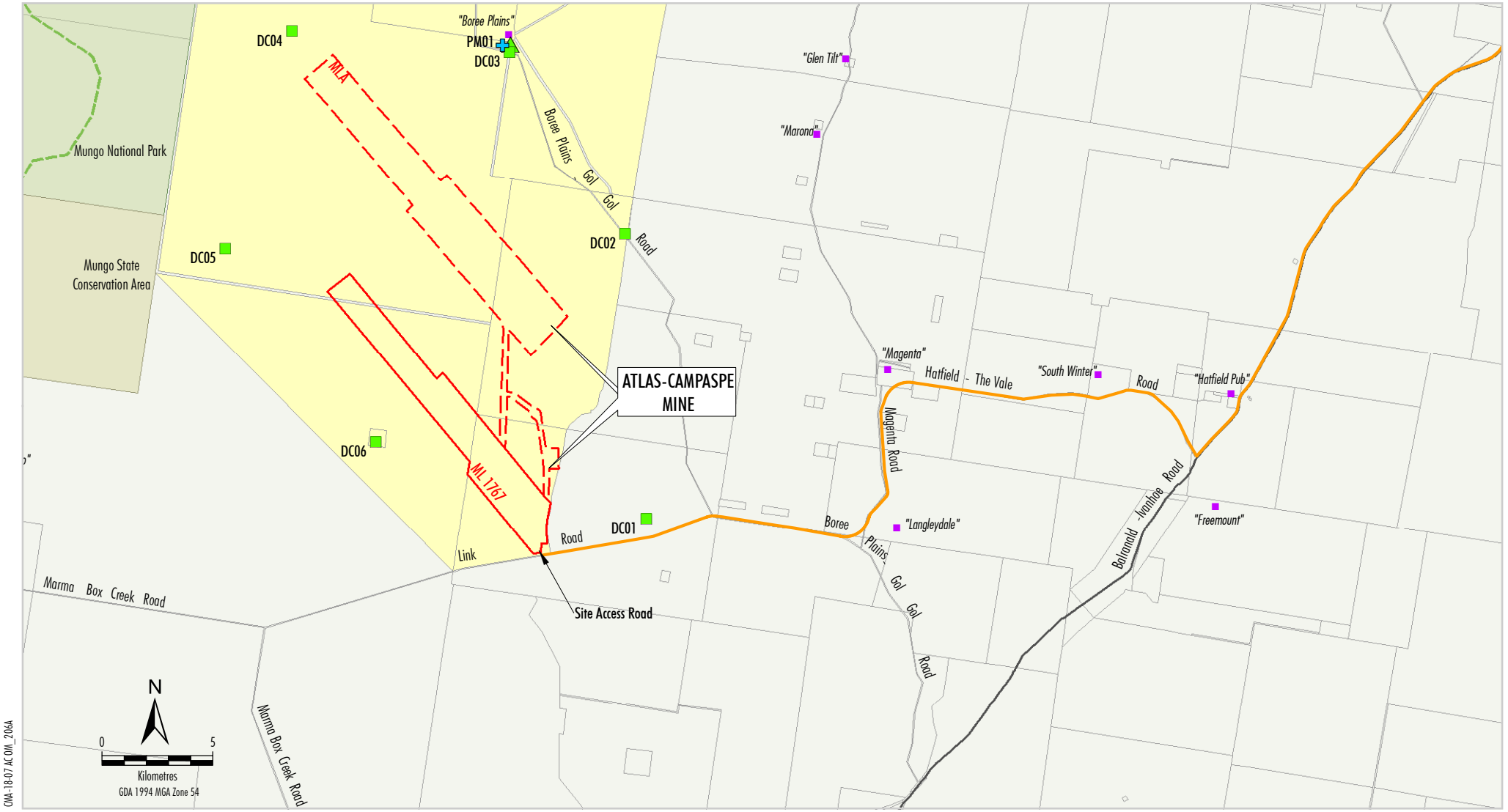
Road Haulage Route

Dust emissions generated by the transport of mineral concentrates on unsealed sections of the road haulage route were not expected to result in any exceedance of the relevant air quality criteria at any residence along the road haulage route (Figure 8) (Katestone, 2013).

Management and Monitoring Regime

In accordance with Condition 21, Schedule 3 of Development Consent (SSD_5012), an Air Quality Management Plan (CMA, 2018b) has been prepared for the Project. The Air Quality Management Plan includes:

- emission control and management measures;
- an air quality monitoring program; and
- air quality management protocols.



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LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Automatic Weather Station
- Dust Gauge Location
- PM_{10} /TSP Monitoring Site

Source: © NSW Department of Finance, Services & Innovation (2018)
Cristal Mining Australia (2012)

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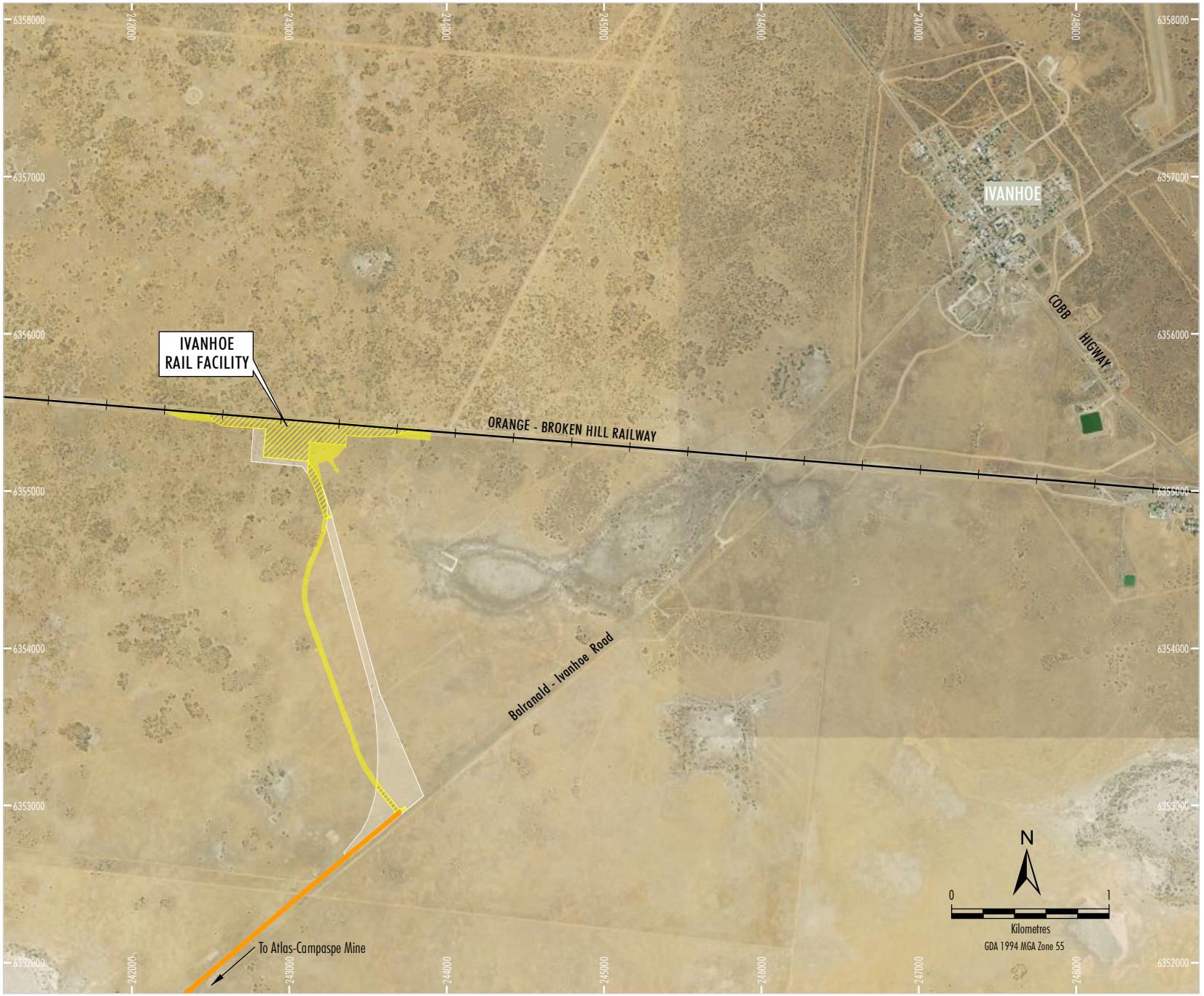
OPTIMISATION MODIFICATION

Atlas-Campaspe Mine
- Air Quality Monitoring Sites

Figure 8



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2018)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility and Surrounds

Figure 9

CMA-18-07 AC OM_215D

In accordance with Condition 20(d), Schedule 3 of Development Consent (SSD_5012), dust deposition monitoring is conducted at six locations (DC01 to DC06), and particulate matter (PM_{10} and TSP) monitoring is conducted at one location in the vicinity of the Atlas-Campaspe Mine (PM01) (Figure 8).

The results of the air quality monitoring program are assessed against the air quality criteria described in Condition 19, Schedule 3 of Development Consent (SSD_5012).

Dust deposition monitoring to date shows that the average annual dust deposition rate is below the relevant Development Consent (SSD_5012) criterion of 4 grams per square metre per month [g/m^2/month]) (Appendix B).

24-hour average PM_{10} measurements recorded at PM01 exceeded the Development Consent (SSD_5012) 24-hour PM_{10} criterion of 50 micrograms per cubic metre ($\mu g/m^3$) on a total of nine days during the period 4 September 2018 to 8 February 2019 (Appendix B).

PM01 is located approximately 18 km north of current Project activities at the Atlas deposit. It is expected that other, more localised sources of particulate matter are contributing to elevated PM_{10} levels at PM01, such as increased wind-blown dust due to the dry and warm conditions present throughout 2018 and 2019, and the proximity of nearby ephemeral lakes (Appendix B).

The average TSP concentration calculated to date complies with the Development Consent (SSD_5012) criterion of 90 $\mu g/m^3$ (Appendix B).

During the 2018 Annual Review reporting period, Tronox received no complaints in regard to air quality (Appendix B).

Air Quality Criteria

Subsequent to the grant of Development Consent (SSD_5012), the Approved Methods (DEC, 2005) were updated to include criteria for $PM_{2.5}$ (consistent with the Air-NEPM advisory standard assessed by Katestone [2013] in the AQGHG Assessment).

The updated Approved Methods (EPA, 2016) also includes a reduced annual average PM_{10} criterion of 25 $\mu g/m^3$.

Katestone (2019) has assessed the potential air quality impacts of the Modification against the updated Approved Methods (EPA, 2016).

It is noted, however, that baseline air quality levels (i.e. before Project activities commenced) were in excess of the reduced annual average PM_{10} criterion.

3.3.2 Potential Impacts

The Air Quality Review (Appendix B) has evaluated the potential air quality impacts of the Modification and a summary is provided below.

Atlas-Campaspe Mine

The following components of the Modification would have the potential to alter particulate matter (e.g. dust) emissions at the Atlas-Campaspe Mine (Appendix B):

- increased mineral concentrate production (i.e. increased product stacking, road train loading and on-site haulage of mineral concentrate); and
- option to use conveyors to transfer overburden (i.e. reduction in wheel-generated dust by overburden haul trucks).

The increased mineral concentrate production is expected to increase total emissions from the modified Atlas-Campaspe Mine by approximately 4 percent (%) compared to emissions from the approved Atlas-Campaspe Mine (if conveyors are not adopted for overburden transport) (Appendix B).

Overburden haulage (by haul trucks) will account for an estimated 30% of total PM_{10} emissions at the approved Atlas-Campaspe Mine. As the use of conveyors instead of haul trucks for overburden transport would reduce dust emissions due to overburden haulage by approximately 95%, the use of conveyors (if adopted) would result in an overall reduction in PM_{10} emissions (and other dust metrics) from the approved Atlas-Campaspe Mine (Appendix B).

Given the Modification would result in either a decrease or a relatively small increase in emissions (depending on whether conveyors are adopted), and the significant distances to the nearest sensitive receptors, it is likely the conclusions of the AQGHG Assessment (Katestone, 2013) for the approved Project would remain valid (i.e. the potential air quality impacts of the modified Atlas-Campaspe Mine on privately-owned sensitive receptors would be very low) (Appendix B).

However, as described in Section 3.3.1, due to the arid/semi-arid location of the Atlas-Campaspe Mine, there is the potential for exceedances of relevant air quality criteria with or without a contribution from the Project (i.e. due to elevated background levels).

Notwithstanding, with the continued implementation of reasonable and feasible mitigation measures (Section 3.3.3), the modified Atlas-Campaspe Mine is not predicted to materially contribute to any exceedances of the relevant air quality criteria.

Ivanhoe Rail Facility

The following components of the Modification would have the potential to alter particulate matter (e.g. dust) at the Ivanhoe Rail Facility (Appendix B):

- increased mineral concentrate transport truck movements along the Ivanhoe Rail Facility access road;
- increased mineral concentrate handling;
- revised alignment of the Ivanhoe Rail Facility access road and access road intersection (i.e. increased distance from the nearest privately-owned sensitive receptors);
- extension to the Ivanhoe Rail Facility hardstand area and rail siding (i.e. increased size of stockpile areas); and
- addition of a groundwater supply bore (i.e. water would be available for dust suppression resulting in less wheel-generated dust).

The proposed increase in mineral concentrate handling and associated increase in the mineral concentrate transport rate would increase emissions at the Ivanhoe Rail Facility. However, the watering of the Ivanhoe Rail Facility access road (from the proposed groundwater supply bore) would reduce wheel-generated dust emissions from the access road. The Modification would therefore result in an overall 15% reduction in emissions from the Ivanhoe Rail Facility (Appendix B).

It is therefore likely that the conclusions of the AQGHG Assessment (Katestone, 2013) for the approved Project would remain valid (i.e. the potential air quality impacts of the modified Ivanhoe Rail Facility on privately-owned sensitive receptors would be very low) (Appendix B).

However, as described in Section 3.3.1, due to the arid/semi-arid location of the Ivanhoe Rail Facility, there is the potential for exceedances of relevant air quality criteria with or without a contribution from the Ivanhoe Rail Facility (i.e. due to elevated background levels).

Notwithstanding, with the continued implementation of the mitigation measures described in the Air Quality Management Plan (CMA, 2018b) (Section 3.3.1), the modified Ivanhoe Rail Facility is not predicted to materially contribute to any exceedances of the relevant air quality criteria (Appendix B).

Road Haulage Route

The proposed increase in truck trips from 24 to 35 per day along unsealed sections of the road haulage route is unlikely to result in additional exceedances of the relevant air quality criteria, given the relatively small contribution of the road haulage route emissions to ground-level concentrations and the distance between the road haulage route and sensitive receptors (Appendix B).

3.3.3 Management Measures

The Air Quality Management Plan (CMA, 2018b) would continue to be implemented for the Modification.

Given the Modification is not expected to contribute to any additional exceedances of the relevant air quality criteria at any sensitive receptors in the vicinity of the Project, Tronox does not propose any additional air quality management measures.

Notwithstanding, the Air Quality Management Plan (CMA, 2018b) would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.4 NOISE

A Noise Review was undertaken for the Modification by Wilkinson Murray (2019) and is presented in Appendix C.

3.4.1 Background

Sensitive Receptors

The Project components are located at significant distances from sensitive receptors (Section 3.3.1).

Previous Assessment

The Noise Assessment for the approved Project (Wilkinson Murray, 2012) was prepared in accordance with the *Industrial Noise Policy* (INP) (EPA, 2000) and considered the noise impacts associated with the Atlas-Campaspe Mine, Ivanhoe Rail Facility and mineral concentrate transport between the Atlas-Campaspe Mine and the MSP.

The results of the Noise Assessment for the approved Project (Wilkinson Murray, 2012) are outlined below.

Atlas-Campaspe Mine

Wilkinson Murray (2012) concluded that the approved Atlas-Campaspe Mine will comply with the project-specific noise criteria and the applicable sleep disturbance criteria at all privately-owned sensitive receptors during construction and operation.

It was predicted that the approved Atlas-Campaspe Mine will comply with the relevant amenity criteria at the Mungo National Park, Mungo State Conservation Area and the Willandra Lakes Region World Heritage Area (Wilkinson Murray, 2012).

It was concluded that no cumulative impacts between the approved Project and the Balranald Mineral Sands Project will occur (Wilkinson Murray, 2012).

Ivanhoe Rail Facility

Wilkinson Murray (2012) determined that the approved Ivanhoe Rail Facility will comply with the Project-specific noise criteria and the applicable sleep disturbance criteria at all modelled privately-owned sensitive receptors during construction and operation.

Road Transport

Wilkinson Murray (2012) determined that the additional Project-related traffic movements on the road haulage route are expected to result in measurable increases in traffic noise levels along Magenta Road, Hatfield-The Vale Road and Balranald-Ivanhoe Road (north of the intersection with Hatfield-The Vale Road); however, compliance at the nearest private receptors was predicted.

Rail Movements

Wilkinson Murray (2012) determined that the approved Project would result in two additional exceedances of the ARTC Environment Protection Licence (EPL) night-time rail noise criteria along the Orange-Broken Hill Railway. Notwithstanding, given that the peak approved Project-related noise increase was anticipated to be less than 2 A-weighted decibels (dBA), an assessment of 'reasonable and feasible' noise mitigation measures was not considered warranted (Wilkinson Murray, 2012).

Management and Monitoring Regime

In accordance with Condition 18, Schedule 3 of Development Consent (SSD_5012), a Noise Management Plan (CMA, 2018c) has been prepared for the Project. The Noise Management Plan:

- identifies relevant noise criteria;
- identifies potential sources of noise during the construction and operational phases;
- identifies noise mitigation and management measures;
- details the noise monitoring program;
- establishes proactive and responsive noise emission management protocols; including a standard protocol, a complaint response protocol and an amenity protocol; and
- establishes community consultation protocols.

In accordance with Condition 18(c), Schedule 3 of Development Consent (SSD_5012), noise monitoring is conducted at three sites at the Atlas-Campaspe Mine and three sites at the Ivanhoe Rail Facility (Figures 10 and 11). The results of the noise monitoring program are assessed against criteria in Condition 16, Schedule 3 of Development Consent (SSD_5012).

No exceedances of the relevant noise monitoring criteria have been recorded to date (CMA, 2019d).

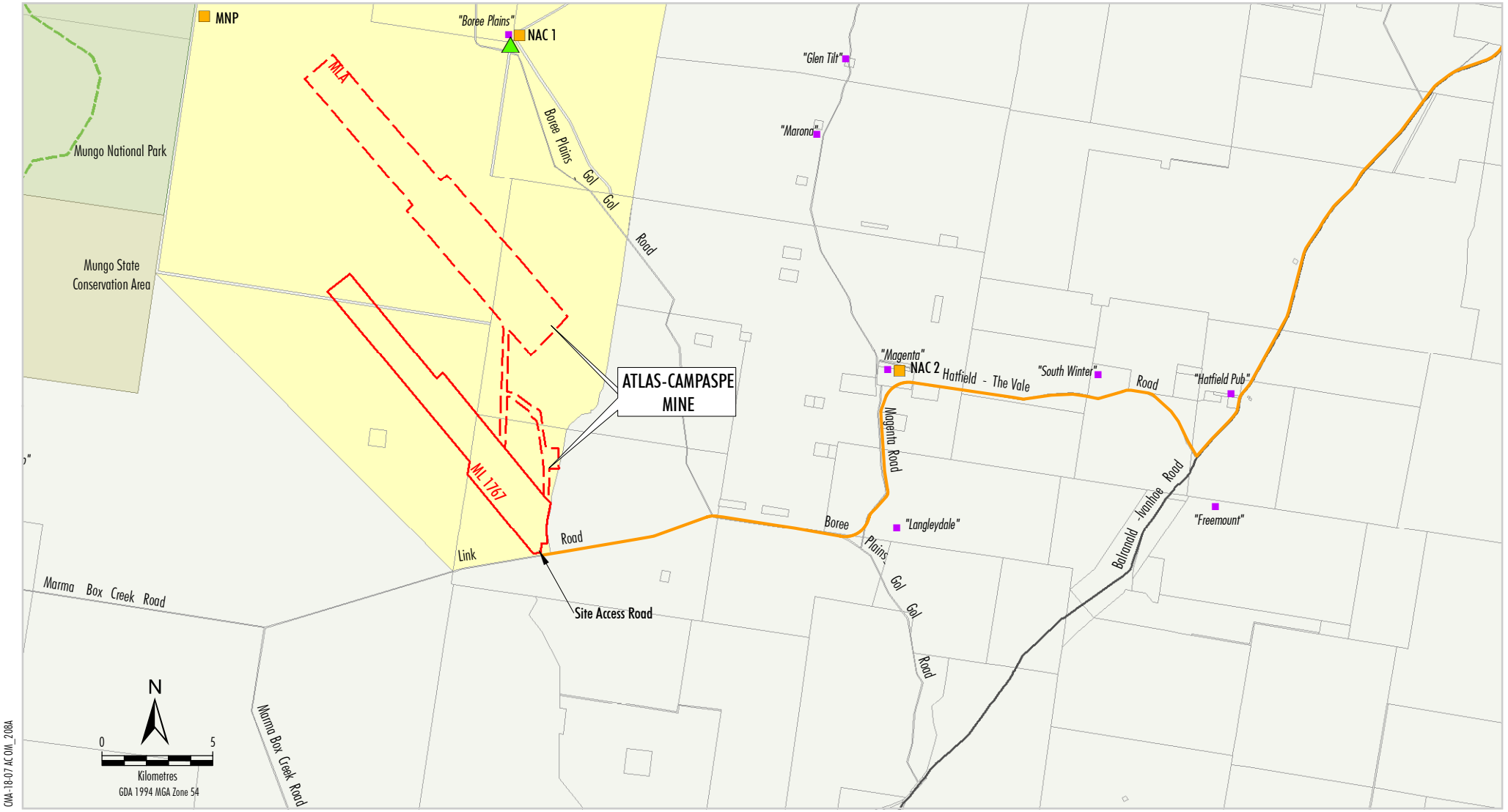
During the 2018 Annual Review reporting period, Tronox received no complaints in regard to noise (Wilkinson Murray, 2019).

Noise Criteria

The Noise Assessment for the approved Project (Wilkinson Murray, 2012) was prepared in accordance with the INP (EPA, 2000), which has since been superseded by the *Noise Policy for Industry* (NPfI) (EPA, 2017).

The INP defines a minimum noise criterion of 35 dBA for the day, evening and night-time. Based on background monitoring conducted for the approved Project, the project-specific noise criteria determined for the Project were the minimum applicable criteria (i.e. 35 dBA for the day, evening and night-time).

The NPfI increased the minimum daytime noise criterion to 40 dBA, while the evening and night-time criteria remained at 35 dBA. Wilkinson Murray (2019) therefore considered the potential noise impacts of the Modification against the NPfI criteria (Section 3.4.2).



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Automatic Weather Station
- Noise Monitoring Location

Source:© NSW Department of Finance, Services & Innovation (2017); Cristal Mining Australia (2012)

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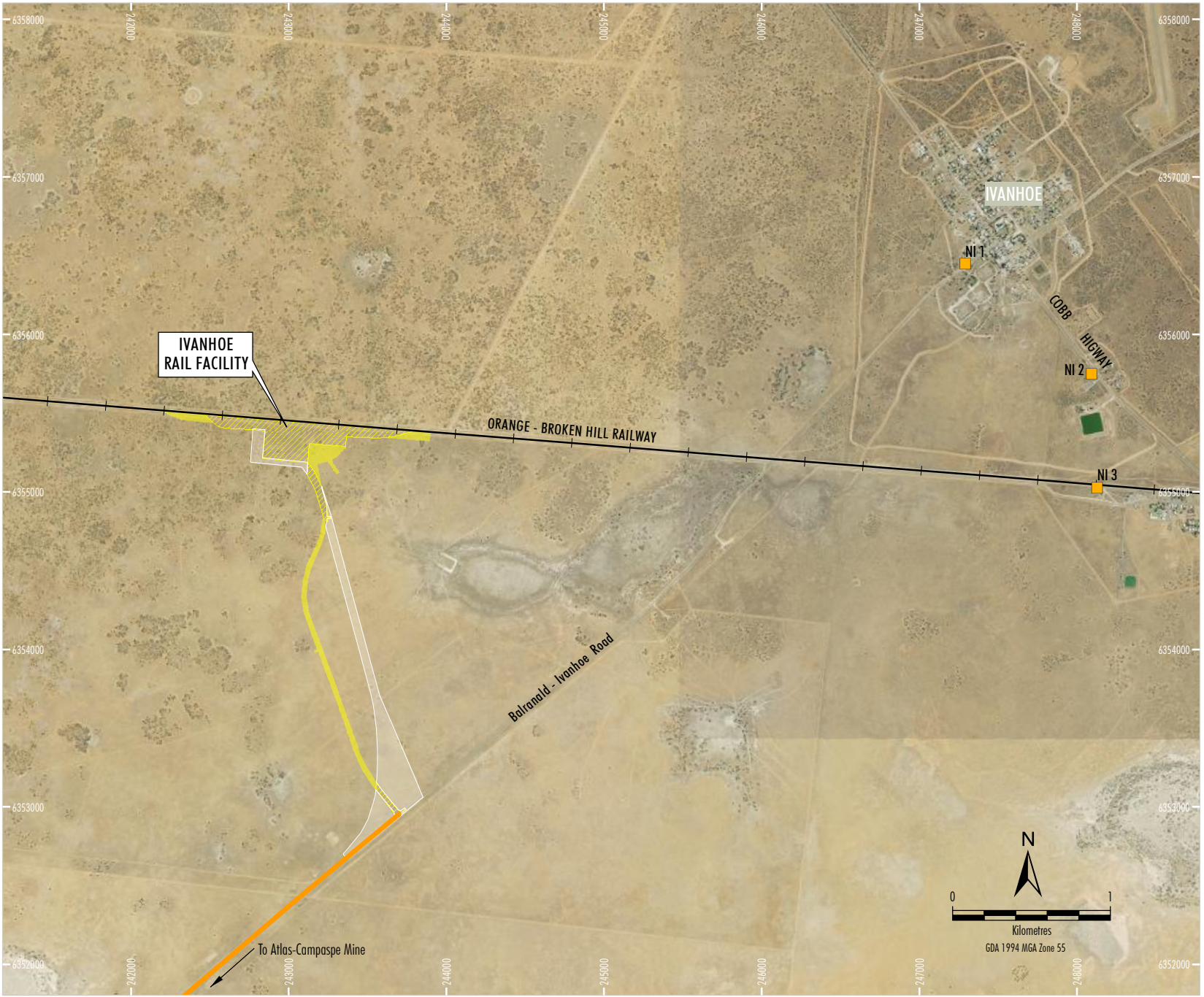
OPTIMISATION MODIFICATION

Atlas-Campaspe Mine - Noise Monitoring Sites

Figure 10



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Noise Monitoring Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Noise Monitoring Sites

Figure 11

CMA-18-07 AC OM_209C

3.4.2 Potential Impacts

The Noise Review (Appendix C) has evaluated the potential noise impacts of the Modification and a summary is provided below.

Atlas-Campaspe Mine

Given no changes to the major construction and operational mobile and fixed equipment are proposed during Year 1, the Year 1 noise levels from the modified Atlas-Campaspe Mine would be unchanged and therefore comply with the relevant noise criteria for all modelled receivers under neutral and adverse meteorological conditions (Appendix C).

The Modification would include changes to the operational mobile and fixed equipment after Year 1 of the Project (Section 2.1.1), which could alter noise levels associated with the Atlas-Campaspe Mine (Appendix C).

Wilkinson Murray (2019) conducted a review of the approved and modified mobile and fixed equipment sound power levels (SWLs), and concluded that the Modification would not result in an increase in the overall SWL at the Atlas-Campaspe Mine (Appendix C). Given the above, the Modification would not result in an increase in operational noise at the modified Atlas-Campaspe Mine, and compliance with the NPfI noise criteria for all modelled receivers under neutral and adverse meteorological conditions is predicted (Appendix C).

Additionally, the Modification would include the option to use conveyors to transfer some or all of the overburden at the Atlas-Campaspe Mine (rather than haul trucks). The SWL of a typical conveyor system is significantly lower than that generated by haul or product trucks; therefore, if they were adopted, the overall noise emissions generated by the modified Atlas-Campaspe Mine would be lower than those of the approved Atlas-Campaspe Mine (Appendix C).

Ivanhoe Rail Facility

As described in Section 2.3.2, the Modification would change the operational mobile equipment at the Ivanhoe Rail Facility. The additional equipment would increase the overall SWL associated with the Ivanhoe Rail Facility by 3 dBA, assuming concurrent operation of all sources (Appendix C).

Notwithstanding, Wilkinson Murray (2019) determined that the increased noise emissions at the modified Ivanhoe Rail Facility would not result in any material increase in noise levels at surrounding receivers, and all NPfI noise criteria are predicted to be achieved.

Road Transport

The Modification would increase mineral concentrate transport truck trips from 24 per day to 35 per day, which would increase noise levels over the daytime and night-time periods by approximately 1.6 dBA. Notwithstanding, noise generated by increased traffic associated with the Modification is predicted to comply with the relevant assessment criteria at all receiver locations given predicted compliance at the closest receiver (Magenta) (Appendix C).

Rail Movements

The Modification would increase the mineral concentrate transport train length from 600 m to 920 m and train frequency from six to eight train movements per week. As the increased train frequency is not expected to result in any change to the maximum number of train movements per day, the approved rail noise impacts as previously assessed by Wilkinson Murray (2012) for the approved Project would remain unchanged (Appendix C).

3.4.3 Management Measures

The Noise Management Plan (CMA, 2018c) would continue to be implemented for the Modification.

Given the Modification is not expected to contribute to any additional exceedances of the relevant noise criteria at any sensitive receptors in the vicinity of the Project, Tronox does not propose any additional noise management measures.

Notwithstanding, the Noise Management Plan (CMA, 2018c) would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.5 BIODIVERSITY

As the Modification would not change the extent of the approved Atlas-Campaspe Mine surface development area (Table 2), this section considers potential biodiversity impacts associated with the modified Ivanhoe Rail Facility surface development area.

3.5.1 Background

Biodiversity Values

Australian Museum Business Services (AMBS) (2013a; 2013b) assessed the biodiversity values within a study area surrounding the Ivanhoe Rail Facility.

The Ivanhoe Rail Facility is largely located within a paddock subject to grazing by goats, introduced non-native vegetation and past clearing. The native vegetation which remains comprises of Native Grassland/Sparse Acacia/Chenopod Shrubs (Plant Community Type [PCT] 166) (Plate 1) and smaller areas of Belah-Rosewood/Acacia (PCT 57) (Plate 2) (AMBS, 2013a) (Figure 12).

No threatened flora species or ecological communities listed under the *Biodiversity Conservation Act, 2016* (BC Act) or *Environment Protection and Biodiversity Conservation Act, 1999* (EPBC Act) are present within the approved or modified Ivanhoe Rail Facility surface development areas (AMBS, 2013a).

No threatened fauna species listed under the BC Act or EPBC Act have been recorded within the approved or modified Ivanhoe Rail Facility surface development areas. Three wide-ranging threatened birds species, namely Major Mitchell's Cockatoo (*Lophochroa leadbeateri),* Little Eagle (*Hieraaetus morphnoides)* and White-fronted Chat (*Epthianura albifrons)* were recorded outside the approved Ivanhoe Rail Facility area.

A vegetation condition assessment of the approved and modified Ivanhoe Rail Facility surface development area was carried out in June 2019 (Appendix D). The assessment consisted of the collection of vegetation condition (vegetation integrity) data from nine vegetation plots in accordance with the *Biodiversity Assessment Method* (BAM) (OEH, 2017) (Appendix D).

Vegetation Management Area

In accordance with Condition 13, Schedule 3 of Development Consent (SSD_5012), the approved Ivanhoe Rail Facility will include retention and management of 15 ha of existing vegetation in a Vegetation Management Area (VMA) (Figure 13).

Management and Monitoring Regime

In accordance with Condition 14, Schedule 3 of Development Consent (SSD_5012), a Biodiversity Management Plan (CMA, 2018d) has been prepared for the Project.

Of relevance to the Ivanhoe Rail Facility, the Biodiversity Management Plan contains measures for the short, medium, and long-term management of the VMA at the Ivanhoe Rail Facility (Figure 13).

3.5.2 Potential Impacts

No additional potential impacts on biodiversity are likely to occur as a result of the Modification. Instead, approximately 12 ha less native vegetation/habitat clearance[1] would be required for the modified Ivanhoe Rail Facility, resulting in retention of 0.1 ha of Belah-Rosewood/ Acacia (PCT 57) and 11.9 ha of Native Grassland/ Sparse Acacia/Chenopod Shrubs (PCT 166) that would otherwise be cleared (Table 5 and Figure 12).

Table 5
Vegetation Communities at the Ivanhoe Rail Facility

PCT	Approved Surface Development Area (ha)	Modified Surface Development Area (ha)	Difference (ha)
Belah-Rosewood/ Acacia (PCT 57)	10	9.9	-0.1
Native Grassland/ Sparse Acacia/Chenopod Shrubs (PCT 166)	30	18.1	-11.9
Total	**40**	**28**	**-12**

[11] The Modification would result in an approximate 14 ha reduction in the size of the Ivanhoe Rail Facility surface development area (Section 2.3.1), comprising approximately 12 ha of native vegetation, and approximately 2 ha of existing road and rail infrastructure.

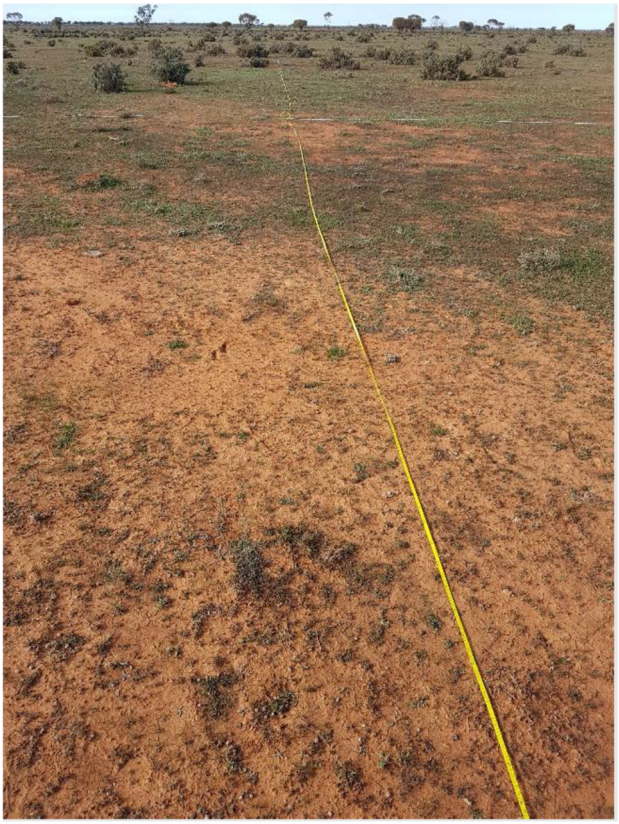
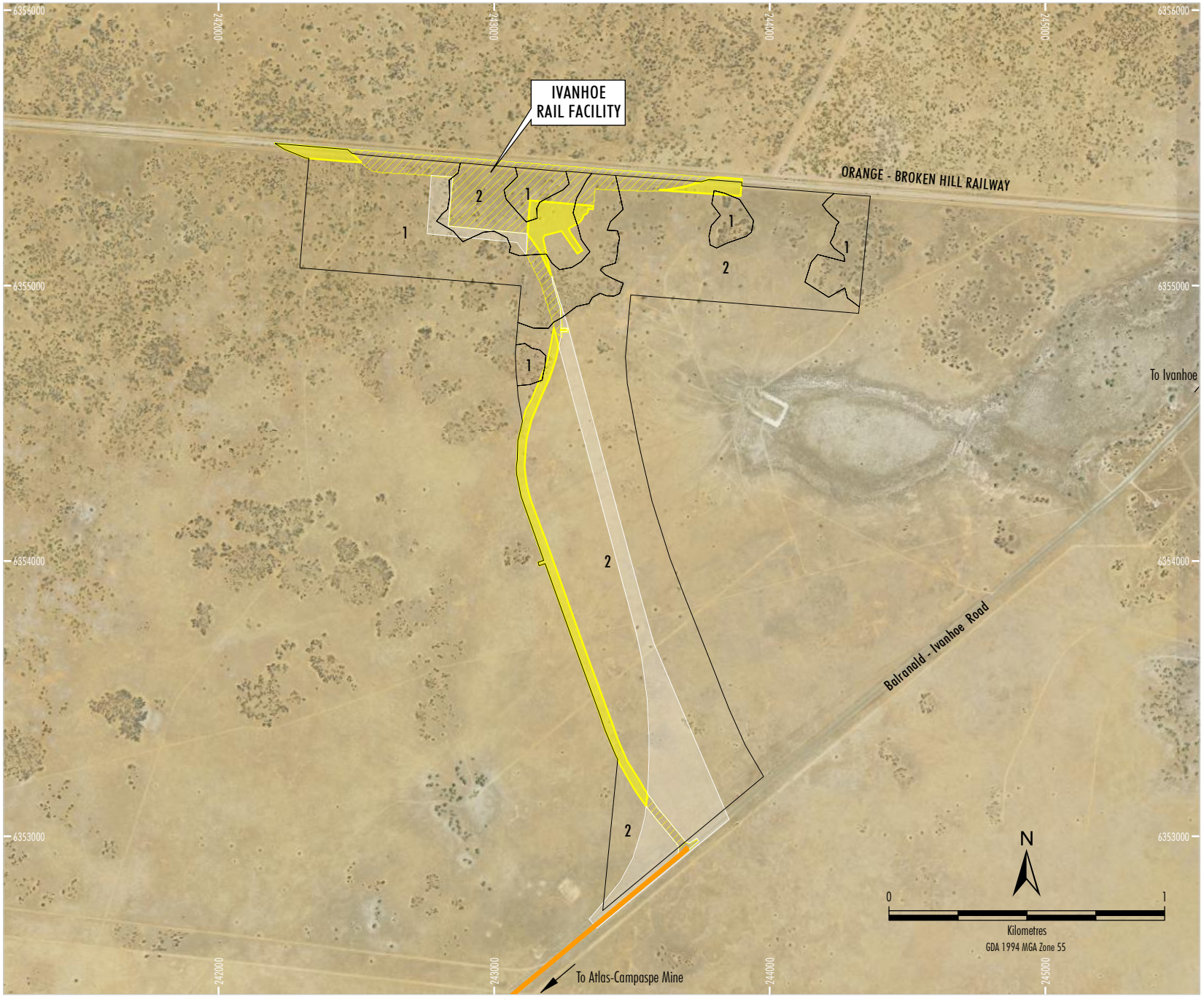


Plate 1 Native Grassland/ Sparse Acacia/ Chenopod Shrubs (PCT 166) in the Additional Surface Development Area

Plate 2 Belah-Rosewood/ Acacia (PCT 57) in the Additional Surface Development Area



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*

Vegetation Communities

- 1 Belah-Rosewood/Acacia Woodland
- 2 Native Grassland/Sparse Acacia/ Chenopod Shrubs

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); AMBS (2012); Tronox (2019) and GHD (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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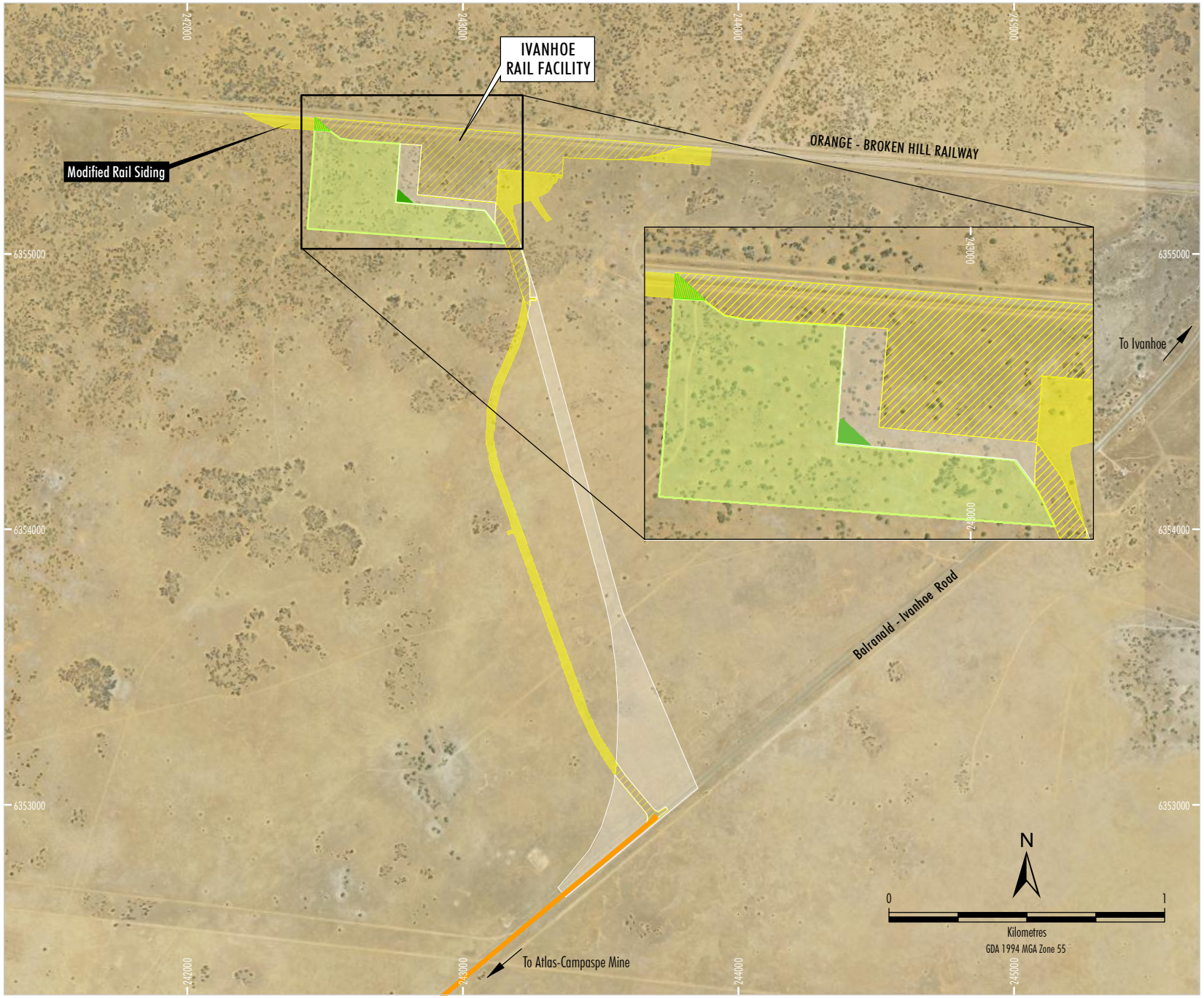
OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Vegetation Communities

Figure 12

CMA-18-07 AC OM_210C



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Approved Vegetation Management Area
- Approved Vegetation Managment Area to be Replaced
- Replacement Vegetation Management Area

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2015); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Vegetation Management Area

Figure 13

CMA-18-07 AC OM_213B

A separate Biodiversity Development Assessment Report (BDAR) is not required for the Modification, as the Modification would not increase impacts on biodiversity values, with reference to section 7.17(2)(c) of the BC Act and the *Biodiversity Development Assessment Report Waiver Determinations for SSD and SSI Applications* (DP&E, 2018).

The potential impact of the modified Ivanhoe Rail Facility on biodiversity values is further described in Table 6.

Vegetation Management Area

The Modification would impact approximately 0.17 ha of the approved VMA at the Ivanhoe Rail Facility (Figure 13). To maintain the overall size of the VMA, a portion (i.e. 0.17 ha) of the approved surface development area no longer required would be incorporated in the VMA at the Ivanhoe Rail Facility (Figure 13).

3.5.3 Management Measures

Given the Modification would not result in any additional biodiversity impacts, no additional management measures are proposed as part of the Modification.

The Biodiversity Management Plan (CMA, 2018d) would be reviewed and, if necessary, revised by Tronox to include the Modification, such as the revised VMA (subject to any modified Development Consent conditions).

Table 6
Biodiversity Values Consideration

Biodiversity Value	Meaning	Relevant (✓ or NA)*	Explanation
Vegetation abundance *1.4(b) BC Regulation*	*Occurrence and abundance of vegetation at a particular site*	✓	The Modification would result in a net reduction (approximately 12 ha) in the amount of native vegetation clearance associated with the modified Ivanhoe Rail Facility.
Vegetation integrity *1.5(2)(a) BC Act*	*Degree to which the composition, structure and function of vegetation at a particular site and the surrounding landscape has been altered from a near natural state*	✓	The Vegetation Integrity Score (VIS) calculated using the BAM Calculator indicates that there is a slight difference in the condition of the vegetation between the additional surface development area and approved surface development area no longer required; however, the apparent difference in the calculated VIS is likely natural variation and not a material measure that the vegetation is in better condition in the additional Ivanhoe Rail Facility surface development area (Appendix D). Notwithstanding, even if the apparent differences in the calculated VIS between the additional surface development area and approved surface development area no longer required are real, the approximate 12 ha reduction in native vegetation clearance required for the modified Ivanhoe Rail Facility would lead to an overall net reduction of impacts on native vegetation (Appendix D).
Habitat suitability *1.5(2)(b) BC Act*	*Degree to which the habitat needs of threatened species are present at a particular site*	✓	The Modification would result in a net reduction (approximately 12 ha) in the amount of native vegetation/habitat clearance associated with the modified Ivanhoe Rail Facility. No other habitat features (e.g. karst, caves, crevices, cliffs and other geological features of significance, rocks, human made structures or non-native vegetation) are present within the approved or modified Ivanhoe Rail Facility surface development areas. No threatened flora species or ecological communities listed under the BC Act or EPBC Act are present within the approved or modified Ivanhoe Rail Facility surface development areas.

Table 6 (Continued)
Biodiversity Values Consideration

Biodiversity Value	Meaning	Relevant (✓ or NA)*	Explanation
Habitat suitability *1.5(2)(b) BC Act* (Cont.)	*Degree to which the habitat needs of threatened species are present at a particular site* (Cont.)	✓	No threatened fauna species listed under the BC Act or EPBC Act have been recorded within the approved or modified Ivanhoe Rail Facility surface development areas. Three wide-ranging threatened bird species, namely Major Mitchell's Cockatoo (*Lophochroa leadbeateri),* Little Eagle (*Hieraaetus morphnoides)* and White-fronted Chat (*Epthianura albifrons)* were recorded outside the approved Ivanhoe Rail Facility area.
Threatened species abundance *1.4(a) BC Regulation*	*Occurrence and abundance of threatened species or threatened ecological communities, or their habitat, at a particular site*	✓	The Modification would result in a net reduction (approximately 12 ha) in the amount of native vegetation/habitat clearance associated with the modified Ivanhoe Rail Facility.
Habitat connectivity *1.4(c) BC Regulation*	*Degree to which a particular site connects different areas of habitat of threatened species to facilitate the movement of those species across their range*	N/A	The native vegetation/habitat in the associated with the modified Ivanhoe Rail Facility does not connect different areas of habitat of threatened species to facilitate the movement of those species across their range.
Threatened species movement *1.4(d) BC Regulation*	*Degree to which a particular site contributes to the movement of threatened species to maintain their lifecycle*	N/A	The native vegetation/habitat in the associated with the modified Ivanhoe Rail Facility would not contribute to the movement of threatened species to maintain their lifecycle.
Flight path integrity *1.4(e) BC Regulation*	*Degree to which the flight paths of protected animals over a particular site are free from interference*	N/A	The Modification would not interfere with any flight paths of protected animals.
Water sustainability *1.4(f) BC Regulation*	*Degree to which water quality, water bodies and hydrological processes sustain threatened species and threatened ecological communities at a particular site*	N/A	The Modification would not impact water quality, water bodies and hydrological processes that sustain threatened species. The Groundwater Review (Appendix F) demonstrates that the Ivanhoe Rail Facility groundwater supply bore would not result in impacts on groundwater dependent ecosystems as none are present.

* *A biodiversity value is not relevant to a proposed development if the value is not present on the development site and there is no potential for direct or indirect impacts on the biodiversity value if it occurs off-site* (DP&E, 2018).

3.6 ABORIGINAL CULTURAL HERITAGE

An ACHA has been prepared for the Modification by Landskape Natural and Cultural Heritage Management (Landskape) (2019) and is presented in Appendix E.

As the Modification would not change the extent of the approved Atlas-Campaspe Mine surface development area (Table 2), this section considers potential Aboriginal heritage impacts associated with the modified Ivanhoe Rail Facility surface development area.

3.6.1 Background

The ACHA for the Modification has been undertaken in consideration of relevant requirements of various advisory documents and guidelines, including but not limited to (Appendix E):

- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010* (DECCW, 2010a);
- *Due Diligence Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b); and
- *Guide to investigating, assessing and reporting on Aboriginal Cultural Heritage in NSW* (OEH, 2011).

Previous Archaeological Investigations

An Aboriginal and Non-Aboriginal Cultural Heritage Assessment was previously prepared for the approved Project by Niche Environment and Heritage (Niche) (2012). The assessment recorded 22 Aboriginal cultural heritage sites in the vicinity of, but not within, the approved Ivanhoe Rail Facility surface development area (Niche, 2012) (Figure 14). Of the 22 sites, 15 consisted of stone artefact scatters (five with hearths), and seven consisted of isolated finds of stone artefacts (Niche, 2012).

A detailed description of previous archaeological investigations and assessments undertaken in the region surrounding the Project is provided in Appendix E.

Management and Monitoring Regime

In accordance with Condition 28, Schedule 3 of Development Consent (SSD_5012), a Heritage Management Plan (CMA, 2017a) has been prepared for the approved Project. The Heritage Management Plan:

- identifies Aboriginal heritage sites and values;
- details the management of Aboriginal heritage sites, including:
  - protocol for the ongoing involvement of the Aboriginal community; and
  - monitoring, management and avoidance measures for known and unknown Aboriginal objects;
- establishes a contingency plan; and
- establishes the roles and responsibilities of Tronox staff with regard to the Heritage Management Plan.

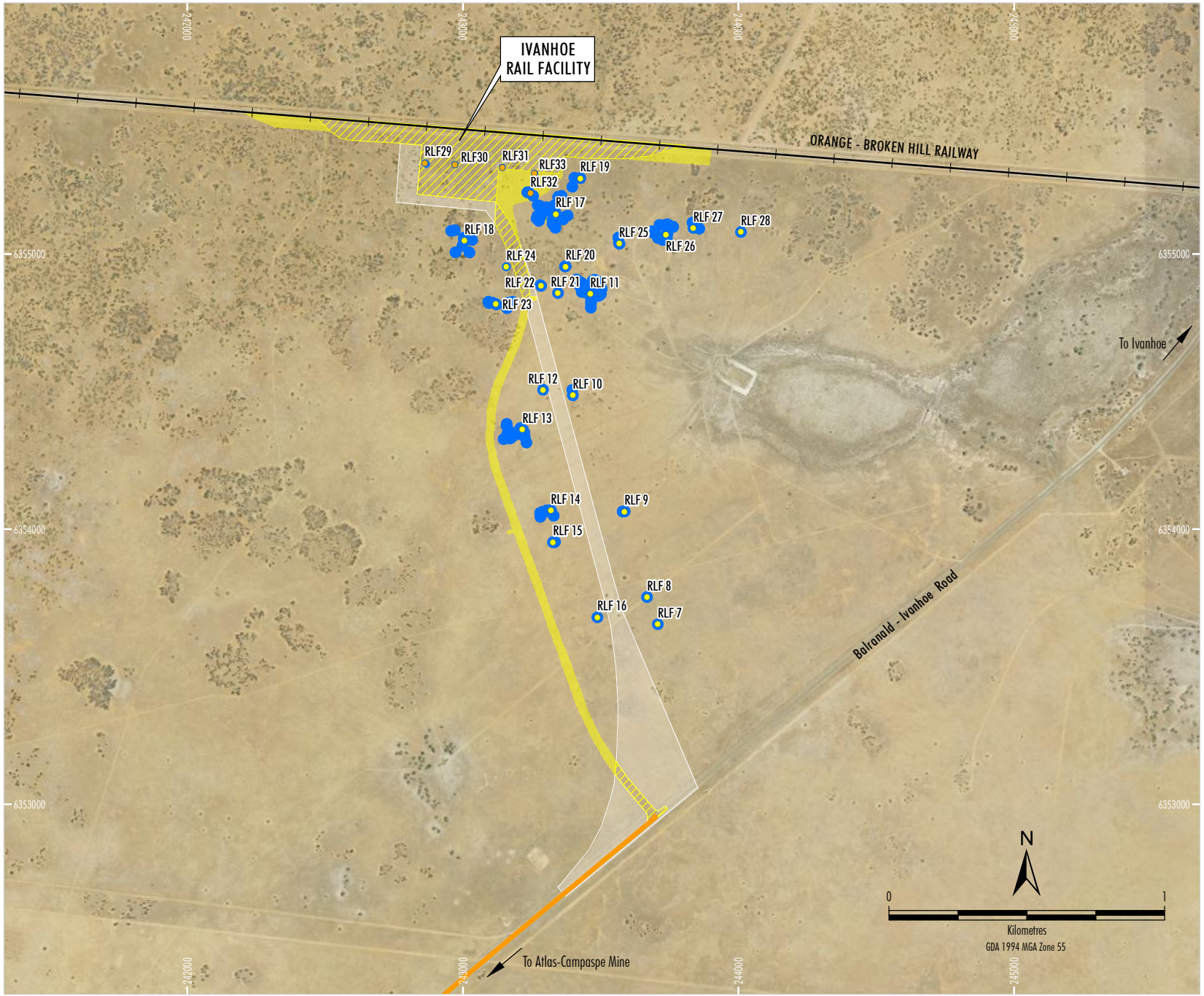
The Heritage Management Plan (CMA, 2017a) provides for the fencing and demarcation of six of the 22 Aboriginal heritage sites identified in the vicinity of the approved Ivanhoe Rail Facility sites (namely RLF 11, RLF 13, RLF 17, RLF 18, RLF 22 and RLF 26), which will be undertaken prior to any surface disturbance activities occurring in the vicinity of the sites.

Consultation

The ACHA included consultation with 11 Registered Aboriginal Parties (RAPs), which were identified during the registration process undertaken for the approved Project, consistent with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW, 2010a) (Appendix E).

Consultation with the Aboriginal community regarding the approved Project has been extensive and involved various methods of communication including public notices, meetings, written and verbal correspondence and archaeological survey attendance, review of the draft Heritage Management Plan (CMA, 2017a) and archaeological salvage at the Atlas-Campaspe Mine.

A detailed description of the consultation undertaken with the RAPs for the Modification is provided in Appendix E, and a summary is provided below.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Aboriginal Heritage Site (Niche, 2012)
- Aboriginal Heritage Site (Landskape, 2019)
- Extent of Aboriginal Heritage Site

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Niche (2012); Tronox (2019) and Landskape (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Aboriginal Heritage Sites

Figure 14

CMA-18-07 AC OM_212C

Information Session

Information regarding the Modification was provided in writing to all RAPs on 29 March 2019, which included an invitation to attend an information session about the Modification, which was held on 30 April 2019 in Ivanhoe. The information session was attended by representatives of one RAP, the Ivanhoe Community Working Party (Appendix E).

Aboriginal Cultural Heritage Field Survey

All RAPs were invited to attend a field survey of the modified Ivanhoe Rail Facility, which was held on 1 May 2019. The field survey was attended by representatives of one RAP, the Ivanhoe Community Working Party (Appendix E).

Review of the Draft ACHA

A copy of the draft ACHA was provided to all RAPs on 17 May 2019, and comments were requested by 21 June 2019. No comments were received on the draft ACHA (Appendix E).

Desktop Review

An Aboriginal Heritage Information Management System (AHIMS) search was undertaken in May 2019 for the modified Ivanhoe Rail Facility and surrounds. The search identified no Aboriginal heritage sites located within the modified Ivanhoe Rail Facility surface development area (Appendix E).

Archaeological Survey and Results

The field survey of the modified Ivanhoe Rail Facility surface development area was undertaken by suitably qualified archaeologist Dr Matt Cupper (Landskape, 2019) in consultation with the Registered Aboriginal Parties on 1 May 2019.

Five Aboriginal cultural heritage sites were identified during the survey, namely RLF 29, RLF 30, RLF 31, RLF 32 and RLF 33 (Figure 14) (AHIMS site numbers 33-4-0031, 33-4-0030, 33-4-0029, 33-4-0028 and 33-4-0027, respectively). These sites consist of two stone artefact scatters and three isolated finds of stone artefacts. Three of these sites are located in the approved surface development area, while two are located within the additional surface development area (Figure 14).

The five sites identified during the survey are not of high scientific or cultural significance (Appendix E).

3.6.2 Potential Impacts

Direct and Indirect Impacts

Construction of the modified Ivanhoe Rail Facility would disturb the current land surface and would likely directly impact the five Aboriginal cultural heritage sites identified in the modified Ivanhoe Rail Facility surface development area (i.e. sites RLF 29, RLF 30, RLF 31, RLF 32 and RLF 33) if not relocated prior to disturbance (Appendix E).

Notwithstanding, harm can be avoided to the 22 Aboriginal cultural heritage sites identified by Niche (2012) located adjacent to the modified Ivanhoe Rail Facility surface development area, the management measures for which are described in Appendix E.

Although the modified Ivanhoe Rail Facility surface development area was sufficiently surveyed, there remains the potential for additional Aboriginal cultural heritage sites to be located within this area. Such previously unidentified features, should they occur, would probably be isolated finds or low-density concentrations of stone artefacts (Appendix E). The Heritage Management Plan (CMA, 2017a) contains management measures for any newly identified Aboriginal cultural heritage sites.

3.6.3 Management Measures

Management options for the five Aboriginal cultural heritage sites identified by Landskape (2019) at the Ivanhoe Rail Facility were discussed with the RAPs on the day of the survey.

Tronox would arrange collection of the objects prior to the commencement of disturbance activities and engage a suitably qualified archaeologist and representatives of the RAPs to record and collect the artefacts. These items would be properly curated and stored at the approved “Keeping Place”. Artefacts would be replaced within rehabilitated areas in consultation with local Aboriginal groups and the OEH (Appendix E).

The Heritage Management Plan (CMA, 2017a) would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.7 HISTORIC HERITAGE

As the Modification would not change the extent of the approved Atlas-Campaspe Mine surface development area (Table 2), this section considers potential historic heritage impacts associated with the modified Ivanhoe Rail Facility surface development area.

3.7.1 Background

Previous Assessments

An Aboriginal and Non-Aboriginal Heritage Assessment was prepared for the approved Project by Niche (2012).

The assessment was prepared in consideration of the relevant principles and articles contained in the *Burra Charter* (Australia International Council on Monuments and Sites, 1999) and the *NSW Heritage Manual* (NSW Heritage Office and NSW Department of Urban Affairs and Planning, 1996).

No items of state or regional historic heritage significance were identified in the approved Ivanhoe Rail Facility surface development area (Niche, 2012).

Management and Monitoring Regime

In accordance with Condition 28, Schedule 3 of Development Consent (SSD_5012), a Heritage Management Plan (CMA, 2017a) has been prepared for the Project.

The Heritage Management Plan contains measures for historic heritage sites, including avoidance of known sites and management measures for previously unrecorded sites (should they be encountered).

3.7.2 Potential Impacts

No historic heritage sites were recorded during the field survey of the modified Ivanhoe Rail Facility surface development area conducted by Landskape (2019) (Section 3.6.1) (Appendix E).

Although the modified surface development area was sufficiently surveyed, there remains the potential for historic heritage sites to be located within this area. The Heritage Management Plan (CMA, 2017a) contains management measures for any newly identified historic heritage sites.

3.7.3 Management Measures

Given that the Modification would not result in any additional historic heritage impacts, no additional management measures are proposed as part of the Modification. Notwithstanding, the Heritage Management Plan (CMA, 2017a) would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.8 LAND AND AGRICULTURAL RESOURCES

As the Modification would not change the extent of the approved Atlas-Campaspe Mine surface development area (Table 2), this section considers potential land and agricultural resource impacts associated with the modified Ivanhoe Rail Facility surface development area.

3.8.1 Background

An Agricultural Impact Statement was prepared for the approved Project by CMA (2012a), which described the potential impacts of the approved Project on land resources and agricultural production. The Agricultural Impact Statement was prepared in consideration of the NSW Government's *Guideline for Agricultural Impact Statements* (NSW Government, 2012).

Topography

The landform at the Ivanhoe Rail Facility is flat at approximately 100 m Australian Height Datum (AHD) (CMA, 2012b).

Land Use and Agricultural Production

Contemporary land use in the vicinity of the Ivanhoe Rail Facility is dominated by agricultural activities (low-intensity grazing) and the Orange – Broken Hill railway. Opportunistic harvesting of feral goats is known to be undertaken in the Ivanhoe Rail Facility area (CMA, 2012a).

Land and Soil Capability

Land and Soil Capability mapping undertaken by Ogyris Ecological Research (2012) mapped the Ivanhoe Rail Facility area as Class 6, which is defined as *land capable for a limited set of land uses* (OEH, 2012). Calcic Calcarosols are the only mapped soil type at the approved Ivanhoe Rail Facility (CMA, 2012a).

Land Contamination

The Stage 1 Land Contamination Assessment prepared for the approved Project (CMA, 2012b) concluded that no potentially contaminating activities or contaminated areas were identified at the Ivanhoe Rail Facility site, no further investigation was required, and that the Ivanhoe Rail Facility site is suitable for Project use.

No potentially contaminating activities or contaminated areas have been identified in the modified surface development area.

Land Resources Management

Management of land resources for the approved Project is conducted in accordance with the Biodiversity Management Plan (CMA, 2018d), which has been prepared for the Project in accordance with Condition 14, Schedule 3 of Development Consent (SSD_5012).

The Biodiversity Management Plan (CMA, 2018d), in regard to land resources management, includes:

- vegetation clearance protocol; and
- a management program for the vegetation management areas, including bushfire management.

The Biodiversity Management Plan was prepared in consultation with the OEH, NSW National Parks and Wildlife Service, NSW Rural Fire Service and the Commonwealth Department of the Environment and Energy (DoEE).

Management of land resources for the approved Project is also conducted in accordance with the Surface Water Management Plan (CMA, 2018e), prepared for the approved Project In accordance with Condition 26(e), Schedule 3 of Development Consent (SSD_5012). In regard to land resources management, the Surface Water Management Plan includes:

- erosion and sediment control management measures;
- soil-stripping management measures;
- monitoring and reporting requirements; and
- contingency measures.

3.8.2 Potential Impacts

The modified Ivanhoe Rail Facility components would require an additional 10 ha of surface development area (Section 2.3.1).

The following land and agricultural resource aspects could potentially be impacted by the modified Ivanhoe Rail Facility:

- topographic features;
- soils and erosion potential; and
- land use and capability.

It is noted that the Modification would however result in a net reduction in surface development area of approximately 14 ha at the Ivanhoe Rail Facility, therefore there is expected to be an overall reduction in potential land and agricultural resource impacts as a result of the Modification.

Notwithstanding, these potential impacts and how they relate to the Ivanhoe Rail Facility are described in the following sub-sections. Measures to mitigate these potential impacts are also provided in this sub-section.

Topographic Features

The main modifications to the existing topography that would result from the modified Ivanhoe Rail Facility when compared to the approved Ivanhoe Rail Facility comprises:

- a small extension to the Ivanhoe Rail Facility hardstand area;
- extension of the Ivanhoe Rail Facility rail siding; and
- a revised alignment of the Ivanhoe Rail Facility access road and access road intersection.

In the context of the approved Ivanhoe Rail Facility, the landform changes associated with the modified Ivanhoe Rail Facility outlined above represent a very minor modification to the existing topography.

Soils and Erosion

The low rainfall and lack of defined drainage channels in the region generally limit the potential for fluvial erosion and sedimentation.

The potential soil and erosion-related impacts relevant to the Modification include:

- loss of *in situ* soil resources from beneath Project infrastructure;
- alteration of physical and chemical soil properties during stripping and stockpiling operations;

- reduced soil quality (structure, fertility and microbial activity) of long-term stockpiles; and
- erosion and sediment movement due to exposure of soils during clearance and construction activities.

Potential soil and erosion impacts would be managed by the implementation of the measures outlined in the Surface Water Management Plan (CMA, 2018e).

Land Use and Capability

The Modification would result in a net reduction of approximately 12 ha in the amount of potential agricultural land that would be disturbed by the Ivanhoe Rail Facility.

Rehabilitation of the modified Ivanhoe Rail Facility would aim to restore self-sustaining ecosystems, including native species characteristic of vegetation communities cleared and/or surrounding the development through direct seeding or hand-planting tube-stock.

The nature of grazing in the region primarily involves light intensity grazing by livestock on native vegetation. Therefore, by targeting the restoration of self-sustaining ecosystems, including endemic native species in the first instance, Tronox would not preclude either final land use option.

Land Contamination

Potential land contamination risks were identified as part of the Preliminary Hazard Analysis (CMA, 2012c), and included:

- leaks/spills;
- fire;
- explosion;
- theft;
- accident; and
- unplanned movement off-site.

The Modification would not change the potential impacts identified in the Preliminary Hazard Analysis (CMA, 2012c) relevant to the potential land contamination risks described above.

3.8.3 Management Measures

The Biodiversity Management Plan (CMA, 2018d) and Surface Water Management Plan (CMA, 2018e) would continue to be implemented for the modified Ivanhoe Rail Facility.

In addition, the land and agricultural resource aspects of the Biodiversity Management Plan and Surface Water Management Plan would be reviewed and, if necessary, revised for the Modification (subject to any modified Development Consent conditions).

3.9 GROUNDWATER RESOURCES

The Groundwater Review prepared for the Modification (Appendix F) has assessed the potential impacts of the proposed groundwater supply bore at the Ivanhoe Rail Facility. The Groundwater Review is presented in Appendix F.

As the Modification would not change the approved groundwater impacts at the Atlas-Campaspe Mine (Table 2), this section considers potential groundwater impacts associated with the modified Ivanhoe Rail Facility.

3.9.1 Background

Hydrogeological Setting

The Ivanhoe Rail Facility is located within the Willandra Creek catchment in the Lachlan River basin. Willandra Creek is an effluent creek of the lower Lachlan River, which terminates in a series of lignum swamps and intermittent lakes in the Benanee basin south-west of Ivanhoe (Appendix F).

The Ivanhoe Rail Facility is located within the Lower Lachlan Alluvium Groundwater Source as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* and the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the NSW *Water Management Act, 2000* (Appendix F).

The stratigraphy of the Ivanhoe area consists of (Appendix F):

- Surficial Quaternary sediments (alluvial, evaporite, calcrete, aeolian).
- Tertiary-Quaternary Shepparton Formation is a thin fluvio lacustrine deposit comprising clay, silty clay and sand with lenses of coarse sand and gravel, and minor aeolian reworked material.
- Pliocene Calivil Formation is primarily a fluvio-lacustrine sand deposit and is expected to be the water table aquifer at the site.
- Tertiary Renmark Group comprises sands and clays and is a significant aquifer in the region.

- Cretaceous Monash Formation includes sands, sandstone, siltstone and shale, with minor coal.
- Devonian basement rock includes sandstones and metasediments.

The Renmark Group Aquifer is the target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore, and is approximately 40 to 85 m below ground level (Appendix F).

Groundwater Quality

Groundwater salinity mapping of the region (Murray Darling Basin Authority, 2008) indicates salinity of about 10,000 milligrams per litre (mg/L) (Appendix F).

Groundwater Users

A bore census for the Ivanhoe Rail Facility area was conducted by Tronox in April 2019 and is presented in Appendix F.

The bore census confirmed the existence of 10 groundwater bores within 10 km of the Ivanhoe Rail Facility, the closest of which is located approximately 2 km south-east of the Ivanhoe Rail Facility groundwater supply bore (Figure 15) (Appendix F). Of these 10 bores, 7 were confirmed to be in use for stock watering (six bores) and monitoring (one bore) (Appendix F).

The limited groundwater use in the region is expected given the poor groundwater quality (Appendix F).

Groundwater Dependent Ecosystems

No Groundwater Dependent Ecosystems (GDEs) are considered to be present within the locality of the Ivanhoe Rail Facility groundwater supply bore (Appendix F).

Groundwater Licensing

The Ivanhoe Rail Facility is located within the Lower Lachlan Alluvium Groundwater Source as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* and the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the NSW *Water Management Act, 2000* (Appendix F).

Tronox has a total of 100 share components (units or ML) in the Lower Lachlan Alluvium Groundwater Source.

Management and Monitoring Regime

In accordance with Condition 26(f), Schedule 3 of Development Consent (SSD_5012), a Groundwater Management Plan (CMA, 2018f) has been prepared for the Project. The Groundwater Management Plan:

- details relevant groundwater criteria;
- describes a program for groundwater management and monitoring;
- details a contingency plan; and
- describes the groundwater reporting, audit and reviewing requirements of the approved Project.

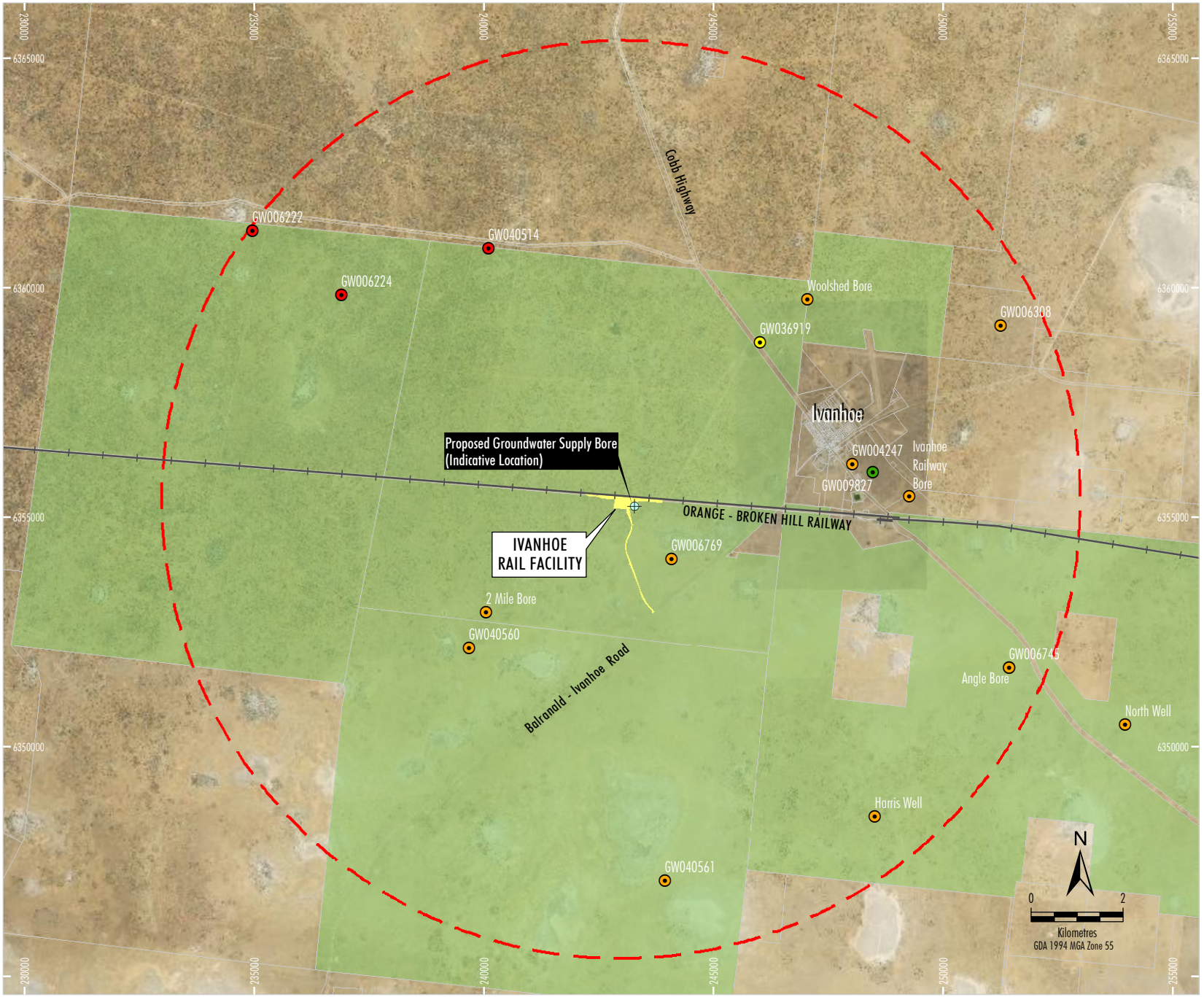
During the 2018 Annual Review reporting period, no incidents relating to groundwater occurred and no complaints were received by Tronox.

3.9.2 Potential Impacts

The Ivanhoe Rail Facility groundwater supply bore would provide up to approximately 60 ML/year of water over the life of the Project.

The Groundwater Review has evaluated the potential impacts of the proposed Ivanhoe Rail Facility groundwater supply bore and concluded (Appendix F):

- the maximum predicted drawdown is low and is not significant beyond 100 m (i.e. predicted maximum drawdown 100 m from the bore is 2 cm);
- there is expected to be no significant change in groundwater quality due to the proposed groundwater supply bore;
- drawdown at the closest bore (approximately 2 km) is predicted to be negligible;
- as there are no GDEs present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore, no impacts on GDEs are expected;
- there are no significant groundwater users in the vicinity of the proposed Ivanhoe Rail Facility groundwater supply bore, and therefore no cumulative impacts are expected;



LEGEND

- Bore Census Area (10 km Buffer)
- Modified Surface Development Area - Ivanhoe Rail Facility
- Leaseholder Consulted

Groundwater Bore Intended Purpose

- Stock
- Domestic
- Monitoring
- Not In Use

Source: © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019); Cristal Mining Australia (2012); Tronox (2019). Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX

OPTIMISATION MODIFICATION

Ivanhoe Rail Facility Bore Census Results

Figure 15

CMA-18-07_Opt_EA_201A

- the proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*; and
- the proposed Ivanhoe Rail Facility groundwater supply bore would meet the relevant rules for granting water supply work approvals in Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*; and
- the proposed Ivanhoe Rail Facility groundwater supply bore would have "minimal impact" as defined in the NSW *Aquifer Interference Policy*.

3.9.3 Management Measures

The Groundwater Management Plan (CMA, 2018f) would be revised to include quarterly water level and quality (electrical conductivity, pH, standard anions and cations, and metals) at the Ivanhoe Rail Facility groundwater supply bore.

Tronox holds sufficient entitlements under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Ivanhoe Rail Facility groundwater supply bore (Section 3.9.1).

Additionally, the Groundwater Management Plan (CMA, 2018f) would be reviewed and, if necessary, revised by Tronox to generally include the Modification (subject to any modified Development Consent conditions).

3.10 SURFACE WATER RESOURCES

As the Modification would not change the approved surface water impacts at the Atlas-Campaspe Mine (Table 2), this section considers potential surface water impacts associated with the modified Ivanhoe Rail Facility surface development area.

3.10.1 Background

Regional Hydrology

The Ivanhoe Rail Facility is located within the Willandra Creek catchment in the Lachlan River basin. Willandra Creek is an effluent creek of the lower Lachlan River which terminates in a series of lignum swamps and intermittent lakes in the Benanee basin south-west of Ivanhoe (Appendix F).

Previous Assessments

A Surface Water Assessment for the approved Project was undertaken by Evans & Peck (2012). The main potential surface water impacts associated with the approved Ivanhoe Rail facility were:

- mobilisation of sediment during construction; and
- surface runoff containing sediments from the stockpile area during operations.

Evans & Peck (2012) concluded that these potential surface water impacts could be addressed through the implementation of standard sediment controls along the access road and hardstand areas during construction.

Surface Water Licensing

The Ivanhoe Rail Facility is located within the Unregulated Effluent Creeks Water Source as defined in the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* under the *Water Management Act 2000*.

Management and Monitoring Regime

As described in Section 3.8.1, a Surface Water Management Plan (CMA, 2018e) has been prepared for the approved Project, and includes a range of erosion and sediment control management measures.

3.10.2 Potential Impacts

Given the Modification would not significantly change the general arrangement and/or water management at the Ivanhoe Rail Facility, no material change to potential surface water impacts are expected as a result of the Modification.

The Ivanhoe Rail Facility is located within the Unregulated Effluent Creeks Water Source as defined in the *Water Sharing Plan for the Lachlan Unregulated and Alluvial Water Sources 2012* under the *Water Management Act 2000*.

Evans & Peck (2012) concluded that no access water licences would be required for the capture and use of water from the retention basin at the Ivanhoe Rail Facility. This conclusion was made on the basis that runoff water contained would be within harvestable rights (i.e. all rain water runoff on landholdings) under the *Water Management Act 2000* and/or would be relevant excluded works under schedule 1 of the *Water Management (General) Regulation 2011*.

The capture and use of water from the retention basin at the Ivanhoe Rail Facility would not significantly change as a result of the Modification and therefore the Evans & Peck (2012) conclusion would still be relevant to the modified Ivanhoe Rail Facility in consideration of schedule 1 of the *Water Management (General) Regulation 2018*.

3.10.3 Management and Monitoring

Given the Modification would not result in any material surface water impacts, no additional management measures are proposed as part of the Modification.

Notwithstanding, the Surface Water Management Plan (CMA, 2018e) would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.11 GREENHOUSE GASES

3.11.1 Background

Previous Assessments

The AQGHG Assessment for the approved Project (Katestone, 2013) assessed the potential impacts of the approved Project on the state and national greenhouse gas inventories, through consideration of the predicted Scope 1, 2 and 3 emissions of the approved Project.

Project direct and indirect greenhouse gas emissions were estimated using published emission factors from the *National Greenhouse Accounts Factors* workbooks (NGA Factors) (Commonwealth Department of Climate Change and Energy Efficiency [DCCEE], 2010; 2011; 2012) (Katestone, 2013).

Katestone (2013) found that the primary Scope 1, 2 and 3 greenhouse gas emissions due to the approved Project will be associated with:

- consumption of diesel fuel in heavy vehicles and on-site diesel generators (Scope 1);
- consumption of electricity at the Ivanhoe Rail Facility (Scope 2); and
- extraction, production and transport of diesel fuel consumed at the Atlas-Campaspe Mine and Ivanhoe Rail Facility, MSP operation, and the consumption of diesel fuel for mineral concentrate transport between the Ivanhoe Rail Facility, the MSP, and Port Pirie (Scope 3).

Katestone (2013) determined that the total Scope 1 emissions from the approved Project would be approximately 0.58 Mt CO_2-e.

Emissions from diesel consumption would be the most significant Scope 1 greenhouse gas source for the Project (Katestone, 2013).

The predicted total indirect greenhouse gas emissions (i.e. Scopes 2 and 3) over the life of the approved Project would be approximately 0.42 Mt CO_2-e (Katestone, 2013).

Management and Monitoring Regime

The Air Quality Management Plan (CMA, 2018b) prepared for the Project contains a number of measures to minimise greenhouse gas emissions, including:

- maximising energy efficiency as a key consideration in the development of the mine plan (e.g. significant savings of greenhouse gas emissions are achieved by mine planning decisions which minimise haul distances for topsoil and overburden, and therefore fuel use);
- regular maintenance of plant and equipment to minimise fuel consumption;
- consideration of energy efficiency in the plan and equipment selection phase; and
- implementation of ‘greenhouse awareness’ training as part of induction programs.

The effectiveness of these measures to reduce the Project’s greenhouse gas emissions (and energy consumption) will be monitored, as Tronox will annually estimate greenhouse gas emissions and energy consumption in accordance with National Greenhouse and Energy Reporting (NGER) scheme requirements (CMA, 2018b).

3.11.2 Potential Impacts

Scope 1 Emissions

Scope 1 greenhouse gas emissions generated by the following Atlas-Campaspe Mine activities would increase proportionally (in some years) with the proposed increase in maximum mineral concentrate production rate:

- increased electricity consumption at the HMC treatment facility (resulting in increased diesel consumption for the on-site diesel generator sets); and
- increased heavy vehicle transport at the Atlas-Campaspe Mine and Ivanhoe Rail Facility.

In other years, Scope 1 emissions at the Atlas-Campaspe Mine would however decrease proportionally with the mineral concentrate production rate.

The Modification would not result in an increase in the following greenhouse gas intensive components of the Atlas-Campaspe Mine:

- mining method; or
- mining rate.

Given the above, it is expected that although annual Scope 1 emissions may increase during certain years, the total Scope 1 emissions due to the modified Project (over the whole mine life) would not change significantly as a result of the Modification as the total amount of mineral concentrates produced during the life of the mine would not significantly change.

In addition, the Modification includes the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine (Section 2.1.5). If developed, it would reduce the diesel consumption of the on-site diesel generator sets, and would therefore reduce potential Scope 1 emissions at the Atlas-Campaspe Mine.

Scope 2 Emissions

Scope 2 emissions associated with the generation of purchased electricity used at the Ivanhoe Rail Facility would not significantly increase as a result of the Modification as electricity consumption at the Ivanhoe Rail Facility would not change significantly.

Scope 3 Emissions

Scope 3 greenhouse gas emissions generated by the following MSP activities would increase proportionally (in some years) with the proposed increase in maximum mineral concentrate production rate:

- consumption of diesel, electricity and Liquefied Petroleum Gas at the MSP; and
- consumption of diesel during transport between the Ivanhoe Rail Facility and MSP, and between the MSP and Port Pirie.

In other years, Scope 3 emissions at the Atlas-Campaspe Mine would however decrease proportionally with the mineral concentrate production rate.

Given the above, it is expected that although annual Scope 3 emissions may increase during certain years, the total Scope 3 emissions due to the modified Project (over the whole mine life) would not change significantly as a result of the Modification as the total amount of mineral concentrates produced during the life of the mine would not significantly change.

3.11.3 Management Measures

The Air Quality Management Plan (CMA, 2018b), which includes a number of measures to minimise greenhouse gas emissions (Section 3.11.1), would continue to be implemented for the Modification, and if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

3.12 ECONOMIC

Previous Assessment

Gillespie Economics (2012) prepared a Socio-Economic Assessment for the approved Project.

The operation of the approved Project was estimated to make up to the following contribution to the regional economy (Gillespie Economics, 2012):

- $279 million (M) in annual direct and indirect regional output or business turnover;
- $152M in annual direct and indirect regional value added;
- $20M in annual direct and indirect household income; and
- 229 direct and indirect jobs.

For the NSW economy, the operation of the approved Project was estimated to make up to the following contributions (Gillespie Economics, 2012):

- $388M in annual direct and indirect regional output or business turnover;
- $202M in annual direct and indirect regional value added;
- $54M in annual direct and indirect household income; and
- 643 direct and indirect jobs.

Total NSW Government royalties over the life of the approved Project were estimated to be $95M (Gillespie Economics, 2012).

3.12.1 Potential Impacts

The Modification would include an increase in the peak mineral concentrate production rate from 546,000 tpa to 665,000 tpa (Section 2.1.2). The estimated NSW Government royalties over the life of the Project (i.e. $95M) would not however significantly change as a result of the Modification as the total amount of mineral concentrates produced during the life of the mine would not significantly change.

The Modification would not change the approved Project workforce (Table 1), and therefore the economic benefits associated with these employment opportunities would be unchanged.

Given the above, the modified Project is expected to result in similar economic benefits to those expected for the approved Project.

3.12.2 Management Measures

Given the Modification would not result in any significant economic impacts, no additional management measures are proposed as part of the Modification.

3.13 HAZARD AND RISK

3.13.1 Background

Previous Assessment

A Preliminary Hazard Analysis was undertaken for the approved Project (CMA, 2012c), in accordance with the general principles of risk evaluation and assessment outlined in the Department of Planning and Infrastructure (DP&I) *Multi-Level Risk Assessment* (DP&I, 2011).

The Preliminary Hazard Analysis for the approved Project also addressed the requirements of *State Environmental Planning Policy No. 33 (Hazardous and Offensive Development)* (SEPP 33) and has been assessed in general accordance with *Hazardous Industry Planning Advisory Paper No. 6: Hazard Analysis* (NSW Department of Planning [DoP], 2011).

The major potentially hazardous materials associated with the Project include MSP process waste, hydrocarbons and chemicals (CMA, 2012c).

The following generic classes of incident associated with on-site storage were identified (CMA, 2012c):

- leaks/spills;
- fire;
- explosion;
- theft;
- accident; and
- unplanned movement off-site.

Following identification of the potential hazards associated with the approved Project, a qualitative assessment of the risks to the public, property and the environment associated with the Project was undertaken (CMA, 2012c).

An assessment of the combination of the consequence and probability rankings concluded that the residual risk levels are tolerable with respect to surrounding land uses, did not preclude approval of the Project, and societal risk is negligible (CMA, 2012c).

3.13.2 Potential Impacts

It is considered that the Modification would not significantly change the existing potential risks or hazard consequences identified in the Preliminary Hazard Analysis for the approved Project, as the proposed activities associated with the Modification are consistent with those for the approved Project.

3.13.3 Management Measures

The environmental management plans relevant to risks and hazards, and their relevant mitigation measures, would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions).

4 STATUTORY CONTEXT

This section outlines the statutory requirements relevant to the assessment of the Modification.

4.1 ENVIRONMENTAL PLANNING AND ASSESSMENT ACT, 1979

4.1.1 Applicability of S4.55(2) of the Environmental Planning and Assessment Act, 1979

The Project was approved under Part 4 of the EP&A Act in 2014 (Development Consent [SSD_5012]). Attachment 1 contains a copy of the current Development Consent (SSD_5012) for the Project.

Tronox is seeking to modify Development Consent (SSD_5012) under section 4.55(2) of the EP&A Act. To date, no modifications have been made to the original Development Consent (SSD_5012) for the Project.

Section 4.55(2) of the EP&A Act relevantly provides:

> **Modifications of consents-generally**
>
> *(2) Other modifications*
>
> *A consent authority may, on application being made by the applicant or any other person entitled to act on a consent granted by the consent authority and subject to and in accordance with the regulations, modify the consent if:*
>
> *(a) it is satisfied that the development to which the consent as modified relates is substantially the same development as the development for which consent was originally granted and before that consent as originally granted was modified (if at all), and*
>
> *(b) it has consulted with the relevant Minister, public authority or approval body (within the meaning of Division 4.8) in respect of a condition imposed as a requirement of a concurrence to the consent or in accordance with the general terms of an approval proposed to be granted by the approval body and that Minister, authority or body has not, within 21 days after being consulted, objected to the modification of that consent, and*
>
> *(c) it has notified the application in accordance with:*
>
> *(i) the regulations, if the regulations so require, or*
>
> *(ii) a development control plan, if the consent authority is a council that has made a development control plan that requires the notification or advertising of applications for modification of a development consent, and*
>
> *(d) it has considered any submissions made concerning the proposed modification within the period prescribed by the regulations or provided by the development control plan, as the case may be.*
>
> *Subsections (1) and (1A) do not apply to such a modification.*

Consideration of the key comparatives detailed in the draft guideline *Modifying an Approved Project* (NSW Government, 2017) when considering whether the Modification could be considered to be "substantially the same" is provided in Table 7.

The Project has demonstrably remained a large mineral sands mining project that incorporates the following key elements approved under Development Consent (SSD_5012) (Table 1):

- mining of two mineral sands deposits;
- overburden emplacements and sand residue emplacement;
- mineral handling and processing facilities;
- mineral concentrate transport activities;
- rail loadout facility;
- water supply and water management systems; and
- supporting infrastructure and facilities.

This would also clearly continue to be the case if the Modification was approved (Table 1), and therefore the consent authority can be satisfied that the Project incorporating the Modification would remain 'substantially the same'.

Table 7
Summary Evaluation for 'Substantially the Same' Test

Key Comparatives	Approved Project	Modified Project
Development size, scale and footprint	Large mineral sands mine incorporating a separate rail loadout facility.	No material change.
Intensity including rates of production	7.2 Mtpa (ore). 546,000 tpa (mineral concentrate).	No change. Increase to 665,000 tpa.
Primary, secondary and ancillary use	Secondary use of the area behind the advancing ore extraction area for sand residue and process waste emplacement. Rehabilitation for light intensity grazing or for nature conservation purposes.	No change.
Project life and hours of operation	Development Consent to 2034. Operating hours are 24 hours per day, seven days per week.	No change.
Extent, duration and severity of impacts	Project life to 2034. Mining within ML 1767 and MLA 1.	No substantial change.

4.1.2 Objectives of the EP&A Act

Section 1.3 of the EP&A Act describes the objects of the EP&A Act as follows:

(a) to promote the social and economic welfare of the community and a better environment by the proper management, development and conservation of the State's natural and other resources,

(b) to facilitate ecologically sustainable development by integrating relevant economic, environmental and social considerations in decision-making about environmental planning and assessment,

(c) to promote the orderly and economic use and development of land,

(d) to promote the delivery and maintenance of affordable housing,

(e) to protect the environment, including the conservation of threatened and other species of native animals and plants, ecological communities and their habitats,

(f) to promote the sustainable management of built and cultural heritage (including Aboriginal cultural heritage),

(g) to promote good design and amenity of the built environment,

(h) to promote the proper construction and maintenance of buildings, including the protection of the health and safety of their occupants,

(i) to promote the sharing of the responsibility for environmental planning and assessment between the different levels of government in the State,

(j) to provide increased opportunity for community participation in environmental planning and assessment.

The Modification is considered to be generally consistent with the objects of the EP&A Act, because it is a Modification which:

- incorporates:
  - development of the State's mineral resources approved to be extracted from the Atlas-Campaspe Mine in a manner that minimises environmental impacts through the implementation of the Environmental Management Strategy (CMA, 2017b) and other measures (Section 3);
  - measures to minimise potential amenity impacts associated with air quality and noise impacts on surrounding land uses (Sections 3.3 and 3.4, respectively);
  - continued employment and other socio-economic benefits to the community;
- involves the orderly economic use and development of land as the Atlas-Campaspe Mine surface development area remains unchanged and wholly within ML 1767 and MLA 1;
- would be conducted in accordance with relevant lease/licence/reserve conditions over Crown land within ML 1767 and at the Ivanhoe Rail Facility;
- would support the ongoing provision of community services and facilities through contributions to NSW Government royalties, NSW Government taxes, Commonwealth tax revenue and voluntary contributions to community initiatives;

- is an application under section 4.55(2) of the EP&A Act that would be determined by the Minister for Planning and Public Spaces, however consultation with the BSC, CDSC and WSC and a range of stakeholders has been undertaken (Section 1.3); and
- involves public involvement and participation through Tronox's consultation activities (Section 1.3), which would be ongoing following the public exhibition of this Modification Report and DPIE assessment of the Modification in accordance with the requirements of the EP&A Act.

4.2 OTHER NSW LEGISLATION

In addition to the EP&A Act, the following NSW Acts may be applicable to the Project, incorporating the Modification:

- *Biosecurity Act, 2015;*
- BC Act;
- *Contaminated Land Management Act, 1997*;
- *Crown Land Management Act, 2016*;
- *Dams Safety Act, 1978*;
- *Dangerous Goods (Road and Rail Transport) Act, 2008*;
- *Fisheries Management Act, 1994*;
- *Heritage Act, 1977*;
- *Local Land Services Act, 2013*;
- *Mining Act, 1992*;
- *National Parks and Wildlife Act, 1974*;
- *Protection of the Environment Operations Act, 1997* (PoEO Act);
- *Radiation Control Act, 1990*;
- *Roads Act, 1993*;
- *Water Management Act, 2000*; and
- *Work Health and Safety Act, 2011*.

Relevant licences or approvals required under these Acts would continue to be obtained for the Project. Key plans that would require revision to incorporate the Modification are outlined in Section 4.6.

Additional detail on the likely requirements under the some of the key Acts is provided in the sub-sections below.

Mining Act, 1992

The modified Atlas-Campaspe Mine would remain wholly within the boundary of ML 1767. Therefore, there is no need for the amendment or variation of existing authorities or the issue of new authorities under the *Mining Act, 1992*.

Under the *Mining Act, 1992*, environmental protection and rehabilitation are regulated by conditions of mining leases, including requirements for the submission of a Mining Operations Plan prior to the commencement of operations, and subsequent Annual Environmental Management Reports (or Annual Reviews).

The current Mining Operations Plan (CMA, 2018g) would require revision to reflect the modified mining operations as a result of the Modification (Section 4.6.1).

Protection of the Environment Operations Act, 1997

The PoEO Act is the primary NSW legislation that regulates pollution control and licensing. One key feature of the Act is the statutory requirement to apply for and obtain an EPL in circumstances where a scheduled activity or activities are being carried out (those activities being defined in schedule 1 of the PoEO Act).

The approved Project is currently licensed under EPL 21007 to conduct "crushing, grinding or separating", "extractive activities" and "metallurgical activities" as defined in schedule 1 of the PoEO Act. EPL 21007 would be varied as required following approval of the Modification.

Water Management Act, 2000

The *Water Management Act, 2000* contains provisions for the licensing, allocation, capture and use of water resources. Under the *Water Management Act, 2000*, water sharing plans are being introduced (and many have commenced) for water sources. Water sharing plans establish rules for sharing water between different users and between the various environmental sources (namely rivers or aquifers).

The Ivanhoe Rail Facility is located within the Lower Lachlan Alluvium Groundwater Source as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* and the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the NSW *Water Management Act, 2000* (Appendix F).

Tronox has obtained a total of 100 share components (units or ML) in the Lower Lachlan Alluvium Groundwater Source of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Ivanhoe Rail Facility, which is sufficient for the modified Ivanhoe Rail Facility.

The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*, and the relevant rules for granting water supply work approvals in Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*/ (Section 3.9.2).

Biodiversity Conservation Act, 2016

The BC Act came into effect in NSW in August 2017 and replaces the TSC Act.

Section 3.5 considers the potential biodiversity impacts associated with the modified Ivanhoe Rail Facility.

As described in Section 3.5, with reference to Section 7.17(2)(c) of the BC Act and the *Biodiversity Development Assessment Report Waiver Determinations for SSD and SSI Applications* (DP&E, 2018), no BDAR is required for the Modification as the Modification would not increase impacts on biodiversity values (Table 6).

Roads Act, 1993

As described in Section 2.2.3, the Project will include various public road-related construction activities, which would not change for the Modification.

Additional road upgrades for the proposed light vehicle access routes would be required for the Modification (Section 2.1.7).

Tronox will apply for the necessary consents under section 138 of the *Roads Act, 1993* for these works. In accordance with section 89K(1)(f) of the EP&A Act, if the Modification is approved, consent under section 138 of the *Roads Act, 1993* cannot be refused and is to be substantially consistent with the Development Consent (SSD_5012).

Crown Land Management Act, 2016

Under section 5.21(1) of the NSW *Crown Land Management Act, 2016*, a Crown Lands Licence is required to authorise the use or occupation of Crown land.

Tronox has obtained a Crown Lands Licence (LI 567639) for the Ivanhoe Rail Facility. Crown Lands Licence (LI 567639) includes the modified Ivanhoe Rail Facility surface development area.

4.3 ENVIRONMENTAL PLANNING INSTRUMENTS

Local environmental plans and State environmental planning policies that may be relevant to the Modification are discussed below.

4.3.1 Local Environment Plans

Balranald Local Environmental Plan 2010

The Atlas-Campaspe Mine is located wholly within the BSC LGA (Figure 1). The following subsection identifies the provisions in the *Balranald Local Environmental Plan 2010* (Balranald LEP) that are relevant to the Modification.

Permissibility

The Atlas-Campaspe Mine and related road upgrades are located within Zone RU1 (Primary Production) within the BSC LGA.

Open cut mining is permissible with consent within Zone RU1 (Primary Production) under the Balranald LEP. Roads are permissible without consent in the RU1 zoning.

Zone Objectives

Clause 2.3(2) of the Balranald LEP provides:

> *The consent authority must have regard to the objectives for development in a zone when determining a development application in respect of land within the zone.*

The objectives of Zone RU1 (Primary Production) include:

- *To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *To encourage diversity in primary industry enterprises and systems appropriate for the area.*
- *To minimise the fragmentation and alienation of resource lands.*
- *To minimise conflict between land uses within this zone and land uses within adjoining zones.*
- *To encourage development that is in accordance with sound management and land capability practices, and that takes into account the environmental sensitivity and biodiversity of the locality.*

- *To support rural communities.*
- *To ensure the provision of accommodation for itinerant workers.*

The modified Project is considered to be consistent with the Zone RU1 (Primary Production) objectives of the Balranald LEP, in that:

- Mining constitutes a primary industry.
- The Modification would not result in the fragmentation and alienation of resource lands.
- The land surrounding the Atlas-Campaspe Mine is also zoned RU1 (Primary Production).
- Environmental assessments have been conducted for the Modification, and the management and mitigation measures to be employed to minimise the potential impacts of the Modification are discussed in Section 3.
- The Project is an employment generating development that is expected to provide economic stimulus in the regional and NSW economies (Section 3.12).

Central Darling Local Environment Plan 2012

The modified Ivanhoe Rail Facility is located within the CDSC LGA. The following subsection identifies the provisions in the *Central Darling Local Environment Plan 2012* (Central Darling LEP) that are relevant to the Modification.

Permissibility

Part 2 of the Central Darling LEP sets out the zone objectives and the land use table that is relevant in determining whether the modified Project, or any other part of the modified Project, is prohibited by the Central Darling LEP.

Under the Central Darling LEP, the modified Ivanhoe Rail Facility is located in the following zones:

- RU1 (Primary Production); and
- SP2 (Infrastructure) (the Orange – Broken Hill railway corridor).

The Ivanhoe Rail Facility is considered to be a "freight transport facility" under the Central Darling LEP:

> ***freight transport facility*** *means a facility used principally for the bulk handling of goods for transport by road, rail, air or sea, including any facility for the loading and unloading of vehicles, aircraft, vessels or containers used to transport those goods and for the parking, holding, servicing or repair of those vehicles, aircraft or vessels or for the engines or carriages involved.*

Under the Central Darling LEP construction and operation of freight transport facilities are permitted with Development Consent on lands zoned as RU1 (Primary Production).

Rail-related facilities (including any development that is ordinarily incidental or ancillary to development for that purpose) are also permitted with Development Consent on land zoned as SP2 (Infrastructure) (the Orange – Broken Hill railway corridor).

Zone Objectives

Clause 2.3(2) of the Central Darling LEP provides that the consent authority must have regard to the objectives for development in a zone when determining a Development Application in respect of land within the zone.

The objectives for Zone RU1 (Primary Production) under the Central Darling LEP are as follows:

- *To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *To encourage diversity in primary industry enterprises and systems appropriate for the area.*
- *To minimise the fragmentation and alienation of resource lands.*
- *To minimise conflict between land uses within this zone and land uses within adjoining zones.*

The modified Ivanhoe Rail Facility is considered to be consistent with the objectives for Zone RU1 (Primary Production), in that:

- It facilitates development of a primary industry (mining) and provides diversification of land use (i.e. alternative use to agriculture).
- It would not result in the fragmentation or alienation of resource lands.
- It would be developed in a manner to minimise potential incompatibilities with surrounding land uses.

The zone objectives for Zone SP2 (Infrastructure) under the Central Darling LEP area as follows:

- *To provide for infrastructure and related uses.*
- *To prevent development that is not compatible with or that may detract from the provision of infrastructure.*

The Modification is consistent with the objectives for Zone SP2 (Infrastructure) as the Modification comprises development for the purposes of rail infrastructure and related uses and is compatible with the existing Orange – Broken Hill railway.

4.3.2 State Environmental Planning Policies

State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007

The *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries)* (Mining SEPP) regularises the various environmental planning instruments that previously controlled mining activities and aims to provide for the proper management of and development of mineral resources.

Clause 5(3) of the Mining SEPP gives it primacy where there is an inconsistency between the provisions of the Mining SEPP and the provisions of any other environmental planning instrument (except the *State Environmental Planning Policy [State Significant Precincts] 2005* and *State Environmental Planning Policy [Coastal Management]* 2018).

Clause 7

Clause 7(1) of the Mining SEPP states that development for any of the following purposes may be carried out only with development consent:

> *(b) mining carried out:*
>
> *(i) on land where development for the purposes of agriculture or industry may be carried out (with or without development consent), or*
>
> *(ii) on land that is, immediately before the commencement of this clause, the subject of a mining lease under the Mining Act 1992 or a mining licence under the Offshore Minerals Act 1999,*
>
> …

The modified Project is on land where agriculture is permissible. Therefore, the Modification activities are permissible with development consent.

Part 3 of the Mining SEPP outlines the matters to be considered when determining development applications. Relevant clauses are discussed further below.

Clause 12

Clause 12 of the Mining SEPP requires that, before determining an application for consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must:

> *(a) consider:*
>
> *(i) the existing uses and approved uses of land in the vicinity of the development, and*
>
> *(ii) whether or not the development is likely to have a significant impact on the uses that, in the opinion of the consent authority having regard to land use trends, are likely to be the preferred uses of land in the vicinity of the development, and*
>
> *(iii) any ways in which the development may be incompatible with any of those existing, approved or likely preferred uses, and*
>
> *(b) evaluate and compare the respective public benefits of the development and the land uses referred to in paragraph (a) (i) and (ii), and*
>
> *(c) evaluate any measures proposed by the applicant to avoid or minimise any incompatibility, as referred to in paragraph (a) (iii).*

Existing/approved land use in the vicinity of the Project is characterised by various agricultural land uses.

The Modification would not change the existing/approved land uses or surface development area associated with the Atlas-Campaspe Mine. The modified Ivanhoe Rail Facility is considered to be compatible with existing and future land uses in the vicinity of the Ivanhoe Rail Facility.

The potential impacts of the Modification on land resources are described in Section 3.8.

The Modification would allow for the economic extraction of mineral concentrate from the approved Atlas-Campaspe Mine.

Tronox would implement a range of measures to avoid or minimise incompatibility of the modified Project with existing and future land uses in the area. This would be achieved through the implementation of the existing Environmental Management Strategy for the Project (CMA, 2017b), with updates to the relevant environmental management plans listed in Section 4.6.

Clause 14

Clause 14(1) of the Mining SEPP requires that, before granting consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider whether or not the approval should be issued subject to conditions aimed at ensuring that the development is undertaken in an environmentally responsible manner, including conditions to ensure the following:

(a) that impacts on significant water resources, including surface and groundwater resources, are avoided, or are minimised to the greatest extent practicable,

(b) that impacts on threatened species and biodiversity, are avoided, or are minimised to the greatest extent practicable,

(c) that greenhouse gas emissions are minimised to the greatest extent practicable.

In addition, clause 14(2) requires that, without limiting clause 14(1), in determining a development application for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider an assessment of the greenhouse gas emissions (including downstream emissions) of the development, and must do so having regard to any applicable state or national policies, programs or guidelines concerning greenhouse gas emissions.

The potential impacts of the Modification on groundwater and surface water resources are discussed in Sections 3.9 and 3.10 respectively, including measures to minimise potential impacts.

The potential biodiversity impacts as a result of the Modification are described in Section 3.5.

An assessment of the potential greenhouse gas emissions due to the Modification is provided in Section 3.11.

Clause 15

Clause 15 of the Mining SEPP requires that:

(1) Before granting consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider the efficiency or otherwise of the development in terms of resource recovery.

(2) Before granting consent for the development, the consent authority must consider whether or not the consent should be issued subject to conditions aimed at optimising the efficiency of resource recovery and the reuse or recycling of material.

(3) The consent authority may refuse to grant consent to development if it is not satisfied that the development will be carried out in such a way as to optimise the efficiency of recovery of minerals, petroleum or extractive materials and to minimise the creation of waste in association with the extraction, recovery or processing of minerals, petroleum or extractive materials.

The Modification would promote the more efficient and economic recovery of mineral sands resources at the Atlas-Campaspe Mine (i.e. through increasing the mineral concentrate production rate without having to increase the mineral sands ore extraction rate). As such, the Modification aims to achieve efficient resource recovery.

Clause 16

Clause 16(1) of the Mining SEPP requires that, before granting consent for development for the purposes of mining or extractive industry that involves the transport of materials, the consent authority must consider whether or not the consent should be issued subject to conditions that do any one or more of the following:

(a) require that some or all of the transport of materials in connection with the development is not to be by public road,

(b) limit or preclude truck movements, in connection with the development, that occur on roads in residential areas or on roads near to schools,

(c) require the preparation and implementation, in relation to the development, of a code of conduct relating to the transport of materials on public roads.

Mineral concentrates generated at the Atlas-Campaspe Mine will be transported by road to the Ivanhoe Rail Facility for transport to the MSP via the Orange-Broken Hill Railway for further processing and transport by rail to port.

The Modification would include an increase in the maximum mineral concentrate production rate from approximately 546,000 tpa to approximately 665,000 tpa (with an associated increase in the mineral concentrate transport rate from 450,000 tpa to 665,000 tpa) (Section 2.1.2).

The primary public road network transport routes to and from the Atlas-Campaspe Mine are generally adjacent to rural areas.

The potential impacts of the Modification on the road transport networks are discussed in Section 3.2, including measures to minimise potential impacts.

In summary, the road upgrade works required by Development Consent (SSD_5012) to be conducted along the approved road haulage route for the Modification would be suitable for traffic generated by the modified Project. Additionally, the increased heavy vehicle trips on the approved road haulage route would be well within the day-to-day variation in traffic volumes and would not have a perceivable impact on the level of service experienced by drivers along the route (Appendix A).

Road transport at the Atlas-Campaspe Mine is currently managed in accordance with the Transport Management Plan (CMA, 2018a).

Given the above, it is considered that the Modification would not result in any significant changes to the potential road transport impacts.

Clause 17

Clause 17 of the Mining SEPP requires that before granting consent for development for the purposes of mining, petroleum production or extractive industry, the consent authority must consider whether or not the approval should be issued subject to conditions aimed at ensuring the rehabilitation of land that will be affected by the development. In particular, the consent authority must consider whether conditions of the consent should:

(a) require the preparation of a plan that identifies the proposed end use and landform of the land once rehabilitated, or

(b) require waste generated by the development or the rehabilitation to be dealt with appropriately, or

(c) require any soil contaminated as a result of the development to be remediated in accordance with relevant guidelines (including guidelines under clause 3 of Schedule 6 to the Act and the Contaminated Land Management Act 1997), or

(d) require steps to be taken to ensure that the state of the land, while being rehabilitated and at the completion of the rehabilitation, does not jeopardize public safety.

The rehabilitation of the Atlas-Campaspe Mine would generally be conducted in accordance with the existing/approved rehabilitation strategy for the Project.

No changes to the existing/approved rehabilitation strategy are proposed as part of the Modification (Section 2.1.9).

State Environmental Planning Policy No. 33 (Hazardous and Offensive Development)

Clause 13 of the *State Environmental Planning Policy No. 33 (Hazardous and Offensive Development)* (SEPP 33) requires the consent authority, in considering a Development Application for a potentially hazardous or a potentially offensive industry, to take into account:

(c) in the case of development for the purpose of a potentially hazardous industry—a preliminary hazard analysis prepared by or on behalf of the applicant, and

(d) any feasible alternatives to the carrying out of the development and the reasons for choosing the development the subject of the application (including any feasible alternatives for the location of the development and the reasons for choosing the location the subject of the application), ...

The environmental management plans relevant to risks and hazards, and their relevant mitigation measures, would be reviewed and, if necessary, revised by Tronox to include the Modification (subject to any modified Development Consent conditions) (Section 3.13).

State Environmental Planning Policy No. 55 (Remediation of Land)

State Environmental Planning Policy No. 55 (*Remediation of Land*) (SEPP 55) aims to provide a State-wide planning approach to the remediation of contaminated land. Under SEPP 55, planning authorities are required to consider the potential for contamination to adversely affect the suitability of the site for its proposed use.

A consent authority must consider the following under Clause 7(1):

(a) it has considered whether the land is contaminated, and

(b) if the land is contaminated, it is satisfied that the land is suitable in its contaminated state (or will be suitable, after remediation) for the purpose for which the development is proposed to be carried out, and

(c) if the land requires remediation to be made suitable for the purpose for which the development is proposed to be carried out, it is satisfied that the land will be remediated before the land is used for that purpose.

Further, under Clause 7(2), before determining an application for consent to carry out development that would involve a change of use of land, the consent authority must consider a report specifying the findings of a preliminary investigation of the land concerned, carried out in accordance with the contaminated land planning guidelines.

The Modification does not include a 'change of use' because the Modification would involve the continuation of the Project activities on the approved Project site.

The Land Contamination Assessment undertaken for the Project EIS concluded that no further investigation was required and that the Atlas-Campaspe Mine and Ivanhoe Rail Facility areas are suitable for the Project use (CMA, 2012b) (Section 3.8).

No potentially contaminating activities or contaminated areas have been identified in the modified surface development area at the Ivanhoe Rail Facility.

State Environmental Planning Policy No. 44 (Koala Habitat Protection)

The *State Environmental Planning Policy No. 44 (Koala Habitat Protection)* (SEPP 44) applies to certain LGAs (including the Central Darling where the Ivanhoe Rail Facility is located), and requires the consideration of whether land that is the subject of the Development Application is considered to be "potential Koala habitat" or "core Koala habitat".

Clause 3 of SEPP 44 outlines the aim of the SEPP, which is to encourage the proper conservation and management of areas of natural vegetation that provide habitat for Koalas to ensure a permanent free-living population over their present range and reverse the current trend of Koala population decline:

(a) by requiring the preparation of plans of management before development consent can be granted in relation to areas of core koala habitat, and

(b) by encouraging the identification of areas of core koala habitat, and

(c) by encouraging the inclusion of areas of core koala habitat in environment protection zones.

Clause 9 of SEPP 44 requires:

(1) Before a council may grant consent to a development application for consent to carry out development on land to which this Part applies that it is satisfied is a core koala habitat, there must be a plan of management prepared in accordance with Part 3 that applies to the land.

(2) The council's determination of the development application must not be inconsistent with the plan of management.

An assessment of Koala habitat for the purposes of SEPP 44 was undertaken for the approved Project. The assessment concluded that the Ivanhoe Rail Facility area does not comprise potential Koala habitat (AMBS, 2013a).

4.4 NSW GOVERNMENT POLICY

Strategic Regional Land Use Plan

The NSW Mining and Petroleum Gateway Panel was established by the NSW Government in October 2013 as part of the Strategic Regional Land Use Policy.

The Strategic Regional Land Use Policy and the 'Gateway Process' only applies to new State Significant Development applications or modifications for mining projects that are located outside of existing mining lease areas (NSW Government, 2012). As the Modification does not require any change to ML 1621, the 'Gateway Process' does not apply.

Aquifer Interference Policy

The AIP (DPI, 2012) has been developed by the NSW Government as a component of the NSW Government's Strategic Regional Land Use Policy. The Aquifer Interference Policy applies State-wide and details water licence and impact assessment requirements.

The stated purpose of the Aquifer Interference Policy is to ensure equitable water sharing between various water users and proper licensing of water taken by aquifer interference activities such that the take is accounted for in the water budget and water sharing arrangements.

The *Water Management Act, 2000* defines an aquifer interference activity as that which involves any of the following:

- *the penetration of an aquifer;*
- *the interference with water in an aquifer;*
- *the obstruction of the flow of water in an aquifer;*

- *the taking of water from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations; and*
- *the disposal of water taken from an aquifer in the course of carrying out mining or any other activity prescribed by the regulations.*

Notwithstanding the NRAR advice (Section 1.3), the minimal impact considerations in the AIP (DPI, 2012) have been addressed in Sections 3.9 and 4.4, and Appendix F.

A Groundwater Review (Appendix F) has been prepared in consideration of the AIP for the proposed groundwater supply bore at the Ivanhoe Rail Facility and the key conclusions are summarised below.

Water Source

The AIP requires all water taken by aquifer interference activities to be accounted for within the extraction limits set by the relevant Water Sharing Plan. The Water Sharing Plan relevant to the Ivanhoe Rail Facility is the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*. Therefore, licensing under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* is required to account for the Modification.

Modelling of Potential Impacts

The potential hydrogeological impacts of the proposed groundwater supply bore at the Ivanhoe Rail Facility have been modelled (GEO-ENG, 2019).

Licensing Requirements

As described above, the Ivanhoe Rail Facility is located within the Lower Lachlan Groundwater Source as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* and the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the *Water Management Act, 2000*.

As described in Section 3.9.1, Tronox holds an appropriate volumetric licence (100 share components [units of ML]) in accordance with the requirements of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the proposed groundwater supply bore at the Ivanhoe Rail Facility.

Minimal Impact Considerations

The AIP establishes minimal impact considerations for highly productive and less productive groundwater.

NSW Office of Water mapping indicates that there is no highly productive groundwater in the vicinity of the Ivanhoe Rail Facility. The target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore (i.e. the Renmark Group Aquifer) is considered to be a 'less productive' alluvial aquifer, due to its high salinity, in accordance with the AIP (Appendix F).

An assessment of the proposed groundwater supply bore against the minimal impact considerations in the AIP was conducted as part of the Groundwater Review and is presented in Appendix F.

The Groundwater Review concluded that the Modification is within the 'Level 1' minimal impact considerations outlined in the AIP (Appendix F).

Other Groundwater Users

The closest groundwater bore to the proposed Ivanhoe Rail Facility groundwater supply bore is located approximately 2 km to the south-east and the drawdown at this bore due to the proposed Ivanhoe Rail Facility groundwater supply bore is predicted to be negligible (i.e. the maximum predicted drawdown would be low and is not significant beyond 100 m) (Appendix F).

4.5 ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT, 1999

The objective of the EPBC Act is to provide for the protection of those aspects of the environment that are of national environmental significance.

Proposals that are likely to have a significant impact on a matter of environmental significance are defined as a controlled action under the EPBC Act. Proposals that are, or may be, a controlled action are required to be referred to the DoEE to determine whether or not the action is a controlled action.

It is concluded that the Modification is unlikely to have a significant impact on Matters of National Environmental Significance (MNES) for the following reasons:

- The modified Project would not have a significant impact on listed threatened species and ecological communities and/or migratory species as the none of these MNES have been identified in the vicinity of the additional surface development areas at the Ivanhoe Rail Facility, and the additional surface development areas at the Ivanhoe Rail Facility comprise a paddock subject to grazing by goats, introduction of non-native vegetation and past clearing.

- The modified Project would not have a significant impact on wetlands of international importance.
- The modified Project would not have a significant impact on world heritage properties or national heritage places (i.e. Willandra Lakes Regional World Heritage Area) as the proposed changes at the Atlas-Campaspe Mine are minor and the Ivanhoe Rail Facility is located approximately 80 km from the Willandra Lakes Regional World Heritage Area.
- The modified Project would not impact the Great Barrier Reef Marine Park and / or Commonwealth marine areas.
- The modified Project is not a nuclear action.
- The modified Project is not a coal mining or coal seam gas project that could have an impact on a water resource.

It is considered that there is no need to refer the Modification to the Commonwealth Minister for the Environment.

4.6 MANAGEMENT/MONITORING PLANS

Some management plans may require revision to reflect updated environmental management measures or changes to Development Consent (SSD_5012) conditions resulting from the Modification, including the:

- Transport Management Plan (CMA, 2018a);
- Air Quality Management Plan (CMA, 2018b);
- Noise Management Plan (CMA, 2018c);
- Biodiversity Management Plan (CMA, 2018d);
- Groundwater Management Plan (CMA, 2018f); and
- Surface Water Management Plan (CMA, 2018e).

4.6.1 Mining Operations Plan

The current Mining Operations Plan (CMA, 2018g) would require revision to reflect the Modification.

5 CONCLUSION AND MODIFICATION JUSTIFICATION

Tronox has undertaken Project optimisation planning in consideration of recent experience at its existing NSW operations.

A key outcome of the Project optimisation planning is revised mine scheduling for the Atlas deposit, which would increase the maximum mineral concentrate production rate; without increasing the approved ore mining rate. Other changes to optimise Project operations were also identified as part of the Project optimisation planning. The optimisation of the Project will increase its efficiency and economic viability (Section 2).

The Modification would implement the outcomes of the optimisation planning and would include:

- increased mineral concentrate production from 546,000 tpa to 665,000 tpa;
- increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- increased mineral concentrate transport train length (from 600 m to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- the option to use an overland conveyor to transfer overburden in addition to haul trucks;
- the relocation of the Atlas-Campaspe Mine accommodation camp;
- the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- development of an emergency airstrip at the Atlas-Campaspe Mine;
- extension to the Ivanhoe Rail Facility hardstand area;
- extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- a revised alignment of the Ivanhoe Rail Facility access road and access road intersection;
- a groundwater supply bore for the Ivanhoe Rail Facility; and
- the use of local roads other than the road haulage route by Project-related light vehicles to access site.

Key elements of the approved Project would remain unchanged for the Modification, including the:

- Mine path or mine life;
- Mining method;
- Mineral concentration methods;
- Overburden and ore extraction rate;
- Sand residue, coarse reject and process waste placement management;
- Annual maximum water supply/demand;
- Rehabilitation works;
- Biodiversity offset area; or
- Workforce.

5.1 JUSTIFICATION FOR MODIFICATION APPROVAL

Approval of the Modification is considered to be justified given:

- The Modification would promote the more efficient and economic recovery of mineral sands resources at the Atlas-Campaspe Mine (i.e. through increasing the mineral concentrate production rate without having to increase the mineral sands ore extraction rate).
- The proposed use of local roads would improve the safety of the Project workforce and the road network.
- The proposed increases in the rate of mineral concentrate production and transport could be achieved with no exceedances of the relevant noise and air quality criteria.
- The proposed telecommunications tower would provide mobile coverage/reception to the Atlas-Campaspe Mine area that would also be able to be used by community members.
- The proposed emergency air strip would improve safety of the Project workforce.
- The proposed changes to the Ivanhoe Rail Facility layout would reduce potential biodiversity and land resource impacts.
- The Modification would improve the productivity of the Project, improving the security of the continued employment of the workforce and ongoing expenditure in the State and local economies.

It is therefore considered that the Modification is justified on environmental, economic and social grounds.

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APPENDIX A

ROAD TRANSPORT ASSESSMENT

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX A

ROAD TRANSPORT ASSESSMENT

TRONOX

Atlas-Campaspe Mineral Sands Project Optimisation Modification

Road Transport Assessment

Prepared for:

Tronox Mining Australia Limited

12 July 2019

The Transport Planning Partnership

E: info@ttpp.net.au

Atlas-Campaspe Mineral Sands Project Optimisation Modification

Road Transport Assessment

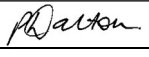
Client: Tronox Mining Australia Limited

Version: Final

Date: 12 July 2019

TTPP Reference: 19069

Quality Record

Version	Date	Prepared by	Approved by	Signature
Final	12/7/19	P. Dalton	P. Dalton	

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1 Introduction

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

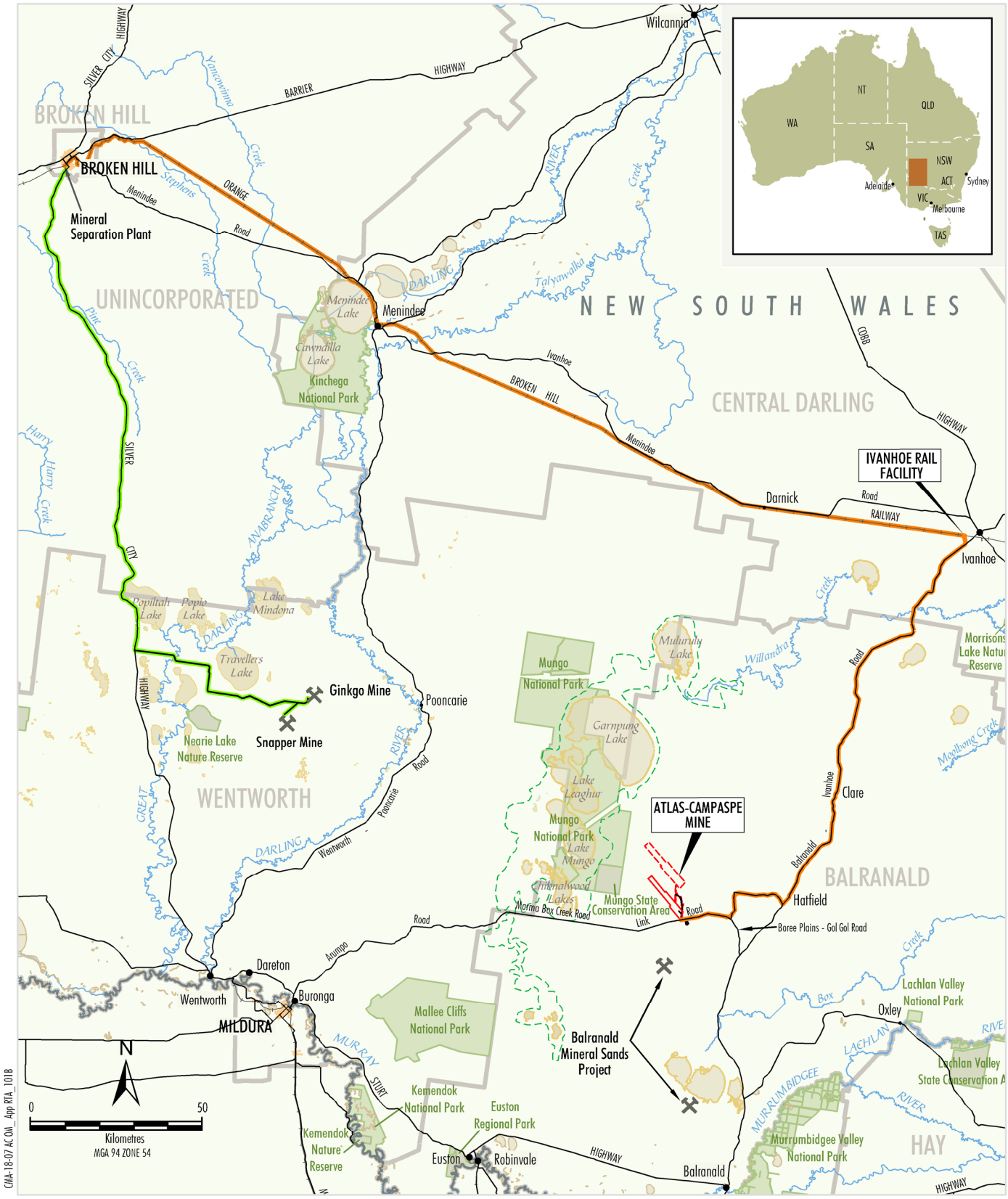
The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, New South Wales (NSW) and 270 km south-east of Broken Hill (Figure 1.1), and the Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine.

Construction of the Project is currently being undertaken in accordance with Development Consent SSD_5012, which was granted pursuant to section 89E of the NSW *Environmental Planning and Assessment Act, 1979* (EP&A Act). Tronox proposes to modify Development Consent (SSD_5012) under Section 4.55(2) of the EP&A Act.

This study examines the road transport implications of the Modification, and is set out as follows:

- Section 2 describes the approved Project;
- Section 3 describes the proposed modification
- Section 4 describes the existing road transport environment;
- Section 5 presents forecasts of the traffic generation of the Modification and its distribution on the road network;
- Section 6 reviews the potential impacts of the Modification on the local road network and identifies the desirable road standards and traffic controls with the Modification;
- Section 7 presents the conclusions of the study.



LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1.1

2 Approved Atlas-Campaspe Mineral Sands Project

2.1 Overview

The Project is approved to extract up to approximately 7.2 million tonnes per annum (Mtpa) of mineral sands ore and to transport up to approximately 450,000 tonnes per annum (tpa) of mineral concentrates over an operational life to 2034.

The Project will integrate with other currently existing/approved Tronox operations, including (Figure 1.1):

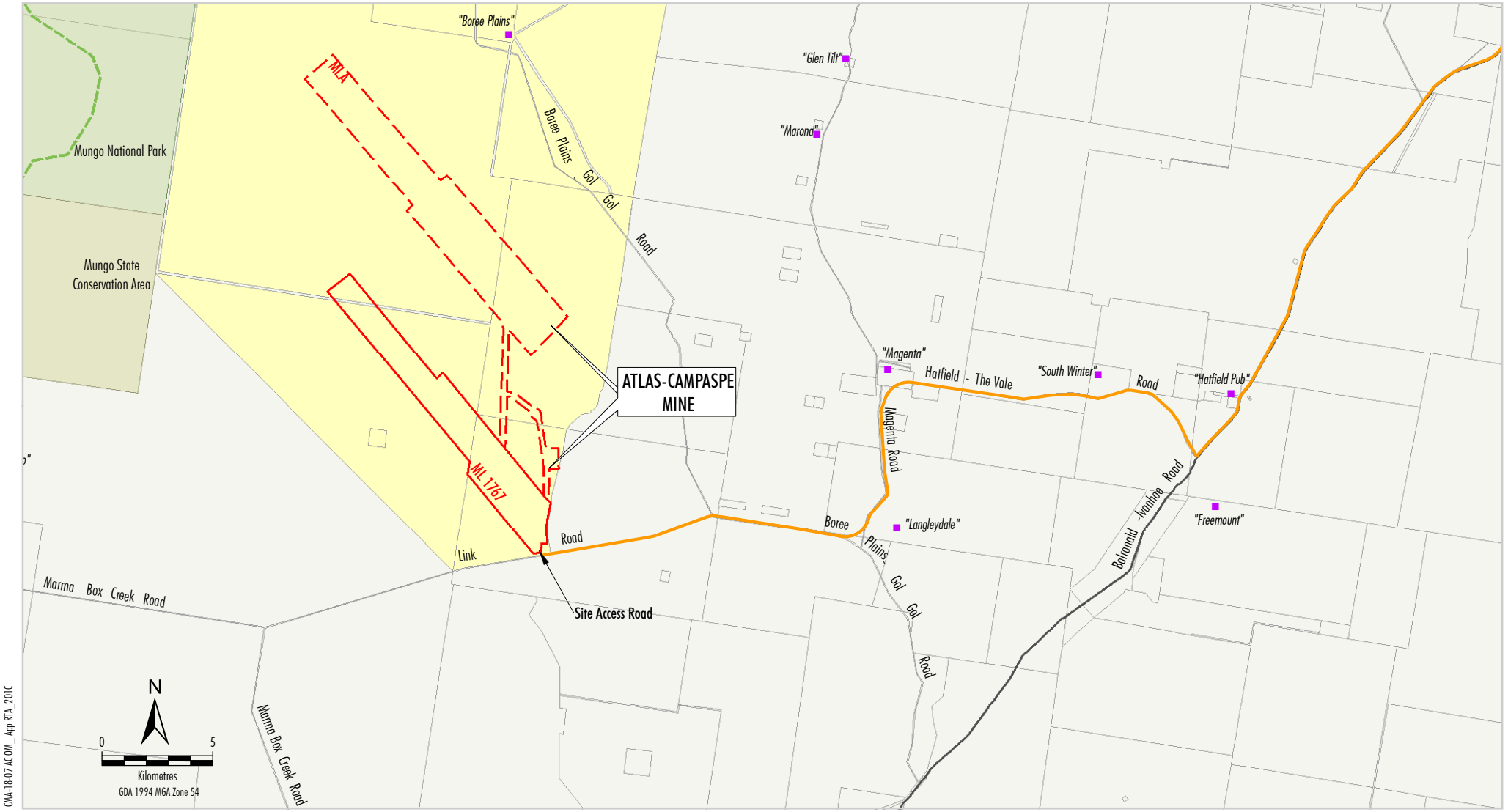
- the Broken Hill Mineral Separation Plan (the MSP) (Development Consent 345-11-02) located approximately 270 km north-west of the Atlas-Campaspe Mine;
- the Snapper Mine (Project Approval 06_0168) located approximately 105 km to the west of the Atlas-Campaspe Mine; and
- the Gingko Mine (Development Consent 251-09-01) located approximately 100 km to the west of the Atlas-Campaspe Mine.

2.2 Mineral Concentrate Transport

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the MSP (Figure 1.1).

The approved road haulage route between the Atlas-Campaspe mine and the Ivanhoe Rail Facility consists of (Figures 1.1, 2.1 and 2.2):

- the Atlas-Campaspe Mine access road;
- Link Road;
- Boree Plains-Gol Gol Road;
- Magenta Road;
- Hatfield-The Vale Road;
- Balranald-Ivanhoe Road; and
- Ivanhoe Rail Facility access road.



OMA-18-07 AC OM_ App RTA_201C

LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route

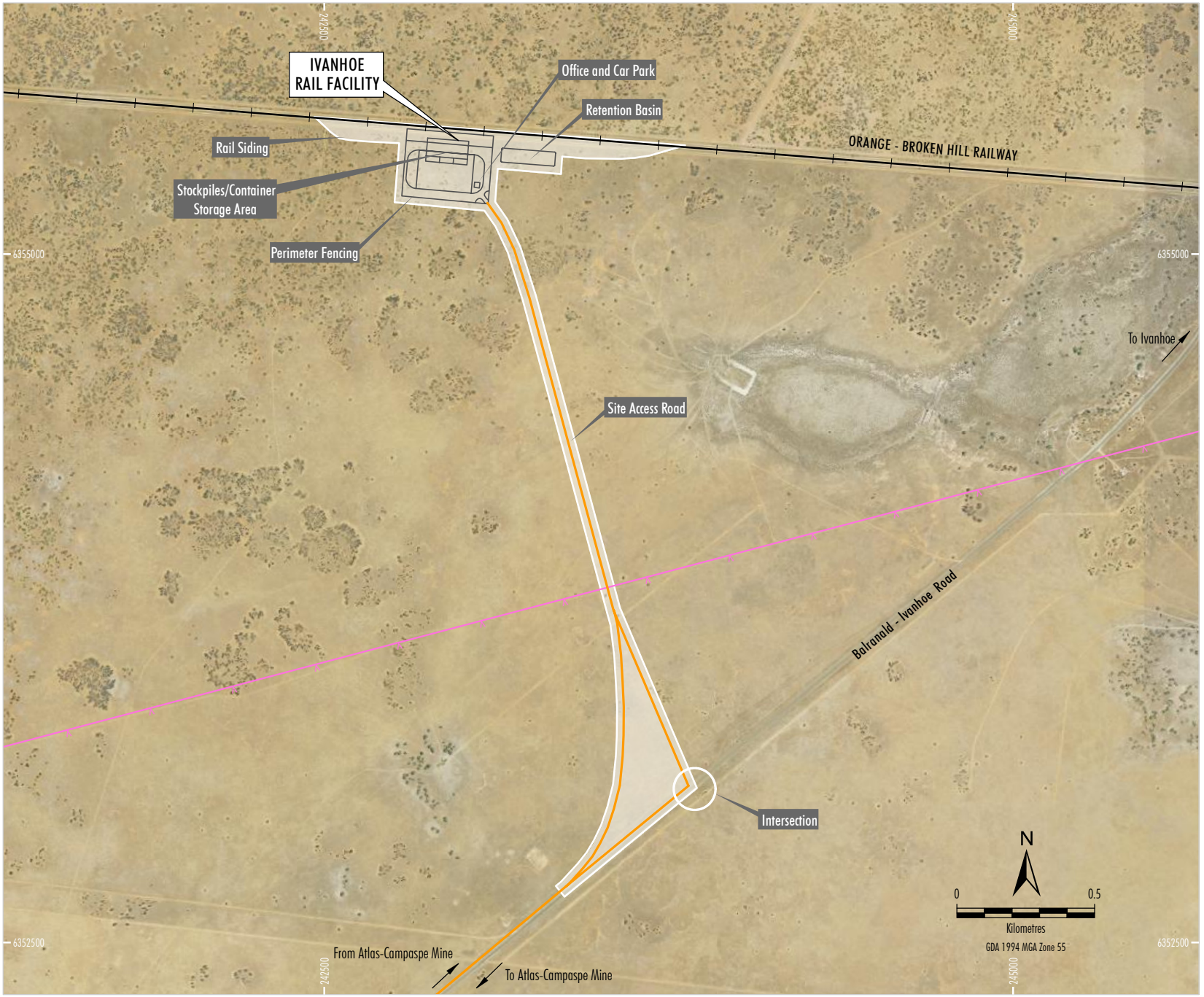
Source: © NSW Department of Finance, Services & Innovation (2018)
Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Atlas-Campaspe Mine
- Local Roads

Figure 2.1



LEGEND

Extent of Approved Surface Development - Ivanhoe Rail Facility

Mineral Concentrate Transport Route*

Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Approved Ivanhoe Rail Facility General Arrangement

Figure 2.2

CMA-18-07 AC OM_ App RTA_205B

Mineral Concentrate Transport Limits

Conditions 7 to 10, Schedule 3 of Development Consent SSD_5012 include the following mineral concentrate transport limits for the Project:

> ***Transportation Limits***
>
> 7. *The Applicant shall not transport more than 450,000 tonnes of mineral concentrate from the site in any calendar year.*
>
> 8. *The Applicant shall ensure that all mineral concentrate is transported in RMS approved vehicles via the haulage route (as shown in Appendix 3).*
>
> 9. *The Applicant shall ensure that no more than 24 haulage vehicle trips (48 vehicle movements) of mineral concentrate are dispatched from the site in any 24 hour period.*
>
> 10. *The Applicant shall restrict train movements to and from the Ivanhoe rail facility to:*
>
> *(a) a maximum of 6 train movements per week; and*
>
> *(b) a maximum of 2 train movements in any 24 hour period.*

Road Haulage Route Road Upgrades

Condition 1, Schedule 3 of Development Consent SSD_5012 requires road haulage route road upgrade works to be implemented prior to the haulage of mineral concentrate, to be to an acceptable standard for Type 1 road trains, and to the satisfaction of the relevant roads authority, being Roads and Maritime Services (RMS), Balranald Shire Council (BSC) or Central Darling Shire Council (CDSC). The required road upgrade works are presented in Table 2.1.

Table 2.1: Project Road Upgrade Works

Measures	Applicable Roads Authority
Upgrade existing Balranald-Ivanhoe Road and Hatfield-The Vale Road intersection	RMS, BSC
Road widening and associated drainage works along: ▪ Hatfield-The Vale Road (14.5 km section); ▪ Magenta Road (3 km section); ▪ Boree Plains-Gol Gol Road (5.5 km section); ▪ Link Road (8 km section)	BSC
Construction of unsealed two lane road between: ▪ Hatfield-The Vale Road and Boree Plains-Gol Gol Road intersections (2 km section); and ▪ Magenta Road and Boree Plains-Gol Gol Road intersections (2 km section).	BSC
Construction of new intersections at: ▪ Hatfield-The Vale Road and Magenta Road; ▪ Magenta Road and Boree Plains-Gol Gol Road; and ▪ Link Road and Atlas-Campaspe site access road.	BSC
Construction of a new intersection at Balranald-Ivanhoe Road and Ivanhoe rail facility access road	RMS, CDSC
Seal and undertake drainage works along Magenta Road (2 km section)	BSC

Road Maintenance Contributions

Tronox will also make financial contributions to the BSC and CDSC to contribute to the maintenance of the road haulage route in accordance Conditions 3 and 4, Schedule 3 of Development Consent SSD_5012.

In addition, Tronox will make financial contributions to the BSC and CDSC to rectify the "high risk" road safety deficiencies along Balranald-Ivanhoe Road in accordance with Condition 5, Schedule 3 of Development Consent SSD_5012.

2.3 Local Road Usage

Condition 6, Schedule 3 of Development Consent SSD_5012 requires that no Project-related traffic, including employees and contractors, is permitted to use local roads to access the site, other than the local roads which form part of the road haulage route (Figure 1.1), except in an emergency to avoid the loss of life, property and/or to prevent environmental harm.

2.4 Transport Management Plan

Tronox has prepared a Transport Management Plan (TMP) (Cristal Mining Australia [CMA], 2018) for the construction phase of the Project in accordance with Condition 9, Schedule 3 of Development Consent SSD_5012. The TMP (for operations) will include:

- a program to monitor and report on the amount of mineral concentrate and MSP process waste transported;
- the measures to be implemented to address the relevant requirements in the Code of Practice for the Safe Transport of Radioactive Materials (ARPANSA, 2001, or its latest version);
- a Road Transport Protocol for all drivers transporting materials to and from the site with measures to ensure:
  - heavy vehicles adhere to the designated road haulage route;
  - all vehicles transporting mineral concentrate are completely covered whilst in transit;
  - the staggering of heavy vehicle departures to minimise impacts on the road network, where practicable;
  - no disruption to school bus timetables;
  - the management of worker fatigue during trips to and from the site;
  - appropriate driver behaviour including adherence to speed limits, safe overtaking and maintaining appropriate distances between vehicles (i.e. a Driver Code of Conduct);
  - adherence to drug and alcohol policies;
  - appropriate vehicle maintenance and safety;
  - contingency plans when the road haulage route is disrupted due to low visibility or closed due to wet weather;
  - emergency response plans;
  - the safe transportation MSP process wastes; and
  - compliance with and enforcement of the protocol.

Tronox received no road transport-related complaints in relation to the Project during the period to 31 December 2018 (CMA, 2019).

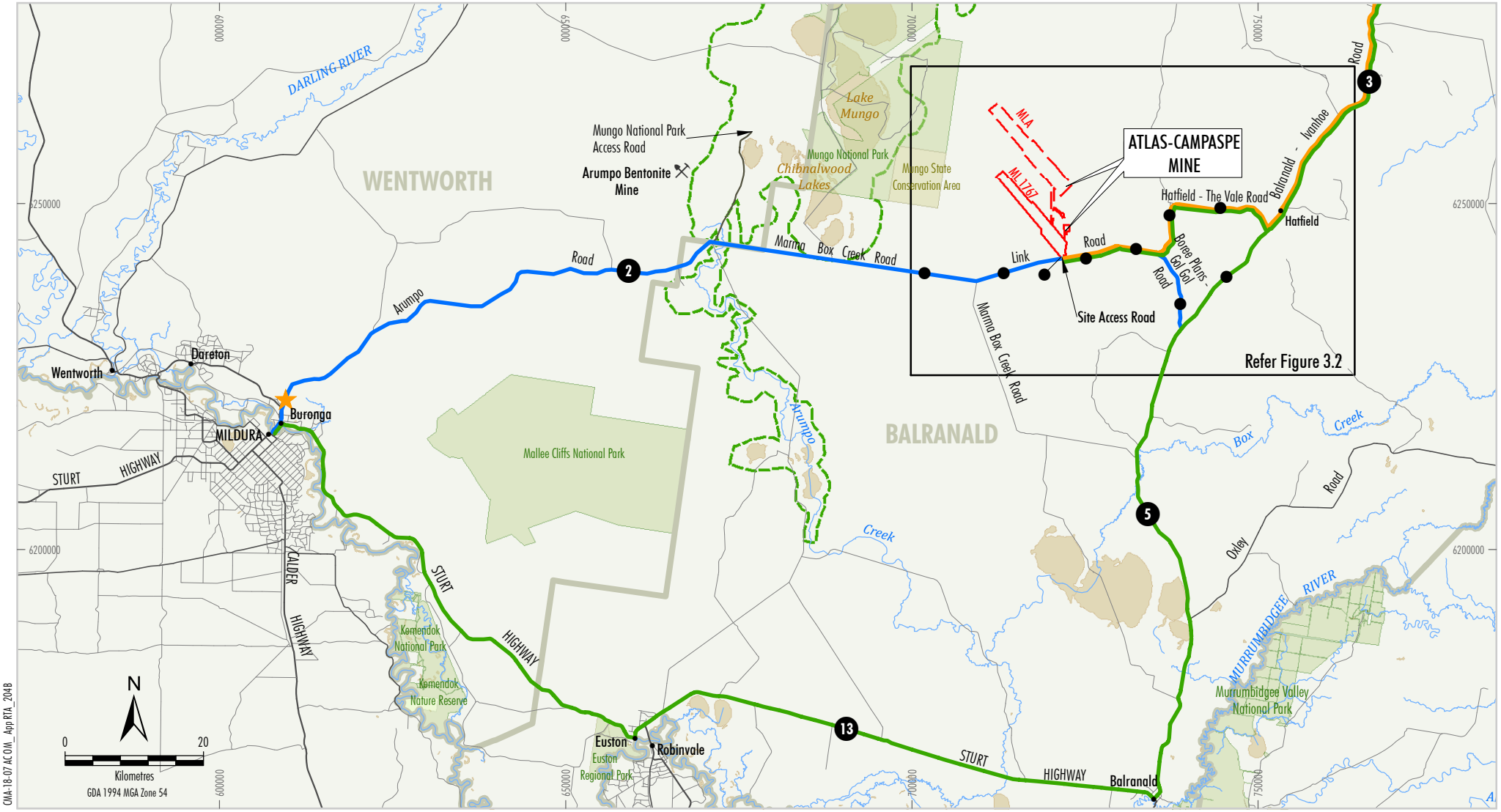
3 Overview of the Modification

The Modification would include:

- the option to use an overland conveyor to transfer overburden in addition to haul trucks;
- increased mineral concentrate production from 546,000 tpa to 665,000 tpa;
- increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- use of local roads other than the road haulage route by Project-related light vehicles to access site (Figure 3.1 and Figure 3.2);
- the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- development of an emergency airstrip at the Atlas-Campaspe Mine;
- construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- increased mineral concentrate transport train length from 600 metres [m] to 920 m, and frequency from six to eight train movements per week, i.e. four arrivals and four departures;
- extension of the Ivanhoe Rail Facility hardstand area;
- extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- revised alignment of the Ivanhoe Rail Facility access road and access road intersection (Figure 3.3);
- a groundwater supply bore for the Ivanhoe Rail Facility; and
- relocation of the Atlas-Campaspe Mine accommodation camp.

The proposed Modification would not change the following components of the Project:

- mine path or mine life;
- mining method;
- mineral concentration methods;
- overburden and ore extraction rate;
- sand reside, coarse reject and process waste placement management practices;
- annual maximum water supply/demand;
- rehabilitation works;
- biodiversity offset area; and
- workforce.



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- National Park
- Nature Reserve
- Regional Park
- State Conservation Area
- Approved Light Vehicle Access Route
- Approved Mineral Concentrate Transport Route
- Proposed Light Vehicle Access Routes
- Traffic Forecast Location
- Traffic Survey Location

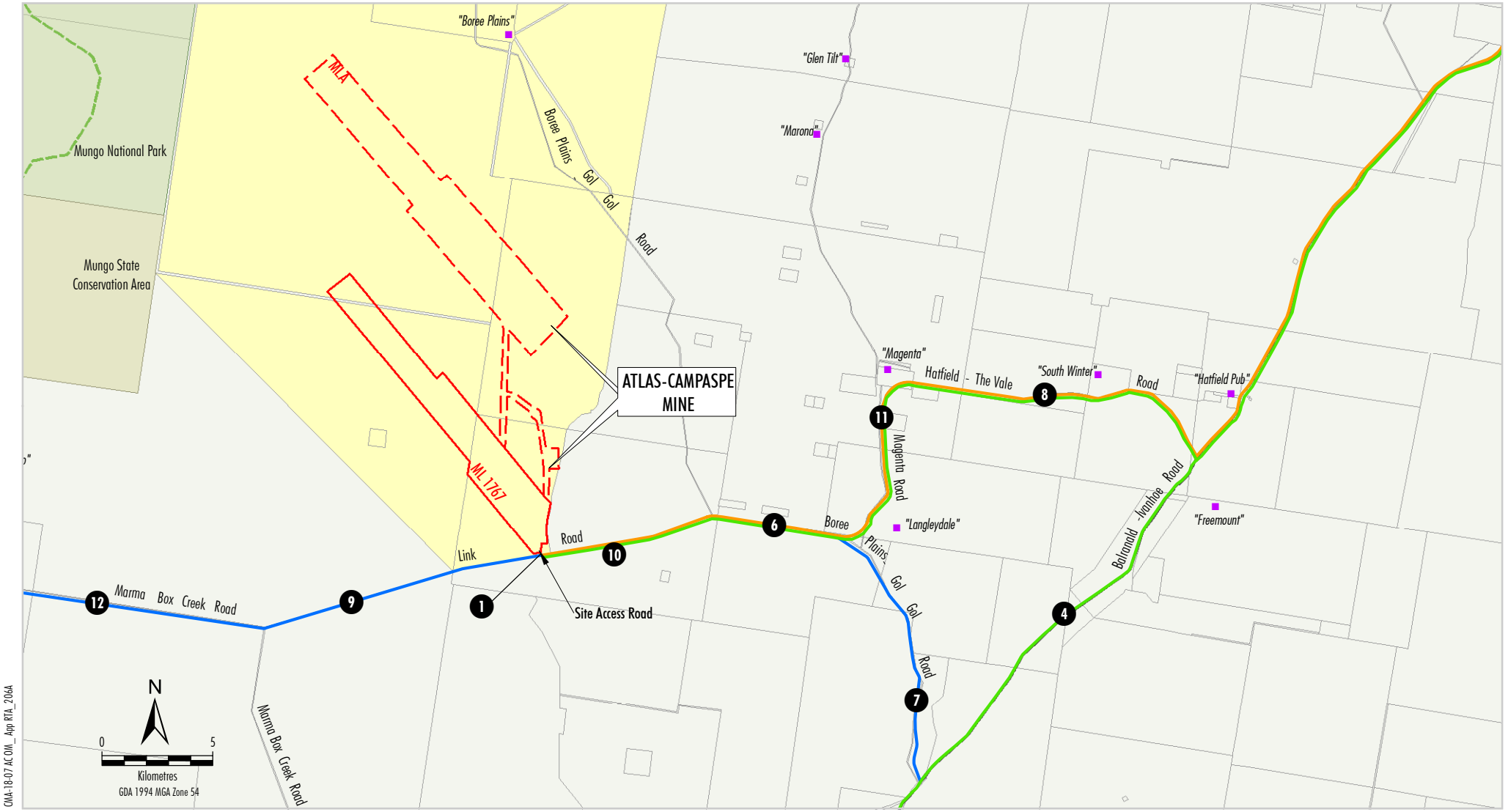
Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012); Tronox (2019) and TTPP (2019)

TRONOX

OPTIMISATION MODIFICATION

Project Road Transpot Routes

Figure 3.1



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Proposed Light Vehicle Access Routes
- Approved Light Vehicle Access Route
- 1 Traffic Forecast Location

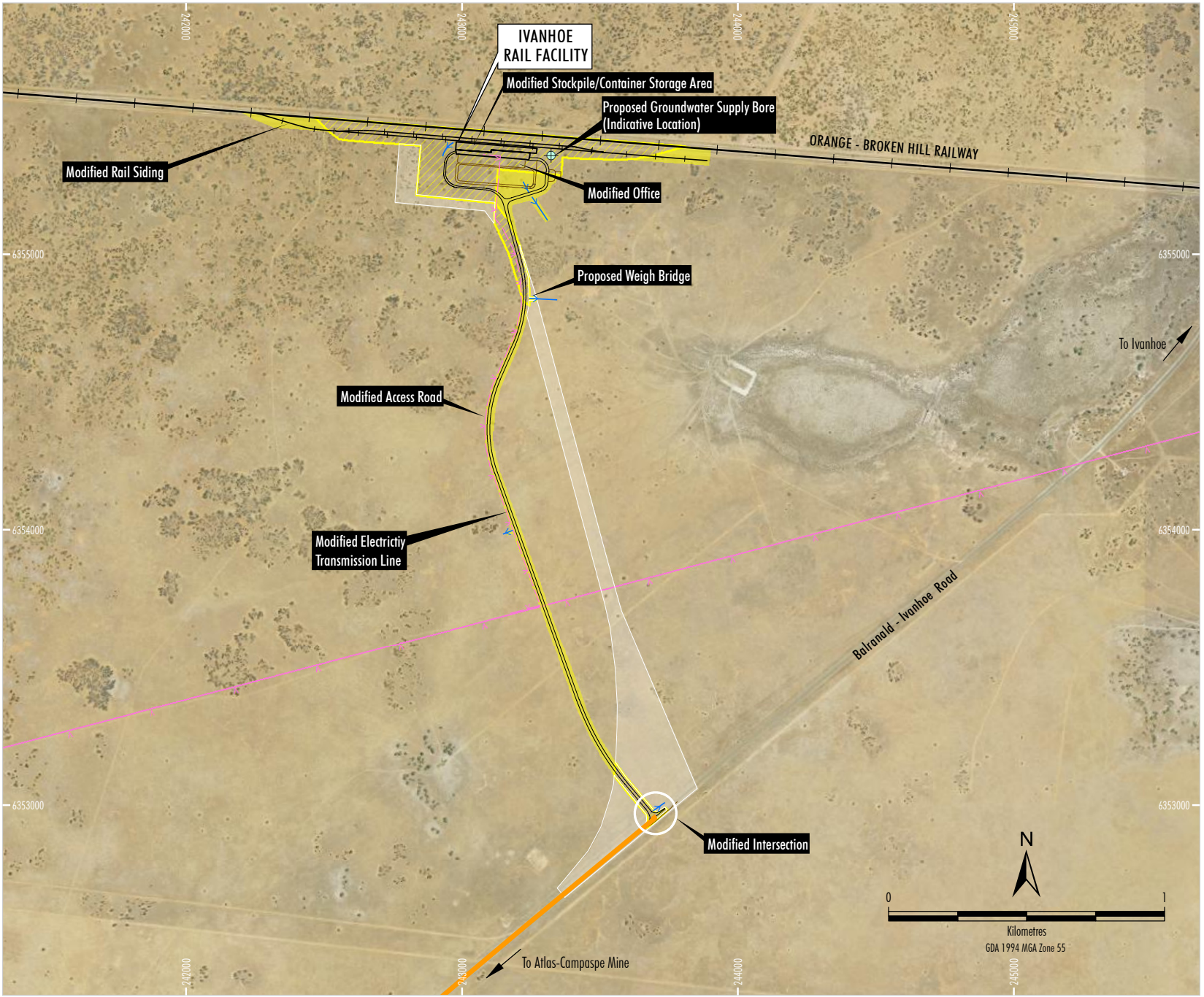
Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012); Tronox (2019) and TTPP (2019)

TRONOX

OPTIMISATION MODIFICATION

Project Road Transport Routes - Inset

Figure 3.2



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 3.3

CMA-18-07 AC OM_ App RTA_202B

Road Transport Aspects of the Modification

With regard to the road transport aspects of the Project, the Modification proposes the following changes:

- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- use of other local roads other than the road haulage route by Project-related light vehicles to access site (Figure 3.1 and Figure 3.2), including
  - to/from Mildura/Buronga via Arumpo Road, Marma Box Creek Road and Link Road;
  - to/from Balranald-Ivanhoe Road then south via Link Road (as approved) and Boree Plains-Gol Gol Road only; and
- revised alignment of the Ivanhoe Rail Facility access road intersection with Balranald-Ivanhoe Road (Figure 3.3).

4 Existing Road Environment

4.1 Road Haulage Route

The approved road haulage route consists of (Figures 1.1, 2.1 and 2.2):

- the Atlas-Campaspe Mine access road;
- Link Road;
- Boree Plains-Gol Gol Road;
- Magenta Road;
- Hatfield-The Vale Road;
- Balranald-Ivanhoe Road; and
- Ivanhoe Rail Facility access road.

4.1.1 Route Description

A description of the relevant public road sections of the road haulage route is provided below.

Link Road is an unsealed local road which provides a link from Marma Box Creek Road to Boree Plains-Gol Gol Road. The intersection of Link Road with the Atlas-Campaspe Mine access road will be constructed to an appropriate standard for use by Type 1 A-double road trains. Link Road will be widened over an 8 km length between its new intersection with the Atlas-Campaspe Mine access road and its intersection with Boree Plains-Gol Gol Road (Table 2.1).

Boree Plains-Gol Gol Road is an unsealed local road which extends from Balranald-Ivanhoe Road via Boree Plains Station to Gol Gol Road on the eastern side of Garnpung Lake. Between Link Road and Magenta Road, Boree Plains-Gol Gol Road forms part of the road haulage route. The intersection of Boree Plains-Gol Gol Road and Link Road is aligned such that Boree Plains-Gol Gol Road has priority. At its intersection with Balranald-Ivanhoe Road, Boree Plains-Gol Gol Road is the minor road. A new intersection will be constructed with Magenta Road, and Boree Plains-Gol Gol Road will be widened with associated drainage works over 5.5 km between Link Road and the new intersection with Magenta Road (Table 2.1).

Magenta Road is a local road which provides a north-south link between Hatfield-The Vale Road and Boree Plains-Gol Gol Road. The intersections of Magenta Road with Hatfield-The Vale Road and Boree Plains-Gol Gol Road are T-intersections, with Magenta Road as the minor road. Magenta Road will be widened with associated drainage works over 3 km between Boree Plains-Gol Gol Road and the new intersection with Hatfield-The Vale Road (Table 2.1). In addition, a 2 km section of Magenta Road will be sealed (Table 2.1).

Hatfield-The Vale Road is a local road which provides an east-west link between Balranald-Ivanhoe Road and Magenta Road, then turns northwards west of Magenta Road to form part of a north-south link via Dockerty Road and Ivanhoe Road to Ivanhoe-Menindee Road west of Ivanhoe. Hatfield-The Vale Road is the minor road at the T-intersection formed with Balranald-Ivanhoe Road, and is the major road at the T-intersection formed with Magenta Road. Hatfield-The Vale Road will be widened with associated drainage works over 14.5 km between Magenta Road and the upgraded intersection with Balranald-Ivanhoe Road (Table 2.1).

Balranald-Ivanhoe Road (MR67) is a Regional Road which links from the Sturt Highway at Balranald, generally north-south via Hatfield to the Cobb Highway (HW21) at Ivanhoe. It is also known as Ivanhoe Road (near Balranald), Hatfield Penarie Road and Balranald Road (near Ivanhoe). North of Hatfield The Vale Road, it forms part of the road haulage route. This road is an approved route for A-double and modular B-triple road trains and 4.6 m high vehicles. Balranald-Ivanhoe Road is a two-lane road, and has a sealed surface between Balranald and a point 71 km north of its intersection with Hatfield-The Vale Road. North of this point, the road is generally unsealed, with short sections of sealed road.

4.1.2 Road Conditions

As outlined in Section 2.2, Tronox will undertake road upgrade works along the road haulage route prior to the haulage of mineral concentrate, to be to an acceptable standard for Type 1 road trains, in accordance with Condition 1, Schedule 3 of Development Consent SSD_5012. The road upgrade works will be undertaken to the satisfaction of the relevant road authority, being RMS, BSC or CDSC.

4.1.3 Traffic Volumes

Traffic surveys undertaken on Balranald-Ivanhoe Road in May 2012 (GTA Consultants, 2012) indicate that at that time, Balranald-Ivanhoe Road carried an average of 35 vehicles per day south of the Orange Broken Hill Railway, and an average of 32 vehicles per day north of Hatfield-The Vale Road. Surveys of other local roads included in the road transport route were not possible due to road surface conditions, however, are expected to be lower than those recorded on Balranald-Ivanhoe Road.

It is not expected that background traffic volumes on the approved road transport route have changed significantly since the surveys were conducted in 2012, as the most significant changes are expected to be directly related to the Project. The GTA (2012) assessment applied a background growth rate of one percent per annum, which would suggest an increase of two to three vehicles per day between 2012 and 2019. This small increase would have negligible impact on the operation of the roads.

Anecdotally, it is noted that a site inspection conducted by TTPP on 26 March 2019 found that traffic volumes along sections of the approved road transport route (specifically Link Road and Boree Plains Gol Gol Road) were very low, recording some four vehicles over a two-hour period between 2.30 pm and 4.30 pm. No vehicles were recorded along Balranald-Ivanhoe Road between 3.45 pm and 4.15 pm.

EMM (2015) examined the road transport implications of the Balranald Mineral Sands Project, and identified the routes to be used by traffic generated during the construction and operational stages of that project. The access routes for the Balranald Mineral Sands Project require all vehicles to approach and depart to and from the south, using Balranald-Ivanhoe Road only south of its intersection with Marma Box Creek Road. Traffic generated by the Balranald Mineral Sands Project would therefore not use the approved road transport route.

4.1.4 Road Safety History

Validated crash data was obtained from RMS covering the period from 1 January 2014 to 31 December 2018, noting that data for the latest nine months of that period is preliminary and subject to change. The data includes those crashes which conform to the national guidelines for reporting and classifying road vehicle crashes based on the following criteria:

- The crash was reported to the police.
- The crash occurred on a road open to the public.
- The crash involved at least one moving vehicle.
- The crash involved at least one person being killed or injured or at least one motor vehicle being towed away.

Crash data was reviewed on the approved road transport route including:

- Link Road between Atlas-Campaspe Mine Road and Boree Plains-Gol Gol Road;
- Boree Plains-Gol Gol Road between Link Road and Magenta Road;
- Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road;
- Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road; and
- Balranald-Ivanhoe Road between Hatfield-The Vale Road and the Orange Broken Hill Railway.

The data indicates that two crashes were reported on those roads over that period, both of which occurred on Balranald-Ivanhoe Road:

- Thursday 25 May 2017 at 10.00 am in fine weather and on a wet unsealed road surface. An eastbound motorcycle on Balranald-Ivanhoe Road travelling at 80 km/h lost control on the carriageway and rolled over. The rider was moderately injured, and neither speed nor fatigue were nominated as contributing factors to the crash. The crash occurred in the Balranald Shire approximately 5.5 km travel distance along Balranald-Ivanhoe Road south west of the boundary with the Central Darling Shire (and approximately 40 km travel distance from Ivanhoe).
- Tuesday 10 June 2017 at 4.00 pm, in fine weather and on a wet sealed road surface. A northbound motorcycle on Balranald-Ivanhoe Road travelling at 90 km/h skidded/slid and lost control, left the carriageway to the right and rolled over. Two people were seriously injured, and neither speed nor fatigue were nominated as contributing factors to the crash. The crash occurred near Katabritoi Lake, 25 km travel distance south west of Cobb Highway at Ivanhoe.

The two crashes on Balranald-Ivanhoe Road occurred at different locations, one on the sealed portion and one on the unsealed portion, and each included a motorcycle rider losing control while travelling below the speed limit on a wet road surface. This does not suggest an inherent safety concern regarding use of the Balranald-Ivanhoe Road by heavy vehicles, noting that Tronox will make financial contributions to maintenance and to rectify "high risk" road safety deficiencies on the route.

4.1.5 School Buses

It is understood that no commercial school buses currently operate on the road haulage route although there are some informal carpooling arrangements along the road haulage route.

4.2 Proposed Local Roads Route

The proposed local road route for light vehicles travelling to and from the west between the Atlas-Campaspe Mine and Mildura/Buronga consists of (Figure 3.1 and Figure 3.2):

- Arumpo Road between Silver City Highway and Marma Box Creek Road;
- Marma Box Creek Road between Arumpo Road and Link Road; and
- Link Road between Marma Box Creek Road and Atlas-Campaspe Mine Access Road.

The proposed local road route for light vehicles travelling to and from the east and south between the Atlas-Campaspe Mine and Balranald, Sydney and Melbourne consists of (Figure 3.1 and Figure 3.2):

- Link Road between Atlas-Campaspe Mine Access Road and Boree Plains-Gol Gol Road (part of the approved road haulage route);

- Boree Plains-Gol Gol Road between Link Road and Magenta Road (part of the approved road haulage route);
- Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road; and
- Balranald-Ivanhoe Road south of Boree Plains-Gol Gol Road (existing approved route).

4.2.1 Route Description

A description of the relevant local roads sections is provided below.

Arumpo Road (MR431) is a Regional Road which links from the Silver City Highway (HW22) north of Buronga to the western side of Lake Mungo at Mungo National Park. Access to the Mungo National Park is available via Arumpo Road. Its intersection with Marma Box Creek Road is a T-intersection and is aligned such that Arumpo Road has priority. Arumpo Road is a two-lane road, and has a sealed surface between the Silver City Highway and a point approximately 18 km north-east of its intersection with the Silver City Highway. North-east of this point, it has a good quality unsealed road surface. Arumpo Road is an approved route for A-double and modular B-triple road trains and 4.6m high vehicles.

Marma Box Creek Road is an unsealed local road which provides an east-west link between Arumpo Road and Link Road. The intersection of Marma Box Creek Road with Link Road is a T-intersection, with Link Road being the minor road (terminating leg) and Marma Box Creek Road the major road which bends through 90 degrees at the intersection.

Descriptions of **Link Road**, **Boree Plains-Gol Gol Road** and **Balranald-Ivanhoe Road** (MR67) are provided in Section 4.1.1.

4.2.2 Existing Road Conditions

TTPP reviewed the existing conditions along the proposed local roads route, by driving the route during daylight hours on Tuesday 26 March 2019. The weather was fine and sunny, the road surfaces were dry and the vehicle used was a Mitsubishi Outlander LS. Observations made along the route are presented in Appendix B, and key findings are described below.

The condition of the unsealed portions of the route changes along the route, but the road surface is poor in sections, with some loose surfaces, rutting, and corrugations. These irregularities along the road profile require drivers to adjust speed to reflect the local conditions. Loose material on the parts of the route includes fine bulldust, which is raised by vehicles and restricts visibility for other drivers.

Stock grids are typically of sufficient width for one vehicle to pass, and have width marker signage (D4-3) on each side of the road at the grid, however many of the width markers are incorrectly located such that they suggest the road width is greater than the available width at the grid. This may cause drivers to misjudge the available width, especially at night.

Signage and guideposts are used along the unsealed part of the route. Warning signs are provided to alert drivers to local conditions, such as diagrammatic curve warning signs, CAMs, approaching intersection signs and GRID warning signs in advance of stock grids. Road directional signs are provided at main intersections, which typically include a sight board, road names and distance and destination advice. Occasional guideposts were observed, typically in the vicinity of curves, local accesses or to highlight other localised hazards such as culverts. Use of guide posts is somewhat inconsistent, with some curves having no guide posts to provide alignment information to drivers particularly at night.

Overall, the alignment of the roads and the intersections is satisfactory, providing adequate sight distance for drivers to observe an obstruction on the road or a vehicle approaching in the opposite direction and adjust their travel path if needed, to observe an approaching intersection, and to observe potentially conflicting vehicles at intersections. Clear zones are generally maintained along the route, however some embankments on Marma Box Creek Road and Link Road appear somewhat steep, which may cause a vehicle which has left the road to overturn rather than allow the driver to be able to correct and steer back to the travel path.

As the observations were undertaken during fine weather and dry conditions, no wet weather conditions were observed, noting that wet weather closes the route to traffic.

4.2.3 Traffic Volumes

Traffic surveys undertaken on Balranald-Ivanhoe Road in May 2012 (GTA Consultants, 2012) indicate that at that time, Balranald-Ivanhoe Road carried an average of 35 vehicles per day south of the Orange Broken Hill Railway, and an average of 32 vehicles per day north of Hatfield-The Vale Road. Surveys of other local roads were not possible due to road surface conditions, however are expected to be lower than those recorded on Balranald-Ivanhoe Road.

RMS collects and publishes traffic volume data at selected locations on its roads. Available data on the proposed local roads route include Arumpo Road 30 m north of Mourquong Road at Mourquong (Station 98156) which carried 394 vehicles per day in 2006 (including 108 or 27 percent heavy vehicles) and 341 vehicles per day in 2010. Data have not been collected at those stations since 2010, so more recent changes in traffic cannot be identified from RMS data. It is noted that traffic volumes at the north-eastern end of Arumpo Road further away from Buronga are expected to be lower (Appendix A).

EMM (2015) examined the road transport implications of the Balranald Mineral Sands Project. EMM reports an estimated daily traffic volume on Arumpo Road at 20 to 30 vehicles per day on its eastern and western sections respectively, based on hourly counts conducted by EMM in October 2014. It is noted however that EMM refers to Marma Box Creek Road as Arumpo Road, hence this estimate actually applies to Marma Box Creek Road west and south of Link Road. EMM (2015) indicates that sections of Marma Box Creek Road will be used by construction traffic during construction of the Nepean mine, and part will also be used as part of the Nepean access road. These sections all lie to the south of the Nepean mine, and do not overlap with the local roads proposed to be used by the modified Project.

EMM (2015) examined the likely routes used by traffic generated during the construction and operational stages of the Balranald Mineral Sands Project, and found that traffic would approach and depart to and from the south, so would not use any of the local roads proposed to be used by Project traffic.

4.2.4 Road Safety History

Validated crash data was obtained from RMS covering the period from 1 January 2014 to 31 December 2018, noting that data for the latest nine months of that period is preliminary and subject to change. Crash data was reviewed on the following roads relevant to the use of the local road routes:

- Arumpo Road between Silver City Highway and Marma Box Creek Road;
- Marma Box Creek Road between Arumpo Road and Link Road;
- Link Road between Marma Box Creek Road and Boree Plains-Gol Gol Road; and
- Boree Plains-Gol Gol Road between Link Road and Balranald-Ivanhoe Road.

The data indicates that six crashes were reported over that period, all of which occurred on unsealed portions of Arumpo Road in the Wentworth Shire:

- Saturday 4 October 2014 at 3.30 pm in fine weather and dry unsealed road surface. An eastbound car in Arumpo Road travelling at 80 km/h lost control on a right-hand bend and left the carriageway to the right. One person suffered a minor/other injury and speed was nominated as a contributing factor. The crash occurred 260 m west of Petro Mail Road.
- Thursday 6 November 2014 at 4.00 pm in unknown weather conditions and dry road surface. The driver of a westbound light truck travelling at 40 km/h on Arumpo Road was distracted outside of the vehicle and struck a westbound B-double travelling at 30 km/h on a straight section of road. One person suffered minor/other injuries. The crash occurred 600 m east of Wamberra Road.

- Tuesday 9 December 2014 at 6.20 pm in fine weather and dry road unsealed road surface. A southbound car in Arumpo Road travelling at an unknown speed struck a southbound B-double travelling at 30 km/h in Arumpo Road. The crash occurred on a straight section of the road and one person suffered minor/other injuries. The crash occurred approximately 31 km north of Silver City Highway (approximately 12 km north-east of Wamberra Road) and the road was noted to have potholes/corrugations.
- Tuesday 21 June 2016 at 4.00 pm in fine weather and on a wet unsealed road surface. An eastbound light truck travelling at 100 km/h lost control on a straight section of road. Two people suffered minor/other injuries. The crash occurred approximately 60 km east of Silver City Highway (approximately 3 km east of Petro Mail Road).
- Monday 11 July 2016 at 6.00 pm (dusk) in fine weather and on a wet unsealed road surface. An eastbound four-wheel drive with an insecure or projecting load travelling at 70 km/h on Arumpo Road lost control on the carriageway on a bend where the road was flooded/submerged. Three people suffered minor/other injuries and speed was nominated as a contributing factor. The crash occurred 500 m east of Petro Mail Road.
- Monday 4 June 2018 at 1.00 pm in fine weather and on a dry unsealed road surface. An eastbound motorcycle travelling at 40 km/h in Arumpo Road lost control on a bend and left the carriageway. Speed was nominated as a contributing factor and one person suffered minor/other injuries. The crash occurred 50 m east of Wamberra Road.

Two of the six reported crashes occurred on a section of Arumpo Road which has now been sealed, i.e. Arumpo Road is now sealed for approximately 6 km to the north-east of Wamberra Road.

Speed was nominated as a contributing factor to three of the six reported crashes, noting that in all three crashes, the speed of the vehicle was below the 100 km/h speed limit. A vehicle is assessed as having been speeding based on certain criteria, including that the vehicle was performing a manoeuvre characteristic of excessive speed, such as skidding, sliding or losing control on a bend and that the driver was not distracted, drowsy or ill and was not swerving to avoid an animal or other vehicle, or failure of the vehicle occurred. Only one crash involved a vehicle travelling at the 100 km/h speed limit, and it occurred on a wet unsealed road surface.

The crash data for the route does not suggest an inherent safety concern regarding use of Arumpo Road by light vehicles.

5 Approved and Modified Project Traffic

The road transport aspects of the Project were examined by GTA Consultants (2012), which considered the volume and distribution of traffic generated by the Project during its peak construction phase, and in the longer term during its operational phase with the cumulative impacts of background traffic growth and operational activity associated with Iluka Resources Limited's Balranald Mineral Sands Project. This section summarises and updates those forecasts as relevant to the Modification. These forecasts do not consider the number of vehicle trips expected to be generated directly between the township of Ivanhoe and the Ivanhoe Rail Facility, as the number of trips is small and would not be impacted by the Modification.

5.1 Approved Project

5.1.1 Approved Project Trip Generation

Construction Employees

With the exception of up to ten employees working at the Ivanhoe Rail Facility, the construction workforce will be housed in the accommodation camp at the Atlas-Campaspe Mine. The construction employees will travel to and from the accommodation camp at the start and end of their roster periods, being five days on (weekdays) and two days off (weekends). The Modification would not change the number and residential distribution of the peak construction workforce, nor the rosters and shift arrangements that were examined by GTA Consultants (2012). Table 5.1 summarises the vehicle trips generated by the peak construction workforce travelling to and from the Atlas-Campaspe Mine site on Mondays, being the busiest day of the week for the movement of the construction workforce.

Table 5.1: Peak Construction Employee Vehicle Trips to/from Atlas-Campaspe Mine

Residential Location	AM Peak[A]	PM Peak[A]	Daily[B]
Mildura/Buronga	54	54	108
Broken Hill	27	27	54
Balranald	22	22	44
Ivanhoe	6	6	12
Total Trips	**109**	**109**	**218**

Source: GTA Consultants (2012)
[A] Vehicle trips per hour (AM Peak Monday and Saturday, PM Peak Monday and Friday)
[B] Vehicle trips per day (Monday)

Construction Visitors and Deliveries

GTA Consultants (2012) found that on a typical day during peak construction, five visitors would be expected to the Atlas-Campaspe Mine, generating 10 light vehicle trips per day. Visitors will be drawn from:

- Sydney and Melbourne 6 vehicle trips per day;
- Mildura 2 vehicle trips per day; and
- Broken Hill 2 vehicle trips per day.

GTA Consultants (2012) found that on a typical day during peak construction, five deliveries would be expected to the Atlas-Campaspe Mine, generating 10 heavy vehicle trips per day. Deliveries will be drawn from:

- Sydney and Melbourne 6 vehicle trips per day;
- Mildura 2 vehicle trips per day; and
- Broken Hill 2 vehicle trips per day.

Operational Employees

With the exception of up to three employees working at the Ivanhoe Rail Facility, the operational workforce will be housed in the accommodation camp at the Atlas-Campaspe Mine during their roster period. The operational employees would travel to and from the accommodation camp at the start and end of their roster periods, which vary for different types of employees. The GTA Consultants (2012) assessment examined the arrivals and departures of the operational employees based on the roster arrangements and found that a maximum of 83 percent of the operational workforce will start or end a roster on any one day, generating up to 136 vehicle trips per day. These busiest days are expected to occur on 10 to 11 days per year. The busiest peak hour was identified by GTA Consultants (2012) as occurring on half of the busiest days, when a morning peak of 92 vehicle trips and an evening peak of 44 vehicle trips would occur.

As a robust assessment consistent with GTA Consultants (2012), the two peaks are each assumed to occur within one hour. On this basis, Table 5.2 summarises the vehicle trips generated by the operational workforce travelling to and from the Atlas-Campaspe Mine site.

Table 5.2: Operational Employee Vehicle Trips to/from Atlas-Campaspe Mine

Residential Location	Average Day	Busiest Days of the Year		
		AM Peak[A]	PM Peak[A]	Daily[B]
Mildura/Buronga	14	36	18	54
Broken Hill	7	17	9	26
Balranald	11	28	14	42
Ivanhoe	4	9	5	14
Total Trips	**36**	**92**	**44**	**136**

Source: GTA Consultants (2012)
[A] Vehicle trips per hour on the busiest 5 to 6 days per year
[B] Vehicle trips per day on the busiest 10 to 11 days per day

Operational Visitors and Deliveries

GTA Consultants (2012) found that on a typical day, 10 visitors will be expected to the Atlas-Campaspe Mine, generating 20 light vehicle trips per day. Visitors will be drawn from:

- Melbourne 10 vehicle trips per day;
- Sydney 4 vehicle trips per day;
- Mildura 4 vehicle trips per day; and
- Broken Hill 2 vehicle trips per day.

GTA Consultants (2012) found that on a typical day, five deliveries will be expected to the Atlas-Campaspe Mine, generating 10 heavy vehicle trips per day. Deliveries will be drawn from:

- Sydney and Melbourne 6 vehicle trips per day;
- Mildura 2 vehicle trips per day; and
- Broken Hill 2 vehicle trips per day.

Mineral Concentrate Transport

Project-generated mineral concentrate will be hauled via road approximately 175 km from the Atlas-Campaspe Mine to the Ivanhoe Rail Facility, using a fleet of RMS approved vehicles via the road haulage route. Later in the project life, MSP process waste containers will be unloaded from trains at the Ivanhoe Rail Facility and backloaded to the Atlas-Campaspe Mine using the same fleet of vehicles which transport mineral concentrate from the Atlas-Campaspe Mine.

The number of loaded vehicles travelling from the Atlas-Campaspe Mine to the Ivanhoe Rail Facility is approved to a maximum of 24 per day. With the return of empty vehicles or waste containers, the approved Project would therefore generate a maximum of 48 vehicle trips per day on the approved road haulage route.

The haulage vehicles will operate 24 hours per day, so the trips would be spread throughout the day and night, generating an average of two vehicle trips per hour. To take account of hour-to-hour variations in production and transport rates, GTA Consultants (2012) assumed that mineral concentrate transport may generate up to five haulage vehicle trips per hour during peak hours.

The approved Project would generate a maximum of three trains per week travelling from the Ivanhoe Rail Facility to the MSP, generating up to six train movements per week (three arrivals and three departures).

5.1.2 Approved Project Total Traffic on Road Network

Table 5.3 summarises the distribution of the Project-generated traffic on the road network as approved, during the peak construction and operational stages.

Table 5.3: Approved Project Traffic on the Road Network

Road and Location[A]	Construction Stage			Operational Stage		
	AM Peak[B]	PM Peak[B]	Daily[C]	AM Peak[D]	PM Peak[D]	Daily[E]
1. Atlas-Campaspe Mine Access Road	114 (5)	114 (5)	228 (10)	101 (12)	55 (12)	156 (80)
2. Arumpo Road between Marma Box Creek Road and Silver City Highway	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
3. Balranald-Ivanhoe Road between Ivanhoe Rail Facility and Hatfield-The Vale Road	34 (1)	34 (1)	68 (2)	27 (8)	15 (8)	42 (72)
4. Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road	80 (4)	80 (4)	160 (8)	0 (4)	0 (4)	0 (8)
5. Balranald-Ivanhoe Road between Boree Plains-Gol Gol Road and Sturt Highway	80 (4)	80 (4)	160 (8)	35 (4)	21 (4)	56 (8)
6. Boree Plains-Gol Gol Road between Link Road and Magenta Road	114 (5)	114 (5)	228 (10)	62 (12)	36 (12)	98 (80)
7. Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road	0 (0)	0 (0)	0 (0)	35 (0)	21 (0)	56 (0)
8. Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road	114 (5)	114 (5)	228 (10)	27 (12)	15 (12)	42 (80)
9. Link Road between Atlas-Campaspe Mine access and Marma Box Creek Road	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
10. Link Road between Atlas-Campaspe Mine access and Boree Plains-Gol Gol Road	114 (5)	114 (5)	228 (10)	62 (12)	36 (12)	98 (80)
11. Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road	114 (5)	114 (5)	228 (10)	27 (12)	15 (12)	42 (80)
12. Marma Box Creek Road between Link Road and Arumpo Road	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
13. Sturt Highway between Balranald and Mildura	55 (1)	55 (1)	110 (2)	0 (1)	0 (1)	0 (2)

Note: light vehicles (heavy vehicles)
[A] Refer to Figures 3.1 and 3.2
[B] Vehicle trips per hour (AM Peak Monday and Saturday, PM Peak Monday and Friday)
[C] Vehicle trips per day, Monday only
[D] Vehicle trips per hour, busiest 5 to 6 days of the year
[E] Vehicle trips per day, busiest 10 to 11 days of the year

5.1.3 Approved Project Ivanhoe Rail Facility Intersection

The intersection of the Ivanhoe Rail Facility access road and Balranald-Ivanhoe Road will be construction to the satisfaction of RMS and CDSC (Section 2.2). While a detailed design has not been prepared, the conceptual layout of the intersection includes a large radius left turn slip road for the loaded trucks entering the Ivanhoe Rail Facility from Balranald-Ivanhoe Road. Right turns into and out of the Ivanhoe Rail Facility and left turn out of the Ivanhoe Rail Facility would occur at a standard T-intersection, at which the access road would meet Balranald-Ivanhoe Road at 90 degrees, and standard intersection priority rules would apply.

The operational Project-generated vehicle turning movements at the intersection with the approved Project will include:

- loaded haulage vehicles would turn left from Balranald-Ivanhoe Road via the slip lane into the access road (24 trips per day, up to three trips per hour);
- empty (or backloaded MSP process waste) haulage vehicles will turn right from the access road to Balranald-Ivanhoe Road (24 trips per day, up to three trips per hour);
- employees, visitors and deliveries travelling between the Atlas-Campaspe Mine and Ivanhoe or Broken Hill will travel northbound or southbound along Balranald-Ivanhoe Road past the access road (up to 44 trips per day, up to 28 trips per hour);
- Ivanhoe Rail Facility employees will turn right from Balranald-Ivanhoe Road into the access road at the start of their shift (three trips per day, up to three trips per hour); and
- Ivanhoe Rail Facility employees will turn left from the access road on to Balranald-Ivanhoe Road at the end of their shift (three trips per day, up to three trips per hour).

5.2 Modified Project

5.2.1 Modified Project Trip Generation

Construction Employees

The Modification would not change the number and residential distribution of the peak construction workforce, nor the rosters and shift arrangements that were examined by GTA Consultants (2012). The peak construction workforce for the modified Project would therefore generate the same number of vehicle trips as described in Section 5.1.

Construction Visitors and Deliveries

The Modification would not change the number of vehicle trips made by visitors and deliveries to the Project during peak construction from that described in Section 5.1.

Operational Employees

The Modification would not change the number and residential distribution of the operational workforce, nor the rosters and shift arrangements that were examined by GTA Consultants (2012). The operational workforce for the modified Project would therefore generate the same number of vehicle trips as described in Section 5.1.

It is understood that Tronox is currently reviewing the feasibility of operating shuttle buses between the Atlas-Campaspe Mine and Buronga/Mildura or Balranald for Project workers. If a Project worker shuttle bus was to operate it would reduce the number of vehicle trips described in Section 5.1.

Operational Visitors and Deliveries

The Modification would not change the number and distribution of vehicle trips made by visitors and deliveries to the Project.

Mineral Concentrate Transport

With the proposed increase in production with the Modification, the number of haulage vehicle departures from the Atlas-Campaspe Mine would increase. From approximately Year 12 of the Project, MSP process waste containers would be unloaded from trains at the Ivanhoe Rail Facility and backloaded to the Atlas-Campaspe Mine using the same fleet of vehicles which transport mineral concentrate from the Mine. The Modification would not change this backloading arrangement, which will not impact the number of haulage truck trips on the haulage route.

With the Modification, the number of loaded vehicles travelling from the Atlas-Campaspe Mine to the Ivanhoe Rail Facility would increase from 24 to 35 per day. With the return of empty vehicles or waste containers, the Modification would therefore increase the maximum haulage vehicle trips on the haulage route from 48 vehicle trips per day to 70 vehicle trips per day.

The haulage vehicles will operate 24 hours per day, so the trips would be spread throughout the day and night. The Modification would increase the average number of haulage vehicle trips per hour from two to three trips per hour. It has been assumed for this assessment that to take account of hour-to-hour variations in production and transport rates, mineral concentrate transport may generate up to seven haulage vehicle trips per hour during peak hours.

With the Modification, the number of trains travelling from the Ivanhoe Rail Facility to the MSP would increase, from a maximum of three to four per week, generating up to eight train movements per week (four arrivals and four departures).

5.2.2 Modified Project Total Traffic on Road Network

The Modification would not change the number of vehicle trips generated during the construction phase of the Project, nor would it change the origin/destination of the generated trips. The Modification would however permit the use of alternative local roads by construction employees and visitors in light vehicles, impacting the routes used to and from:

- Mildura/Buronga – employees and visitors may use the proposed route via Link Road, Marma Box Creek Road and Arumpo Road instead of via Link Road, Magenta Road, Hatfield-The Vale Road, Balranald-Ivanhoe Road and Sturt Highway; and
- Balranald, Sydney and Melbourne – employees and visitors may use the route via Boree Plains-Gol Gol Road to Balranald-Ivanhoe Road instead of via Magenta Road, Hatfield-The Vale Road and south along Balranald-Ivanhoe Road.

Similarly, the Modification would not change the number of vehicle trips generated by employees, visitors and deliveries during the operational phase of the Project, nor would it change the origin/destination of those trips. The Modification would however permit the use of alternative local roads by operational employees and visitors in light vehicles, impacting the routes used to and from:

- Mildura/Buronga – employees and visitors may use the proposed route via Link Road, Marma Box Creek Road and Arumpo Road instead of via Link Road, Magenta Road, Hatfield-The Vale Road, Balranald-Ivanhoe Road and Sturt Highway; and
- Balranald, Sydney and Melbourne – employees and visitors may use the route via Boree Plains-Gol Gol Road to Balranald-Ivanhoe Road instead of via Magenta Road, Hatfield-The Vale Road and south along Balranald-Ivanhoe Road.

With the proposed increase in production, an increase in the number of trips generated between the Atlas-Campaspe Mine and the Ivanhoe Rail Facility would occur, which would continue to use the approved road transport route.

Table 5.4 summarises the distribution of the Project-generated traffic on the road network as modified, during the peak construction and operational stages.

If Tronox was to operate a Project worker shuttle bus between the Atlas-Campaspe Mine and Buronga/Mildura or Balranald, the number of light vehicle trips on Link Road, Marma Box Creek Roads, Arumpo Road and Boree Plains-Gol Gol Road shown in Table 5.4 would reduce.

Table 5.4: Modified Project Traffic on the Road Network

Road and Location[A]	Construction Stage			Operational Stage		
	AM Peak[B]	PM Peak[B]	Daily[C]	AM Peak[D]	PM Peak[D]	Daily[E]
1. Atlas-Campaspe Mine Access Road	114 (5)	114 (5)	228 (10)	101 (12)	55 (12)	156 (80)
2. Arumpo Road between Marma Box Creek Road and Silver City Highway	55 (0)	55 (0)	110 (0)	38 (0)	20 (0)	58 (0)
3. Balranald-Ivanhoe Road between Ivanhoe Rail Facility and Hatfield-The Vale Road	34 (1)	34 (1)	68 (2)	27 (8)	15 (8)	42 (72)
4. Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road	0 (4)	0 (4)	0 (8)	0 (4)	0 (4)	0 (8)
5. Balranald-Ivanhoe Road between Boree Plains-Gol Gol Road and Sturt Highway	25 (4)	25 (4)	50 (8)	35 (4)	21 (4)	56 (8)
6. Boree Plains-Gol Gol Road between Link Road and Magenta Road	59 (5)	59 (5)	118 (10)	62 (12)	36 (12)	98 (80)
7. Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road	25 (0)	25 (0)	50 (0)	35 (0)	21 (0)	56 (0)
8. Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road	34 (5)	34 (5)	68 (10)	27 (12)	15 (12)	42 (80)
9. Link Road between Atlas-Campaspe Mine access and Marma Box Creek Road	55 (0)	55 (0)	110 (0)	38 (0)	20 (0)	58 (0)
10. Link Road between Atlas-Campaspe Mine access and Boree Plains-Gol Gol Road	59 (5)	59 (5)	118 (10)	62 (12)	36 (12)	98 (80)
11. Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road	34 (5)	34 (5)	68 (10)	27 (12)	15 (12)	42 (80)
12. Marma Box Creek Road between Link Road and Arumpo Road	55 (0)	55 (0)	110 (0)	38 (0)	20 (0)	58 (0)
13. Sturt Highway between Balranald and Mildura	0 (1)	0 (1)	0 (2)	0 (1)	0 (1)	0 (2)

Note: light vehicles (heavy vehicles)
[A] Refer to Figures 3.1 and 3.2
[B] Vehicle trips per hour (AM Peak Monday and Saturday, PM Peak Monday and Friday)
[C] Vehicle trips per day, Monday only
[D] Vehicle trips per hour, busiest 5 to 6 days of the year
[E] Vehicle trips per day, busiest 10 to 11 days of the year

5.2.3 Modified Project Ivanhoe Rail Facility Intersection

The Modification includes a revised alignment of the intersection between the Ivanhoe Rail Facility access road and Ivanhoe-Balranald Road (Figure 2.2). A preliminary design for the modified intersection has been prepared, which is presented in Figure 3.3.

The operational Project-generated vehicle turning movements at the intersection with the Modification would include:

- loaded haulage vehicles would turn left from Balranald-Ivanhoe Road into the access road (35 trips per day, up to four trips per hour);
- empty (or backloaded MSP process waste) haulage vehicles would turn right from the access road to Balranald-Ivanhoe Road (35 trips per day, up to four trips per hour);
- employees, visitors and deliveries travelling between the Atlas-Campaspe Mine and Ivanhoe or Broken Hill would travel northbound or southbound along Balranald-Ivanhoe Road past the access road (up to 44 trips per day, up to 28 trips per hour);
- Ivanhoe Rail Facility employees would turn right from Balranald-Ivanhoe Road into the access road at the start of their shift (three trips per day, up to three trips per hour);
- Ivanhoe Rail Facility employees would turn left from the access road on to Balranald-Ivanhoe Road at the end of their shift (three trips per day, up to three trips per hour).

6 Impacts of the Modification

6.1 Project Traffic on the Road Network

Table 6.1 compares the distribution of Project-generated construction traffic on the road network with the approved Project and with the Modification.

Table 6.1: Approved and Modified Project Construction Traffic on the Road Network

Road and Location[A]	Approved Project			Modified Project		
	AM Peak[B]	PM Peak[B]	Daily[C]	AM Peak[B]	PM Peak[B]	Daily[C]
1. Atlas-Campaspe Mine Access Road	114 (5)	114 (5)	228 (10)	114 (5)	114 (5)	228 (10)
2. Arumpo Road between Marma Box Creek Road and Silver City Highway	0 (0)	0 (0)	0 (0)	55 (0)	55 (0)	110 (0)
3. Balranald-Ivanhoe Road between Ivanhoe Rail Facility and Hatfield-The Vale Road	34 (1)	34 (1)	68 (2)	34 (1)	34 (1)	68 (2)
4. Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road	80 (4)	80 (4)	160 (8)	0 (4)	0 (4)	0 (8)
5. Balranald-Ivanhoe Road between Boree Plains-Gol Gol Road and Sturt Highway	80 (4)	80 (4)	160 (8)	25 (4)	25 (4)	50 (8)
6. Boree Plains-Gol Gol Road between Link Road and Magenta Road	114 (5)	114 (5)	228 (10)	59 (5)	59 (5)	118 (10)
7. Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road	0 (0)	0 (0)	0 (0)	25 (0)	25 (0)	50 (0)
8. Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road	114 (5)	114 (5)	228 (10)	34 (5)	34 (5)	68 (10)
9. Link Road between Atlas-Campaspe Mine access and Marma Box Creek Road	0 (0)	0 (0)	0 (0)	55 (0)	55 (0)	110 (0)
10. Link Road between Atlas-Campaspe Mine access and Boree Plains-Gol Gol Road	114 (5)	114 (5)	228 (10)	59 (5)	59 (5)	118 (10)
11. Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road	114 (5)	114 (5)	228 (10)	34 (5)	34 (5)	68 (10)
12. Marma Box Creek Road between Link Road and Arumpo Road	0 (0)	0 (0)	0 (0)	55 (0)	55 (0)	110 (0)
13. Sturt Highway between Balranald and Mildura	55 (1)	55 (1)	110 (2)	0 (1)	0 (1)	0 (2)

Note: light vehicles (heavy vehicles)
[A] Refer to Figures 3.1 and 3.2
[B] Vehicle trips per hour (AM Peak Monday and Saturday, PM Peak Monday and Friday)
[C] Vehicle trips per day, Monday only

Table 6.2 compares the distribution of Project-generated operational traffic on the road network with the approved Project and with the Modification.

Table 6.2: Approved and Modified Project Operational Traffic on the Road Network

Road and Location[A]	Approved Project			Modified Project		
	AM Peak[B]	PM Peak[B]	Daily[C]	AM Peak[B]	PM Peak[B]	Daily[C]
1. Atlas-Campaspe Mine Access Road	101 (10)	55 (10)	156 (58)	101 (12)	55 (12)	156 (80)
2. Arumpo Road between Marma Box Creek Road and Silver City Highway	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
3. Balranald-Ivanhoe Road between Ivanhoe Rail Facility and Hatfield-The Vale Road	27 (6)	15 (6)	42 (50)	27 (8)	15 (8)	42 (72)
4. Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road	73 (4)	41 (4)	114 (8)	0 (4)	0 (4)	0 (8)
5. Balranald-Ivanhoe Road between Boree Plains-Gol Gol Road and Sturt Highway	73 (4)	41 (4)	114 (8)	35 (4)	21 (4)	56 (8)
6. Boree Plains-Gol Gol Road between Link Road and Magenta Road	101 (10)	55 (10)	156 (58)	62 (12)	36 (12)	98 (80)
7. Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road	0 (0)	0 (0)	0 (0)	35 (0)	21 (0)	56 (0)
8. Hatfield-The Vale Road between Magenta Road and Balranald-Ivanhoe Road	101 (10)	55 (10)	156 (58)	27 (12)	15 (12)	42 (80)
9. Link Road between Atlas-Campaspe Mine access and Marma Box Creek Road	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
10. Link Road between Atlas-Campaspe Mine access and Boree Plains-Gol Gol Road	101 (10)	55 (10)	156 (58)	62 (12)	36 (12)	98 (80)
11. Magenta Road between Boree Plains-Gol Gol Road and Hatfield-The Vale Road	101 (10)	55 (10)	156 (58)	27 (12)	15 (12)	42 (80)
12. Marma Box Creek Road between Link Road and Arumpo Road	0 (0)	0 (0)	0 (0)	38 (0)	20 (0)	58 (0)
13. Sturt Highway between Balranald and Mildura	38 (1)	20 (1)	58 (2)	0 (1)	0 (1)	0 (2)

Note: light vehicles (heavy vehicles)
[A] Refer to Figures 3.1 and 3.2
[B] Vehicle trips per hour (AM Peak Monday and Saturday, PM Peak Monday and Friday)
[C] Vehicle trips per day, Monday only

Table 6.1 and Table 6.2 indicate that the Modification would result in the following changes to daily traffic generated by the Project compared with that of the approved Project:

Busiest Days During Peak Construction Stage

- decrease of 160 light vehicle trips per day on that part of the road haulage route along Magenta Road, Hatfield-The Vale Road and Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road;
- decrease of 110 light vehicle trips per day on that part of the road haulage route along Link Road and Boree Plains-Gol Gol Road between the Atlas-Campaspe Mine access and the intersection of Boree Plains-Gol Gol Road with Magenta Road;
- decrease of 110 light vehicle trips per day along Balranald-Ivanhoe Road south of Boree Plains-Gol Gol Road and along Sturt Highway between Balranald and Mildura;
- increase of 110 light vehicle trips per day along the proposed local road route to Mildura via Link Road, Marma Box Creek Road and Arumpo Road; and
- increase of 50 light vehicle trips per day along Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road.

Busiest Days During Operational Stage

- decrease of 58 light vehicle trips per day on that part of the road haulage route along Link Road and Boree Plains-Gol Gol Road between the Atlas-Campaspe Mine access and the intersection of Boree Plains-Gol Gol Road with Magenta Road;
- decrease of 114 light vehicle trips per day on that part of the road haulage route along Magenta Road, Hatfield-The Vale Road and Balranald-Ivanhoe Road between Hatfield-The Vale Road and Boree Plains-Gol Gol Road;
- increase of 22 heavy vehicle trips per day on the road haulage route between the Atlas-Campaspe Mine access and the Ivanhoe Rail Facility access (Link Road, Boree Plains-Gol Gol Road, Magenta Road, Hatfield-The Vale Road and Balranald-Ivanhoe Road);
- decrease of 58 light vehicle trips per day along Balranald-Ivanhoe Road south of Boree Plains-Gol Gol Road and along Sturt Highway between Balranald and Mildura;
- increase of 58 light vehicle trips per day along the proposed local road route to Mildura via Link Road, Marma Box Creek Road and Arumpo Road; and
- increase of 56 light vehicle trips per day along Boree Plains-Gol Gol Road between Magenta Road and Balranald-Ivanhoe Road.

6.2 Future Traffic Volumes

6.2.1 Local Roads Routes

Based on the surveyed traffic volumes in 2012 (GTA Consultants, 2012), the local roads along the local roads route to and from the west via Arumpo Road, Marma Creek Box Creek Road and Link Road are expected to carry fewer than 35 vehicles per day. Similarly, Boree Plains-Gol Gol Road to Balranald-Ivanhoe Road is expected to carry fewer than 35 vehicles per day.

During peak construction, the modified Project would generate 110 vehicles per day on Mondays, along the local roads route to and from the west via Arumpo Road, Marma Creek Box Creek Road and Link Road. On Fridays and Saturdays, this would reduce to 56 and 54 vehicle trips per day respectively. On the remaining days, the modified Project would generate negligible traffic on this route.

Once operational, on the busiest 10 to 11 days of the year, the modified Project would generate some 58 vehicles per day on the local roads route to and from the west via Arumpo Road, Marma Creek Box Creek Road and Link Road. On an average day, this would reduce to fewer than 20 vehicles per day.

If Tronox was to operate a Project worker shuttle bus between the Atlas-Campaspe Mine and Buronga/Mildura or Balranald, the number of light vehicle trips on Link Road, Marma Box Creek Roads, Arumpo Road and Boree Plains-Gol Gol Road would reduce.

6.2.2 Road Haulage Route

The Modification would increase mineral concentrate transport from 48 to 70 heavy vehicles per day (two way) on the approved haulage route between the Atlas-Campaspe Mine and the Ivanhoe Rail Facility.

The surveyed traffic volume on Balranald-Ivanhoe Road south of Orange Broken Hill Railway in 2012 was an average of 35 vehicles per day (GTA Consultants, 2012), with background growth assessed at a rate of one percent per annum. EMM (2015) forecasts that the Balranald Mineral Sands Project will not generate any traffic on Balranald-Ivanhoe Road north of its intersection with Marma Box Creek Road.

Allowing for ten years of growth in background traffic, future traffic volumes on Ivanhoe-Balranald Road on the approved road transport route would remain well below 160 vehicles per day and fewer than 50 vehicles per hour in any one hour. The increased maximum haulage proposed with the Modification would have negligible impact on the future traffic volumes on the road transport route, representing an average increase of one vehicle trip per hour compared with the approved Project. This is well within the day-to-day variation in traffic volumes and would not have a perceivable impact on the level of service experienced by drivers along the route.

6.3 Impact on Travel Distances

The proposed alternative local road routes would reduce the travel distance for trips between the Atlas-Campaspe Mine and Mildura/Buronga or Balranald.

The proposed local roads route to the west of the Atlas-Campaspe Mine would reduce the road distance between the Atlas-Campaspe Mine and Mildura/Buronga by approximately 150 km, compared with using with approved route via Magenta Road, Hatfield-The Vale Road and Balranald. Over 12 months of operations of the Project, this represents a saving of over 1.7 million vehicle kilometres travelled (VKT) associated with the movement of employees and visitors between the Atlas-Campaspe Mine and Mildura/Buronga.

The proposed local roads route to the south via Boree Plains-Gol Gol Road would reduce the road distance between the Atlas-Campaspe Mine and Balranald by approximately 32 km, compared with using with approved route via Magenta Road, and Hatfield-The Vale Road. Over 12 months of operations of the Project, this represents a saving of over 400,000 VKT associated with the movement of employees and visitors between the Atlas-Campaspe Mine and Balranald, Sydney and Melbourne.

6.4 Ivanhoe Rail Facility Intersection

A preliminary design for the modified intersection has been prepared (Figure 3.3), the general layout of which has been reviewed by TTPP with regard to intersection operation and Austroads warrants for intersection treatments, discussed in this section.

6.4.1 Intersection Traffic Volumes

The operational Project-generated vehicle turning movements at the intersection with the Modification are described in Section 0 for the approved Project and in Section 5.2.3 for the modified Project. The impact of the Modification on those turning movements is negligible, being:

- an increase of 11 trips per day and one trip per hour by loaded haulage vehicles turning left from Balranald-Ivanhoe Road into the access road; and
- an increase of 11 trips per day and one trip per hour by empty (or backloaded MSP process waste) haulage vehicles turning right from the access road to Balranald-Ivanhoe Road.

The surveyed traffic volume on Balranald-Ivanhoe Road south of Orange Broken Hill Railway in 2012 was an average of 35 vehicles per day (GTA Consultants, 2012), with background growth assessed at a rate of one percent per annum. EMM (2015) forecasts that the Balranald Mineral Sands Project will not generate any traffic on Balranald-Ivanhoe Road past the Ivanhoe Rail Facility access.

6.4.2 Intersection Capacity

At unsignalised intersections with minor roads, where there are relatively low volumes of through and turning vehicles, capacity considerations are usually not significant, and detailed analysis of capacity is not warranted. Austroads (2009) indicates that as a guide, at volumes below the following combinations of maximum design hour volumes at a cross intersection with a two lane two-way road, capacity analysis is not necessary:

- major road 400 vehicles per hour, minor road 250 vehicles per hour;
- major road 500 vehicles per hour, minor road 200 vehicles per hour; and
- major road 650 vehicles per hour, minor road 100 vehicles per hour.

The proposed intersection of the Ivanhoe Rail Facility access road with Balranald-Ivanhoe Road is a T-intersection with fewer potentially conflicting movements than a cross intersection. The forecast peak period vehicle movements at the intersection are well below the threshold volumes, and as such, there is no capacity concerns anticipated at the intersection that would suggest additional capacity would be needed. The average delay to turning vehicles would be low, and the Level of Service experienced by drivers would be good. Formal analysis of the operation of the intersection is not warranted.

6.4.3 Intersection Treatment Warrants

Austroads (2017) sets out warrants for major road turn treatments for basic, auxiliary lane and channelised treatments at rural intersections. The warrants focus on safety performance, while operational performance may require a higher level treatment, although such is not required at the intersection of Balranald-Ivanhoe Road with the Ivanhoe Rail Facility access road (Section 6.4.2).

The peak hour number of vehicles turning from Balranald-Ivanhoe Road into the Ivanhoe Rail Facility with the modified Project would be up to four vehicles turning left in and up to three vehicles turning right in. For these turning volumes, and considering the volumes travelling past on Balranald-Ivanhoe Road, Austroads (2017) indicates that basic left (BAL) and basic right (BAR) turn treatments are warranted in Balranald-Ivanhoe Road at the Ivanhoe Rail Facility access intersection. This is the general minimum preferred treatment at rural road intersections.

The proposed intersection layout includes a rural BAL treatment on Balranald-Ivanhoe Road, with a widened shoulder which assists vehicles turning left to move further off the through carriageway, making it easier for through vehicles to pass a vehicle turning left into the Ivanhoe Rail Facility access road.

The proposed intersection layout includes a rural BAR treatment on Balranald-Ivanhoe Road, with a widened shoulder on Balranald-Ivanhoe Road that allows through vehicles, having slowed, to pass to the left of vehicles which are turning right into the Ivanhoe Rail Facility access road.

Although not addressed by the Austroads (2017) warrants, the BAL treatment on a minor road allows turning movements to occur from a single lane, with a shoulder that is too narrow to be used by left-turning vehicles, so as to prevent vehicles from standing two abreast at the holding line. These design features are preferred to safely manage the movement of vehicles in the high-speed rural environment. The proposed intersection layout includes such a BAL treatment on the Ivanhoe Rail Facility access road.

The proposed design for the intersection is consistent with the treatments warranted by Austroads (2017) and would be constructed with consideration of the swept path of the vehicles to be used for hauling mineral concentrates (Type 1 A-double road trains) and in accordance with Austroads design requirements. The design proposes all linemarking and signage be installed in accordance with AS 1742.2 (2009) and RMS guidelines.

6.5 Recommended Road Improvements

6.5.1 Local Roads Route

Desirable Geometric Road Standards

With the existing traffic volumes and traffic forecast to be generated by the Modification (Section 6.2.1) and its connectivity within the road network, the proposed unsealed roads on the route between Arumpo Road and the Atlas-Campaspe Mine are considered to be Class 4B (minor) roads under ARRB's (2009) classification system for unsealed roads. Class 4B roads are used for connections between local centres of population (in this case, the Atlas-Campaspe Mine) and the primary road network (Arumpo Road). Such roads may or may not be sealed depending on the importance and function of the road, taking into account the economic viability of sealing. They typically carry in the range of 50 to 150 vehicles per day (average daily traffic), and are all-weather two-lane roads formed and gravelled, or single-lane sealed roads with gravel shoulders.

The desirable standard and geometric characteristics for the unsealed local roads along the proposed route based on safety, costs and environmental considerations and in flat terrain (ARRB, 2009) are:

- operating speed 70 kilometres per hour (km/h);
- minimum carriageway width (lanes and shoulders) 7.0 m;
- minimum formation width (carriageway and verges) 9.0 m;
- minimum horizontal radius curve 250 m;
- minimum stopping sight distance 120 m;
- minimum vertical grade 6 per cent;
- minimum crossfall 5 per cent; and
- maximum superelevation 6 per cent.

It is understood that the BSC indicated that it adopts an operating speed of 90 km/h and a minimum horizontal radius curve of 500 m for its local road designs.

Comparing the desirable geometric road standards with the observed conditions (Section 4.2.2), it is evident that much of the route is likely to meet the desirable geometric standard for minimum carriageway width and formation width, and that the generally straight alignment and level terrain provides the required curve geometry and sight distances. Vertical grades, crossfalls and superelevations were not quantified by the observations.

The width of Link Road between Marma Box Creek Road and the Atlas-Campaspe Mine is narrower than the minimum carriageway and formation width requirements for a Class 4B unsealed road.

Road Surface Conditions

The observations of the existing condition of the proposed local roads route (Section 4.2.2) indicate that the condition of the road surface varies along the route, with notable issues being rutting, corrugations, loose material and some steep embankments. It is recommended that the road surface be improved as part of maintenance activities to establish a good riding surface with reduced dust emissions, and monitor and maintain the surface.

At the intersection of Balranald-Ivanhoe Road with Boree Plains-Gol Gol Road, it is recommended that the surface of Boree Plains-Gol Gol Road be sealed on its approach to the intersection, to reduce the likelihood of dust or gravel being transferred onto the high-speed carriageway of Balranald-Ivanhoe Road which can create a hazard for those vehicles.

Recommended Traffic Controls

It is recommended that additional guide posts with reflective markers be provided along the proposed local roads route in accordance with Australian Standard 1742.2 (2009) to enhance delineation of the path to be travelled in both daylight and night-time conditions. At minimum, installation of guide posts should be used in a consistent manner to mark locations where additional instruction about the road alignment is required (typically locations of culverts, tight curves, and across causeways). They should be installed at a uniform distance from the edge of the road formation, with a minimum clearance of 7.0 m between opposite guide posts.

The general alignment of the unsealed component of the local road route is straight, with few curves, noting that Boree Plains-Gol Gol Road has more curves than the other parts of the route. If required, curve warning signs are recommended on all approaches to any high risk sites. Any substandard curves should be delineated with curve alignment markers (CAMs) (D4-6) in accordance with AS1742.2 (2009).

Individual potential hazards may be signposted as appropriate, e.g., curve warning signs, crest warning signs, side road junction signs, and stock grid warning signs, noting that advisory speed signs should not be used along the unsealed roads.

At all stock grids, width marker signs (W4-3) should be located in accordance with AS1742.2, with the inner edges on the line of the vertical obstruction, indicating the width of the travel lane. GRID signs (W5-16) should also be used to warn of each stock grid on the road, and additional signage used in accordance with AS1742.2 if the grid is less than 5.0 m wide.

Give way control signage may not be required at the intersections between unsealed roads in remote areas, and it is generally considered that the priority at intersections along the route is clear from the road layouts. Sight boards should be installed to face the stem of a T-intersection where standard intersection signage would not provide adequate warning of the intersection. If the approach speed on the terminating leg is low, a bidirectional hazard marker (D4-2-3) may be used, otherwise two unidirectional hazard markers (D4-1-1) placed end to end should be used. Sight boards are provided at most intersections along the route, although not all are compliant with the requirements of AS1742.2.

6.5.2 Road Haulage Route

It is recommended that the road upgrade works required by Development Consent SSD_5012 (Section 2.2) be conducted along the road haulage route for the modified Project. These road upgrade works would be suitable for the modified Project traffic generation.

6.6 Road Haulage Road Maintenance

It is recommended that the existing contributions to the maintenance of the road haulage route required by Development Consent SSD_5012 (Section 2.2) be adopted for the modified Project. These road maintenance contributions will increase with the proposed increase in movement of mineral concentrate proposed as part of the Modification.

6.7 Road Safety Implications

With the implementation of the improvements along the local road routes described in Section 6.5, the Modification can be expected to have positive impacts on the safety of the road network and road users (including Project workers) compared with the approved Project, due to:

- reduced VKT by Project-generated light vehicles, reducing exposure to crash risks;
- reduced travel times for the Atlas-Campaspe Mine workforce residing in Mildura/Buronga and Balranald, reducing the risk of drivers either driving or working while fatigued; and
- improved road condition along local road routes for all road users with the recommended surface upgrades, maintenance and traffic controls.

Access to the Mungo National Park is available via Arumpo Road. As described above, the Modification is expected to have positive impacts on the safety of all road users on the road network (including Arumpo Road users) as it would include proposed road improvements (e.g. road surface improvements).

6.8 School Buses

It is anticipated that the TMP would address haulage management measures in the event that the road haulage route is used by school buses during the life of the Project. Such management measures may include some of the following:

- restricting haulage activity to outside the times and/or locations that school buses use the route;
- reducing haulage truck speeds during the hours and locations that the school buses use the route; and
- reducing haulage truck speeds while near to or passing a school bus.

The specific management measures would be most appropriately developed in consultation with school bus operators.

6.9 Railway Level Crossing

GTA (2012) considered the risk of the road and rail traffic interaction associated with the Project at the railway level crossing south of Ivanhoe and concluded:

> *As the total volume of road traffic through the road level crossing south of Ivanhoe would be relatively low and the Project would not generate additional rail traffic movements at this road level crossing, it is considered that the incremental risk of road and rail traffic interaction associated with the Project at this road level crossing would be low. No upgrades to the road level crossing are therefore required.*

As the Modification would not change Project-generated road or rail movements at the road level crossing south of Ivanhoe, it is considered that there would be no change to the risk of road and rail traffic interaction associated with the Project at this road level crossing and no upgrades to the road level crossing are therefore required.

6.10 Transport Management Plan

Tronox has prepared a TMP for the construction phase of the Project in accordance with Condition 9, Schedule 3 of Development Consent SSD_5012 (Section 0). It is recommended that the TMP be updated to incorporate the modified Project.

7 Conclusions

This study has examined the road transport implications of the proposed Modification. The study concludes that:

- subject to the implementation of the recommended road improvements, the proposed local roads routes would satisfactorily accommodate the Project-generated traffic;
- the Modification would reduce VKT associated with Project traffic, and have safety benefits for Project and other road users;
- the existing road haulage route road upgrades required by Development Consent SSD_5012 should be implemented for the modified Project;
- contributions to the road haulage route maintenance required by Development Consent SSD_5012 should be adopted for the modified Project;
- the following improvements to the local road routes should be implemented as part of ongoing road maintenance activities:
  - Link Road between Marma Box Creek Road and the Atlas-Campaspe Mine should be upgraded to meet the minimum carriageway and formation width requirements for a Class 4B unsealed road;
  - the road surface of relevant sections of the local road routes should be improved to establish a good riding surface with reduced dust emissions;
  - the surface of Boree Plains-Gol Gol Road should be sealed on its approach to its intersection with Balranald-Ivanhoe Road;
  - appropriate traffic control signs should be installed along the local road routes;
- the modified intersection of Balranald-Ivanhoe Road with the Ivanhoe Rail Facility access road is consistent with Austroads requirements for the expected traffic demands, and all linemarking and signage be installed in accordance with AS 1742.2 (2009) and RMS guidelines.
- the Project Transport Management Plan (CMA, 2018) should be updated to incorporate the modified Project.

Appendix A

Road Crash Data

Detailed Crash Report

Transport for NSW — Centre for Road Safety

Crash No.	Data Source	Date	Day of Week	Time	Distance		ID Feature	Loc Type	Alignment	Weather	Surface Condition	Speed Limit	No. of Tus	Tu Type/Obj	Age/Sex	Street Travelling	Speed Travelling	Manoeuvre	Degree of Crash-Detailed	Killed	Seriously Inj.	Moderately Inj.	Minor/Other Inj.	Uncateg'd Inj.	Factors S F
South West Region																									
Balranald LGA																									
Mungo																									
Turlee Leaghur Rd																									
1067212	P	14/04/2015	Tue	14:00	1.6 km	N	MARMA BOX CREEK RD	2WY	CRV	Fine	Dry	100	1	VAN	F54	N in TURLEE LEAGHUR RD	60	Proceeding in lane	SC	0	1	0	0	0	S
E57194937								RUM	86	Off left/left bend															
Wentworth LGA																									
Arumpo																									
Arumpo Rd																									
1108332	P	11/07/2016	Mon	18:00	500 m	E	PETRO MAIL RD	2WY	CRV	Fine	Wet	100	1	4WD	M43	E in ARUMPO RD	70	Proceeding in lane	OC	0	0	0	3	0	S
E61571004								RUM	88	Out of cont on bend															
1045763	P	04/10/2014	Sat	15:30	260 m	W	PETRO MAIL RD	2WY	CRV	Fine	Dry	100	1	CAR	M29	E in ARUMPO RD	80	Proceeding in lane	OC	0	0	0	1	0	S
E55898072								RUM	82	Off right/right bend															
1106536	P	21/06/2016	Tue	16:00	60 km	E	SILVER CITY HWY	2WY	STR	Fine	Wet	100	1	TRK	M63	E in ARUMPO RD	100	Proceeding in lane	OC	0	0	0	2	0	
E61706638								RUM	74	On road-out of cont.															
1071320	P	09/12/2014	Tue	18:20	31 km	N	SILVER CITY HWY	2WY	STR	Fine	Dry	100	2	CAR	M22	S in ARUMPO RD	Unk	Proceeding in lane	OC	0	0	0	1	0	
E57138267								RUM	30	Rear end				BDBL	M U	S in ARUMPO RD	30	Proceeding in lane							
Wentworth																									
Arumpo Rd																									
1185986	P	04/06/2018	Mon	13:00	50 m	E	WAMBERRA RD	2WY	CRV	Fine	Dry	100	1	M/C	M33	E in ARUMPO RD	40	Proceeding in lane	OC	0	0	0	1	0	S
E68781070								RUM	88	Out of cont on bend															
1047980	P	06/11/2014	Thu	16:00	600 m	E	WAMBERRA RD	2WY	STR	Unk	Dry	100	2	TRK	M50	W in ARUMPO RD	40	Proceeding in lane	OC	0	0	0	1	0	
E55686415								RUM	30	Rear end				BDBL	M64	W in ARUMPO RD	30	Proceeding in lane							

Report Totals: Crashes: 7 Fatal Crashes(FC): 0 Serious Injury Crashes(SC): 1 Moderate Injury Crashes(MC): 0 Minor/Other Injury Crashes(OC): 6 Uncategorised Injury Crashes(UC): 0 Non-Casualty Crashes(NC): 0

Killed(K): 0 Seriously Injured(S): 1 Moderately Injured(M): 0 Minor/Other Injured(O): 9 Uncategorised Injured(U): 0

Session dataset Balranald, Wentworth LGAs; all crashes for 2014, 2015, 2016, 2017, 2018 reporting years. Blue route

Note: *Data for the 9 month period prior to the generated date of this report are incomplete and are subject to change.*

Crash self reporting, including self reported injuries began Oct 2014. Trends from 2014 are expected to vary from previous yrs. More unknowns are expected in self reported data. Reporting yrs 1996-2004 & 2018 Q4 onwards contain uncategorised inj crashes.

Detailed Crash Report

Crash No.	Data Source	Date	Day of Week	Time	Distance	ID Feature	Loc Type	Alignment	Weather	Surface Condition	Speed Limit	No. of Tus	Tu Type/Obj	Age/Sex	Street Travelling	Speed Travelling	Manoeuvre	Degree of Crash-Detailed	Killed	Seriously Inj.	Moderately Inj.	Minor/Other Inj.	Uncateg'd Inj.	Factors	S	F
South West Region																										
Balranald LGA																										
Ivanhoe																										
Balranald Rd																										
1142710	P	25/05/2017	Thu	10:00		Unk Unk UNKNOWN UK	2WY	STR	Fine	Wet	100	1	M/C	M68	E in BALRANALD RD	80	Proceeding in lane	MC	0	0	1	0	0		
E64650657							RUM:	74	On road-out of cont.																	
Western Region																										
Unincorporated LGA																										
Broken Hill																										
Menindee Rd																										
1134648	P	16/04/2017	Sun	21:00	30 km E	BROKEN HILL TN	2WY	STR	Fine	Dry	100	1	4WD	M36	W in MENINDEE RD	100	Proceeding in lane	NC	0	0	0	0	0	S	F
E387969192							RUM:	74	On road-out of cont.																	
1069067	P	08/05/2015	Fri	18:00	65 km E	BROKEN HILL TN	2WY	STR	Fine	Dry	110	1	TRK	M22	W in MENINDEE RD	110	Proceeding in lane	MC	0	0	2	0	0		
E57575744							RUM:	74	On road-out of cont.																	
1174567	P	06/07/2018	Fri	17:00	18.5 km S	HOLTON DR	2WY	STR	Fine	Dry	110	1	4WD	M57	N in MENINDEE RD	110	Proceeding in lane	FC	1	0	1	0	0		F
E68689743							RUM:	70	Off road to left																	

Report Totals: Crashes: 4 Fatal Crashes(FC): 1 Serious Injury Crashes(SC): 0 Moderate Injury Crashes(MC): 2 Minor/Other Injury Crashes(OC): 0 Uncategorised Injury Crashes(UC): 0 Non-Casualty Crashes(NC): 1

Killed(K): 1 Seriously Injured(S): 0 Moderately Injured(M): 4 Minor/Other Injured(O): 0 Uncategorised Injured(U): 0

Session dataset Balranald, Unincorporated, Wentworth LGAs; all crashes for 2014, 2015, 2016, 2017, 2018 reporting years. orange route

Note: *Data for the 9 month period prior to the generated date of this report are incomplete and are subject to change.*

Crash self reporting, including self reported injuries began Oct 2014. Trends from 2014 are expected to vary from previous yrs. More unknowns are expected in self reported data. Reporting yrs 1996-2004 & 2018 Q4 onwards contain uncategorised inj crashes.

Appendix B

Existing Road Conditions

Arumpo Road – from Silver City Highway to Marma Box Creek Road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
0	11.7	11.7	Asphalt	Sealed, good condition, well maintained, centre line marking and guide posts used.	80	6.6	10-13	A sign-posted speed limit is provided once along Arumpo Road proximal to the intersection with Silver City Highway. The speed along the road is restricted to 80km/hr. Below is an image of the general road conditions for this section of Arumpo Road.
11.7	16.9	5.2	Asphalt	Surface becomes rougher		6.6	10	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
16.9	19	2.1	Asphalt	Continues as above.		6.6	8-10	Stock grid 6.6 m wide

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
19	24.5	5.5	Asphalt	No line-marking Signposted prior to end of seal "CAUTION ROAD SURFACE CONDITIONS VARY"		6.6	8-10	 End of sealed road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
24.5	25.9	1.4	Gravel for initial 50 m, then transitions to primarily dirt	Poor, rough, unsealed road cambers to the centre, with rutting and corrugations along vehicle paths. The rutting can influence vehicle direction and veer vehicles off a straight path if close attention is not made to the shape of the road. Smaller vehicles may be subject to scraping as the ruts can lower the vehicle to the ground. Some dust raised by passing vehicles, but visibility maintained.	No sign-posted speed limit	-	12-15	Sign posted warning: roads cannot be used when wet, fines apply. TTPP intentionally drove along the positive mounds (crests created by the ruts/troughs) along this section to prevent scraping the underside of the car, or avoided the visible tyre paths altogether and drove closer to the centre of the road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
25.9	27.1	1.2	Gravel and dirt	Road flattens out, harder surface, finer gravel with some dirt sections showing truck tyre paths	N/A	-	12	
27.1	28.3	1.2	Gravel, dirt, hard clay	Continues as above	N/A	-	12	
28.3	28.8	0.5		Continues as above	N/A	-	15	Stock grid ~7m wide
28.8	29.3	0.5		Road becomes lumpy and dusty, truck tyre paths with ruts can be seen in the road	N/A	-	15	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
29.3	33.9	4.6		Centre of road flattens out, with lumpy sections along the shoulders. Truck tyre paths are visible.	N/A	-	15 with some sections narrowing to 12	
33.9	42.1	8.2		Road becomes harder with intermittent loose gravel/dirt sections and harder clay, gravel sections, with a particularly rough section.	N/A	-	12	Dust raised by a passing B99 and a passing truck and dog while driving along this section restricted visibility, TTPP had to slow and wait for the dust to clear before proceeding.

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
42.1	45.8	3.7	Primarily dirt with some loose gravel	Visible rutting and corrugations	N/A	-	12	
45.8	46.5	0.7	Sand/dirt	Road becomes quite sandy and lumpy with visible rutting	N/A	-	15-20	
46.5	47.6	1.1	Sand/ hard clay, dirt	Road flattens out temporarily with dirt/sand sections on the shoulders.	N/A	-	-	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
47.6	54	6.4	Hard clay, gravel	Road becomes harder and flatter	N/A	-	-	
54	61.5	7.5		Continues as above	N/A	-	-	Stock grid @ 54 km, on short length of seal, width does not allow for two vehicles to pass

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
61.5	73	11.5	Hard clay, sand and gravel	Some rocky sections, primarily flat with sections showing visible rutting. There is a some particularly rough sections along this part of the route	N/A	-	-	Stock grid @ 61.5km, width does not allow for two vehicles to pass Wider stock grid with a wet weather warning sign provided along the section: Road signs are given close to the intersection of Arumpo and Marma Box Creek Road

Marma Box Creek Road – from Arumpo Road to Link Road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
0	0.3	0.3	Dirt road with gravel	Road is lumpy and rocky on approach to the stock grid	N/A	N/A	7	Some road signs have poor visibility and are not standing upright Stock grid @ 0.3 km
0.3	3.1	2.8	Hard clay	Road flattens out	N/A	N/A	7	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
3.1	5.1	2	Hard clay, gravel and sand	Road becomes gravellier with some sandy sections				
5.1	6.1	1	Primarily sand with hard clay	Road becomes smoother (less gravel)			7-10	Road detour past single-lane stock grid

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
6.1	7.6	1.5	Gravel and sand	Road becomes very gravelly with some sand			7-10	Some rocks were observed, which could puncture the tyres
7.6	14.8	7.2	Hard clay and gravel	Road is primarily hard clay with loose gravel with some notably rough sections immediately before and after stock grids.			10	Stock grid @ 7.6km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
14.8	15.7	0.9	Hard clay and gravel	Road becomes very gravelly			10	Stock grid @ 15.7km
15.7	18.7	3	Hard clay and gravel	Continues as above			10	
18.7	20.1	1.4	Hard clay and gravel	Mix of very gravelly sections and smoother sections			10	Stock grid @ 20.1 km
20.1	29.4	9.3	Hard clay and gravel	Continues as above			10	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
29.4	33.8	4.4	Hard clay, gravel and sand	Road becomes sandier and there is corrugations and visible rutting along wheel paths. There are intermittent sections of hard clay with occasional gravel sections.			7-15	
33.8	36.4	2.6	Hard clay and sand	Road becomes sandier but primarily hard clay			10	Stock grid @ 36.4km
36.4	37	0.6	Hard clay and gravel	Road becomes gravellier			10	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes and Photos
37	39	2	Hard clay, gravel and sand	Road is very sandy initially then transitions to gravelly clay			7-11	

Link Road – from Marma Box Creek Road to Boree Plains Road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
0	1.3	1.3	Hard clay and gravel and dirt	Road is significantly narrower than both Arumpo and Marma Box Creek Roads. Initial 50 m is some 10 m wide, narrowing to 5-6 m thereafter, with visible rutting.			5-10	
1.3	1.7	0.4	Hard clay, gravel and dirt	Road widens out, lumpy with gravel			8	

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
1.7	8.9	7.2	Hard clay and gravel	Coarser gravel with some sandy sections.			10	
8.9	10	1.1		Road becomes more gravelly and rougher/bumpier			10	Stock grid @ 8.9 km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
10	13.4	3.4		Some lumpy rough sections created by the rutting and due to rocks on the road			10	Stock grid @ 13.4 km
13.4	15.9	2.5		Continues as above			10	Mine entrance on left in this section
15.9	16.5	0.6	Hard clay, gravel and dirt	Road is gravelly and hard with lots of broken rock. Road condition is very poor around the mine access			10-12	
16.5	20.7	4.2	Hard clay, gravel and dirt	Lumpy, gravelly road, flatter than previous section. Some sections have very poor conditions similar to the mine access.			7-10	TTPP drove on the right hand side of the road along some sections to avoid the ruts

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
20.7	21	0.3		Road is very gravelly and bumpy on approach and exit of stock grid.				

Boree Plains Road – Link Road to Boree Plains Road

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
0	0.1	0.1	Hard clay and gravel	Hard clay, gravelly flat road			10	
0.1	2	1.9	Hard clay, gravel and dirt	Continues as above			12	Stock grid @ 0.1km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
2	5	3	Hard clay, gravel and dirt	Road becomes harder and flatter, with minimal gravel for some sections			7-10	
5	6	1		Continues as above			7-10	Stock grid @ 5km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
6	8.3	2.3		Road becomes very gravelly with rocks				
8.3	10.1	1.8		Continues as above			10	Stock grid @ 8.3km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
10.1	10.5	0.4		Continues as above			10	Stock grid @ 10.1 km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
10.5	13.2	2.7		Road is flatter in some sections and has visible rutting			10	 Stock grid @ 12.1km

Section Start (km)	Section End (km)	Section Length (km)	Road Type	Road Condition	Posted Speed Limit (km/h)	Road Width (m)	Unsealed Road Width (m)	Notes
13.2	18	4.8		Road narrows at curves in the road. Some sections of road have visible wheel paths which have created ruts			10-15	Stock grid @ 17.9km

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APPENDIX B

AIR QUALITY REVIEW

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX B

AIR QUALITY REVIEW

TRONOX

katestone
www.katestone.com.au

16 July 2019

Attn: Haakon Nielssen

Tronox Mining Australia Limited
PO Box 4032
MILDURA VIC 3502

Re: Air Quality Review for the Atlas-Campaspe Mineral Sands Project Optimisation Modification

Dear Haakon,

Katestone has prepared an Air Quality Review for the proposed Atlas-Campaspe Mineral Sands Project Optimisation Modification. The Air Quality Review of the potential air quality impacts associated with the Modification is based on:

- A review of the existing air quality monitoring in the vicinity of the Atlas-Campaspe Mine
- A comparison of dust emissions for the modified Project with the information presented in the existing Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project.

The Air Quality Review found that the Modification is unlikely to alter the outcomes of the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project and the modified Project would not contribute to any additional exceedances of the relevant air quality criteria at any sensitive receptors in the vicinity of the Project.

Please contact the undersigned on (07) 3369 3699 if you would like to discuss the review.

Yours sincerely,

Tania Haigh – Senior Air Quality Consultant

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1. INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (Figure 1).

The Project will integrate with currently existing/approved Tronox operations in western NSW, including (Figure 1):

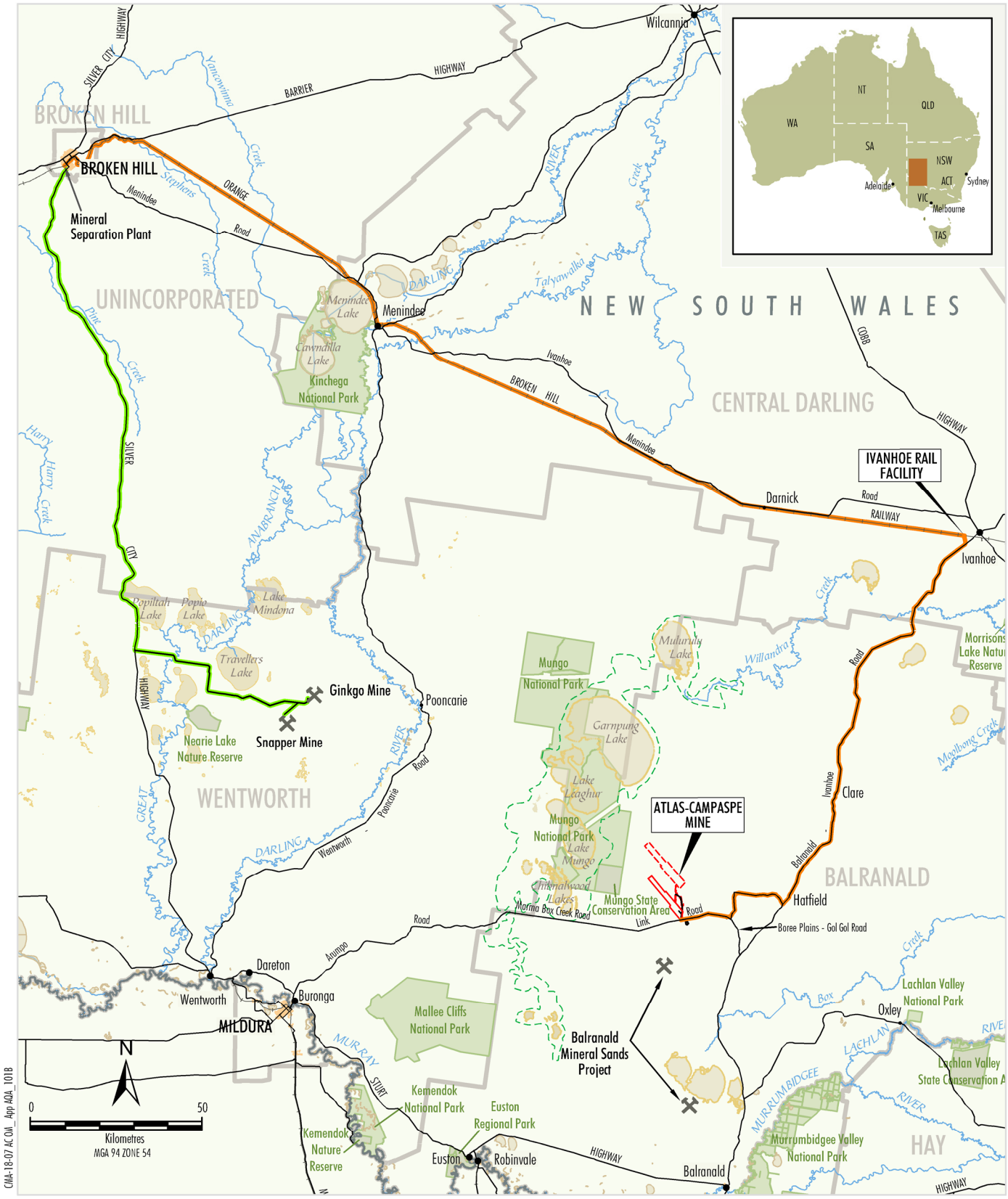
- the MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

This Air Quality Review has been prepared to support the application to modify Development Consent (SSD 5012) for the Project.

2. OVERVIEW OF THE MODIFICATION

Tronox proposes to modify Development Consent (SSD 5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would include:

- The option to use an overland conveyor to transfer overburden in addition to haul trucks;
- Increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- Increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- Increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- Use of local roads other than the road haulage route by Project-related light vehicles to access site (Figure 1);
- The option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets (Figure 2);
- Development of an emergency airstrip at the Atlas-Campaspe Mine (Figure 2);
- Relocation of the accommodation camp (inside the approved surface development area) (Figure 2);
- Construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- Increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- Extension to the Ivanhoe Rail Facility hardstand area (Figure 3);
- Extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection (Figure 3); and
- A groundwater supply for the Ivanhoe Rail Facility (Figure 3).



LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

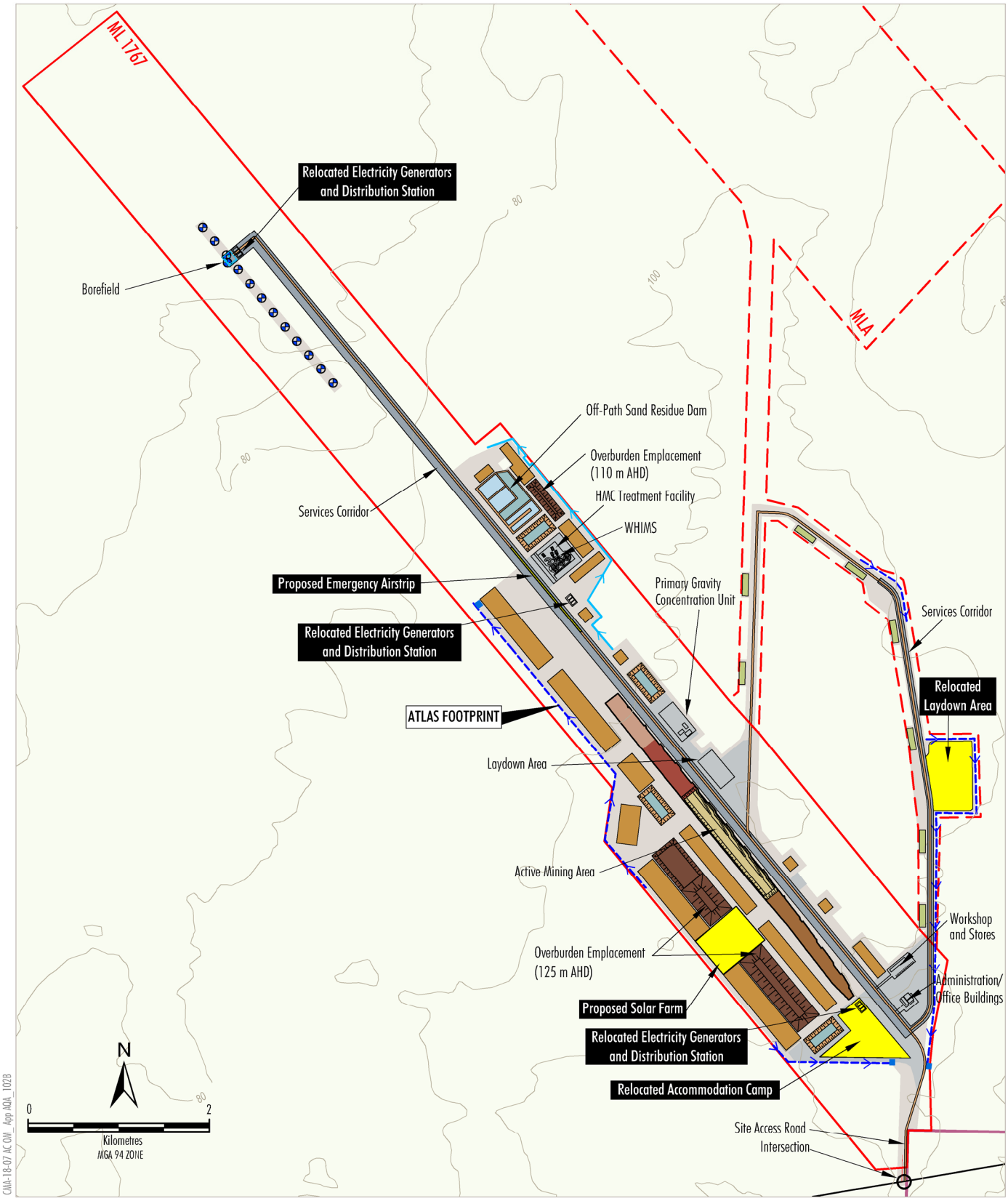
TRONOX

OPTIMISATION MODIFICATION

Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1



Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012) and Tronox (2019)

LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Exploration Licence Boundary (EL)
- Up-catchment Diversions
- Collection Drains
- Bore
- Approximate Extent of Surface Development - Year 2
- Fixed Infrastructure Areas
- Soil Stockpile
- Process Water Storage
- Overburden Emplacement
- Stage 1 Rehabilitation - Stabilised Landform with Seed/Cover Crop Application

Active Mining Area

- Vegetation Clearance/Soil Stripping
- Overburden Removal
- Ore Zone/Extraction Area
- Overburden Replacement/Process Waste Emplacement/Soil Replacement
- Sediment Basin

ACMSP Modification

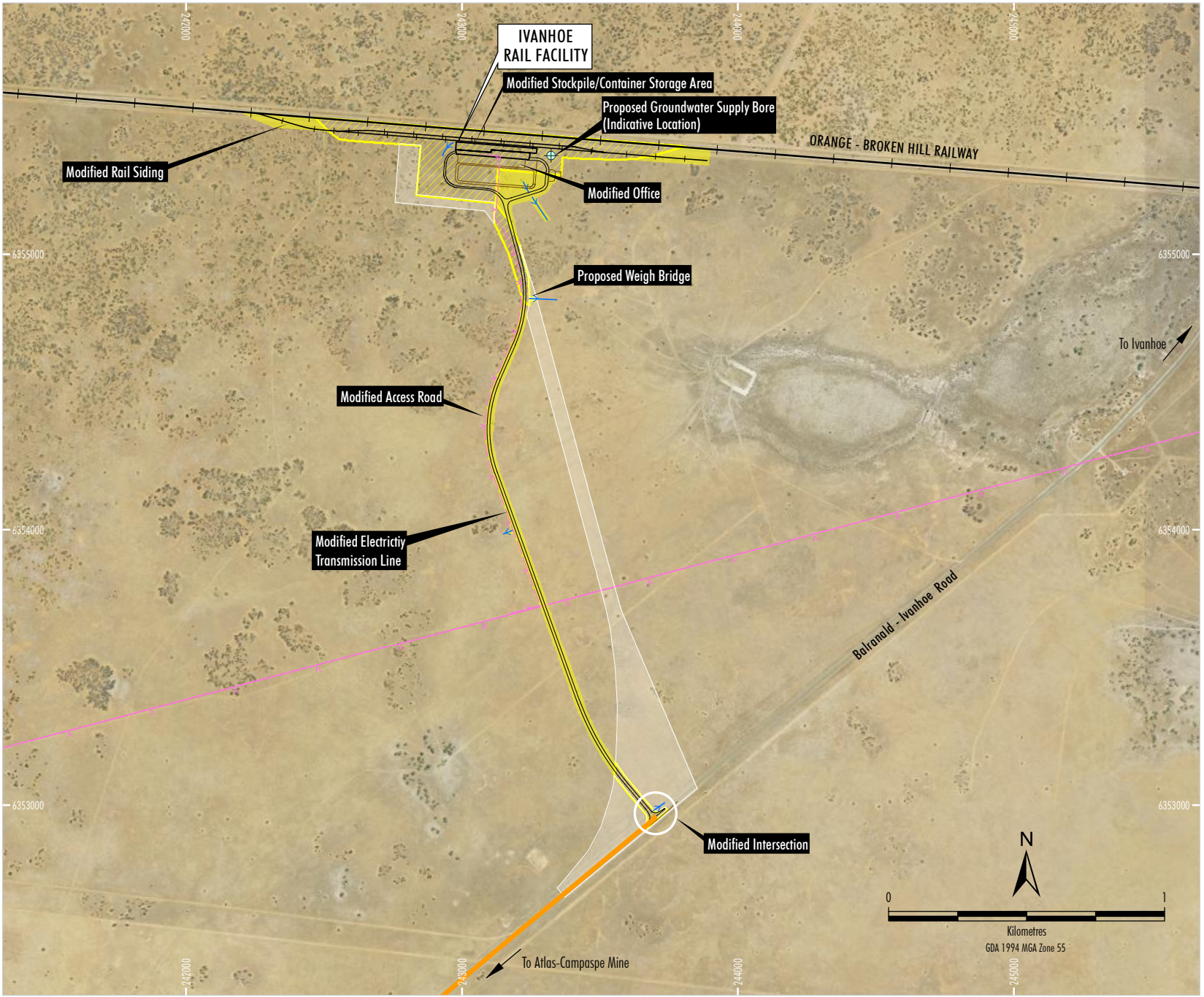
- Modification Surface Development Area

TRONOX

OPTIMISATION MODIFICATION

Modified Atlas-Campaspe Mine
General Arrangement - Year 2

Figure 2



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 3

CMA-18-07 AC OM_ App AQA_201C

The Modification would not change the following components of the Project:

- Mine path or mine life;
- Mining method;
- Mineral concentration methods;
- Overburden and ore extraction rate;
- Sand residue, coarse reject and process waste placement management;
- Annual maximum water supply/demand;
- Rehabilitation works;
- Biodiversity offset area; or
- Workforce.

3. RELEVANT AIR QUALITY CRITERIA AND PERFORMANCE MEASURES

3.1 RELEVANT AIR QUALITY GUIDELINES

The Air Quality and Greenhouse Gas Assessment for the approved Project (Katestone Environmental, 2013) was prepared in accordance with the (now) superseded *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (NSW Department of Environment and Conservation [DEC], 2005) (Section 6).

Subsequent to the grant of Development Consent (SSD_5012), the *Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales* (Environment Protection Authority [EPA], 2017) (Approved Methods) were introduced, which lists the statutory methods and air quality criteria that are to be used to model and assess emissions and impacts of air pollutants from stationary sources in NSW. The Approved Methods (EPA, 2017) introduced criteria for $PM_{2.5}$, and a reduced annual average PM_{10} criterion of 25 µg/m^3.

Ambient air quality in each state in Australia must be monitored and reported against the standards and goals defined in the *National Environment Protection (Ambient Air Quality) Measure 1998* (Air NEPM) (National Environment Protection Council [NEPC], 2016). Whilst these standards exist to evaluate ambient air quality, rather than the potential impact of an individual Project, they have been considered here for completeness.

3.2 DEVELOPMENT CONSENT (SSD 5012)

Air quality criteria are provided in Condition 19, Schedule 3 of Development Consent (SSD_5012). These conditions are reproduced below.

Air Quality Criteria

The Applicant shall ensure that all reasonable and feasible avoidance and mitigation measures are employed to ensure particulate matter emissions generated by the development do not exceed the criteria in Table 5, 6 and 7 at any residence on privately-owned land.

Table 5: Long term impact assessment criteria for particulate matter

Pollutant	***Averaging Period***	***[d]Criterion***
Total suspended particulate (TSP) matter	*Annual*	*[a] 90 µg/m^3*
Particulate matter < 10 µm (PM_{10})	*Annual*	*[a] 30 µg/m^3*

Table 6: Short term impact assessment criterion for particulate matter

Pollutant	***Averaging Period***	***[d]Criterion***
Particulate matter < 10 µm (PM_{10})	*24 hour*	*[a] 50 µg/m^3*

Table 7: Long term impact assessment criteria for deposited dust

Pollutant	Averaging Period	Maximum increase in deposited dust level	[d]Criterion
[c]Deposited Dust	Annual	[b] 2 g/m^2/month	[a] 4 g/m^2/month

Notes to Tables 5-7:

a Total impact (i.e. incremental increase in concentrations due to the development plus background concentrations due to all other sources);

b Incremental impact (i.e. incremental increase in concentrations due to the development on its own);

c. Deposited dust is to be assessed as insoluble solids as defined by Standards Australia, AS/NZS 3580.10.1:2003: Methods for Sampling and Analysis of Ambient Air - Determination of Particulate Matter - Deposited Matter - Gravimetric Method; and

d. Excludes extraordinary events such as bushfires, prescribed burning, dust storms, fire incidents or any other activity agreed by the Secretary.

The air quality related operating conditions are detailed in Condition 20, Schedule 3 of Development Consent (SSD_5012) and reproduced below.

Operating Conditions

The Applicant shall:

a) implement all reasonable and feasible measures to minimise off-site odour, fume, dust and greenhouse gas emissions of the development;
b) minimise any visible off-site air pollution generated by the development;
c) minimise the surface disturbance of the site;
d) operate an air quality management system that uses dust deposition gauges to monitor the performance of the development and implement air quality mitigation measures to ensure compliance with the relevant condition of this consent; and
e) minimise the air quality impacts of the development during adverse meteorological conditions and extraordinary events (see note d under Table 7),

to the satisfaction of the Secretary.

3.3 ENVIRONMENT PROTECTION LICENCE 21007

Tronox holds Environment Protection Licence (EPL) 21007 issued under the NSW *Protection of the Environment (Operations) Act 1997* (POEO Act) for the Project. Although EPL 21007 does not include air quality criteria, Condition M2.2 of EPL 21007 does identify six locations in the vicinity of the Atlas-Campaspe Mine site where dust deposition monitoring must be conducted on a monthly basis, and one location in the vicinity of the Atlas-Campaspe Mine site where a high-volume air sampler is to be operated to monitor PM_{10} and TSP every six days.

Operating conditions relevant to air quality are provided in Conditions O3 and O4 of EPL 21007:

O3 Dust

O3.1 All operations and activities occurring at the premises must be carried out in a manner that will minimise the emission of dust from the premises.

O3.2 Trucks entering and leaving the premises that are carrying loads must be covered at all times, except during loading and unloading.

O3.3 The premises must be maintained in a condition which minimises or prevents the emission of dust from the premises.

3.4 SUMMARY OF AIR QUALITY CRITERIA

Air quality criteria relevant to the Project are reproduced in Table 1.

Table 1 Particulate and dust deposition monitoring criteria for the Project

Pollutant	Averaging Period	Criterion	Source
TSP	Annual	90 µg/m^3	Development Consent, Approved Methods
PM_{10}	24-hour	50 µg/m^3	Development Consent, Approved Methods, Air NEPM
	Annual	30 µg/m^3	Development Consent
	Annual	25 µg/m^3	Approved Methods, Air NEPM
$PM_{2.5}$	24-hour	25 µg/m^3	Approved Methods, Air NEPM
	Annual	8 µg/m^3	Approved Methods, Air NEPM
Deposited dust	Annual	2 g/m^2/month (incremental)	Development Consent, Approved Methods
	Annual	4 g/m^2/month (total)	Development Consent, Approved Methods

4. EXISTING AIR QUALITY MANAGEMENT

Air quality management at the Project is undertaken in accordance with the Air Quality Management Plan (AQMP) (Cristal Mining Australia [CMA], 2018). The AQMP was prepared in accordance with Condition 21, Schedule 3 of Development Consent (SSD 5012) and includes:

- A description of the key sources of emissions
- Relevant air quality criteria applicable to the Project
- Air quality management measures for the Project
- Air quality monitoring program components
- A contingency plan to manage any unpredicted impacts and their consequences.

Table 2 provides a summary of the air quality management measures and controls included in the AQMP.

Tronox have advised that no air quality-related complaints have been received to date.

Table 2 Air Quality Management Measures and Controls

Project Phase	Management Measure
Construction	• Regular watering of roads and exposed areas to reduce wheel-generated dust and restricting vehicle speeds. • Dust-generating activities such as earthworks will not be carried out during high wind conditions (greater than 10 m/s). • Establishment of vegetation on stockpiled materiel material to prevent wind erosion. • Minimisation of haul trips and trip distances, where practicable. • Erecting physical barriers such as bunds and/or wind breaks around stockpiles or areas where earth moving is required, where practicable. • Earth moving activities will be avoided during unfavourable meteorological conditions, where practicable. • Minimising speed (speed limit of 40 kilometres per hour) of on-site traffic, where applicable, to minimise wheel generated dust.
Operational (Atlas-Campaspe Mine site)	• Watering of exposed haul roads within the active mining area. • Watering during topsoil removal. • Progressive rehabilitation of exposed areas. • Control of truck speeds. • Minimisation of travel speed and distance travelled for bulldozing.
Operational (mineral concentrate transport route)	• All vehicles transporting mineral concentrate from the Atlas-Campaspe Mine site will be covered to minimise potential losses. • All rail wagons transporting mineral concentrate along the Orange-Broken Hill Railway will be covered to minimise potential losses. • All MSP process waste transport will be undertaken in sealed containers.

Source: CMA (2018).

5. EXISTING AIR QUALITY ENVIRONMENT

5.1 SENSITIVE RECEIVERS

The Boree Plains residence (Tronox owned) is the closest residence to the Atlas-Campaspe Mine footprint and is located approximately 7 km away from the Campaspe deposit and approximately 18 km away from the Atlas deposit (where Project activities are occurring) (Figure 4). Other rural residences (e.g. Marona, Glen Tilt, Magenta and Langleydale) are located at least 14 km away from the Atlas-Campaspe Mine footprint (Figure 4).

The nearest receptors to the mineral concentrate transport route are located approximately 800 m (Magenta) and 1,300 m (Langleydale) from the unsealed sections of the haul road (Figure 4).

The township of Ivanhoe is representative of the closest residential area to the Ivanhoe Rail Facility. The Ivanhoe Rail Facility is located approximately 4.5 km from Ivanhoe (Figure 3).

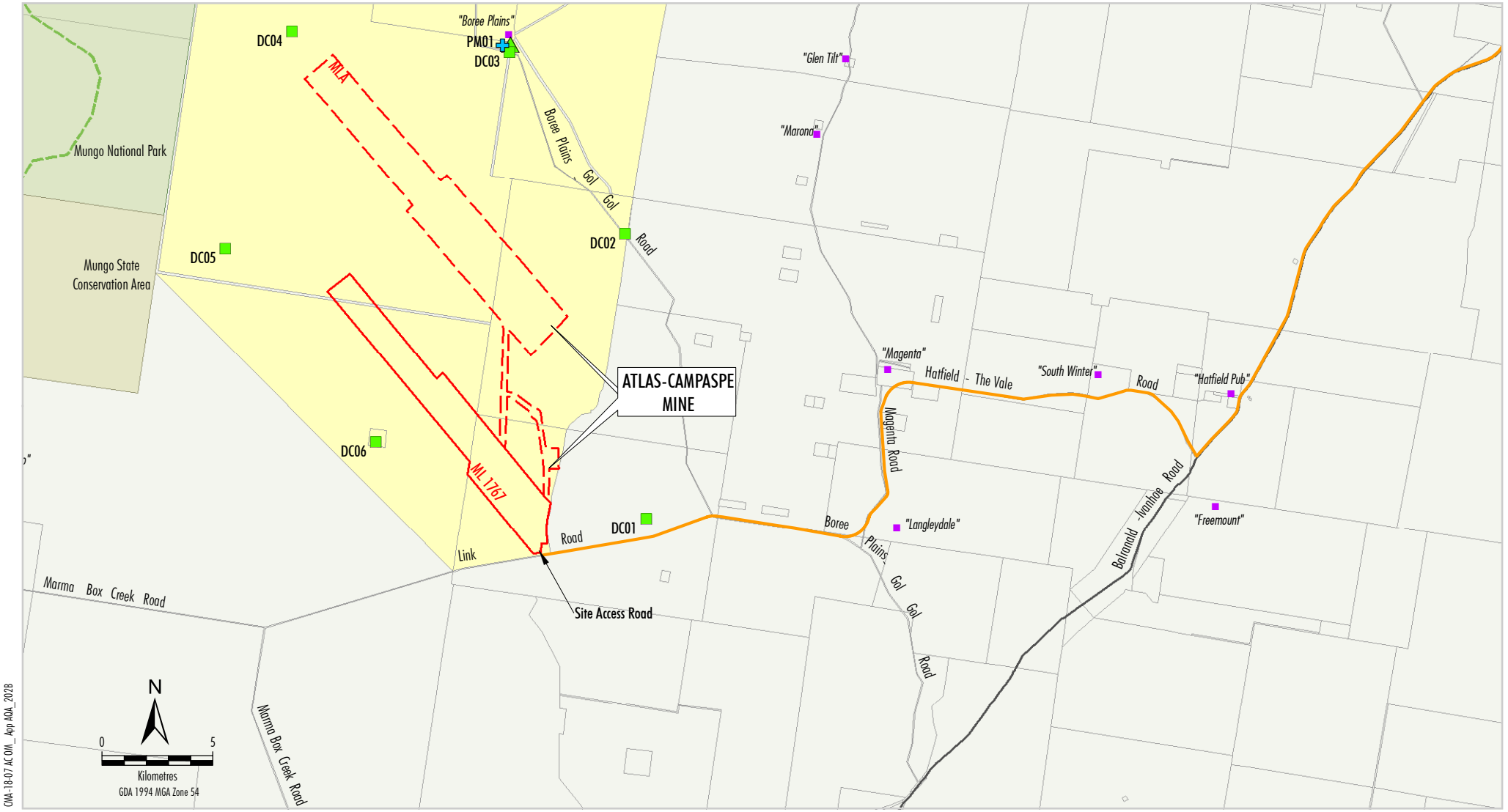
5.2 AIR QUALITY MONITORING

Tronox operates a network of dust deposition gauges (DC01 to DC06), as well as a high volume air sampler (HVAS) (PM01) (Figure 4) in accordance with the AQMP.

A summary of the air quality monitoring results is provided below.

Particulate Monitoring

PM_{10} and TSP are monitored using a high-volume sampler on a 1-in-6 day schedule. The high-volume sampler is located near the sensitive receptor (i.e. Boree Plains – Figure 4) with the highest predicted ground-level concentrations due to the Atlas-Campaspe Mine site operations in the Air Quality Assessment (Katestone Environmental, 2013). The TSP concentration is calculated based on the PM_{10} measurement applying a PM_{10}/TSP ratio of 0.67.



LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Automatic Weather Station
- Dust Gauge Location
- PM_{10} /TSP Monitoring Site

Source: © NSW Department of Finance, Services & Innovation (2018)
Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Atlas-Campaspe Mine
- Air Quality Monitoring Sites

Figure 4

Table 3 summarises the PM_{10} monitoring data collected between 4 September 2018 and 8 February 2019. Figure 5 shows PM_{10} monitoring data over the same period. Measurements reported on 22 and 28 December 2018 and 3 January 2019 were identical, as were the two measurements reported on 15 and 25 January 2019. Tronox advised this was due to the filter paper not being changed during these periods and the single sample result has been reported for each sampling period.

Table 3 Summary of PM_{10} monitoring data from the Project site collected to date

Parameter	Number of samples*	Maximum 24-hour average (µg/m³)	Number of measurements > 50 µg/m³	Average (µg/m³)
PM_{10}	27	242.0	9	45.8
PM_{10} – excluding measurements known to have been recorded during periods with dust storms	25	89.3	7	33.8
Criterion	**-**	**50.0**	**-**	**25/30**

Table note:

* Measurements reported on 22 and 28 December 2018 and 3 January 2019 were identical, as were the two measurements reported on 15 and 25 January 2019. Tronox advised that this was due to the filter paper not being changed during these periods and a single sample result reported for each sampling period.

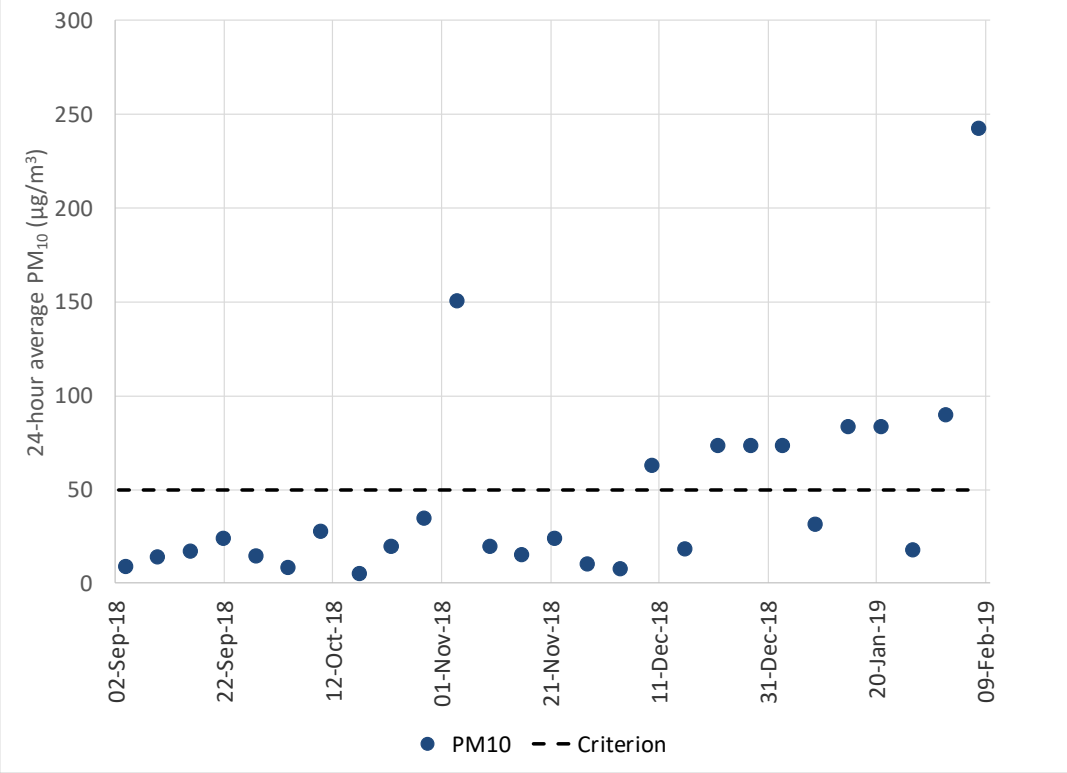


Figure 5 24-hour average PM_{10} concentrations measured at PM01

Twenty-four hour average PM_{10} measurements recorded at PM01 exceeded the Development Consent (SSD 5012) 24-hour PM_{10} criterion of 50 µg/m^3 on a total of nine days during this period (Table 3 and Figure 5).

It is expected that natural sources of wind-blown dust are likely to contribute to ambient concentrations in the region. This is particularly due to the location and proximity of the Project to nearby ephemeral lakes, which can be a considerable source of dust in dry periods. Significant amounts of silt can be deposited into these lakes as rain water drains into them, and after the surface dries this material becomes available to be swept up by the wind (Katestone Environmental, 2013). These conditions are expected to be currently present as 2018 was the sixth-driest year on record in New South Wales since 2002 (BoM, 2019a) and the warmest year on record. Whilst above average monthly rainfall was recorded for the state during October and November, overall rainfall measured in western New South Wales was below average for the year. Summer 2018-2019 was also a record warm summer with very dry conditions across the state, and a number of dust storms occurred during the period (BoM, 2019b). Meteorological monitoring stations in western New South Wales, including at Broken Hill Airport, measured higher than average maximum and minimum temperatures and low to average rainfall during summer. Dust storms were noted by Tronox at the site on 4 November 2018 and 8 February 2019.

In addition, as PM01 is located approximately 18 km north of current Project activities, it is expected that other closer sources in the region such as wind-blown dust are contributing to particulate matter levels at PM01.

Daily average meteorological data recorded at the on-site monitoring station indicates that the winds on most exceedance days were from southerly directions, which is the predominant wind direction at the Project site, particularly during summer. During southerly winds, the monitoring station would be downwind of the Atlas-Campaspe Mine site.

Whilst there is not a full year of data available to calculate an annual average, the average of the data collected to date shows that the average PM_{10} concentration recorded to date is 45.8 µg/m^3 based on all data (and 33.8 µg/m^3 excluding dates on which dust storms occurred). This is above the Development Consent (SSD 5012) annual average PM_{10} criterion of 30 µg/m^3 and the Approved Methods criterion of 25 µg/m^3 (Table 1).

The average TSP concentration calculated to date is 68.7 µg/m^3, which complies with the air quality criteria of 90 µg/m^3.

Given the elevated PM_{10} measurements recorded during the construction period, consideration could be given to additional PM_{10} monitoring to determine the contribution of activities at the Atlas-Campaspe Mine site to measured concentrations. For example, one additional PM_{10} monitoring station on the southwestern side of the Atlas-Campaspe Mine may assist in distinguishing the likely contribution of elevated ambient background concentrations and on-site activities to elevated PM_{10} measurements.

Dust Deposition Monitoring

Figure 6 presents the monthly dust deposition measurements from the six monitoring sites collected between January 2018 to February 2019. Also shown for comparison on Figure 6 is the guideline of 4 grams per square meter per month (g/m^2/month); however, it should be noted this applies to the annual average, not monthly dust deposition rates. Rolling annual averages for the available period are presented in Table 4, and these are well below the guideline of 4 g/m^2/month.

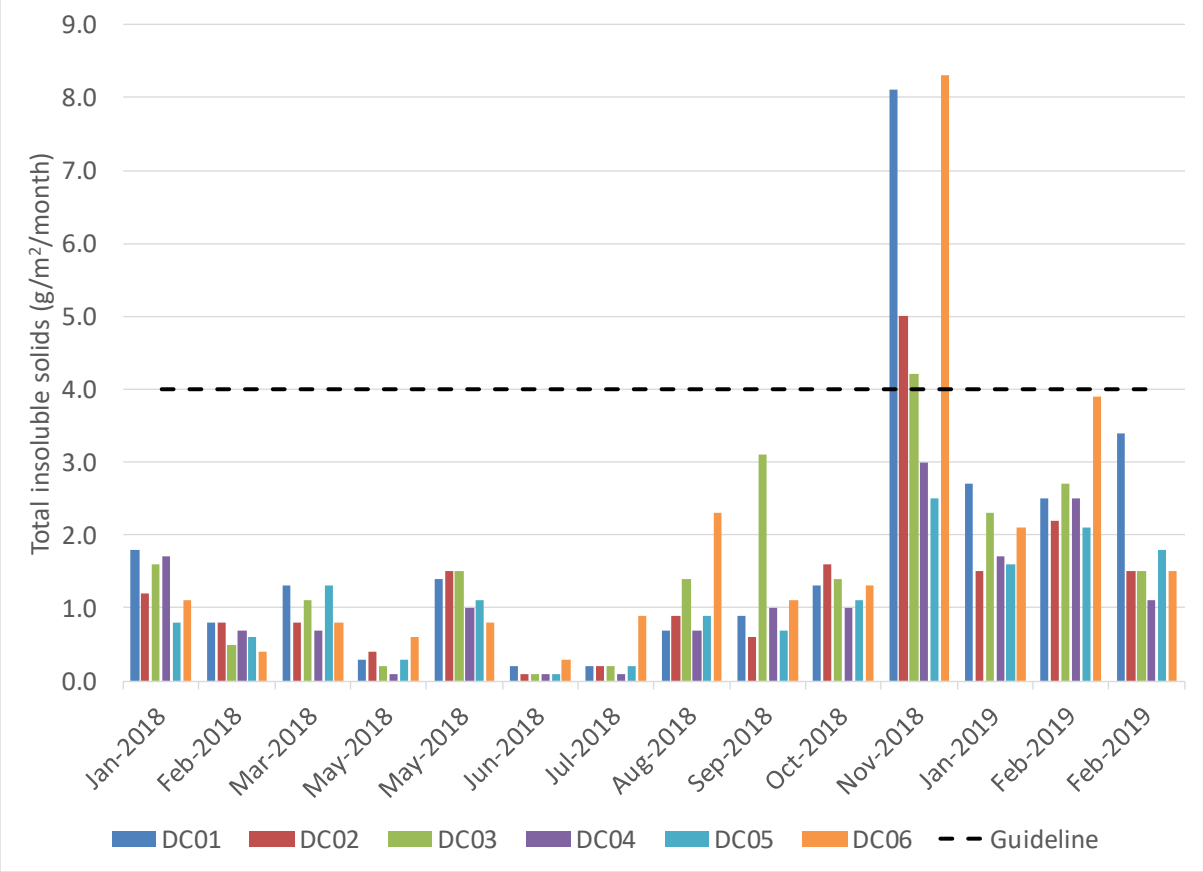


Figure 6 **Monthly dust deposition measurements**

Table 4 **Annual average dust deposition measurements**

Date	12-month average dust deposition (g/m²/month)					
	DC01	DC02	DC03	DC04	DC05	DC06
24-Jan-2018 – 9-Jan-2019	1.6	1.2	1.5	1.0	0.9	1.7
16-Feb-2018 – 5-Feb-2019	1.7	1.3	1.6	1.1	1.0	1.9
27-Mar-2018 – 26-Feb-2019	1.9	1.4	1.6	1.1	1.1	2.0
Objective	**4.0**					

6. OVERVIEW OF EXISTING AIR QUALITY ASSESSMENT

An Air Quality and Greenhouse Gas Assessment for the Project was undertaken for the Project by Katestone Environmental (2013). As described in Section 3.1, the assessment was conducted in accordance with the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005) and included an assessment of the potential air quality impacts associated with the Atlas-Campaspe Mine, Ivanhoe Rail Facility and mineral concentrate transport between the Atlas-Campaspe Mine and Ivanhoe Rail Facility.

6.1 ATLAS-CAMPASPE MINE SITE

Potential air quality impacts at the Atlas-Campaspe Mine were modelled for Year 16 of the Project to assess the potential impact at sensitive receptors, including the nearest residence (Boree Plains – which is now Tronox owned) (Figure 4). The next nearest residence is approximately 14 km away from the Atlas-Campaspe Mine.

An emission inventory was prepared for Year 16 of the Atlas-Campaspe Mine operations in consideration of the anticipated mining activities for that year, including topsoil and overburden removal rates, haul road distances and routes, stockpile and pit areas and equipment operating hours. The major emission sources were associated with overburden removal; on-site haulage; and wind erosion from exposed areas (Katestone Environmental, 2013). The assessment of Year 16 operations accounted for the maximum overburden extraction rate from the Project life (notwithstanding that those maximum rates were scheduled to occur in Year 5) thereby providing a conservative estimate of potential air quality impacts (Katestone Environmental, 2013).

Consideration of the potential cumulative impacts associated with the construction and operation of the Balranald Mineral Sands Project were conservatively incorporated in the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013).

The Air Quality and Greenhouse Gas Assessment concluded (Katestone Environmental, 2013):

- The operation of the Atlas-Campaspe Mine plus contemporaneous background concentrations is not predicted to result in any additional exceedances of the impact assessment criterion for 24-hour average PM_{10} of 50 µg/m^3 at any sensitive receptors.
- Annual average PM_{10} and TSP, $PM_{2.5}$ and dust deposition rates at the nearest sensitive receptors due to the Project and ambient background concentrations were not predicted to result in any additional exceedances compared to background concentrations.
- No cumulative air quality impacts are expected from the coincident construction and operation of the Project and the Balranald Mineral Sands Project.

6.2 IVANHOE RAIL FACILITY

Potential air quality impacts at the Ivanhoe Rail Facility were also assessed in the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013). As operations at the Ivanhoe Rail Facility would generally remain unchanged throughout the Project life, one scenario that would represent all years of operation was assessed. An emissions inventory was prepared for the Ivanhoe Rail Facility and the major emission source was determined to be wheel generated dust from unpaved haul road (Katestone Environmental, 2013).

The Air Quality and Greenhouse Gas Assessment concluded (Katestone Environmental, 2013):

- The operation of the Ivanhoe Rail Facility plus contemporaneous background concentrations is not predicted to result in any additional exceedances of the impact assessment criterion for 24-hour average PM_{10} of 50 µg/m^3 at any sensitive receptors.
- Annual average PM_{10} and TSP, $PM_{2.5}$ and dust deposition rates at the nearest sensitive receptors due to the Project and ambient background concentrations were not predicted to result in any additional exceedances compared to background concentrations.

6.3 MINERAL CONCENTRATE TRANSPORT

The Air Quality and Greenhouse Gas Assessment also addressed the potential air quality impacts associated with mineral concentrate transport on unsealed sections of the mineral concentrate transport route and concluded (Katestone Environmental, 2013):

- The maximum 1-hr average PM_{10} concentration at a distance of 25 m from the unsealed sections of the mineral concentrate transport route were predicted to range from 40.4 µg/m^3 to 25.6 µg/m^3 for vehicles travelling at 100 km/hr and 40 km/hr, respectively, which is below the 24-hour average air quality objective of 50 µg/m^3.

- At a distance of 500m from the road, the maximum 1-hour average PM_{10} concentration from the unsealed sections of the mineral concentrate transport route were predicted to range from 2.3 µg/m^3 to 1.5 µg/m^3 to for vehicles travelling at 100km/hr and 40 km/hr, respectively, which is well below the 24-hour average air quality objective of 50 µg/m^3.

7. POTENTIAL AIR QUALITY IMPACTS DUE TO THE MODIFICATION

7.1 ATLAS-CAMPASPE MINE SITE

The following components of the Modification have the potential to change the TSP, PM_{10} and $PM_{2.5}$ emissions at the Atlas-Campaspe Mine:

- Increased mineral concentrate production from 546,000 tpa to 665,000 tpa;Addition of conveyors to transfer overburden (haul trucks are currently approved).

Emission rates of TSP, PM_{10} and $PM_{2.5}$ due to Year 16 of operations for the approved Atlas-Campaspe Mine and modified Atlas-Campaspe Mine are presented in Table 5.

Table 5 Summary of emission rates due to Year 16 of the Approved and Modified Atlas-Campaspe Mine operations

Activity	Emission rate (g/s) due to the Approved Atlas-Campaspe Mine*			Emission rate (g/s) due to the Modified Atlas-Campaspe Mine			% increase
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	
Topsoil removal	1.8	0.4	0.2	1.8	0.4	0.2	0%
Overburden removal	18.6	7.4	1.6	18.6	7.4	1.6	0%
Ore removal	0.7	0.3	0.1	0.7	0.3	0.1	0%
Ore processing – screening	2.9	1.0	0.1	2.9	1.0	0.1	0%
Product stacking	0.0018	0.0008	0.0001	0.0022	0.0010	0.0002	22%
Road train loading	0.004	0.002	0.0003	0.004	0.002	0.0003	22%
Overburden haulage	20.3	6.5	0.7	20.3	6.5	0.7	0%^
HMC/MSP on-site haulage	5.2	1.3	0.1	7.6	1.9	0.2	46%
Grading	0.9	0.3	0.03	0.9	0.3	0.03	0%
Wind erosion	7.7	4.3	0.7	7.7	4.3	0.7	0%
TOTAL	**58.0**	**21.5**	**3.4**	**60.4**	**22.1**	**3.4**	**4%**

Table notes:

* Katestone Environmental (2013)

^ Note that emissions would reduce if conveyors are adopted.

Emissions due to product stacking and road train loading are expected to increase by 22% and on-site haulage of mineral concentrate is also expected to increase by 46% due to increased production. Overall, emissions from the modified Atlas-Campaspe Mine site are expected to increase by 4% compared to emissions from the approved Atlas-Campaspe Mine.

The use of conveyors to transport some or all of the overburden rather than haul trucks would reduce emissions from the Atlas-Campaspe Mine. Overburden haulage accounts for 6.5 grams per second (g/s), or 30%, of the estimated Atlas-Campaspe Mine emissions of PM_{10}. Based on an estimated 95% reduction in dust emissions, the use of conveyors instead of haul trucks would reduce emissions from overburden transport from 6.5 g/s to 0.3 g/s. Given that PM_{10} emissions from the modified Atlas-Campaspe Mine are expected to increase by 0.6 g/s due to the higher mineral concentrate production rate, the transport of even a portion of overburden via conveyor instead of haul truck would result in overall PM_{10} emissions rates that are lower than those assessed for the approved Atlas-Campaspe Mine.

Given that the Modification would result in either a decrease or a relatively small increase in emissions (depending if the conveyor is adopted) (Table 5) and the significant distances to the nearest sensitive receptors (Figure 4), it is likely that the conclusions of the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project (Section 6.1) would remain valid, and the modified Project would not contribute to any additional exceedances of the relevant air quality criteria at any sensitive receptors in the vicinity of the Atlas-Campaspe Mine site.

7.2 IVANHOE RAIL FACILITY

The following components of the Modification have the potential to change the TSP, PM_{10} and $PM_{2.5}$ emissions at the Ivanhoe Rail Facility:

- Increased mineral concentrate transport/handling from 450,000 tpa to 665,000 tpa
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day
- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate the longer trains
- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection (i.e. increased distance from the nearest privately-owned receptors)
- Addition of a groundwater supply (i.e. water would be available for dust suppression resulting in less wheel-generated dust).

Table 6 presents the emission rates for the approved Ivanhoe Rail Facility and the modified Ivanhoe Rail Facility.

Table 6 Summary of emission rates due to the Ivanhoe Rail Facility – as per the Air Quality Report, and due to the proposed amended Project

Activity	Emission rate (g/s) at the Approved Ivanhoe Rail Facility*			Emission rate (g/s) at the Modified Ivanhoe Rail Facility			% increase
	TSP	PM_{10}	$PM_{2.5}$	TSP	PM_{10}	$PM_{2.5}$	
Wheel generated dust from unpaved access road	4.17	1.04	0.11	3.39	0.84	0.1	-16%
Dumping of mineral concentrates onto stockpiles	0.0056	0.0026	0.0004	0.0083	0.0039	0.0006	48%
FEL transfer of mineral concentrates from stockpile to rail wagon	0.017	0.008	0.001	0.025	0.012	0.002	48%
Wind erosion of mineral concentrate stockpiles	0.007	0.004	0.001	0.011	0.006	0.001	50%
TOTAL	**4.20**	**1.06**	**0.12**	**3.44**	**0.86**	**0.10**	**-15%**

* Katestone Environmental (2013)

Overall the Modification would result in a 15% reduction in emissions from the Ivanhoe Rail Facility.

Whilst the proposed increase in mineral concentrate handling and associated increase in mineral concentrate transport truck trips would increase emissions at the Ivanhoe Rail Facility, the addition of a bore at the Ivanhoe Rail Facility will provide water for dust suppression on the access road that would reduce emissions associated with wheel generated dust from mineral concentrate transport trucks. The addition of dust suppression on the haul road results in a 16% decrease in emissions in from wheel generated dust from access road despite the increase in mineral concentrate truck numbers compared to the Air Quality and Greenhouse Gas Assessment, which did not account for dust suppression on the haul road.

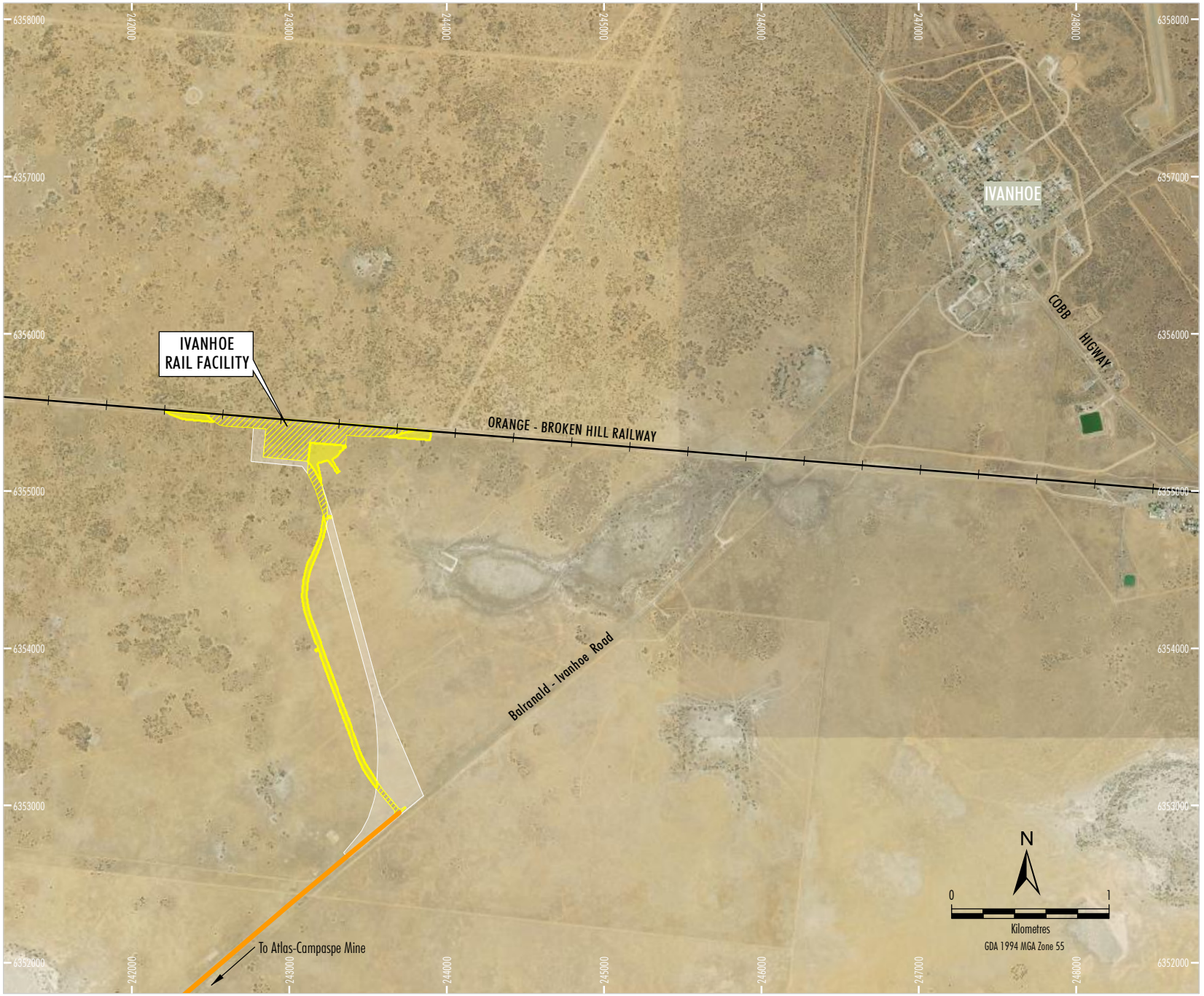
The modified Ivanhoe Rail Facility layout (e.g. minor changes to the site access road alignment and stockpile areas) also results in changes to emissions from wind erosion and wheel generated dust from the haul road.

Given that the Modification would result in reduction in emissions from the Ivanhoe Rail Facility (Table 6) and the distances to the nearest sensitive receptors (Figure 7), it is likely that the conclusions of the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project (Section 6.1) would remain valid, and the modified Project would not contribute to any additional exceedances of the relevant air quality criteria at any sensitive receptors in the vicinity of the Ivanhoe Rail Facility.

7.3 MINERAL CONCENTRATE TRANSPORT

Emissions of dust due to product transport along unsealed sections of the mineral concentrate transport route are expected to increase by approximately 46% due to the increase in trips per day from 24 to 35.

An increase in trips per day from 24 to 35 along the mineral concentrate transport route is however unlikely to result in additional exceedances of the relevant air quality criteria given the relatively small contribution of the mineral concentrate transport route emissions to ground-level concentrations, the reduction in this contribution with increasing distance from the mineral concentrate transport route and the distance between the mineral concentrate transport route and sensitive receptors.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2018)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility and Surrounds

Figure 7

CMA-18-07 AC OM_ App AQA_203A

8. CONCLUSIONS

This Air Quality Review of the potential air quality impacts associated with the Modification is based on:

- A review of the existing air quality monitoring in the vicinity of the Atlas-Campaspe Mine
- A comparison of dust emissions for the modified Project with the information presented in the existing Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project.

The Air Quality Review found that the Modification is unlikely to alter the outcomes of the Air Quality and Greenhouse Gas Assessment (Katestone Environmental, 2013) for the approved Project and the modified Project would not contribute to any additional exceedances of the relevant air quality criteria at any sensitive receptors in the vicinity of the Project.

9. REFERENCES

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APPENDIX C

NOISE REVIEW

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX C

NOISE REVIEW

TRONOX

ACOUSTICS AND AIR

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION

NOISE REVIEW

REPORT NO. 11241-A
VERSION A

JULY 2019

PREPARED FOR

TRONOX MINING AUSTRALIA LIMITED

WILKINSON MURRAY

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GLOSSARY OF ACOUSTIC TERMS

Most environments are affected by environmental noise which continuously varies, largely as a result of road traffic. To describe the overall noise environment, a number of noise descriptors have been developed and these involve statistical and other analysis of the varying noise over sampling periods, typically taken as 15 minutes. These descriptors, which are demonstrated in the graph below, are here defined.

Maximum Noise Level (L_{Amax}) – The maximum noise level over a sample period is the maximum level, measured on fast response, during the sample period.

L_{A1} – The L_{A1} level is the noise level which is exceeded for 1% of the sample period. During the sample period, the noise level is below the L_{A1} level for 99% of the time.

L_{A10} – The L_{A10} level is the noise level which is exceeded for 10% of the sample period. During the sample period, the noise level is below the L_{A10} level for 90% of the time. The L_{A10} is a common noise descriptor for environmental noise and road traffic noise.

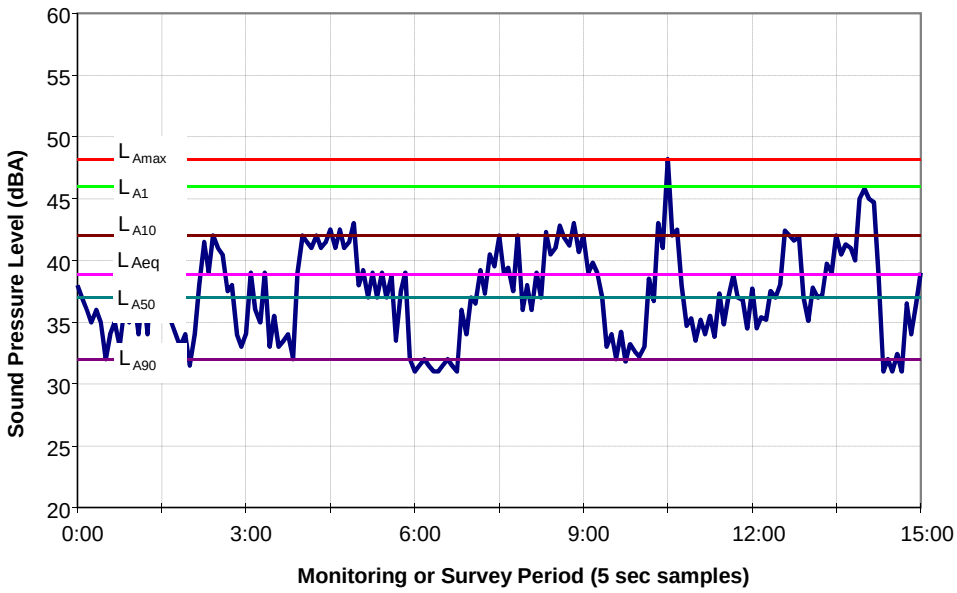
L_{A90} – The L_{A90} level is the noise level which is exceeded for 90% of the sample period. During the sample period, the noise level is below the L_{A90} level for 10% of the time. This measure is commonly referred to as the background noise level.

L_{Aeq} – The equivalent continuous sound level (L_{Aeq}) is the energy average of the varying noise over the sample period and is equivalent to the level of a constant noise which contains the same energy as the varying noise environment. This measure is also a common measure of environmental noise and road traffic noise.

ABL – The Assessment Background Level is the single figure background level representing each assessment period (daytime, evening and night time) for each day. It is determined by calculating the 10th percentile (lowest 10th percent) background level (L_{A90}) for each period.

RBL – The Rating Background Level for each period is the median value of the ABL values for the period over all of the days measured. There is therefore an RBL value for each period – daytime, evening and night time.

Typical Graph of Sound Pressure Level vs Time



1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

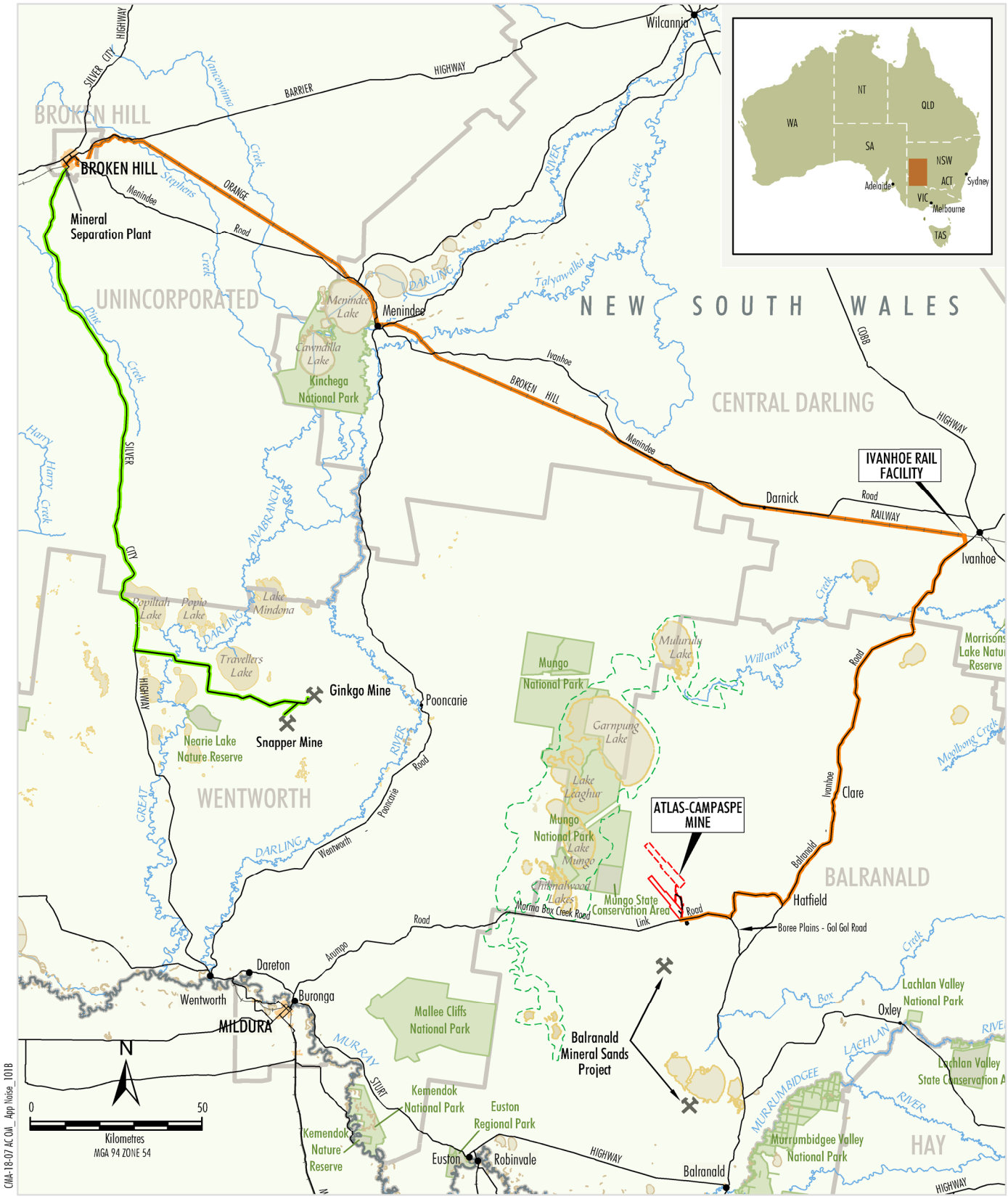
The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1-1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1-1).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (Figure 1-1).

The Project will integrate with currently existing / approved Tronox operations in western NSW, including (Figure 1-1):

- the MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine;
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine; and
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

This Noise Review has been prepared to support the application to modify Development Consent (SSD_5012) for the Project.



LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1-1

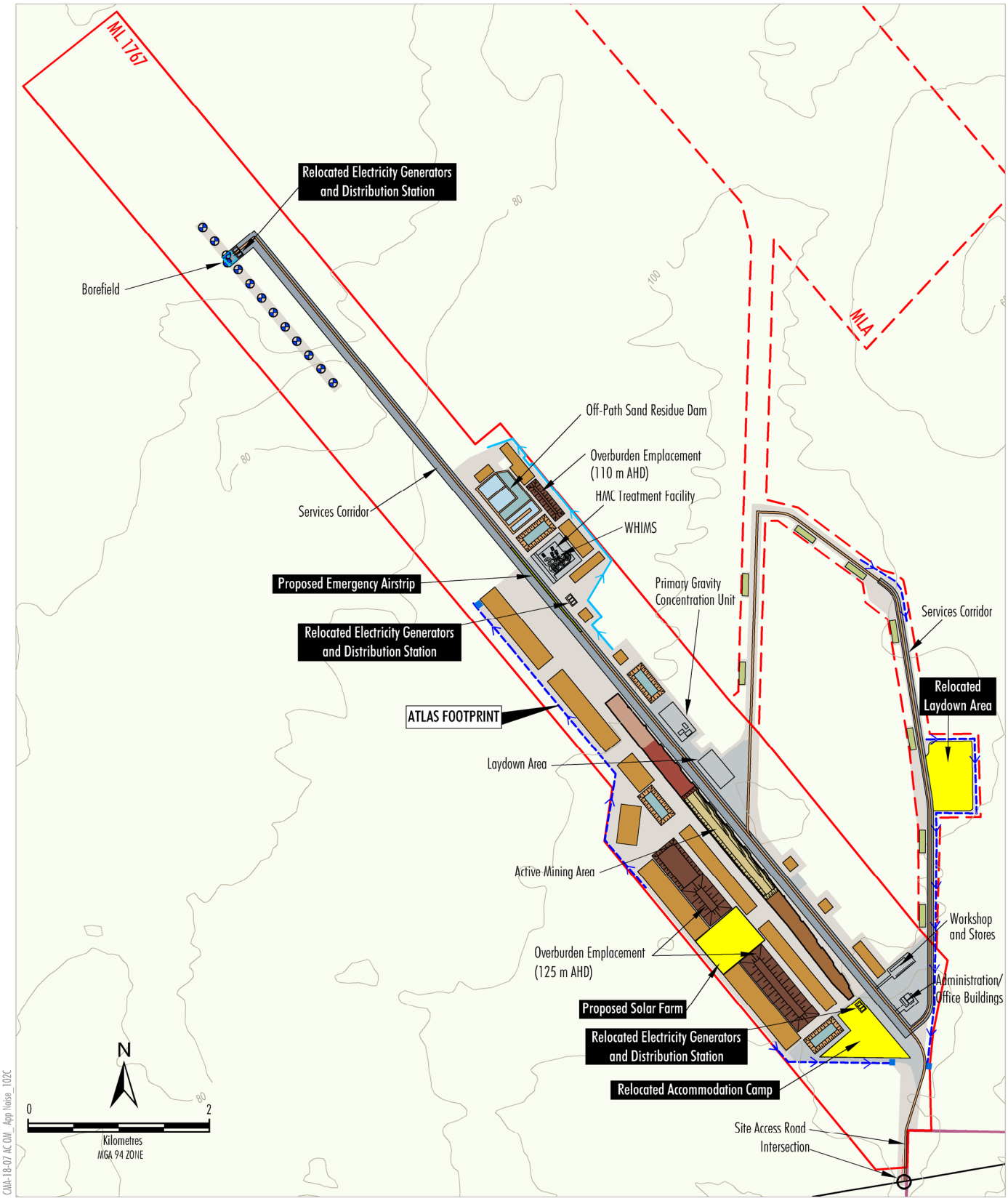
2 OVERVIEW OF THE MODIFICATION

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would include:

- Increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- Increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- Increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- Increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- The option to use an overland conveyor to transfer overburden in addition to haul trucks;
- The relocation of the Atlas-Campaspe Mine accommodation camp;
- The option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets (Figure 2-1);
- Development of an emergency airstrip at the Atlas-Campaspe Mine (Figure 2-1);
- Construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- An extension to the Ivanhoe Rail Facility hardstand area (Figure 2-2);
- An extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding (Figure 2-2);
- A revised alignment of the Ivanhoe Rail Facility access road and access road intersection (Figure 2-2);
- A groundwater supply bore for the Ivanhoe Rail Facility (Figure 2-2); and
- The use of local roads other than the road haulage route by Project-related light vehicles to access site (Figure 1-1).

The Modification would not change the following components of the Project:

- Mine path or mine life;
- Mining method;
- Mineral concentration methods;
- Overburden and ore extraction rate;
- Sand residue, coarse reject and process waste placement management;
- Annual maximum water supply/demand;
- Rehabilitation works;
- Biodiversity offset area; or
- Workforce.



Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012) and Tronox (2019)

LEGEND

- Mining Lease Boundary (ML)
- Mining Lease Application Boundary (MLA)
- Exploration Licence Boundary (EL)
- Up-catchment Diversions
- Collection Drains
- Bore
- Approximate Extent of Surface Development - Year 2
- Fixed Infrastructure Areas
- Soil Stockpile
- Process Water Storage
- Overburden Emplacement
- Stage 1 Rehabilitation - Stabilised Landform with Seed/Cover Crop Application

Active Mining Area

- Vegetation Clearance/Soil Stripping
- Overburden Removal
- Ore Zone/Extraction Area
- Overburden Replacement/Process Waste Emplacement/Soil Replacement
- Sediment Basin

ACMSP Modification

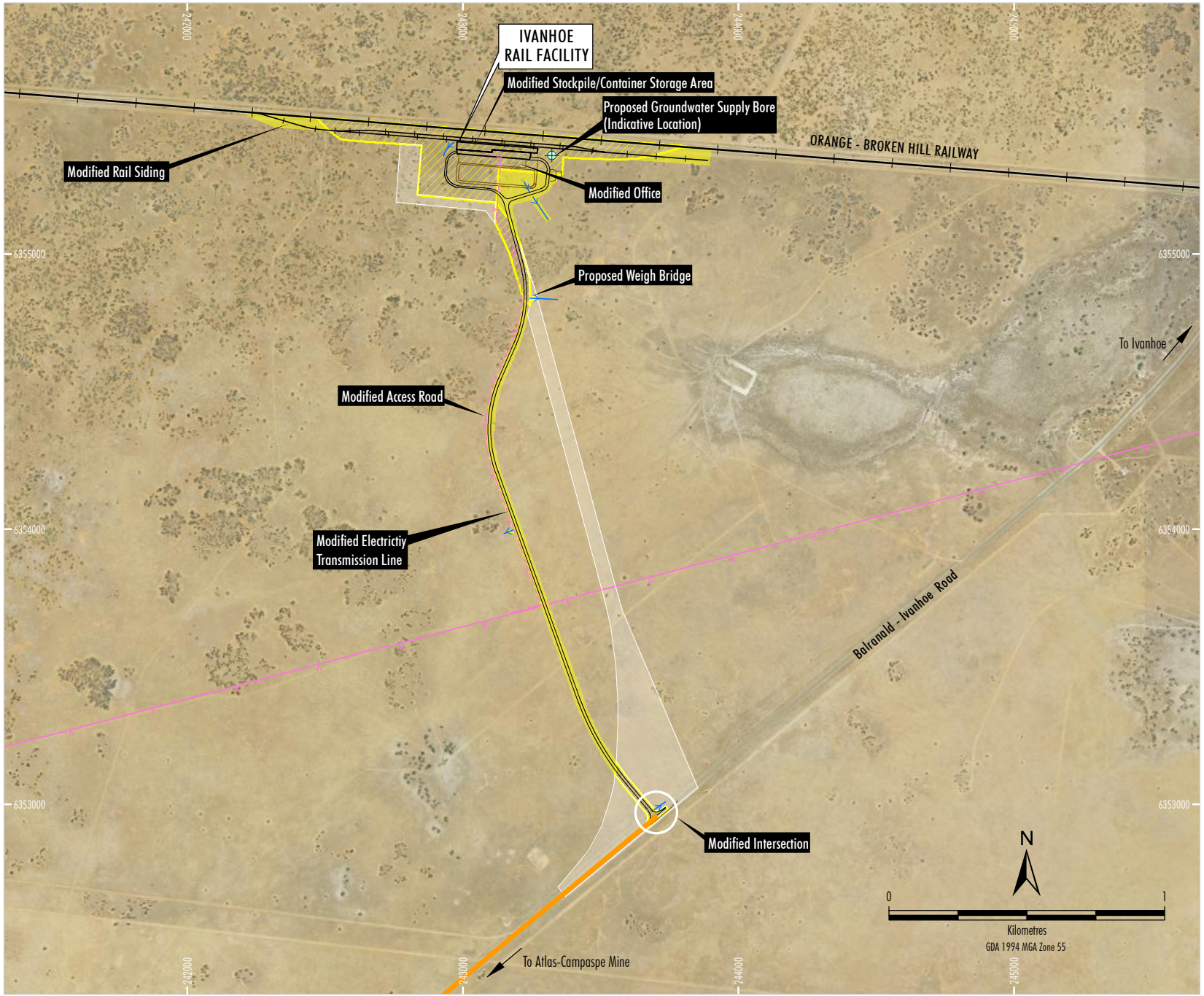
- Modification Surface Development Area

TRONOX

OPTIMISATION MODIFICATION

Modified Atlas-Campaspe Mine
General Arrangement - Year 2

Figure 2-1



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 2-2

3 NOISE CRITERIA

3.1 Operational Noise

The applicable operational noise criteria for the Project is stipulated in Condition 16, Schedule 3 of Development Consent (SSD_5012) and are reproduced in Table 3-1.

Table 3-1 Development Consent (SSD_5012) Operational Noise Criteria

Location	Day	Evening	Night	
	$L_{Aeq,15min}$	$L_{Aeq,15min}$	$L_{Aeq,15min}$	$L_{Aeq,1min}$
All privately-owned land	35	35	35	45
Mungo National Park & Mungo State Conservation Area	50	50	50	-

The applicable operational noise criteria for the Project (Table 3-1) were based on rating background levels (RBL) of 30 dBA for the day, evening and night periods (i.e. the minimum RBLs assumed for assessment purposes in accordance with the procedures documented in the Industrial Noise Policy [INP] [Environmental Protection Authority, 2000]), based on the background noise survey conducted by Wilkinson Murray (2012) for the approved Project (Section 4.2).

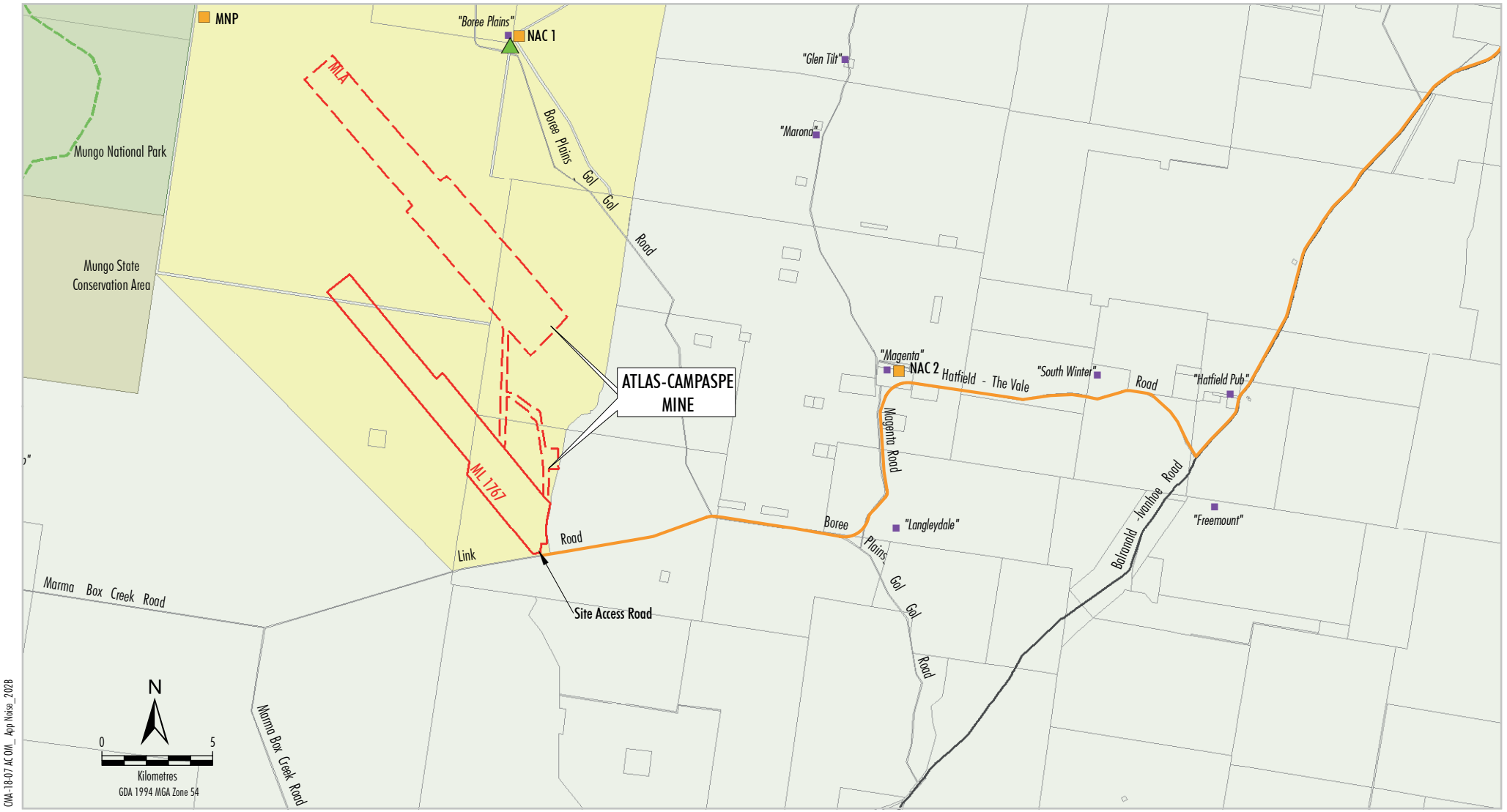
In accordance with Condition 16, Schedule 3 of Development Consent (SSD_5012), the criteria in Table 3-1 do not apply under the following meteorological conditions:

- Periods of rain or hail;
- Average wind speed exceeding 5 metres per second (m/s);
- Wind speeds greater than 3 m/s at 10 m above ground level; or
- Temperature inversions greater the 3 degrees Celsius (°C) / 100 m.

Also in accordance with Condition 16, Schedule 3 of Development Consent (SSD_5012), these criteria do not apply where Tronox has an agreement with the owner/s or leaseholders of the residence to generate higher noise levels, and Tronox has advised the Department of Planning and Environment in writing of the terms of this agreement.

Tronox holds Environment Protection Licence (EPL) 21007 issued under the NSW *Protection of the Environment Operations Act 1997* for the Project. Condition L3.1 details the criteria applicable to noise generated by the operations measured at each monitoring point established under EPL 21007. The EPL 21007 operational noise criteria are shown in Table 3-2.

The monitoring locations are as identified in the Noise Management Plan (Cristal Mining Australia [CMA], 2018) prepared in accordance with Condition 18, Schedule 3 of Development Consent (SSD_5012) and are shown on Figure 3-1.



OMA-18-07 AC OM_ App Noise_202B

LEGEND

- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Willandra Lakes Region World Heritage Area
- National Park
- State Conservation Area
- Tronox Owned Land
- Private Landholder
- Dwelling
- Approved Mineral Concentrate Transport Route
- Automatic Weather Station
- Noise Monitoring Location

Source:© NSW Department of Finance, Services & Innovation (2017); Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Atlas-Campaspe Mine - Noise Monitoring Sites

Figure 3-1

Table 3-2 EPL 21007 Operational Noise Criteria

Location	Noise Level (Day, Evening and Night) $L_{Aeq,15min}$ dBA
Mungo National Park (MNP)	50
NAC1 "Boree Plains"	35
NAC2 "Magenta"	35

dBA = A-weighted decibel

The Noise Management Plan (CMA, 2018) also includes monitoring locations representative of privately-owned receivers most likely to be affected by noise generated by the Ivanhoe Rail Facility (NI1, NI2 and NI3). NI1, NI2 and NI3 and are shown in Figure 3-2. NI1 is representative of Ivanhoe Township, NI2 represents residences on the Cobb Highway and NI3 represents the Warakirri Correctional Centre.

The EPL 21007 operational noise criteria are consistent with Development Consent (SSD_5012).

Noise Policy for Industry Project Trigger Levels

The *Noise Policy for Industry* (NPfI) (Environment Protection Authority [EPA], 2017) outlines a process for determining Project Noise Trigger Levels for assessing potential operational noise impacts, and supersedes the INP (EPA, 2000).

The Project Noise Trigger Levels for the Project determined in accordance with the NPfI are outlined in Table 3-3.

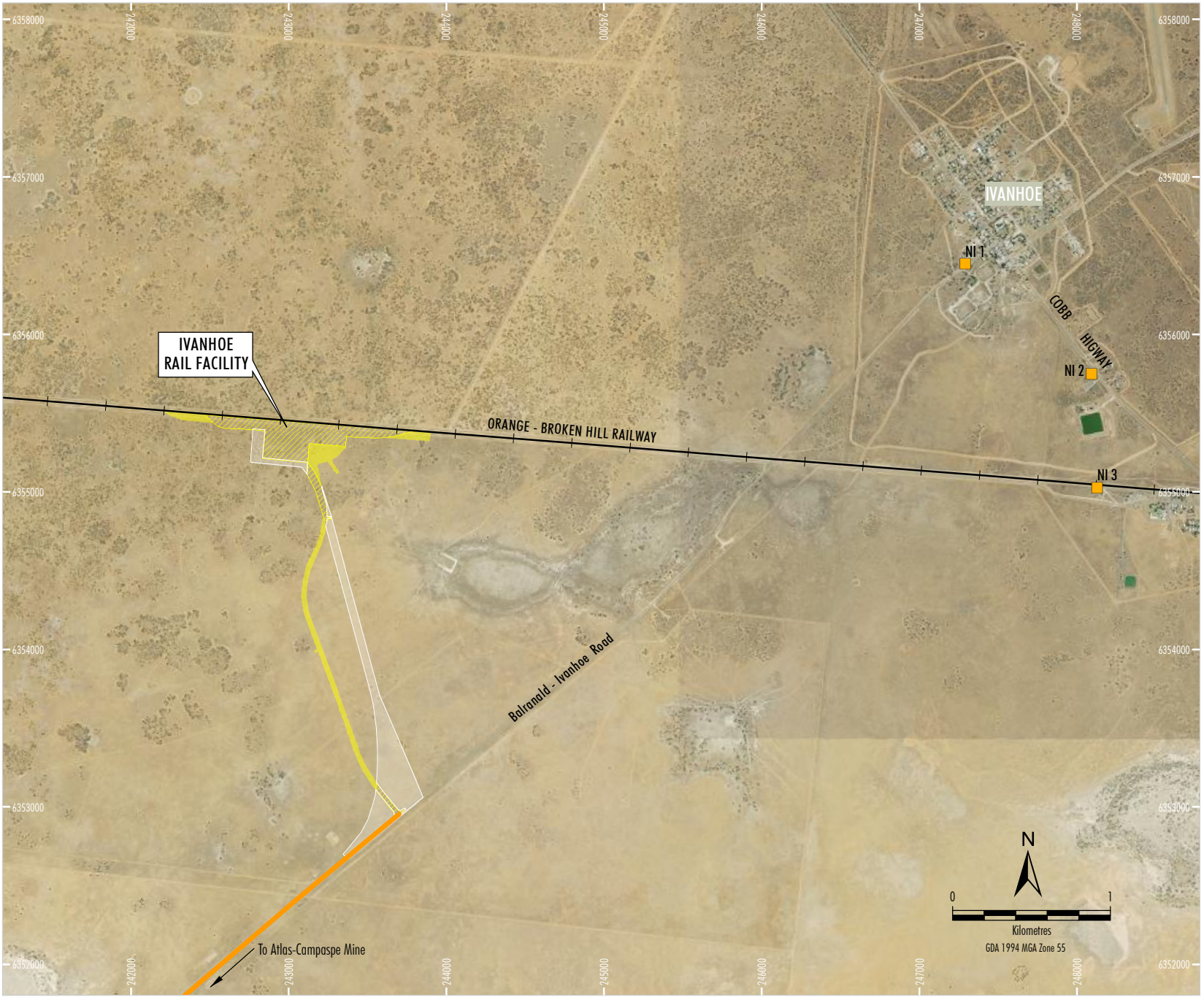
Table 3-3 NPfI Project Noise Trigger Levels

Location	Day	Evening	Night	
	$L_{Aeq,15min}$	$L_{Aeq,15min}$	$L_{Aeq,15min}$	L_{AFmax}
All privately-owned land	40	35	35	52

The Project Noise Trigger Levels outlined in Table 3-3 are based on the following:

- RBLs of 35 dBA, 30 dBA, and 30 dBA (i.e. the minimum assumed RBLs in accordance with the NPfI) for the day, evening and night periods respectively, based on the background noise survey conducted by Wilkinson Murray (2012) for the approved Project (Section 4.2).
- The surrounding receivers are situated in an area which would be classified as "Rural" under the NPfI, and the relevant recommended $L_{Aeq,Period}$ amenity noise levels are 50 dBA, 45 dBA and 40 dBA for daytime, evening and night time periods, respectively.

The existing Development Consent and EPL 21007 noise criteria (Tables 3-1 and 3-2) are more stringent than the NPfI Project Noise Trigger Levels outlined in Table 3-3. The potential noise impacts of the Modification have been assessed against the NPfI criteria in Section 7.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Noise Monitoring Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Noise Monitoring Sites

Figure 3-2

CMA-18-07 AC OM_ App Noise_203B

3.2 Road Traffic Noise

Development Consent (SSD_5012) does not stipulate any quantitative criteria in regard to noise from road or rail traffic. Condition 17, Schedule 3 of Development Consent (SSD_5012) does however include operating conditions to manage and minimise road or rail traffic emissions as follows:

The Applicant shall:

(a) implement all reasonable and feasible measures to minimise the construction, operational, road and rail noise of the development;

…

(d) only use locomotives and rolling stock that are approved to operate on the NSW rail network in accordance with the noise limits in the ARTC's EPL.

Criteria for assessment of noise from traffic on public roads are set out in the NSW *Road Noise Policy* (RNP) (Department of Environment, Climate Change and Water, 2011). These criteria are shown in Table 3-4.

Table 3-4 Criteria for Traffic Noise – Residences

Type of Development	Noise Level Criterion	
	Day (7am-10pm)	**Night (10pm-7am)**
Existing residences affected by **additional traffic** on existing freeways/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq,15hour}$ 60 dBA	$L_{Aeq,9hour}$ 55 dBA
Existing residences affected by **additional traffic** on existing local roads generated by land use developments.	$L_{Aeq,1hour}$ 55 dBA	$L_{Aeq,1hour}$ 50 dBA

The RNP states:

> *In assessing feasible and reasonable mitigation measures, an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

The RNP defines daytime as 7.00am to 10.00pm and night time as 10.00pm to 7.00am.

Noise monitoring location NAC2 ("Magenta"), as shown on Figure 3-1, is representative of the privately-owned receiver most likely to be affected by noise generated by Project road traffic on the road haulage route.

3.3 Rail Traffic Noise

Criteria for assessment of noise from rail traffic operating on the Orange-Broken Hill Railway are documented in the Australian Rail Track Corporation's (ARTC) (operator of the Orange-Broken Hill Railway) EPL 3142. Condition L6 of EPL 3142 does not nominate specific environmental noise limits but notes that:

> *It is an objective of this Licence to progressively reduce noise levels to the goals of 65 dB(A)Leq, (day time from 7am – 10pm), 60 dB(A)Leq, (night time from 10pm – 7am) and 85dB(A) (24 hr) max pass-by noise, at one metre from the façade of affected residential properties through the implementation of the Pollution Reduction Programs.*

In addition, the EPA's *Environmental Assessment Requirements for Rail Traffic – Generating Developments* (Office of Environment and Heritage, 2012) provides rail noise assessment criteria which are presented in Table 3-5.

Table 3-5 EPA Rail Noise Assessment Criteria

Descriptor	Rail Traffic Noise Goal
$L_{Aeq,24hour}$	60 dBA
Maximum Pass-by L_{Amax} (95th percentile)	85 dBA

Note: 95th percentile equates to the 5% exceedance value.

The EPA's rail noise assessment criteria are similar to the ARTC's EPL 3142 noise goals, however, the EPA assessment criteria have an averaging period of 24 hours, rather than daytime (15 hours) and night time (9 hours) as for the ARTC's EPL 3142 noise goals. The EPA rail noise assessment requirements also provide:

> *Where the cumulative noise level exceeds the noise assessment trigger levels, and project-related noise increases are predicted, all feasible and reasonable noise mitigation measures should be implemented. As a general principle, where the reduction of existing noise levels can be achieved through feasible and reasonable measures, a reduction in noise levels to meet the noise assessment trigger levels is the primary objective. In all cases where the LAeq noise level increases are more than 2dB(A), strong justification should be provided as to why it is not feasible or reasonable to reduce the increase.*

In addition, the EPA's *Environmental Assessment Requirements for Rail Traffic – Generating Developments* also provide guidance in relation to the geographical extent of rail noise assessment which should be undertaken for a rail traffic generating development (such as the Project):

> *Ideally, the geographical extent of the rail noise assessment should be to where project/related rail noise increases are less than 0.5dB. This roughly equates to where project/related rail traffic represents less than 10% of total line/corridor rail traffic.*

The EPA's *Rail Infrastructure Noise Guideline* (EPA, 2013) provides the following criteria for rail traffic generating developments:

Rail traffic generating developments

- $L_{Aeq,9hour}$ = 55 dBA;
- $L_{Aeq,15hour}$ = 60 dBA; and
- L_{Amax} (95th percentile) = 80 dBA.

4 EXISTING NOISE ENVIRONMENT

4.1 Receiver Locations

The potentially sensitive receiver locations in vicinity of the Project areas are shown on Figure 3-1 and Figure 3-2.

The Boree Plains residence (Tronox owned) is the closest residence to the Atlas-Campaspe Mine footprint and is located approximately 7 km away from the Campaspe deposit and approximately 18 km away from the Atlas deposit (where Project activities are occurring) (Figure 3-1). Other rural residences (e.g. Marona, Glen Tilt, Magenta and Langleydale) are located at least 14 km away from the Atlas-Campaspe Mine footprint (Figure 3-1).

The closest residential receivers to the mineral concentrate transport route in the Project area were identified as follows (and are shown on Figure 3-1):

- South Winter – approximately 1 km from Hatfield-The Vale Road;
- Magenta – approximately 0.8 km from Magenta Road;
- Langleydale – approximately 1.3 km from Magenta Road;
- Kilfera – approximately 1.5 km from Balranald-Ivanhoe Road; and
- Hatfield Pub – approximately 49 m from Balranald-Ivanhoe Road.

The township of Ivanhoe is representative of the closest residential area to the Ivanhoe Rail Facility. The Ivanhoe Rail Facility is located approximately 4.5 km from Ivanhoe (Figure 3-2).

4.2 Ambient Noise Monitoring

Monitoring to characterise the noise environment of the area surrounding the Project was carried out by Wilkinson Murray (2012) for the Project. The survey results are shown in Table 4-1.

Table 4-1 Background Noise Survey Results

Location	Site	Monitoring Period	RBL (dBA)		
			Day	Evening	Night
Boree Plains (NAC1)	Atlas-Campaspe Mine	15/11/2011 to 30/11/2011	28	27	24
Min Min		15/11/2011 to 26/11/2011	25	25	25
32 Mitchell Street, Ivanhoe (NI1)	Ivanhoe	12/04/2012 to 19/04/2012	28	29	25

dBA = A-weighted decibel

4.3 Compliance Noise Monitoring

Compliance noise monitoring in accordance with the Noise Management Plan (CMA, 2018) was carried out by GHD on behalf of Tronox on 14 May 2018. The results are shown in Table 4-2. No mechanically-generated noise was audible from the Atlas-Campaspe Mine throughout the measurement period and the measured levels are well below the Project-specific noise limits as required under Development Consent (SSD_5012) and EPL 21007 conditions.

Table 4-2 Compliance Survey Ambient Noise Monitoring Results

Location	Time	Measured Noise Levels dBA		Estimated Project Contribution dBA
		$L_{Aeq,15min}$	$L_{A90,15min}$	$L_{Aeq,15min}$
NAC2	1022-1037	24	18	Inaudible
NAC2	1040-1055	24	18	Inaudible
NAC1	1146-1200	28	19	Inaudible
NAC1	1207-1222	27	19	Inaudible
MNP	1326-1340	23	19	Inaudible
MNP	1345-1359	24	18	Inaudible

4.4 Meteorology

4.4.1 General

At relatively large distances from a source the resultant noise levels from a noise source will be influenced by meteorological conditions, specifically:

- wind; and
- temperature gradients.

Wind can increase noise at a receiver when it blows from the direction of the noise source at relatively low wind speeds (below 3 m/s). An increase in wind strength greater than 3 m/s generally results in a corresponding increase in wind noise at the receiver which masks noise from the source under investigation.

Temperature inversions (positive temperature gradients) can increase noise levels at surrounding receivers by the reflection of sound waves from warmer upper layers of air. Temperature inversions occur predominantly at night.

In assessing noise impacts, the criteria are expected to apply under weather conditions that are likely to occur at a particular site for a significant period of time.

The NPfI describes two approaches for assessing these effects; the simple and the more detailed approach.

The simple approach forgoes a detailed analysis of meteorological data and simply applies given default meteorological parameters to predict noise levels. This approach assumes that meteorological effects are present for a significant amount of time, avoiding the need to quantify these effects in detail. It is conservative, in that it is likely to predict the upper range of increases in noise levels due to meteorological conditions.

The more detailed approach involves an analysis of meteorological data to determine whether inversions and/or wind effects are significant features warranting assessment. Where assessment is warranted, default parameters are available for use in predicting noise or where preferred, measured values maybe used instead.

Tronox has installed an automatic weather station (AWS) at the Atlas-Campaspe Mine (Figure 3-1). In the absence of data from the AWS, the following summary of the synthetic site-specific meteorological data for both the Atlas-Campaspe Mine and the Ivanhoe Rail Facility are as presented in the Katestone Environmental Pty Ltd (2012) *Air Quality and Greenhouse Gas Assessment* prepared for the Project.

4.4.2 Wind

Figure 4-1 and Figure 4-2 show seasonal wind roses for the Atlas-Campaspe Mine and the Ivanhoe Rail Facility, respectively. For both sites the highest frequencies of winds generally occur from the south and southwest.

Figure 4-1 Seasonal Wind Roses for the Atlas-Campaspe Mine (Katestone, 2012)

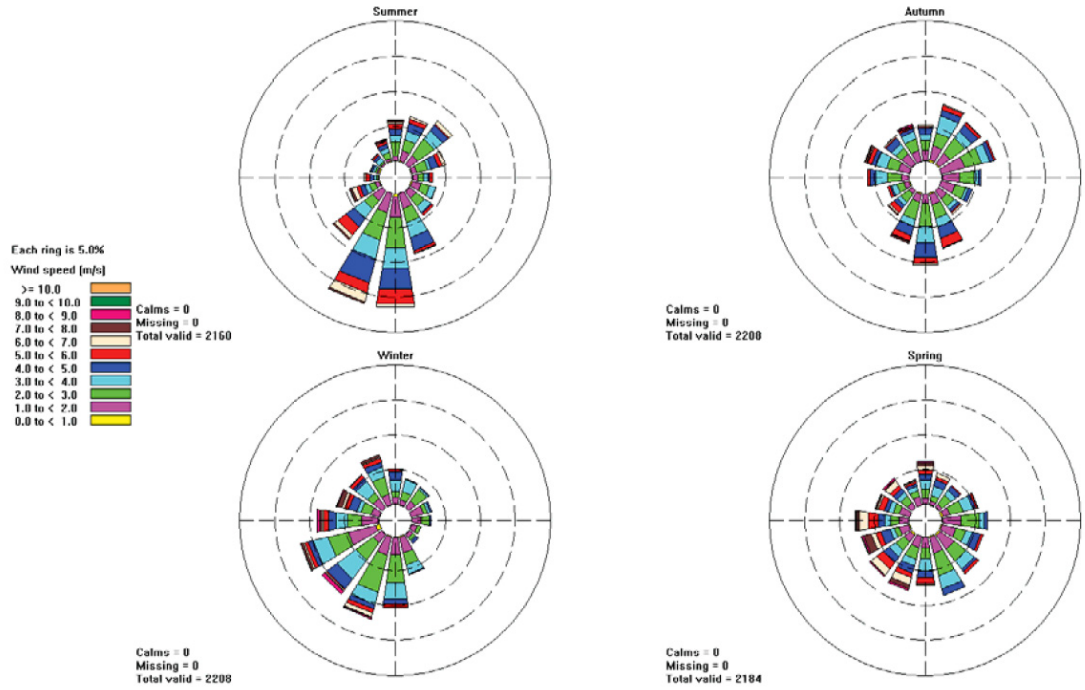


Figure 4-2 Seasonal Wind Roses for the Ivanhoe Rail Facility (Katestone, 2012)

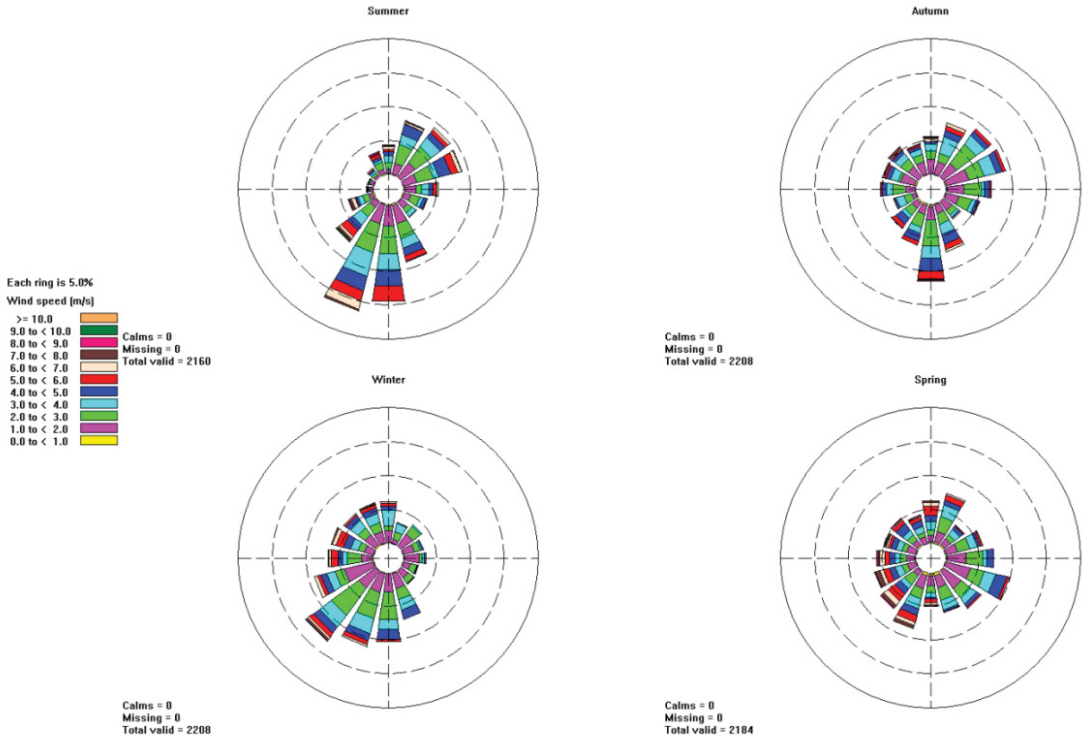


Figure 4-1 and Figure 4-2 indicate that the winds at the Atlas-Campaspe Mine and Ivanhoe Rail Facility are similar and can be considered predominantly moderate. These figures also show that approximately 50 percent (%) of winds are between 2 and 4 m/s, with little seasonal variation.

4.4.3 Temperature Inversion

Pasquill-Gifford stability conditions indicate the potential for temperature inversions. There are seven stability classes referred to as A to G. The predicted frequencies of occurrence of stability class are shown in Table 4-3 and Table 4-4 for the Atlas-Campaspe Mine and for the Ivanhoe Rail Facility, respectively.

Pasquill-Gifford stability conditions A to D indicate lapse conditions (negative temperature gradient). Pasquill-Gifford stability conditions E to G indicate temperature inversion conditions, E indicating a temperature gradient of between -0.5 and 1.5 ^{o}C / 100 m, F indicating a temperature gradient of between 1.5 and 4^{o}C / 100 m and G indicating a temperature gradient greater than 4^{o}C / 100 m.

Table 4-3 Distribution of Atmospheric Stability Categories for the Atlas-Campaspe Mine

Stability	Percentage Occurrence
A	1.3
B	7.9
C	18.2
D	28.9
E	11.3
F/G	32.4

Table 4-4 Distribution of Atmospheric Stability Categories for the Ivanhoe Rail Facility

Stability	Percentage Occurrence
A	1.5
B	8.6
C	19.1
D	26.8
E	9.4
F/G	34.6

Stability Classes F and G apply normally at night when winds are light, and the sky is clear. Class E describe intermediate conditions between those described above.

There is a high percentage of D, E, F and G class conditions for both areas (Table 4-3 and Table 4-4), reflecting a prevalence of stable meteorological conditions.

4.5 Meteorological Conditions Used for Noise Assessment Purposes

For the detailed noise assessment carried out for the Project, Wilkinson Murray (2012) used the following INP (EPA, 2000) default meteorological parameters to predict noise levels at each receiver. The Project area is located in an arid/semi-arid area that has annual average rainfall of less than 500 millimetres. For such conditions, the INP recommends the following default meteorological conditions that enhance noise levels:

- Strong (G-class stability category) inversions:

  8^{o}C / 100 m inversion strength and source-to-receiver drainage flow wind of 1 m/s.

- Gradient wind:

  Source-to-receiver gradient wind of 3 m/s.

Comparison of the synthesised wind and temperature inversion conditions with the INP default conditions indicates that the INP default meteorological conditions provide a maximum-case scenario in terms of enhancement of operational noise due to meteorological factors.

The NPfI recommends different default meteorological conditions that enhance noise levels under the conditions experienced at the Project:

- 4^{o}C / 100 m inversion strength and source-to-receiver drainage flow wind of 2 m/s.

The default meteorological parameters adopted by Wilkinson Murray (2012) in accordance with the INP are considered to be conservative in the context of the NPfI default meteorological conditions.

5 EXISTING NOISE MANAGEMENT

Noise management at the Project is undertaken in accordance with the Noise Management Plan (CMA, 2018). The Noise Management Plan (CMA, 2018) was prepared in accordance with Condition 18, Schedule 3 of Development Consent (SSD_5012) and includes the following noise management measures for the Project:

- Development and implementation of an equipment maintenance schedule to maintain equipment noise emission levels and reduce the likelihood of tonal noise impacts;
- Development and implementation of a noise awareness program to educate employees on the effects of noise and quiet work practices;
- Drivers will be made aware of the potential for noise impact through site-specific inductions and staff education programs to reinforce quiet driving styles/attitudes;
- An awareness of industry developments will be maintained in relation to noise mitigation engineering for individual plant items in order to assess inherent cost and practicability;
- The number of vehicle trips to and from the Atlas-Campaspe Mine will be optimised by ensuring that transport trucks are loaded to their operating capacity;
- All loose and rattling truck body parts will be fixed or tightened to minimise noise emissions from 'body rumble' (i.e. when loose panels vibrate when a truck hits a bump, causing noise to emanate from the panel);
- The use of locomotives and rolling stock that are approved to operate on the NSW rail network in accordance with ARTC's EPL 3142; and
- Implementation of operational changes to minimise noise impacts during periods of adverse meteorological conditions in accordance with Condition 17(c), Schedule 3 of Development Consent (SSD_5012).

Tronox has advised that no noise-related complaints have been received to date.

6 OVERVIEW OF PREVIOUS ASSESSMENT

Wilkinson Murray (2012) prepared a Noise Assessment for Project in accordance with the *Industrial Noise Policy* (EPA 2000) and considered the noise impacts associated with the Atlas-Campaspe Mine, Ivanhoe Rail Facility and mineral concentrate transport between the Atlas-Campaspe Mine and the MSP.

6.1 Atlas-Campaspe Mine Site

Operational noise emissions at the Atlas-Campaspe Mine were modelled for two scenarios, namely (Wilkinson Murray, 2012):

- An initial construction scenario (Year 1) where infrastructure will be built, dry mining unit (DMU) assembled, etc. The construction activities will be largely concentrated at the south-eastern end of the Atlas footprint. The mobile fleet will include construction specific items.
- A typical maximum-case operational scenario when all plant is working concurrently during Year 16 with operations 24 hours a day. The major items of mobile fleet will be consistent throughout the life of the Project. As such, Year 16 of operations was chosen for modelling due to its proximity to the nearest residential receiver (Boree Plains).

A schedule of major operational and construction mobile and fixed equipment for the Atlas-Campaspe Mine relevant to Year 1 (i.e. the plant with potential to contribute to noise levels at the receiver locations) and the modelled sound power level (SWL) associated with each item was prepared and is reproduced in Table 6-1.

The predicted Year 1 noise levels for the Atlas-Campaspe Mine (including maximum case Year 1 under meteorological gradient wind of 3 m/s and night time noise contours for 8°C / 100 m inversion strength and 1 m/s wind) complied with Project-specific noise criteria of 35 dBA for all modelled receivers.

Table 6-1 Approved Equipment and Sound Power Levels– Year 1

Equipment	Construction No. of Units	L_{Aeq} SWL (dBA)	Source
Backhoe (CAT 330B)	1	102	WM Measurements
Bobcat	1	97	WM Measurements
Bus (Toyota Coaster)	2	109	WM Measurements
Road Roller/Compactor (CAT 825G)	2	109	WM Measurements
Scraper (Water Cart) (CAT 740)	1	115	WM Measurements
Grader (CAT 16G)	2	108	WM Measurements
Front End Loader (IT62G)	1	113	WM Measurements
Crane (GROVE RT650E/ LIEBHERR LTM 1100)	4	105	WM Measurements
Mobile Fuel Tank (MACK)	1	109	WM Measurements

Equipment	Construction No. of Units	L_{Aeq} SWL (dBA)	Source
1,000 kVA Generators	4	98	WM Measurements
Scraper / Laser Bucket (Case STX 535/ New Holland t9060)	9	115	WM Measurements
Dozer (CAT D11)	3	116	WM Measurements
Excavator (EX 1900/PC1800)	3	114	WM Measurements
Haul Truck (CAT 777D)	12	115	WM Measurements
Water Truck (CAT 773)	2	115	WM Measurements
Service Truck (MACK)	1	109	WM Measurements
Maintenance Truck (Isuzu)	1	109	WM Measurements
Lighting Tower (ALL Light)	8	103	WM Measurements
Garbage Truck	1	109	WM Measurements
Electric Pump	4	103	WM Measurements
Sewage Treatment Plant	1	97	WM Measurements
Accommodation Block	1	102	WM Measurements
Total		130	

Source: Wilkinson Murray (2012)
WM Measurements = Wilkinson Murray Measurements
kVA = kilovolt-ampere

For the Year 16 operational noise scenario, a schedule was prepared of the indicative major operational mobile and fixed equipment for the Atlas-Campaspe Mine relevant to mining operations (i.e. the plant with potential to contribute to noise levels at the receiver locations) and the modelled SWL associated with each item. The plant and equipment schedule is reproduced in Table 6-2.

Based on the Year 16 modelling, noise levels associated with the Atlas-Campaspe Mine (including those under maximum-case meteorological gradient wind of 3 m/s and also night time 8°C / 100m inversion strength and 1 m/s wind) were predicted to readily comply with Project-specific noise criteria of 35 dBA for all modelled receivers for the life of the Atlas-Campaspe Mine.

Table 6-2 Approved Equipment and Sound Power Levels – Years 2-20

Equipment	No. of Units	L_{Aeq} SWL (dBA)	Source
Dozer (CAT D11)	4	116	WM Measurements
Excavator (EX1900/PC1700)	4	114	WM Measurements
Scraper (Water Cart) (CAT740)	1	115	WM Measurements
Front End Loader (CAT990)	3	113	WM Measurements
Front End Loader (CAT IT62G)	1	113	WM Measurements
Grader (CAT 16G)	2	108	WM Measurements
Road Roller/Compactor (CAT 825G)	1	109	WM Measurements
Front End Loader (CAT980H)	2	111	WM Measurements
Water Truck (CAT 773)	2	115	WM Measurements

Equipment	No. of Units	L_{Aeq} SWL (dBA)	Source
1,000 kVA generators	4	98	WM Measurements
Haul Truck (CAT 777D)	12	115	WM Measurements
Scraper (Laser Bucket) (Case STX535/New Holland t9060)	9	115	WM Measurements
DMUs	2	112	Holmes Air Sciences (2007)
Primary Gravity Concentration Unit	1	103	Holmes Air Sciences (2007)
Electric Pumps	16	103	Holmes Air Sciences (2007)
Truck (Kenworth T650)	2	109	WM Measurements
Bobcat	1	97	WM Measurements
Bus (Toyota Coaster)	2	109	WM Measurements
Crane (GROVE RT650E/ LIEBHERR LTM 1100)	1	105	WM Measurements
Mobile Fuel Tank (MACK)	1	109	WM Measurements
Service Truck (MACK)	1	109	WM Measurements
Maintenance Truck (Isuzu)	1	109	WM Measurements
Lighting Tower (ALL Light)	8	103	WM Measurements
Garbage Truck (International 8 m^3)	1	109	WM Measurements
Sewerage Treatment plant	1	97	WM Measurements
Accommodation Block	1	102	WM Measurements
Total		131	

Source: Wilkinson Murray (2012)
WM Measurements = Wilkinson Murray Measurements
kVA = kilovolt-ampere

Noise levels at the boundary of the Mungo National Park, the Mungo State Conservation Area and the Willandra Lakes Region World Heritage Area were also predicted to readily comply with the relevant amenity criteria of 50 dBA for an "area specifically reserved for passive recreation" during maximum case operations. Noise levels would be less than 20 dBA and would likely be inaudible in most instances (Wilkinson Murray, 2012).

Modelling of L_{Amax} noise levels at nearby receivers was undertaken for typical instantaneous noise sources, such as reversing alarms. This analysis concluded that predicted noise levels would comply comfortably with the 45 dBA $L_{A1,1\ min}$ criterion applicable to assessment of potential sleep disturbance at all privately-owned receivers.

Consideration was given to the potential cumulative impacts associated with the construction and operation of the Iluka Resources Limited Balranald Mineral Sands Project (SSD-5285). Based upon the Project Scoping Report for the Balranald Mineral Sands Project (Iluka Resources Limited, 2012), mining of the West Balranald and Nepean deposits would be undertaken in series. Whilst mining is being undertaken at the Atlas deposit, operations at the Balranald Mineral Sands Project would be focussed on the West Balranald deposit (approximately 45 km south of the Atlas deposit). By the time operations at the Balranald Mineral Sands Project progress to the Nepean deposit (northern-most deposit) Project mining operations would be focussed at the Campaspe deposit.

The Balranald Mineral Sands Project would be operating at its northern-most extent during Year 11 of operations at the Atlas-Campaspe Mine. This would result in a distance between the operational ore extraction areas of the Atlas-Campaspe Mine and the Balranald Mineral Sands Project (Nepean deposit) of approximately 21 km.

Modelling demonstrated that the maximum-case operational noise contour of 35 dBA resulting from the Atlas-Campaspe Mine would extend no further than approximately 4.5 km south from the Atlas-Campaspe Mine active mining area.

Accordingly, it was concluded that no cumulative noise impact would occur from the coincident construction or operation of the Project and the Balranald Mineral Sands Project (Wilkinson Murray, 2012).

6.2 Ivanhoe Rail Facility

Table 6-3 outlines the indicative equipment schedule and associated SWLs adopted for modelling and assessment of Ivanhoe Rail Facility.

Table 6-3 Sound Power Levels and Proposed Equipment – Ivanhoe Rail Facility

Equipment	No. of Units	L_{Aeq} SWL (dBA)	Source
Front End Loader (Cat 988)	1	114	WM Measurements
Truck (Kenworth T650)	1	109	WM Measurements
Forklift (Hyster 12 to 16 tonne)	1	106	WM Measurements
Locomotive (81 class Locomotive)	2	109	WM Measurements
Total		117	

Under the maximum-case meteorological gradient wind of 3 m/s scenario and night time 8°C / 100 m inversion strength and 1 m/s wind assessment scenario, the predicted 35 dBA operational noise contour was established not to extend as far as the Ivanhoe township. As such, it was concluded that operational noise would achieve Project-specific noise limits at all modelled receivers.

Modelling of L_{Amax} noise levels at nearby receivers was undertaken for typical instantaneous noise sources, such as reversing alarms. This analysis concluded that predicted noise levels would comply comfortably with the 45 dBA $L_{A1,1\ min}$ criterion applicable to assessment of potential sleep disturbance at all privately-owned receivers.

6.3 Road Traffic

The Road Transport Assessment (GTA, 2012) projected the future traffic volumes on roads in the Project region for Year 1 and Year 20[1] of operations. Traffic noise levels at the closest residential receiver (Magenta residence which is approximately 0.8 km from Magenta Road [Figure 3-1]) were predicted by Wilkinson Murray (2012) based on the estimated traffic scenarios presented in the Road Transport Assessment (GTA, 2012). The predicted traffic noise levels at the Magenta residence were found to be well within both day and night time road traffic noise criteria. Accordingly, the criteria would be met at all other receivers along the road.

[1] Year 20 projections include a conservative estimate of traffic generated by the Balranald Mineral Sands Project.

Balranald-Ivanhoe Road represents the greatest potential cumulative impact of light vehicle traffic from the Project and the Balranald Mineral Sands Project. An assessment of road traffic-related noise was undertaken to determine the anticipated noise levels as a result of potential cumulative increased traffic volumes (particularly light vehicle movements) as presented in the Road Transport Assessment (GTA, 2012). The noise levels were evaluated for compliance with the relevant road noise criteria by Wilkinson Murray (2012) and it was concluded that the relative increase in traffic noise level resulting from the Project-related traffic movements on the Balranald-Ivanhoe Road is likely to be less than 2dB. The RNP states that *an increase of up to 2 dB represents a minor impact that is considered barely perceptible to the average person.*

6.4 Rail Traffic

Mineral concentrates and MSP process waste will be railed between the Ivanhoe Rail Facility and the MSP via the Orange-Broken Hill Railway. The Project will result in a maximum of two train passbys in any one 24-hour period and the following scenarios could occur:

- Scenario 1 – two train passbys occurring during the daytime (between 7.00am and 10.00pm); or
- Scenario 2 – one passby occurring during the day (between 7.00am and 10.00 pm) and one at night (between 10.00pm and 7.00am); or
- Scenario 3 – two passbys occurring at night (between 10.00pm and 7.00am).

The existing and proposed noise levels at different setback distances from the Orange-Broken Hill Railway were calculated. Prediction of the existing and future proposed offset distances from the Orange-Broken Hill Railway in order to meet the relevant criteria concluded:

- The maximum increase in distance from the railway line at which the ARTC EPL criteria are met including the Project rail movements, compared with the existing/approved rail movements, would be 3 m for daytime operations and 5 m for night time operations. It is anticipated that this increase in distance would not result in any additional exceedances of the daytime criterion, however, would result in an additional exceedance of night time criterion at two additional residential receivers along the Orange-Broken Hill Railway.
- The maximum increase in distance from the railway line at which the EPA criteria are met including the Project rail movements, compared with the existing/approved rail movements, would be 2 m for 24-hour operations. This increase in distance would not result in any additional exceedances of criterion at residential receivers along the Orange-Broken Hill Railway.
- There would be no change to the maximum passby noise as a result of the Project rail movements.

The predicted noise levels indicated that for the Orange-Broken Hill Railway west of the Ivanhoe Rail Facility the peak noise increase associated with the Project was predicted to be approximately 0.7 dBA. Given that the peak Project related noise increase is anticipated to be less than 2 dBA, an assessment of 'reasonable and feasible' noise mitigation measures was not considered necessary.

7 ASSESSMENT OF MODIFIED POTENTIAL NOISE IMPACTS

7.1 Operational Noise Atlas-Campaspe Mine Site

7.1.1 Methodology

Prediction of operational noise levels at the identified receiver locations for the detailed noise assessment was carried out using the Environmental Noise Model (ENM). Factors that are addressed in the modeling are:

- equipment sound level emissions and location;
- screening effects from buildings (if relevant);
- receiver locations;
- ground topography;
- noise attenuation due to geometric spreading;
- ground absorption; and
- atmospheric absorption.

The Wilkinson Murray (2012) modelling assumed all plant and equipment to be operating concurrently and as such, the predicted results are considered to be conservative.

To assess any potential changes in the previously predicted noise levels (and associated potential noise impact) (Section 6.1), a screening assessment has been conducted based upon changes to the plant and equipment schedules for Year 1 (construction) and Year 2 onwards. The total SWLs of the overall approved mining fleets for each previously assessed stage have been compared with the total SWLs of the modified mining fleets. Where no change in the overall SWLs would occur as a result of the Modification, further modelling of noise emissions is not required.

7.1.2 Operational Noise – Year 1

Table 7-1 shows the indicative modified major operational and construction mobile and fixed equipment for the Atlas-Campaspe Mine in Year 1 (i.e. the plant with potential to contribute to noise levels at the receiver locations) and the modelled SWL associated with each item.

No changes are proposed to either the approved major operational and construction mobile and fixed equipment during the Year 1 stage as a result of the Modification. Given the above, the modified Project operational noise levels during Year 1 would be unchanged from the predicted noise levels in Wilkinson Murray (2012) for the approved Project.

The modified Year 1 noise levels from the Atlas-Campaspe Mine would therefore comply with Project-specific noise criteria of 35 dBA for all modelled receivers under neutral and adverse meteorological conditions.

As described in Section 3.1, the existing Development Consent and EPL 21007 noise criteria (Tables 3-1 and 3-2) are more stringent than the NPfI Project Noise Trigger Levels outlined in Table 3-3. Given the above, the modified Year 1 noise levels from the Atlas-Campaspe Mine are therefore expected to comply with relevant NPfI Project Noise Trigger Levels.

Table 7-1 Modified Equipment and Sound Power Levels – Year 1

Equipment	Construction No. of Units	L_{Aeq} SWL (dBA)	Source
Backhoe (CAT 330B)	1	102	WM Measurements
Bobcat	1	97	WM Measurements
Bus (Toyota Coaster)	2	109	WM Measurements
Road Roller/Compactor (CAT 825G)	2	109	WM Measurements
Scraper (Water Cart) (CAT 740)	1	115	WM Measurements
Grader (CAT 16G)	2	108	WM Measurements
Front End Loader (IT62G)	1	113	WM Measurements
Crane (GROVE RT650E/ LIEBHERR LTM 1100)	4	105	WM Measurements
Mobile Fuel Tank (MACK)	1	109	WM Measurements
1,000 kVA Generators	4	98	WM Measurements
Scraper / Laser Bucket (Case STX 535/New Holland t9060)	9	115	WM Measurements
Dozer (CAT D11)	3	116	WM Measurements
Excavator (EX 1900/PC1800)	3	114	WM Measurements
Haul Truck (CAT 777D)	12	115	WM Measurements
Water Truck (CAT 773)	2	115	WM Measurements
Service Truck (MACK)	1	109	WM Measurements
Maintenance Truck (Isuzu)	1	109	WM Measurements
Lighting Tower (ALL Light)	8	103	WM Measurements
Garbage Truck	1	109	WM Measurements
Electric Pump	4	103	WM Measurements
Sewage Treatment Plant	1	97	WM Measurements
Accommodation Block	1	102	WM Measurements
Total		130	

WM Measurements = Wilkinson Murray Measurements
kVA = kilovolt-ampere

7.1.3 Operational Noise – Year 2 Onwards

Table 7-2 shows the indicative modified major operational mobile and fixed equipment for the Atlas-Campaspe Mine for Year 2 onwards (i.e. the plant with potential to contribute to noise levels at the receiver locations) and the modelled SWL associated with each item.

The changes to the mining equipment fleet proposed as a result of the Modification would involve inclusion of alternative models of excavator, front end loader, grader and haul trucks. The SWLs of these alternative models would not be higher than the levels previously nominated by Wilkinson Murray (2012) for the approved Project, nor would there be any resulting change in the overall SWL of the total fleet.

Table 7-2 Optimisation Modification Sound Power Levels and Proposed Equipment – Year 2 Onwards

Equipment	No. of Units	L_{Aeq} SWL (dBA)	Source
Dozer (CAT D11)	4	116	WM Measurements
Excavator (EX1900/PC1700/**Cat6040**)	4	114	WM Measurements
Scraper (Water Cart) (CAT740)	1	115	WM Measurements
Front End Loader (CAT990/**980**)	3	113	WM Measurements
Front End Loader (CAT IT62G)	1	113	WM Measurements
Grader (CAT 16G, **24H**)	2	108	WM Measurements
Road Roller/Compactor (CAT 825G)	1	109	WM Measurements
Front End Loader (CAT980H)	2	111	WM Measurements
Water Truck (CAT 773)	2	115	WM Measurements
1,000 kVA generators	4	98	WM Measurements
Haul Truck (CAT 777D/**785/793**)	12	115	WM Measurements
Scraper (Laser Bucket) (Case STX535/New Holland t9060)	9	115	WM Measurements
DMUs	2	112	Holmes Air Sciences (2007)
Primary Gravity Concentration Unit	1	103	Holmes Air Sciences (2007)
Electric Pumps	16	103	Holmes Air Sciences (2007)
Truck (Kenworth T650)	2	109	WM Measurements
Bobcat	1	97	WM Measurements
Bus (Toyota Coaster)	2	109	WM Measurements
Crane (GROVE RT650E/ LIEBHERR LTM 1100)	1	105	WM Measurements
Mobile Fuel Tank (MACK)	1	109	WM Measurements
Service Truck (MACK)	1	109	WM Measurements
Maintenance Truck (Isuzu)	1	109	WM Measurements
Lighting Tower (ALL Light)	8	103	WM Measurements
Garbage Truck (International 8 m^3)	1	109	WM Measurements
Sewerage Treatment plant	1	97	WM Measurements
Accommodation Block	1	102	WM Measurements
Total		131	

The Modification includes the possible addition of conveyors to transfer some or all of the overburden rather than the currently approved haul trucks. The SWL of a typical conveyor system has previously been measured at 100 dBA/100 m, which is significantly lower than that generated by haul or product trucks. This introduction of conveyors would reduce noise emissions generated by Atlas-Campaspe Mine operations.

With no change expected in the overall SWL associated with mining operations from Year 2 onwards, there would be no change in operational noise predicted noise levels in Wilkinson Murray (2012) for the approved Project.

The Modification would therefore not change the operational noise propagated to the surrounding environment from Year 2 onwards and noise levels at the surrounding receiver locations considered would be below 35 dBA under neutral and adverse meteorological conditions.

As described in Section 3.1, the existing Development Consent and EPL 21007 noise criteria (Tables 3-1 and 3-2) are more stringent than the NPfI Project Noise Trigger Levels outlined in Table 3-3. Given the above, the modified noise levels from the Atlas-Campaspe Mine for Year 2 onwards are therefore expected to comply with relevant NPfI Project Noise Trigger Levels.

7.2 Ivanhoe Rail Facility

Table 7-3 outlines the modified Ivanhoe Rail Facility equipment (i.e. the plant with potential to contribute to noise levels at the receiver locations) and the SWL.

Table 7-3 Optimisation Modification Sound Power Levels & Proposed Equipment – Ivanhoe Rail Facility

Equipment	No. of Units	L_{Aeq} SWL (dBA)	Source
Front End Loader (Cat 988)	1	114	WM Measurements
Truck (Kenworth T650)	1	109	WM Measurements
Forklift (Hyster 12 to 16 tonne)	1	106	WM Measurements
Reach Stacker Kalmar DRT450 2014 MODEL	1	110	Kalmar measured data
Water cart 16,000L	1	115	WM Measurements
Locomotive (81 class Locomotive)	2	109	WM Measurements
Total		120	

With the addition of a Reach Stacker and water cart, the overall SWL associated with the Ivanhoe Rail Facility operations would increase by a maximum 3 dBA, assuming concurrent operation of all sources.

The Modification would therefore not significantly change the operational noise propagated to the surrounding environment and noise levels at the surrounding receiver locations considered would be below 35 dBA under neutral and adverse meteorological conditions.

Computer modelling of the modified Ivanhoe Rail Facility, based on the model developed by Wilkinson Murray (2012), confirmed that noise levels at the surrounding receiver locations considered would be below 35 dBA (generally below 30 dBA) under neutral and adverse meteorology.

7.3 Road Traffic Noise

The Modification includes an increase in the mineral concentrate transport truck trips from 24 per day to 35 per day. This proposed increase represents a potential 1.6 dBA increase in noise level over the daytime and night time periods (assuming equivalent distribution of vehicles over daytime and night time periods).

On this basis the predicted noise levels at the residential receivers previously assessed by Wilkinson Murray (2012) are presented in Table 7-4.

Table 7-4 Calculated Traffic Noise Levels – Optimised Modification

Location	Predicted Noise Level dBA	Criterion Day / Night dBA	Complies
Magenta	Peak 1 hour $L_{Aeq,1hour}$ 38	55 / 50	Yes
Hatfield – The Vale Road	Peak 1 hour $L_{Aeq,1hour}$ 38	55 / 50	Yes
Balranald / Ivanhoe Road (Kilfera)	$L_{Aeq,15hour}$ / $L_{Aeq,9hour}$ (Day / Night) <25 / <25	60 / 55	Yes
Hatfield Pub	$L_{Aeq,15hour}$ / $L_{Aeq,9hour}$ (Day / Night) 45 / 46	60 / 55	Yes
Balranald-Ivanhoe Road – South of the proposed Balranald Mineral Sands Project Location J	$L_{Aeq,15hour}$ / $L_{Aeq,9hour}$ (Day / Night) 57 / 53	60 / 55	Yes

Noise generated by increased traffic associated with the modified Project complies with the relevant assessment criteria at all receiver locations.

7.4 Rail Traffic Noise

Under the Modification, mineral concentrate transport train length would increase from 600 m to 920 m and train frequency would increase from six to eight train movements per week (i.e. four arrivals, four departures). The hardstand area and rail siding would be extended to accommodate the increase train length. There is also a revised alignment of the Ivanhoe Rail Facility access road and access road intersection (Figure 3-2).

The proposed increase in train frequency is not expected to result in any change to the number of train movements per day. Train movements would occur over additional days per week. Accordingly, the approved rail noise impacts as previously assessed in Wilkinson Murray (2012) would remain unchanged as follows:

- No additional exceedance of the ARTC EPL daytime criterion, however an additional exceedance of night time criterion at two additional residential receivers along the Orange-Broken Hill Railway locations within 5 m of the railway line.
- The EPA criteria would be met with no additional exceedances of the criterion at residential receivers along the Orange-Broken Hill Railway.
- There would be no change to the maximum passby noise as a result of the optimised Project rail movements.

8 CONCLUSION

This Noise Review has reviewed the aspects of the Modification that have the potential to generate noise to the surrounding environment. These operations have been reviewed in relation to the Noise Assessment (Wilkinson Murray, 2012) previously prepared for the Project.

This review concludes that the proposed modifications at the Atlas-Campaspe Mine are not expected to cause any significant increase in operational noise levels at the nearest surrounding receivers. All operational noise criteria (including NPfI Project Noise Trigger Levels) are predicted to be achieved.

Noise emissions due to proposed modifications at the Ivanhoe Rail Facility would not result in any significant increase in noise levels at surrounding receivers. All operational noise criteria (including NPfI Project Noise Trigger Levels) are predicted to be achieved.

Road traffic noise resulting from the modified Project would meet the relevant regulatory limits at receivers located in proximity to the transport routes.

Noise generated as a result of Project rail movements would not increase as a result of the proposed modifications to Project rail operations. In summary, the Noise Review found that the Modification is unlikely to significantly alter the outcomes of the Noise Assessment (Wilkinson Murray, 2012) for the approved Project.

9 REFERENCES

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APPENDIX D

VEGETATION CONDITION ASSESSMENT

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX D

VEGETATION CONDITION ASSESSMENT

TRONOX

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION

VEGETATION CONDITION ASSESSMENT

Project No. CMA-18-07
Document No. 00987790

1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

Tronox is seeking to modify the Project under section 4.55(2) of the EP&A Act. The Project Optimisation Modification (the Modification) would include changes to the approved Ivanhoe Rail Facility, resulting in a modified surface development footprint (Figure 1). There would be a net reduction (approximately 12 hectares [ha]) in the amount of native vegetation clearance associated with the modified Ivanhoe Rail Facility (Figure 1).

1.1 PURPOSE

This report has been prepared to document the condition of the vegetation in the additional surface development area associated with the modified Ivanhoe Rail Facility (approximately 10.2 ha), compared to the condition of the vegetation in the surface development area associated with the approved Ivanhoe Rail Facility that would no longer be required to be cleared (approximately 22.1 ha).

2 METHODS

2.1 VEGETATION MAPPING

Flora surveys of the approved Ivanhoe Rail Facility surface development area were conducted by Australian Museum Business Services (AMBS) in October 2012 (AMBS, 2013). The surveys were undertaken using standard techniques (quadrats, rapid data points, vegetation mapping, condition assessment and threatened species searches) in accordance with the *Threatened Biodiversity Survey and Assessment: Guidelines for Developments and Activities* (Department of Environment and Conservation, 2004).

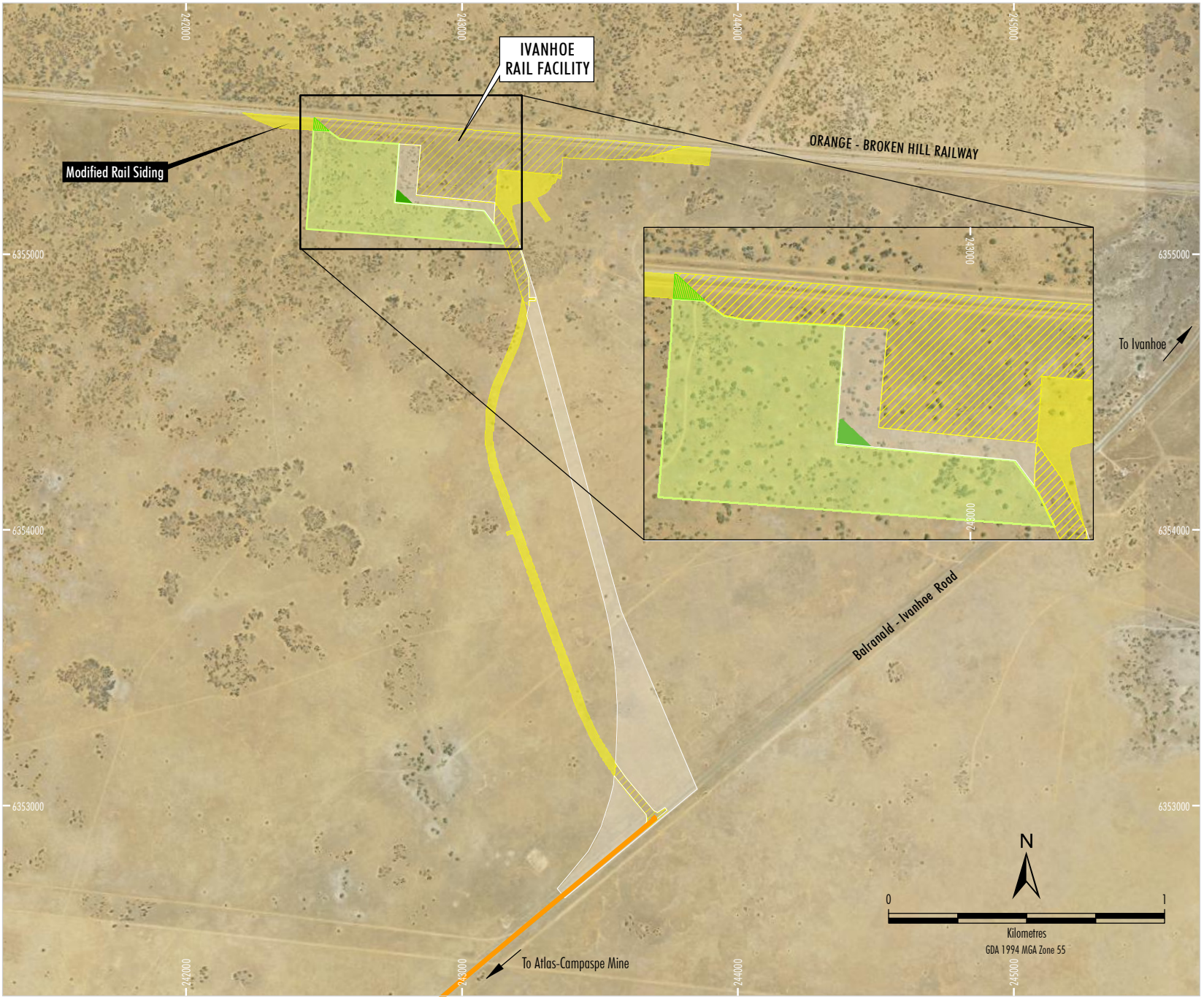
Regional mapping of Plant Community Types (PCTs) (Office of Environment and Heritage [OEH], 2019a) was considered in the assignment of vegetation communities mapped by AMBS (2013) to PCTs as per the BioNET Vegetation Classification (OEH, 2019b).

The Ivanhoe Rail Facility is located in the Darling Depression IBRA Subregion of the Murray Darling Depression IBRA Region (Commonwealth Department of Environment and Energy, 2012). It is also located in the Ivanhoe – Nangara Sandplains Mitchell Landscape (OEH, 2018).

2.2 VEGETATION CONDITION

A vegetation condition assessment of the modified Ivanhoe Rail Facility surface development area was carried out by Botanist Greg Cranston (GHD) on 19 and 20 June 2019. The assessment consisted of nine vegetation plots; five located in the approved Ivanhoe Rail Facility surface development area no longer required, and four located in the modified Ivanhoe Rail Facility surface development area (Figure 2). The number of vegetation plots and data collected at each plot was in accordance with the Biodiversity Assessment Method (BAM) (OEH, 2017).

A vegetation integrity score (VIS) was then calculated using the data obtained by GHD for each of the plots using the BAM Calculator. The calculations were carried out by Jamie Gleeson (Resource Strategies) (assessor accreditation number 0056).



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Approved Vegetation Management Area
- Approved Vegetation Managment Area to be Replaced
- Replacement Vegetation Management Area

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2015); Tronox (2019) Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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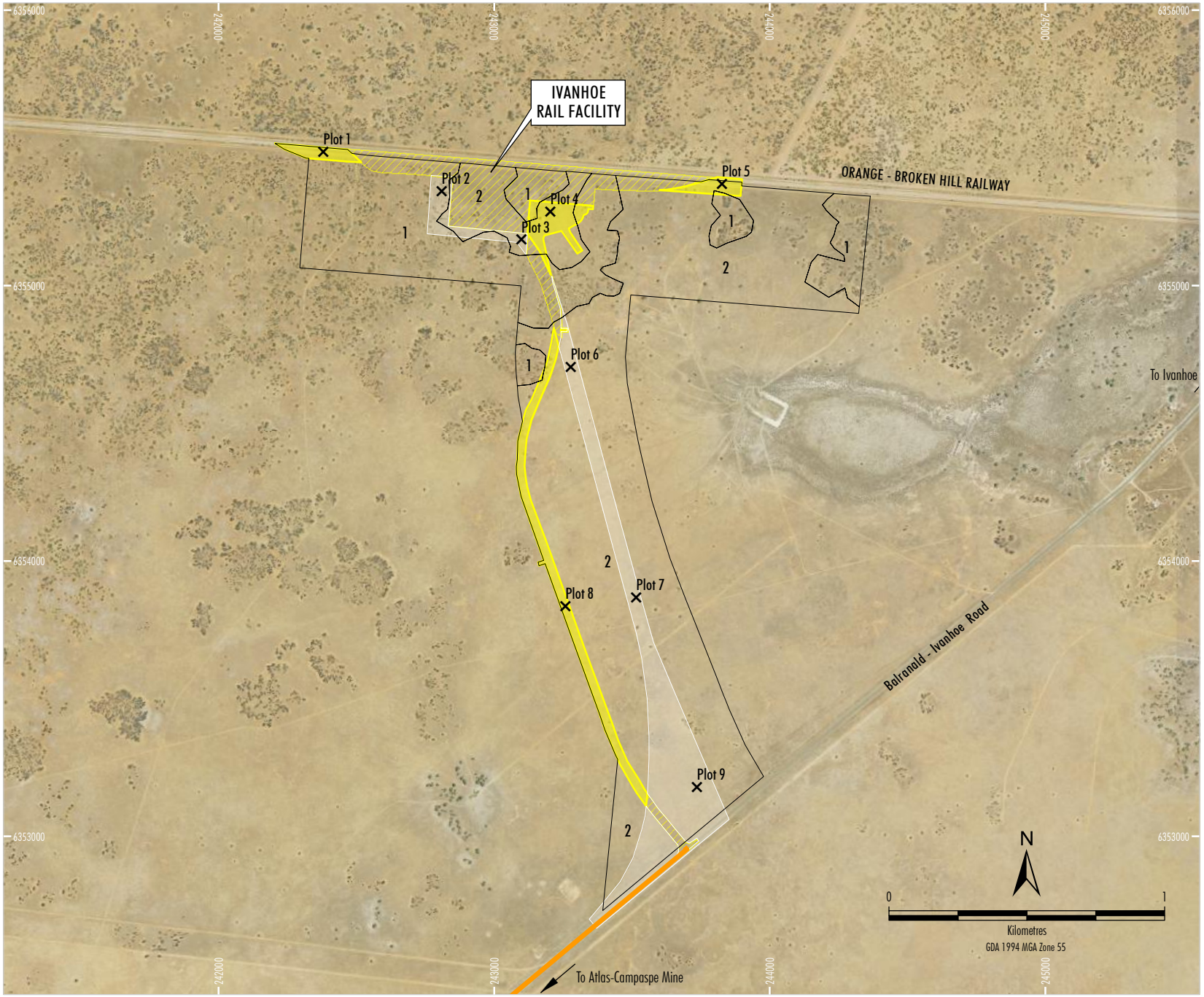
OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Surface Development Area

Figure 1

CMA-18-07 AC OM App VC_201B



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*

Vegetation Communities

- 1 Belah-Rosewood/Acacia Woodland
- 2 Native Grassland/Sparse Acacia/ Chenopod Shrubs
- × Survey Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); AMBS (2012); Tronox (2019) and GHD (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

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OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Vegetation Communities

Figure 2

CMA-18-07 AC OM App VC_202B

3 RESULTS

The same vegetation communities/PCTs recorded in the approved Ivanhoe Rail Facility surface development area (i.e. Native Grassland/Sparse Acacia/Chenopod Shrubs (PCT 166) and Belah-Rosewood/Acacia (PCT 57) are present in the modified Ivanhoe Rail Facility surface development area (Figure 2). No threatened ecological communities under the *Biodiversity Conservation Act, 2016* Act or *Environment Protection and Biodiversity Conservation Act, 1999* occur in either the approved or modified surface development areas. It is unlikely that rare or threatened flora species would occur in the paddock due to the high level of disturbance from agricultural practises.

The vegetation condition plot data for the modified Ivanhoe Rail Facility surface development area is provided in Appendix A and for the approved Ivanhoe Rail Facility surface development area no longer required is provided in Appendix B.

Outputs from the BAM Calculator included scores for composition, structure and function attributes (Table 1). The modified Ivanhoe Rail Facility surface development area has a VIS of 31.3 for PCT 57 and 31 for PCT 166, while the approved Ivanhoe Rail Facility surface development area no longer required has a VIS of 21.3 for PCT 57 and 21 for PCT 166 (Table 1).

Table 1
Ivanhoe Rail Facility Vegetation Integrity Scores

PCT	Area (ha)	BAM Calculator Output			
		Composition Condition Score	Structure Condition Score	Function Condition Score	VIS[1]
Modified Surface Development Area (Plots 1, 4, 5 and 8)					
57[2]	1.7	66.6	16.6	27.7	31.3
166[3]	8.5	71.3	13.5	-	31.0
Approved Surface Development Area (No Longer Required) (Plots 2, 3, 6, 7 and 9)					
57[2]	1.8	62.9	14.5	10.6	21.3
166[3]	20.4	75.6	5.8	-	21.0

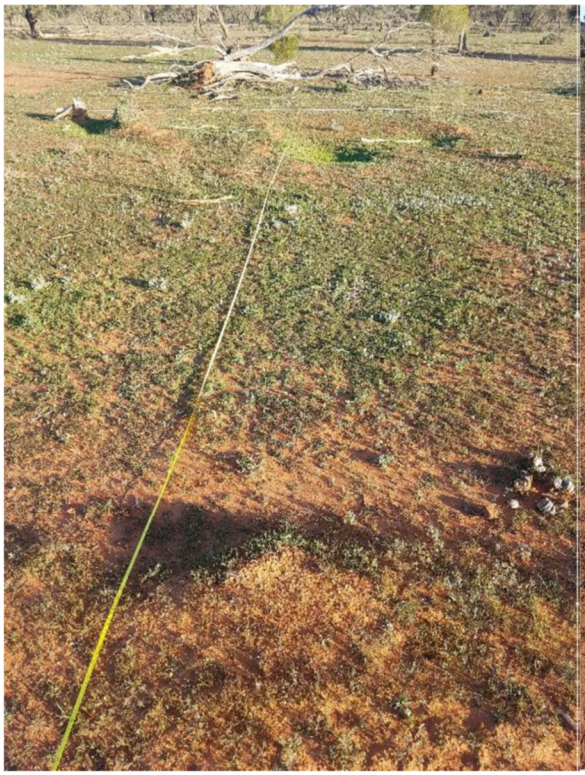
[1] The vegetation integrity score is the measure of vegetation integrity as calculated in the BAM Calculator using input from plot data. Vegetation integrity is the condition of native vegetation assessed for each vegetation zone against the benchmark for the PCT.

[2] PCT 57 – Belah/Black Oak – Western Rosewood – Wilga woodland of central NSW including the Cobar Peneplain Bioregion.

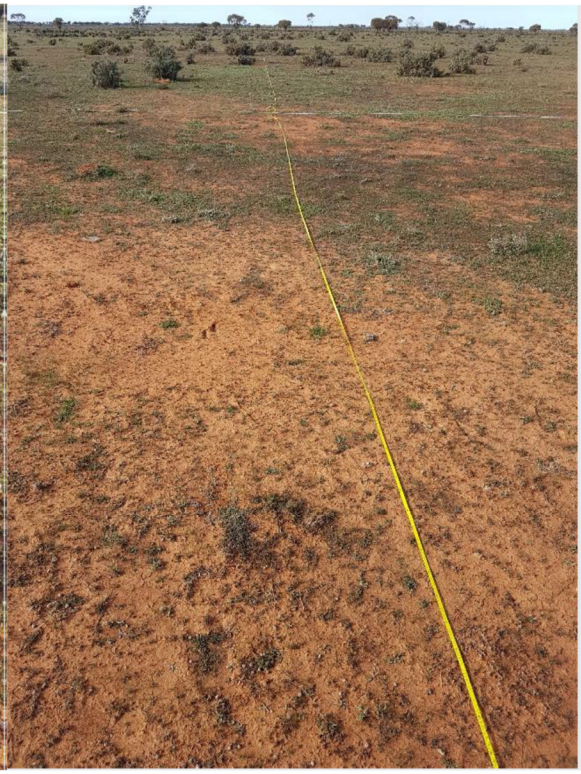
[3] PCT 166 – Disturbed annual saltbush forbland on clay plains and inundation zones mainly of south-western NSW.

The apparent differences in the calculated VIS between the modified Ivanhoe Rail Facility surface development area and approved Ivanhoe Rail Facility surface development area no longer required is likely natural variation and not an actual measure that the vegetation is in better condition in the modified Ivanhoe Rail Facility surface development area. The reasons for this are:

- the quantities of vegetation clearance are so small such that the BAM (OEH, 2017) only requires minimal plots to be sampled (e.g. <2 ha clearance of PCT 57 is sampled by a single BAM plot in accordance with the BAM [OEH, 2017]);
- there are no obvious differences in the vegetation of the respective areas (Plates 1 to 4 and 5 to 9); and
- the vegetation in the paddock is subject to the same agricultural practises and thus has been subject to the same disturbances such as grazing by goats, introduction of non-native vegetation and clearing.



Plot 1 – PCT 57



Plot 4 – PCT 166

Plot 5 – PCT 166

Plot 8 – PCT 166

Plates 1 to 4 Modified Ivanhoe Rail Facility Surface Development Area

Plot 2 – PCT 57

Plot 3 – PCT 166

Plot 6 – PCT 166

Plot 7 – PCT 166

Plot 9 – PCT 166

Plates 5 to 9 Approved Ivanhoe Rail Facility Surface Development Area no Longer Required

4 CONCLUSION

The following conclusions are made:

- less native vegetation clearance would be required for the modified Ivanhoe Rail Facility, resulting in retention of 0.1 ha of PCT 57 and 11.9 ha of PCT 166 that would otherwise be cleared;
- the VIS calculated using the BAM Calculator indicate that there is a slight difference in the condition of the vegetation, however the apparent differences in the calculated VIS between the modified Ivanhoe Rail Facility surface development area and approved Ivanhoe Rail Facility surface development area no longer required is likely natural variation and not a material measure that the vegetation is in better condition in the modified Ivanhoe Rail Facility surface development area; and
- even if the apparent differences in the calculated VIS between the modified Ivanhoe Rail Facility surface development area and approved Ivanhoe Rail Facility surface development area no longer required are real, the approximate 12 ha reduction in native vegetation clearance required for the modified Ivanhoe Rail Facility would lead to an overall net reduction of impacts on native vegetation.

5 REFERENCES

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Website Accessed: January 2019.

APPENDIX A

VEGETATION CONDITION PLOT DATA FOR THE MODIFIED IVANHOE RAIL FACILITY SURFACE DEVELOPMENT AREA

Vegetation Condition Data for the Modified
Ivanhoe Rail Facility Surface Development Area

Plot	Zone	PCT	Easting	Northing	Bearing	Patchsize	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLenFallenLogs	funTreeStem5to9	funTreeStem10to19	funTreeStem20to29	funTreeStem30to49	funTreeStem50to79	funTreeRegen	funHighThreatExotic
1	55	57	242380	6355487	180	100	0	8	0	4	0	0	0	13.3	0	2.1	0	0	0	0	4	23	0	1	1	0	0	0	35.4
4	55	166	243204	6355269	185	100	0	12	0	1	0	0	0.0	21.2	0.0	0.1	0.0	0.0	0	0	3.8	0.0	0	0	0	0	0	0	14.0
5	55	166	243827	6355369	180	100	0	7	1	5	0	0	0.0	12.5	0.2	6.6	0.0	0.0	0	0	4.0	0.0	1	1	0	0	0	0	40.0
8	55	166	243259	6353835	270	100	0	5	0	5	0	0	0.0	9.9	0.0	6.1	0.0	0.0	0	0	1.0	0.0	0	0	0	0	0	0	24.0

APPENDIX B

VEGETATION CONDITION PLOT DATA FOR THE APPROVED IVANHOE RAIL FACILITY SURFACE DEVELOPMENT AREA

Vegetation Condition Data for the Approved Ivanhoe Rail Facility
Surface Development Area no Longer Required

Plot	Zone	PCT	Easting	Northing	Bearing	Patchsize	compTree	compShrub	compGrass	compForbs	compFerns	compOther	strucTree	strucShrub	strucGrass	strucForbs	strucFerns	strucOther	funLargeTrees	funHollowtrees	funLitterCover	funLenFallenLogs	funTreeStem5to9	funTreeStem10to19	funTreeStem20to29	funTreeStem30to49	funTreeStem50to79	funTreeRegen	funHighThreatExotic
2	55	57	242810	6355343	180	100	0	7	1	3	0	0	0.0	12.4	0.2	1.3	0.0	0.0	0	0	7.4	4.0	0	1	1	0	0	0	51.0
3	55	166	243099	6355167	180	100	0	10	0	1	0	0	0.0	10.3	0.0	0.5	0.0	0.0	0	0	2.8	0.0	0	0	0	0	0	0	41.0
6	55	166	243278	6354704	90	100	0	6	1	5	0	0	0.0	10.0	1.0	12.1	0.0	0.0	0	0	4.2	0.0	0	0	0	0	0	0	17.0
7	55	166	243516	6353867	260	100	0	7	0	4	0	0	0.0	4.6	0.0	12.3	0.0	0.0	0	0	1.0	0.0	0	0	0	0	0	0	12.1
9	55	166	243736	6353180	270	100	0	5	0	7	0	0	0.0	3.4	0.0	7.4	0.0	0.0	0	0	2.0	0.0	0	0	0	0	0	0	29.0

APPENDIX E

ABORIGINAL CULTURAL HERITAGE ASSESSMENT

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX E

ABORIGINAL CULTURAL HERITAGE ASSESSMENT

TRONOX

Atlas-Campaspe Mineral Sands Project Optimisation Modification

Aboriginal Cultural Heritage Assessment

Report to Tronox Mining Australia Limited

12 July 2019

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Atlas-Campaspe Mineral Sands Project Optimisation Modification

Aboriginal Cultural Heritage Assessment

Natural and Cultural Heritage Management

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EXECUTIVE SUMMARY

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe.

This Aboriginal Cultural Heritage Assessment has been prepared to support the application to modify Development Consent (SSD 5012) for the Project.

The Modification does not change the approved Atlas-Campaspe Mine surface disturbance footprint, however a portion of the modified Ivanhoe Rail Facility surface disturbance footprint is situated outside of the approved Ivanhoe Rail Facility surface disturbance area. Hence, this ACHA has been prepared in consideration of the modified Ivanhoe Rail Facility only (herein referred to as the Modification area).

This report presents an assessment of the Aboriginal cultural heritage related issues for the Modification area in accordance with the general requirements of the *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (Part 6 National Parks and Wildlife Act* 1974) (DECCW, 2010a), *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b), *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011), *Draft Guidelines for Aboriginal Cultural Impact Assessment and Community Consultation* (DEC, 2005), The Australia International Council on Monuments and Sites (ICOMOS) Burra Charter (Australia ICOMOS 1999), NSW National Parks and Wildlife Service *Aboriginal Cultural Heritage: Standards and Guidelines Kit* (NPWS, 1997), the Australian Heritage Commission *Ask First; A Guide to Respecting Indigenous Heritage Places and Values* (AHC 2002) and NSW Minerals Council *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects* (NSW Minerals Council, 2010).

The specific objectives of the cultural heritage assessment were to:

- Consult the local Aboriginal community to identify any concerns they may have (consultation with the Aboriginal community followed *Aboriginal Cultural Heritage Community Consultation Requirements for Proponents* [DECCW, 2010a]).
- Conduct a desktop assessment to delineate areas of known and predicted cultural heritage within the Modification area.
- Undertake an archaeological survey of known and predicted cultural heritage identified in the desktop assessment with representatives of the local Aboriginal community.

- Record any cultural heritage sites within the Modification area and assess their significance.
- Identify the nature and extent of potential impacts of the Modification on cultural heritage.
- Devise options in consultation with the community to avoid or mitigate potential impacts of the development on cultural heritage places and items.

No Aboriginal cultural heritage places or items have previously been recorded in the Modification area. The present survey encountered five Aboriginal cultural heritage sites, however two of these were located outside of the Modification area. These are two small stone artefact scatters and three isolated finds of stone artefacts. This assessment concludes these sites are not of high scientific or cultural significance. No non-Aboriginal heritage sites were recorded in the Modification area. Based on the results of this cultural heritage investigation and consultation with representatives of the Registered Aboriginal Parties the following is recommended:

- The Modification be allowed to proceed because the Modification area would be located in an area where harm to highly significant cultural heritage would be avoided.
- A suitably qualified archaeologist and representatives of the local Aboriginal community should be engaged to record and collect the Aboriginal objects in the Modification area. These items should be properly curated and stored at the approved “Keeping Place”. The artefacts should be replaced within rehabilitated areas in consultation with local Aboriginal groups and the NSW Office of Environment and Heritage (OEH).
- In the unlikely event that human skeletal remains are encountered during the course of activities associated with the Modification, all work in that area must cease. Remains must not be handled or otherwise disturbed except to prevent further disturbance. If the remains are thought to be less than 100 years old, the Police or the State Coroner’s Office (tel: 02 9552 4066) must be notified. If there is reason to suspect that the skeletal remains are more than 100 years old and Aboriginal, Tronox should contact the NSW Office of Environment and Heritage’s Environmental Line (tel: 131 555) for advice. In the unlikely event that an Aboriginal burial is encountered, strategies for its management would need to be developed with the involvement of the local Aboriginal community.
- Tronox should revise the Heritage Management Plan (HMP) for the Atlas-Campaspe Mine to reflect the results and recommendations of this assessment. The HMP should continue to remain active for the life of the Modified Project and define the tasks, scope and conduct of all Aboriginal cultural heritage management activities. The HMP should be revised in consultation with the local Aboriginal community.
- Tronox should continue to provide training to all on-site personnel regarding the HMP strategies relevant to their employment tasks.
- Tronox should continue to involve the registered Aboriginal parties and any other relevant Aboriginal community groups or members in matters pertaining to the Modification.

1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (**Figure 1**).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (**Figure 1**).

The Project will integrate with currently existing / approved Tronox operations in western NSW, including (**Figure 1**):

- the MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine;
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine; and
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

Tronox proposes to modify Development Consent (SSD 5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). To this end, Tronox commissioned Landskape Natural and Cultural Heritage Management (Landskape) to undertake an Aboriginal Cultural Heritage Assessment (ACHA) of the Modification. This Aboriginal Cultural Heritage Assessment (ACHA) has been prepared to support the application to modify Development Consent (SSD_5012) for the Project.

The Modification (detailed in Section 3) does not change the approved Atlas-Campaspe Mine surface disturbance footprint, however a portion of the modified Ivanhoe Rail Facility surface disturbance footprint is situated outside of the approved Ivanhoe Rail Facility surface disturbance area. Hence, this ACHA has been prepared in consideration of the modified Ivanhoe Rail Facility only (herein referred to as the Modification area).

1.1 AIM AND OBJECTIVES OF THE ASSESSMENT

The objective of this assessment is to provide Tronox with an ACHA to support an approval for the Modification under the EP&A Act and the NSW *Environmental Planning and Assessment Regulation, 2000*.

This investigation provides a description of the context of the Modification and surrounds, identification of heritage places and cultural values within the Modification area, an assessment of the potential impacts to Aboriginal heritage as a result of the Modification, and development of recommendations to minimise, manage and mitigate these potential impacts.

This assessment has been undertaken in accordance with the relevant requirements of the various advisory documents and guidelines. These guidelines and documents include:

- *Aboriginal Cultural Heritage Consultation Requirements for Proponents 2010 (Part 6 National Parks and Wildlife Act* 1974) (NSW Department of Environment, Climate Change and Water [DECCW] 2010a).
- *Due Diligence Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b).
- *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (NSW Office of Environment and Heritage [OEH], 2011)
- *Draft Guidelines for Aboriginal Cultural Impact Assessment and Community Consultation* (NSW Department of Environment and Conservation [DEC], 2005).
- The Australia International Council on Monuments and Sites (ICOMOS) Burra Charter (Australia ICOMOS, 1999).
- *Aboriginal Cultural Heritage: Standards and Guidelines Kit* (NSW National Parks and Wildlife Service [NPWS] 1997).
- *Ask First; A Guide to Respecting Indigenous Heritage Places and Values* (Australian Heritage Commission, 2002).
- *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects* (NSW Minerals Council, 2010).

1.2 STRUCTURE OF THIS REPORT

This report has been prepared in consideration of the requirements of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in New South Wales* (DECCW, 2010b) and as such includes the following specific information:

Section 1: Outlines the Modification and the objectives and structure of this report.

Section 2: Lists the investigators and contributors involved with this report.

Section 3: Provides a summary description of the development proposal.

Section 4: Details the consultation and partnership with indigenous communities.

Section 5: Outlines the landscape context and includes descriptions of land use history, geology and vegetation within the locality of the Modification area.

Section 6: Provides background information relevant to previous archaeological works including relevant ethno-history, the regional archaeological context and previous predictive models for the locality.

Section 7: Describes predictions for the Modification and documents the archaeological survey and data collection, and includes information regarding the method of the survey and a description of the areas surveyed. Lists the results of the survey and provides a discussion and analysis of these results.

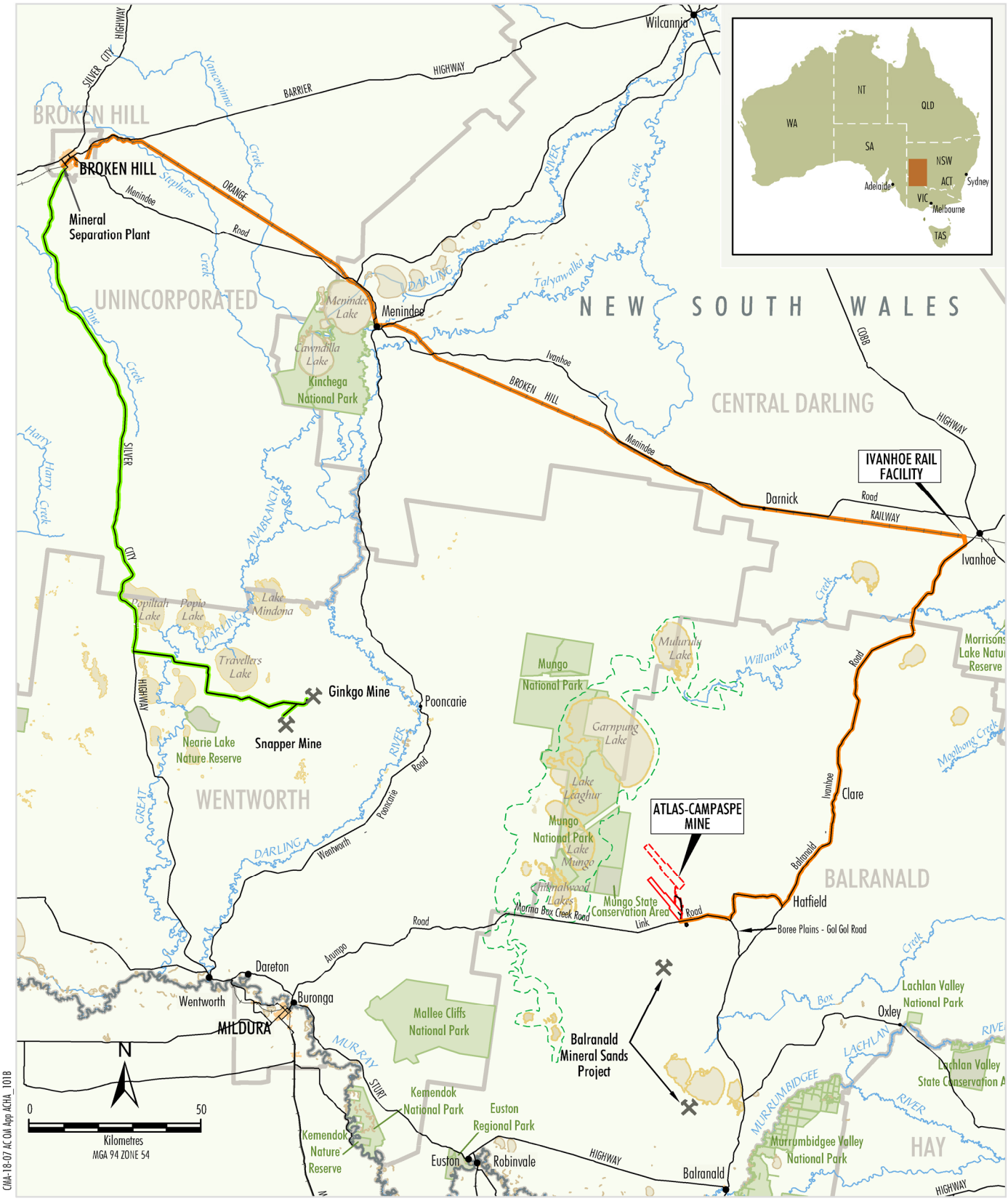
Section 8: Assesses the cultural heritage significance of the Modification.

Section 9: Assesses the impact of the Modification on Aboriginal heritage.

Section 10: Lists the management, mitigation measures and recommendations.

Section 11: Lists the references cited in this report.

A glossary of commonly used terms in the report is provided in **Appendix 1**.



LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1

2 INVESTIGATORS

Landskape was commissioned by Tronox in April 2019 to complete the ACHA for the Modification and to prepare this report.

Dr Matt Cupper, a qualified archaeologist and geoscientist with 20 years' experience as a cultural heritage advisor, was Landskape's project archaeologist.

The field investigation for the Modification was completed on 1 May 2019, and was attended by members of the Ivanhoe Community Working Party (Brian Etrich, Shana Kennedy and Joan Slade).

Community consultation pursuant to the OEH policy *Aboriginal cultural heritage consultation requirements for proponents 2010* (Consultation Guidelines) (DECCW, 2010a) was managed by Tronox.

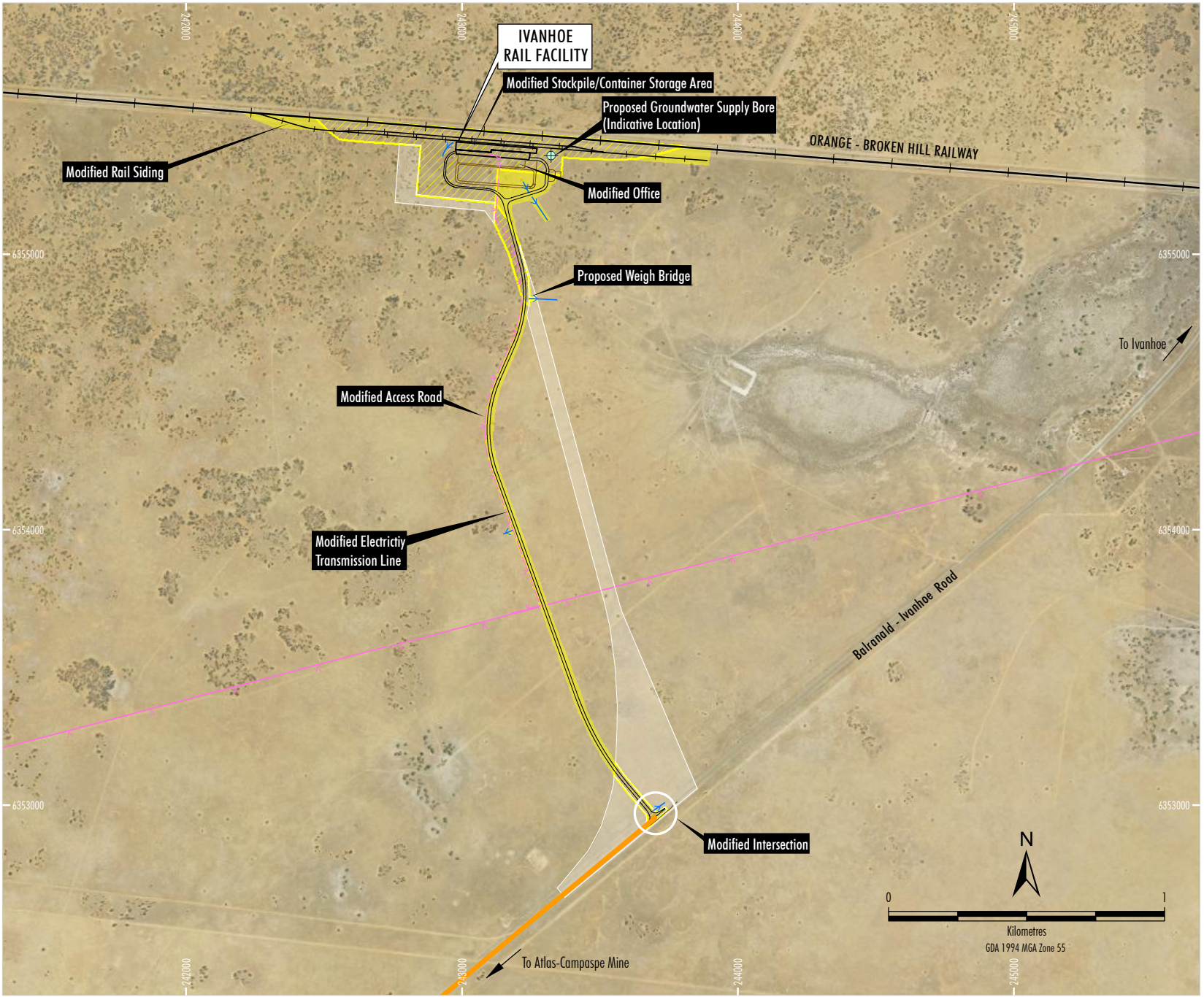
3 DESCRIPTION OF THE MODIFICATION

As described in Section 1, Tronox proposes to modify Development Consent (SSD 5012) for the Project to allow for changes to optimise the Project. The Modification would include:

- increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- increased mineral concentrate transport truck trips from 24 per day to 35 per day;
- increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]) (**Figure 2)**;
- increased MSP process waste disposal from 50,000 tpa to 65,000 tpa;
- the option to use an overland conveyor to transfer overburden in addition to haul trucks;
- the relocation of the Atlas-Campaspe Mine accommodation camp;
- the option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- development of an emergency airstrip at the Atlas-Campaspe Mine;
- construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- extension to the Ivanhoe Rail Facility hardstand area (**Figure 2**);
- extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding (**Figure 2**);
- a revised alignment of the Ivanhoe Rail Facility access road and access road intersection (**Figure 2**);
- a groundwater supply bore for the Ivanhoe Rail Facility (**Figure 2**); and
- the use of local roads other than the road haulage route by Project-related light vehicles to access site.

The Modification would not change the following components of the Project:

- mine path, mine life or mining method;
- mineral concentration methods;
- overburden and ore extraction rate;
- sand residue, coarse reject and process waste placement management;
- annual maximum water supply/demand;
- rehabilitation works;
- biodiversity offset area; or
- workforce.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 2

CMA-18-07 AC OM_ App ACHA_202B

4 ABORIGINAL COMMUNITY CONSULTATION

4.1 INTRODUCTION

In accordance with the Consultation Guidelines (DECCW, 2010a), this assessment has been prepared in consultation with the Aboriginal community (via the Registered Aboriginal Parties [RAPs]).

The following sections describe involvement by the RAPs and demonstrate that the input of the Aboriginal community has been considered when determining and assessing impacts, developing management measures, and making final recommendations relevant to Aboriginal cultural heritage within the Modification area.

4.2 ABORIGINAL COMMUNITY PARTICIPATION

The RAPs were consulted throughout the preparation of this assessment, including:

- review and comment on the Proposed Methodology;
- during the field survey with the representatives of the RAPs;
- during the review period for the draft ACHA; and,
- encouraged to provide feedback and input throughout the assessment process.

The following sections outline the process and outcomes of the community consultation undertaken during preparation of the assessment, and to ascertain the Aboriginal cultural heritage values, and associated management strategies, of the Modification area.

4.2.1 Identification of Registered Aboriginal Parties

In accordance with Sections 4.1 and 4.2 of the Consultation Guidelines (DECCW, 2010a), the following individuals and organisations have been previously identified as Aboriginal stakeholders for the Project:

- Kullila Site Consultants;
- Michael (Mick) Kelly on behalf of Ngiyampaa people;
- Balranald Local Aboriginal Land Council;
- Barkindji Elders Council;
- Badger Bates;
- Ivanhoe Community Working Party;
- Muthi Muthi Nations Aboriginal Corporation;
- National Koorie Site Management;
- Wakool Indigenous Corporation;

- Maria Maher; and,
- Willandra Lakes 2 Traditional Tribal Groups Elders Council.

These Aboriginal stakeholders groups with an interest in Aboriginal heritage at the Project have been previously identified and Tronox has maintained ongoing consultation and engagement with these groups since their individual expressions of interest. These Aboriginal stakeholder groups include those parties who registered for Atlas-Campaspe Mineral Sands Project Aboriginal and Non-Aboriginal Heritage Assessment in 2012 (Niche Environment and Heritage, 2012), and who were consulted during the preparation of the Heritage Management Plan (HMP) (Cristal Mining Australia, 2017) in accordance with Condition 28, Schedule 3 of the Project Development Consent (SSD_5012).

A consultation log with RAPs is included as **Appendix 2**.

4.2.2 Presentation of Information about the Proposed Modification

Information regarding the Modification was provided in writing to all RAPs on 29 March 2019. The correspondence included an invitation to attend an information session and field survey for the Modification and a copy of the Proposed Methodology was provided for review and comment (**Appendix 3**).

A minimum of 28 days were allowed for RAPs to provide input in regards to the following aspects of the Proposed Methodology:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Modification area, or issues of cultural significance.
- Any restrictions or protocols considered necessary in relation to any information of sensitivity that may be provided.
- Any other factors considered to be relevant to the heritage assessment.

The period for commenting on the Proposed Methodology was open between 29 March 2019 and 3 May 2019.

The information session regarding the modification was held on 30 April 2019 in Ivanhoe to explain the Modification and Proposed Methodology and address any RAP queries. The information session was attended by representatives of RAP Ivanhoe Community Working Party (represented by Faye Johnson and Brian Etrich).

4.2.3 Aboriginal Cultural Heritage Field Survey

All RAPs were invited to provide a representative for involvement in the field survey for the Modification. The following RAP participated in the survey:

- Ivanhoe Community Working Party (represented by Brian Etrich, Shana Kennedy and Joan Slade).

The Aboriginal cultural heritage field survey was completed on 1 May 2019. Further details regarding the survey and survey coverage are provided in Section 7.

The field survey was undertaken during the period for review and comment on the Proposed Methodology. It was described in the material provided to all RAPs with the Proposed Methodology and survey invitation, that if any RAP had comments on the Proposed (assessment) Methodology which (subject to agreement by Tronox) would have altered the field survey design/implementation (i.e. pedestrian survey across the Modification area), Tronox would commit to considering those submissions and take reasonable steps to address them, having regard to the survey requirements and the objectives of the Consultation Guidelines (DECCW, 2010a).

As no comments of this nature were received, no additional survey work was undertaken.

4.3 ABORIGINAL COMMUNITY INFORMATION ABOUT CULTURAL SIGNIFICANCE

As part of the review of the Proposed Methodology and during the field survey, the RAPs were asked to contribute their knowledge on the Modification area and surrounds. This information contributed to the assessment of the cultural heritage significance of the Modification area and is discussed further in Section 8.

4.4 REVIEW OF THE DRAFT ACHA

In accordance with the Consultation Guidelines (DECCW, 2010a), an initial draft of this ACHA was provided to all RAPs listed in Section 4.2 for review and comment on 17 May 2019, with feedback requested by 21 June 2019. No comments were received from the RAPs on the draft ACHA.

5 ENVIRONMENTAL CONTEXT

5.1 INTRODUCTION

The *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW, 2010b) requires a review of the environmental context to assist in the determination or prediction of the potential of a landscape to have accumulated or preserved objects, the ways Aboriginal people may have used the landscape in the past, with regard to identifiable resources or focal points for activities, and the likely distribution of the material traces of Aboriginal land use based on these factors.

Detailing the landscape context is an integral procedure in modelling potential past Aboriginal land use practices and/or predicting site distribution patterns. The natural environment of an area influences the availability of local resources such as food and raw materials for artefacts, rock platforms for engravings and axe sharpening, and rock outcrops that may provide shelter. The landscape also provides the sediments that may bury objects and archaeological features, as well as the erosive processes that might expose or disperse them.

Geomorphic (land formative) processes may impact upon the type and frequency of archaeological remains. Past climate may also influence the location and types of resources available, which in turn shapes settlement and mobility patterns of past Aboriginal groups in the area. The location of different site-types (such as middens, stone artefact scatters, etc.) are strongly influenced by factors such as these along with a range of other associated features, which are specific to different land systems.

5.2 GEOLOGY

The Modification area is located in the Central Darling region of the Murray Basin. The surface geology of the region is mostly aeolian (wind-blown) sediments, while underlying sequences within the basin were deposited by shallow seas and lakes over the past 60 million years (Brown and Stephenson, 1991).

5.3 LANDFORMS AND VEGETATION

The Modification area is located in sandplains, aeolian features comprising low, undulating regions of irregular sandy hummocks. The sandplains are vegetated by mosaics of Belah—Rosewood/Acacia Woodland and Native Grassland/Sparse Acacia/Chenopod Shrubs.

The Modification area falls within the Hatfield sandplain land system (Soil Conservation Service, 1985, 1991) (**Figures 3** and **4**). The features of the Hatfield sandplain land system are provided below:

- *Hatfield land system*: plains of solonized brown soils, red and brown texture-contrast soils and red earths with scattered clumps of Rosewood and Belah; moderately dense Bluebushes and Bladder Saltbush (*Atriplex vesicaria*); dunes of deep brownish sands with clumped White Cypress Pine (*Callitris glaucophylla*), Prickly Wattle (*Acacia victoriae*) and Bluebushes; depressions of grey clays with Dillon Bush and Canegrass (*Eragrostis australasica*).

Figure 3. Belah woodland with Bluebush understorey in the Hatfield land system of the northern part of the Modification.

Figure 4. Belah woodland with Bluebush understorey in the Hatfield land system of the southern part of the Modification.

6 ABORIGINAL CULTURAL HERITAGE CONTEXT

Some of the earliest evidence of human occupation of Australia comes from south-western NSW (Bowler *et al*., 1970, 2003; Thorne *et al*., 1999; Cupper and Duncan, 2006; Olley *et al*., 2006). Stone artefacts found at Lake Mungo, about 100 km to the west of the Modification, have been dated to between 46,000 to 50,000 years ago (Bowler *et al*., 2003). The burials of a male and female at Lake Mungo are 42,000 years old (Olley *et al*., 2006, cf. Thorne *et al*., 1999). People were also at nearby Lake Menindee from 45,000 years ago (Cupper and Duncan, 2006) and at Lake Victoria on the Murray River by around 21,000 years ago (Gill, 1973).

6.1 ETHNO-HISTORIC CONTEXT

Aboriginal people of the Ngiyampaa language group occupied the Central Darling region at the time of first contact with Europeans (Sturt, 1982 [1833]; 1984 [1844-6]; Mitchell, 1839; Eyre, 1985 [1842]; Krefft, 1865, Allen, 1974; Tindale, 1974; Hardy, 1976; Hercus, 1982, 1993). These tribes shared similar language and kinship systems, notably the division of members into matrilineal moieties (two-part social classification) known as Mukwara (Wedge-tailed Eagle) and Kilpara (Raven) (Tindale, 1974; Hercus, 1982, 1993; Blows, 1995).

At the time of European contact the Barkandji were hunter-fisher-gatherers and appear to have had a semi-sedentary lifestyle. Early accounts by European observers suggest that they lived near more permanent water sources such as along the stream courses and lakes of the Murrumbidgee and Lachlan Rivers during the warmest months of the year, with people moving into the sandplains to collect food after winter rains (Allen 1974).

Aspects of the initial interaction between Europeans and Ngiyampaa led to violent conflict. Aborigines were shot, poisoned and displaced from their land by pastoral settlers and, in retaliation, sheep and shepherds were speared. Within a decade of the first contact many of the Ngiyampaa were living adjacent to pastoral homesteads, often working as shepherds or engaged in other labouring activities.

6.2 PREHISTORIC CONTEXT

Accounts of Aboriginal land use of the Central Darling during the late nineteenth and early twentieth centuries provide an insight into possible settlement patterns in the prehistoric period. Allen (1974), using these historical ethnographies and the archaeological record, invoked a subsistence model for the region based on the relationship between occupation of the riverine corridors and sandplains. Large populations of people congregated at the rivers during spring and summer and whenever the systems were high. Following seasonal rains smaller, mobile bands dispersed over the plains exploiting ephemeral resources (Allen, 1974).

The material record of this occupation is preserved in the archaeological sites of the Central Darling region, most of which date to the period since the last Ice Age (after around 18,000 years ago) (Hope, 1981; Balme and Hope, 1990; Balme, 1995). All that remains at many of these sites are flakes of stone debris from the making and resharpening of stone tools. These were made both at Aboriginal open habitation areas (campsites) or special activity areas such as stone knapping sites. As well as being the sites of manufacture and maintenance of stone implements, open habitation areas usually contain evidence of domestic and other activities such as cooking and food preparation. Campfires or oven hearths are common, marked by calcrete, baked clay, ferricrete, sandstone and silcrete heat retaining stones or hearthstones and charcoal. Organic remains consist of burnt animal bones, Emu and aquatic bird eggshell and freshwater mussel shell.

6.3 TYPES OF ABORIGINAL CULTURAL HERITAGE SITES IN THE REGION

Based on the results and analytical conclusions of previous archaeological surveys in similar landscape contexts in the Central Darling it is possible to predict the types and topographic contexts of Aboriginal cultural heritage sites in the Modification area. The occurrence and survival of archaeological sites is, however, dependent on many factors including micro-topography and the degree of land surface disturbance.

The types of Aboriginal cultural heritage site previously recorded in the Central Darling are described in Sections 6.3.1-6.3.8.

6.3.1 Stone Artefact Scatters

Scatters of stone artefacts exposed at the ground surface are one of the most commonly occurring types of archaeological site in the region (Hope, 1982). The remains of fire hearths may also be associated with the artefacts. In rare instances, sites that were used over a long period of time may accumulate sediments and become stratified. That is, there may be several layers of occupation buried one on top of another.

Stone artefact scatters are almost invariably located near permanent or semi-permanent water sources. Local topography is also important in that open campsites tend to occur on level, well-drained ground elevated above the local water source. In the Central Darling region they are commonly located on river terraces and along creek-lines and also around the margins of lakes, swamps and claypans.

6.3.2 Hearths

Hearths consist of lumps of burnt clay or stone cobble hearthstones. Sometimes ash and charcoal are preserved. Other materials found in hearths include animal bone, freshwater mussel shell, emu eggshell and stone artefacts. Hearths probably represent the remains of cooking ovens, similar to those described in ethnographic accounts by Major Thomas Mitchell (1839) and Peter Beveridge (1889) (see also Coutts *et al*., 1979). These were lined with baked clay nodules and stone cobbles, possibly to retain heat. Hearths may be isolated or occur in clusters and may be associated with open campsites or middens. They are often located in dune swales, particularly on claypans, near soaks and on floodplain terraces.

6.3.3 Freshwater Shell Middens

Shell middens are deposits of shell and other food remains accumulated by Aboriginal people as food refuse. In inland New South Wales these middens typically comprise shells of the freshwater lacustrine mussel *Velesunio ambiguus* or the freshwater riverine mussel *Alathyria jacksoni*. Freshwater middens are most frequently found as thin layers or small patches of shell and often contain stone or bone artefacts and evidence of cooking. Such sites are relatively common along the Murrumbidgee and Lachlan Rivers and their associated lakes and tributaries.

6.3.4 Earth Mounds

Earth mounds may have been used by Aboriginal people as cooking ovens or as campsites. They are common on the plains of southwestern NSW. Originally they appear to have ranged from 3 to 35 metres in diameter and from 0.5 to 2 metres in height. Today, however, they may be difficult to recognize because of the effects of ploughing, grazing and burrowing rabbits. Earth oven material, stone artefacts, food refuse and the remains of hut foundations have been exposed in excavated earth mounds.

6.3.5 Quarry Sites

Quarries are locations where Aboriginal people obtained raw material for their stone tools or ochre for their art and decoration. Materials commonly used for making flaked stone tools include chert, silcrete, quartz and quartzite. In the Central Darling region stone sources are particularly scarce. Silcrete outcrops occur at a number of locations in south-western New South Wales). Chert is found exposed in cliffs incised by the Murray River in South Australia. Most other stone in the Central Darling region was probably sourced via long-distance trade links with the Barrier Ranges and the southeastern Australian Highlands.

6.3.6 Modified Trees

Slabs of bark were cut from trees by Aboriginal people and used for a variety of purposes including roofing shelters and constructing canoes, shields and containers. Scars also resulted from the cutting of toeholds for climbing trees to obtain honey or to capture animals such as possums. In the Central Darling region River Red Gums and Black Box are the most commonly scarred species. The classification of scarred trees as natural, European or Aboriginal is often problematic. However, if the scar is Aboriginal the tree must now be more than ~150 years old.

6.3.7 Stone Arrangements, Ceremonial Rings and Ceremony and Dreaming Sites

Stone arrangements range from cairns or piles of rock to more elaborate arrangements such as stone circles or standing slabs of rock held upright by stones around the base. Some stone arrangements were used in ceremonial activities whilst others may represent sacred or totemic sites. Other features associated with the spiritual aspects of Aboriginal life are those now called ‘ceremony and dreaming’ sites. These can be either stone arrangements or natural features such as rock outcrops, which may be associated with initiation ceremonies or the activities of ancestral creators.

6.3.8 Burials

Aboriginal burial grounds may consist of a single interment or a suite of burials. Burials tend to be in areas of sandy soil that were easy to dig and above floodwaters. Burials are frequently located in source-bordering sand dunes, sand ridges, lunettes and levees along watercourses (Bonhomme, 1993; Hope, 1993). Knowledge of Aboriginal burial grounds is best sought from local Aboriginal communities.

6.4 PREVIOUSLY RECORDED ABORIGINAL CULTURAL HERITAGE SITES IN THE MODIFICATION AREA

There are no previously recorded Aboriginal cultural heritage sites recorded within the Modification area on the NSW OEH Aboriginal Heritage Information Management System (AHIMS) database (AHIMS search 419820 10 May 2019; **Appendix 5**).

The closest previously recorded sites to the Modification area are twenty-two Aboriginal cultural heritage sites comprising fifteen stone artefact scatters, five with hearths, and seven isolated finds of stone artefacts. These were recorded by Niche Environment and Heritage (2012) in the vicinity of the approved Ivanhoe Rail Facility surface disturbance area, and are located immediately adjacent to the Modification area.

7 CULTURAL HERITAGE FIELD INVESTIGATION

In accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011) and *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECC, 2010b), an archaeological design and survey methodology was prepared as a key component of the cultural heritage field assessment. Details of the archaeological design and survey methodology are presented in the following sections.

7.1 OVERVIEW OF PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

The Aboriginal archaeology of the Central Darling region is known generally from a number of studies, but very little systematic archaeological research has been undertaken in the sandplains of the Central Darling. Archaeological surveys of developments in these areas are limited to those conducted by Niche Environment and Heritage (2012) and Cupper (2018).

Other areas in southwestern NSW that have been archaeologically surveyed include the Darling River and its associated lakes (Hope, 1981; Balme and Hope, 1990; Craib, 1992; Martin *et al.*, 1994; Balme, 1995; Marshall and Smith, 1998; Pardoe and Martin, 2002; Pardoe, 2003), Murray River and Lake Victoria (Bonhomme, 1993; Hope, 1998) and the Willandra Lakes (see Johnston and Clark, 1998). Regional studies and syntheses of the archaeological record of south-western NSW include those of Allen (1974), Hope (1982) and Bonhomme Craib and Associates (1999, 2001).

Niche Environment and Heritage (2012) previously surveyed the areas associated with the approved Project (i.e. the Atlas-Campaspe Mine, mineral concentrate transport route and Ivanhoe Rail Facility). Cupper (2018) further recorded Aboriginal stone artefacts in the areas associated with the approved Project.

Niche Environment and Heritage (2012) recorded twenty-two Aboriginal cultural heritage sites in the vicinity of the approved Ivanhoe Rail Facility surface disturbance footprint. These comprised fifteen stone artefact scatters, five with hearths, and seven isolated finds of stone artefacts.

7.2 CULTURAL HERITAGE SITE PREDICTIVE MODEL

Previous archaeological studies indicate that sandplains of the Central Darling have a low density of cultural heritage places. Occupation sites are almost invariably located at small ephemeral water sources such as swamps and claypans (McIntyre, 1981; Clark, 1983; Witter, 2001; Cupper, 2003a, 2018; Niche Environment and Heritage, 2012). The most frequently recorded Aboriginal sites in the sandplains are stone artefact scatters and hearths (OEH AHIMS site database). Isolated finds of stone artefacts and hearthstones are also represented in the archaeological record. Other Aboriginal cultural heritage site types previously identified in the Central Darling region are shell middens, stone quarries, ceremonial and dreaming sites, trees scarred by Aboriginal people, burials, earth mounds and stone arrangements (OEH AHIMS site database).

Based on these observations of archaeological site types and their distribution and landscape setting, the following predictive model of site types and locations within the Modification area was developed prior to the survey:

- **Stone artefact scatters**, **hearth** sites and **isolated finds of stone artefacts or hearthstones** have the potential to occur within the Modification area. The density of these types of sites was predicted to be low, given the absence of nearby permanent sources of water. Open occupation sites are typically found within 500 m of water sources, so such sites are most likely to be encountered on level ground adjacent to ephemeral swamps and claypans that intermittently retain surface water following rain.
- **Stone quarry** sites have the potential to occur in the Modification area. Silcrete outcrops noted elsewhere in the Central Darling region often occur at topographic low points in the landscape such as abandoned lake beds and playa floors (e.g. Hope, 1998; Cupper, 2003a, 2003b).
- **Scars made by Aboriginal people** are unlikely to occur on any of the trees in the Modification area, because River Red Gum and Black Box trees, the taxa typically scarred by Aboriginal people in the region, are absent in the study area.
- The chance of encountering **shell middens** was predicted to be negligible, as they are usually found near permanent water sources, absent from the area, as are **burial** sites. Source-bordering dunes adjacent to rivers and lakes are the landforms most likely to contain human skeletal remains.
- Although **stone arrangements** have been recorded in the Central Darling region, they are not common and were considered unlikely to be encountered in the area. Stone arrangements tend to occur on level ground, often on elevated landforms such as floodplain terraces.

While predictive studies such as this can be expected to identify areas in which sites associated with economic or subsistence activities may be present, notably open habitation areas, other sites may fall outside such a predictive framework. For example, places associated with spiritual aspects of traditional Aboriginal society such as ceremony and dreaming sites are often located at topographically distinct or unique features, which cannot be identified from an examination of maps or other records. For this reason, it was essential that local Aboriginal communities be consulted so that sites of significance to them can be identified.

7.3 FIELD METHODOLOGY

The archaeological field survey was conducted based on the sampling strategy developed in accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011) and Requirement 5a of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b) and outlined in Section7.1.

The objective of the field survey was to identify places of Aboriginal cultural significance within the Modification area.

7.3.1 Personnel

The survey was conducted over a period of one day on 1 May 2019. The participants of the field survey were project archaeologist Dr Matt Cupper of Landskape, together with the representatives from the RAP listed in Section 4.2.3 (**Figures 5** and **6**).

Figure 5. Survey team members inspecting the Modification area.

Figure 6. Survey team members inspecting the Modification area.

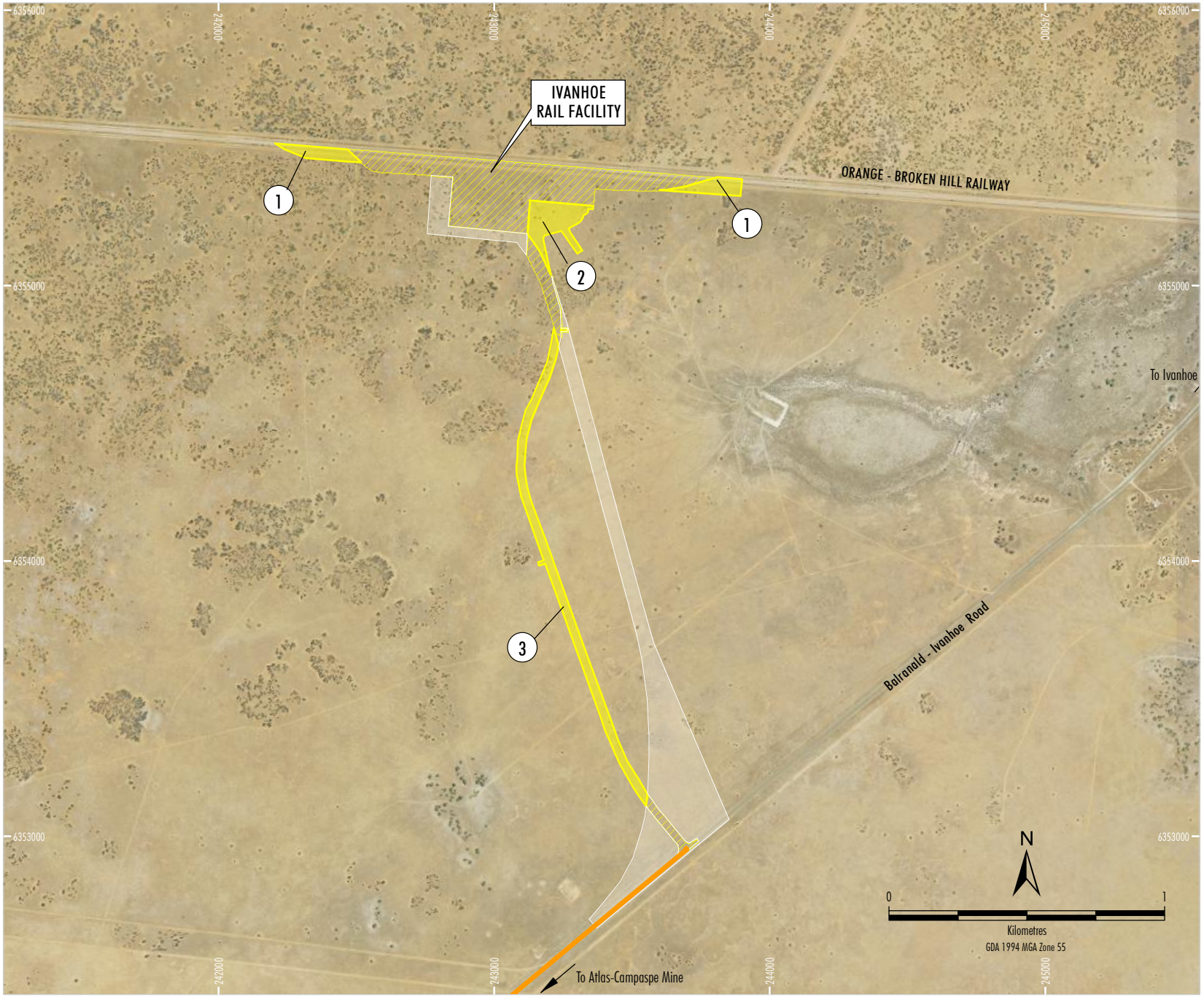
7.3.2 Survey Methods

The Modification area was inspected on foot by the project archaeologist and Aboriginal community representatives. The field team examined the ground surface for any archaeological traces such as stone artefacts, hearths, hearthstones, shells, bones and mounds. All mature trees in the areas of proposed disturbance were inspected for scarring or carving by Aboriginal people.

Particular attention was paid to areas with high ground surface visibility such as along stock and vehicle tracks and in scalds, gullies and other eroded areas.

The team members walked abreast across the surveyed areas in a series of closely spaced transects. These were evenly distributed over the areas of proposed disturbance and approximately 4 m apart. Due to the general openness of the landscape it was usually possible to identify likely site locations from at least 4 m and deviate from the transects to make closer inspections.

Survey units and descriptions of the visibility conditions for each survey unit are provided in **Table 1** and **Figure 7**.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019) and Landskape (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Survey Units

Figure 7

CMA-18-07 AC OM_ App ACHA_203B

Table 1. Visibility Conditions at the Modification.

Survey Unit	Landforms	Vegetation	Exposures	Visibility	Survey Method
1	Sandplain	Belah-Rosewood woodland, Bluebush low shrubland	Animal tracks, Vehicle tracks, Scalds	80 %	Pedestrian
2	Sandplain	Belah-Rosewood woodland, Bluebush low shrubland	Animal tracks, Vehicle tracks, Scalds	80 %	Pedestrian
3	Sandplain	Belah-Rosewood woodland, Bluebush low shrubland	Animal tracks, Vehicle tracks, Scalds	80 %	Pedestrian

7.4 SURVEY COVERAGE DATA

7.4.1 Conditions of Visibility

Conditions of ground surface visibility affect how many sites are located. Visibility may also skew the results of a survey. If, for example, conditions of ground surface visibility vary dramatically between different environments, then this would be reflected in the numbers of sites reported for each area. The area with the best visibility may be reported as having the most sites (because they are visible on the ground) while another area with less visibility but perhaps more sites would be reported as having very little occupation. It is important therefore to consider the nature of ground surface visibility as part of any archaeological investigation.

Conditions of ground surface visibility were typically around 80 % (**Table 1**). Grass and herbaceous plant growth was very low and the ground surface was exposed by erosion by scalding and stock and vehicular traffic (**Figures 8**-**11**).

Survey units and descriptions of the visibility conditions for each survey unit are provided in **Table 1** and **Figure 7**.

Figure 8. Example of surface exposure at the Modification area.

Figure 9. Example of surface exposure at the Modification area.

Figure 10. Example of surface exposure at the Modification area.

Figure 11. Example of surface exposure at the Modification area.

7.4.2 Coverage Analysis

Coverage analysis is a useful measurement to allow cultural resource managers to assess surveys from adjacent areas and it also allows some meaningful calculation of the actual sample size surveyed. The *actual* or *effective* area surveyed by a study depends on the conditions of ground surface visibility. Conditions of surface visibility are affected by vegetation cover, geomorphic processes such as sedimentation and erosion rates and the abundance of natural rock that may obscure the remains of cultural activities.

All of the Modification area was inspected on foot. The areas covered during the survey are outlined in **Table 2** and summarised by landform in **Table 3**. Survey coverage was high, given the intensive nature of the survey.

Table 2. Coverage of the Modification Area.

Survey Unit	Landform	Area (m^2)	Coverage (m^2)	Visibility (%)	Effective Cover (m^2)	Effective Cover (%)	No. Sites
1	Sandplain	20,000	20,000	80	16,000	80	-
2	Sandplain	40,000	40,000	80	32,000	80	5
3	Sandplain	44,000	44,000	80	35,200	80	-
Total		**104,000**	**104,000**	**80**	**83,200**	**80**	**5**

Table 3. Landform Summary of Sampled Areas of the Modification Area.

Landform	Landform Area (m^2)	Area Effectively Covered (m^2)	Landform Effectively Surveyed (%)	No. Sites
Sandplain	104,000	83,200	80	5
Total	**104,000**	**83,200**	**80**	**5**

7.5 SURVEY RESULTS

Five Aboriginal cultural heritage sites were newly identified during the survey in the Modification area. These sites consisted of two stone artefact scatter sites (with three artefacts at each) (RLF29, RLF 32) and three isolated finds of stone artefacts (RLF30, RLF31, RLF33). Summary descriptions of the newly identified Aboriginal cultural heritage sites are below, and in **Table 4**:

- RLF29 - two silcrete angular fragments and one silcrete flake on the scalded sandplain in the northern part of the Modification area;
- RLF30 - one silcrete flake on the scalded sandplain in the northern part of the Modification area;
- RLF31 - one silcrete angular fragment on the scalded sandplain in the northern part of the Modification area;
- RLF32 - three silcrete angular fragments on the scalded sandplain in the northern part of the Modification area; and,
- RLF33 - one silcrete angular fragment on the scalded sandplain in the northern part of the Modification area.

Three of the Aboriginal cultural heritage sites (RLF29, RLF30 and RLF31) are located in the approved Ivanhoe Rail Facility surface disturbance area. The remaining two Aboriginal cultural heritage sites (RLF32 and RLF33) are located in the Modification area.

No non-Aboriginal sites were recorded in the Modification area.

Table 4. Newly Identified Aboriginal Cultural Heritage Sites within and near the Modification Area.

Site Name	Location GDA94 mE (Zone 55)	Location GDA94 mN (Zone 55)	Landform	Size (m)	Contents
RLF29	242862	6355330	Sandplain	5 x 5	2 silcrete angular fragment, 1 silcrete flake
RLF30	242971	6355324	Sandplain	na	1 silcrete flake
RLF31	243143	6355314	Sandplain	na	1 silcrete angular fragment
RLF32	243246	6355220	Sandplain	10 x 10	3 silcrete angular fragments
RLF33	243260	6355292	Sandplain	Na	1 silcrete angular fragment

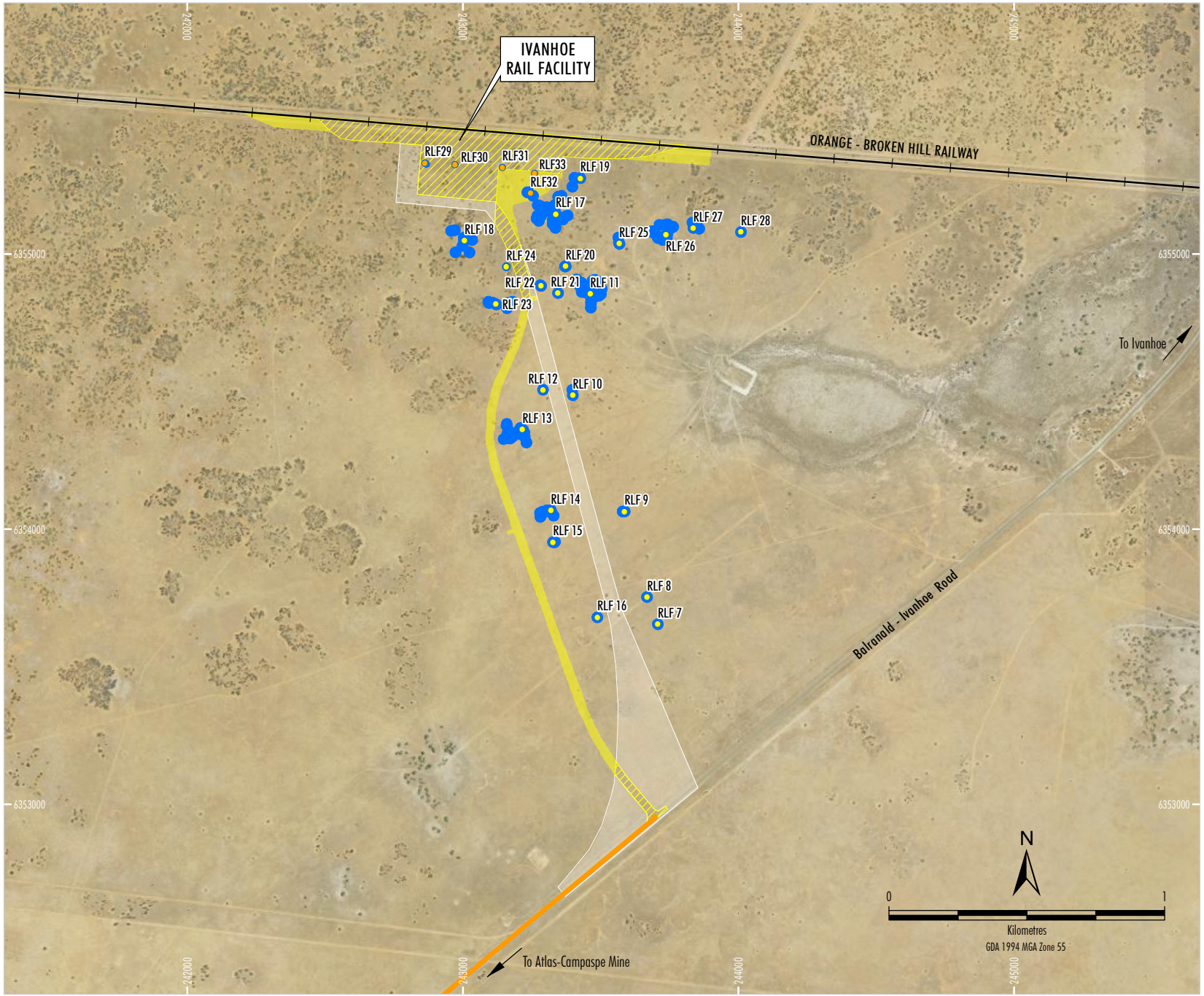
Images of Aboriginal cultural heritage sites at the Modification area are depicted in **Figures 12** to **15.** The locations of the sites are shown on **Figure 16.**

Figure 12. RLF29

Figure 13. RLF30

Figure 14. RLF31

Figure 15. RLF32.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Aboriginal Heritage Site (Niche, 2012)
- Aboriginal Heritage Site (Landskape, 2019)
- Extent of Aboriginal Heritage Site

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Niche (2012); Tronox (2019) and Landskape (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility - Aboriginal Heritage Sites

Figure 16

7.6 IDENTIFIED ABORIGINAL CULTURAL VALUES

As described in earlier sections, this assessment has been prepared in accordance with the Consultation Guidelines (DECCW, 2010a) and the NSW *National Parks and Wildlife Regulation 2009*.

The cultural values assessment undertaken to date has been based on the following:

- Review of background resources including previous archaeological investigations for the surrounding region and the approved Project (Niche Environment and Heritage, 2012; Cupper, 2018);
- Historical research;
- Discussions with RAPs during field survey;
- Discussions with RAPs during community information sessions;
- Requests for comments during the review period for the Proposed Methodology; and
- Specific meetings with RAPs upon request.

These points of consultation provided the opportunity for the Aboriginal community to have direct input into the management of Aboriginal cultural heritage values (both tangible and intangible) in the Modification area.

During the archaeological survey the attending RAPs did not identify any specific locations within the Modification area or wider surrounds as being of high or specific cultural significance.

RAPs identified the Modification area as a place that Aboriginal people had occupied in the past. Generally, the Aboriginal representatives viewed all the Aboriginal cultural heritage sites as significant because they preserve a record of how and where people lived in the past.

8 CULTURAL HERITAGE VALUES

8.1 ABORIGINAL CULTURAL HERITAGE SIGNIFICANCE

The significance of Aboriginal cultural heritage sites such as that found during this study are usually assessed in terms of their importance to archaeologists (i.e. their scientific or research significance), their importance to contemporary Aboriginal people and their importance to the general public. Once the significance of a site has been assessed it can be ranked against others and specific recommendations formulated. Criteria for assessing scientific significance are set out below. The values used in this assessment have been the subject of some discussion in the archaeological literature and the information provided is drawn from a number of sources (e.g. Bowdler, 1983).

8.1.1 Scientific Significance

A number of criteria are used to assess the scientific significance of a site. These include the integrity of a site, its structure and contents. All of these criteria combine to give a site its value as a research tool for archaeologists. In addition to the above criteria a site may also be of scientific significance because of its representativeness or rarity. It is a basic tenet of archaeology that any site which is not represented elsewhere is of great value because archaeologists are concerned with preserving a representative sample of all site types for future generations.

Site Integrity
Site integrity refers to its state of preservation or condition. A site can be disturbed through a number of factors including natural erosional processes, destructive land use practices or repeated use of a site in the past by both humans and animals.

low	highly disturbed or poorly preserved with little research potential.
moderate	some disturbance but remaining cultural material allows for some research potential.
high	little or no disturbance to site, good preservation and considerable research potential.

In terms of site integrity the sites located during this survey would rate low. This assessment is based on the degree of disturbance noted during the investigation. The stone artefact scatters were typically identified in modified contexts such as along gullied drainage lines or graded fence lines. They have been disturbed by repeated traffic of hooved animals and vehicles, coupled with erosion by wind and water.

Site Structure

Site structure refers to the physical dimensions of a site (i.e. its area and depth or stratification). A large site, or a site with stratified deposits, usually has more research potential than a small site or surface scatter. In some instances, however, specific research questions may be aimed at smaller sites in which case they would be rated at a higher significance than normal.

low	small surface scatters with no stratified deposit.
moderate	medium to large surface scatters with or without stratification.
high	large *in situ* surface scatters, any site with stratified deposit.

All of the stone artefact sites are very small in size, with one or two artefacts, and have a low site structure. Artefacts form a lag deposit on scalded or exposed surfaces. The surfaces of all these sites are degrading.

Site Contents

Site contents refers to the range and type of occupation debris found in a site. Generally, sites that contain a large and varied amount of organic and non-organic material are considered to have greater research potential than those sites with small, uniform artefacts.

low	small amount and low diversity of cultural material.
moderate	medium amount and diversity of cultural material.
high	large and diverse amount of cultural material.

The original cultural materials of the sites recorded during the survey have been exposed to weathering. Only stone artefacts remain all of the open sites.

Stone artefacts are of silcrete. The flaked lithics are unmodified flakes and angular fragments. Artefact density at these sites is very low.

The stone artefact sites rate low by the site contents criterion.

Site Representativeness and Rarity

Representativeness or rarity refers to how often a particular site type occurs in an area and requires some knowledge of the background archaeology of the area in which the study is being undertaken. Sites that are representative of the local and regional archaeological record may have value for that reason and if a site is rare or unique in some way then it is *ipso facto* significant (Bowdler, 1983).

low	many of the same site type occurring in a single area or region.
moderate	site type occurs elsewhere but not in great quantity or with good preservation.
high	site type is rare or unique.

On the basis of the results of previous archaeological investigations (e.g. Niche Environment and Heritage, 2012; Cupper, 2018) and information held on the OEH AHIMS site register it is clear that stone artefacts are widespread in the region. These types of archaeological sites located during this study are therefore not unique and are well represented outside the Modification area.

A summary of the archaeological significance assessment of the sites is presented in **Table 5**.

Table 5. Assessment of Significance of the Aboriginal Cultural Heritage Sites.

Site Name	Scientific Significance				Cultural Significance	Educational Significance	Aesthetic Significance
	Integrity	Structure	Contents	Rarity			
RLF29	Low	Low	Low	Low	Moderate	Low	Low
RLF30	Low	Low	Low	Low	Moderate	Low	Low
RLF31	Low	Low	Low	Low	Moderate	Low	Low
RLF32	Low	Low	Low	Low	Moderate	Low	Low
RLF33	Low	Low	Low	Low	Moderate	Low	Low

8.1.2 Aboriginal Social, Cultural, Spiritual and Historical Significance

The significance of a site is not restricted to its scientific or research value. The views of Aboriginal people on the significance of archaeological sites are also important. Their perceptions usually stem from traditional, cultural and educational beliefs although most local Aboriginal communities also value the scientific information that archaeological sites may be able to provide.

Archaeological sites provide connections to the past for the present Aboriginal community and for future generations. Aboriginal cultural heritage sites such as those identified during this survey can also provide information about past lifestyles and strengthen the links between Aboriginal people and the land.

The level of significance attributed to individual sites may vary according to a number of factors including the nature and integrity of the heritage items and the landscape in which the site is located. The views of the Aboriginal representatives involved in the field survey and community field inspections and discussion forums are considered to be indicative of Aboriginal community attitudes.

The Aboriginal significance of the sites listed in **Table 5** was established through consultation with the Aboriginal stakeholders involved with the field survey.

Generally, the Aboriginal community view all archaeological sites as significant because they preserve a record of how and where people lived in the past. Such cultural heritage sites also stand as testimony to the continuation of Aboriginal culture and association with the land. However, the Aboriginal community representatives involved in this assessment did not have particularly high spiritual, traditional, historical or contemporary associations with the archaeological sites identified in the Modification area.

8.1.3 Educational Significance

The value of archaeological sites to the general public is generally assessed by their potential to educate the public about the Aboriginal past. The sites rank low by this criterion. They are small, isolated and unlikely to attract particular interest in Aboriginal heritage.

8.1.4 Aesthetic Significance

Aesthetic significance relates to the scale, form, materials, texture, colour, space and relationship of the components of the place. The relationship of the place with its setting is equally important. The sites are subdued features in the landscape and lack high aesthetic value.

8.2 ABORIGINAL CULTURAL LANDSCAPE

Scientific information collected from the Aboriginal archaeological sites identified during this assessment, combined with social and cultural information provided by the Aboriginal community stakeholders and ethno-historical sources, allows interpretation of the Aboriginal cultural landscape of the Modification area, provided in the following sections.

8.2.1 Summary of the Archaeological Record

The material culture of past Aboriginal occupants of the Modification area comprises five stone artefact sites.

8.2.2 Aboriginal Settlement Patterns

The locations of freshwater sources are likely to have been the main controlling factor of past Aboriginal occupation of the Modification area. Humans carry out most of their activities close to fresh water, rarely straying far from reliable water sources (see Gould, 1969, 1980; Allen, 1974; Jochim, 1976; Mitchell, 1990; McNiven, 1998). They also prefer larger or more persistent water sources to smaller, ephemeral water bodies. As well as the obvious abundance of aquatic molluscs, fish and birds at large, permanent water sources, mammals (such as macropods) that were hunted for protein and skins are also limited by water availability.

The fact that all of the Aboriginal cultural heritage sites identified during the survey were on the margins of ephemeral drainage lines confirms predictive models that occupation will favour well drained land adjacent to waterways (e.g. see Allen, 1974).

There are no permanent streams or wetlands in the Modification area. There are a number of unnamed, ephemeral watercourses that episodically flow for brief periods after heavy rain, but any pools of water rapidly seep away and evaporate. Peak occupation of the Modification area is likely to have corresponded to when these transient supplies were available.

8.2.3 Aboriginal Subsistence Strategies

Hunter-fisher-gatherers obtain the resources necessary for life by foraging and collecting subsistence strategies. Foragers gather food as it is encountered, regularly moving between resource zones and rarely storing food (Binford, 1989). Collectors, alternatively, adopt a logistical strategy for procuring resources. They often rely on stores of food and may maintain base camps, with smaller groups dispersing to collect resources. Foraging and collecting are two end-members of a subsistence continuum, with most hunter-fisher-gatherer societies engaging in a combination of both strategies (Yellen, 1977; Binford, 1989; Renfrew and Bahn, 1991).

Sites occupied by hunter-fisher-gatherer people may reflect these strategies (Binford, 1989). For example, base camps were generally occupied for long periods of the year and were used for a range of domestic and industrial activities. Alternatively, base camps may have been intensively used for part of the year, acting as congregative focal points. Temporary field camps were dispersive sites, created when groups charged with carrying out a specific task journeyed beyond the daily foraging radius.

The frequency of site occupation can sometimes be determined from their contents and structure. Residential base campsites, occupied over relatively long periods of time, tend to have a more complex structure than short-term campsites. Base camps may contain evidence of a wide variety of activities associated with daily habitation. Short-term sites were probably only occupied for a specific reason, such as to collect a particular resource. These usually display evidence of being occupied only once or twice, and are often smaller, with fewer and less diverse archaeological remains.

It is probable that the Aboriginal people who occupied the Modification area were hunter-fisher-gatherers employing both foraging and collecting subsistence strategies. These people would have primarily occupied the riparian zones of the Lachlan River and its more permanent anabranches including Willandra Creek, dispersing from the riverine corridors to exploit ephemeral resources of the more poorly watered hinterland during favourable climatic conditions, as invoked in the subsistence model of Allen (1974).

Only relatively small areas were investigated in a heterogeneous landscape, but it is probable that the archaeological record of the Modification area reflects the occupation of the backcountry by small, mobile bands. Cultural heritage sites in the Modification area probably derive both from temporary habitation sites used by small groups during periods of seasonal dispersal and temporary field camps used by small groups engaging in specific tasks such as procuring lithic resources. This is because the drier bedrock hills and slopes seasonally supported food plants and animals and also contained mineral outcrops exploited for utilitarian purposes.

Plant resources in the Modification area that could have been harvested by winter foragers include seeds from grasses (e.g. Gott, 1983; Porteners, 1993; Latz, 1995). When holding surface water, the nearby claypans could have become havens for birds such as wading species, which may have been hunted. Ephemeral water sources would have also attracted macropods.

8.2.4 Synthesis

Aboriginal people probably occupied the Modification area following the end of the last Ice Age some 18,000 years ago. The Aboriginal archaeological record of the Modification area is probably late Holocene (less than a few thousand years) in age. The lack of reliable, permanent sources of water in the hinterland of the riverine plains would have made the Modification area unattractive for permanent habitation.

The non-stratified stone artefact sites at the Modification area probably represent temporary occupation sites. People from the small, mobile groups that probably periodically journeyed into the backcountry from the rivers and streams of the riverine plains to forage for food and other resources may have occupied such an area for brief durations. Past Aboriginal people probably also transited through the region to access areas for resource exploitation and cultural purposes.

Foraging and collecting subsistence strategies are clearly artificial divisions, and these tactics undoubtedly overlapped.

9 POTENTIAL IMPACTS OF THE MODIFICATION ON ABORIGINAL CULTURAL HERITAGE

The Modification could potentially directly and indirectly impact upon Aboriginal cultural heritage sites. Potential negative direct and indirect impacts may result from the modified Ivanhoe Rail Facility and could include the destruction of the sites via earthmoving, indirect physical affects (e.g. dust deposition) or aesthetic affects.

In accordance with the *Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH, 2011), the principles of ecologically sustainable development were considered in assessing the likely harm of the Modification to Aboriginal cultural heritage sites.

9.1 POTENTIAL DIRECT IMPACTS

Construction of the modified Ivanhoe Rail Facility would disturb the current land surface and would likely directly impact the Aboriginal cultural heritage sites associated with the modified Ivanhoe Rail Facility surface disturbance area if not relocated prior to disturbance.

Such impacts on cultural heritage values typically fall into three categories:

- the loss of information which could otherwise be gained by conducting research today;
- the loss of the cultural heritage resource for future research using methods and addressing questions not available today; and
- the permanent loss of the physical record.

These impacts can usually be mitigated to various degrees, depending on the nature and significance of the cultural heritage. Where sites are of low scientific significance, their destruction may have little scientific consequence. This could be due to the lack of useful information that could be gained from research, or the availability of many equivalent and alternative sites for study.

Aboriginal cultural heritage sites with greater scientific significance may be the subject of investigation prior to their disturbance. This allows for the salvage of information, and the recovery of a sample of artefactual materials according to current methods and research priorities. Sites and site groupings that are common elsewhere may not require the same degree of salvage attention as those which are rare, of high significance, and subject to active deterioration.

Salvage investigations can provide for the discovery of new knowledge about the past human occupation and land use of an area. Despite the loss of physical evidence involved, the information gained can in turn aid the interpretation and better management of the remaining cultural heritage resource.

9.2 POTENTIAL INDIRECT IMPACTS

The surface disturbance area for the modified Ivanhoe Rail Facility, which would disturb the Aboriginal cultural heritage sites, is relatively inflexible. Engineering constraints mean that facility components cannot be relocated away from the Aboriginal cultural heritage sites to avoid disturbance. Additionally, any such relocation would not remove threats to the sites from indirect disturbance.

9.3 CULTURAL HERITAGE AVOIDED BY THE MODIFICATION

Harm can be avoided to twenty-two Aboriginal cultural heritage sites near the proposed disturbance areas for the Modification. These comprise fifteen stone artefact scatters, five with hearths, and seven isolated finds of stone artefacts. These were recorded by Niche Environment and Heritage (2012) in the vicinity of the approved Ivanhoe Rail Facility surface disturbance area and are adjacent to proposed disturbance areas for the Modification area.

9.4 CULTURAL HERITAGE POTENTIALLY IMPACTED BY THE MODIFICATION

Five Aboriginal cultural heritage sites are located within the proposed disturbance area for the modified Ivanhoe Rail Facility. The Aboriginal cultural heritage sites are five stone artefact sites (RLF29 through to RLF33). This assessment has concluded that these sites are not of high scientific significance. The impact of the Modification on Aboriginal cultural heritage sites is determined by the nature and the degree of harm that the construction works for the Ivanhoe Rail Facility will cause. The type of harm is either direct or indirect and therefore the consequence of harm is a total or a partial loss in value (DECCW, 2010b). A total loss in value would occur when the entire site is impacted by the Modification. A partial loss of value would occur when only part of the site (such as in the case of an artefact scatter) is impacted by the Modification.

The potential impacts of the Modification on each of the Aboriginal cultural heritage sites in the Modification area are summarised in **Table 6**.

For the purposes of this assessment, it is conservatively assumed that the construction of the Ivanhoe Rail Facility would be of a nature that would cause direct harm to any Aboriginal objects or areas of cultural value (should they occur).

Table 6. Summary of Potential Impacts to Aboriginal Cultural Heritage Sites.

Site Name	Site Type	Type of Harm	Degree of Harm	Consequence of Harm
RLF29	Artefact (n=3)	Direct	Total	Total loss of value
RLF30	Artefacts (n=1)	Direct	Total	Total loss of value
RLF31	Artefacts (n=1)	Direct	Total	Total loss of value
RLF32	Artefacts (n=3)	Direct	Total	Total loss of value
RLF33	Artefacts (n=1)	Direct	Total	Total loss of value

9.5 POTENTIAL FOR PREVIOUSLY UNIDENTIFIED ABORIGINAL CULTURAL HERITAGE TO OCCUR IN THE MODIFICATION AREA

Although the Modification area was sufficiently surveyed, there remains the potential for Aboriginal cultural heritage sites to be located within this area (e.g. sites that may have been obscured by grass or soil at the time of survey). Such previously unidentified features, should they occur, would probably be isolated finds or low-density concentrations of stone artefacts (based on the predictive model outlined in Section 7.1 and informed by the results of the current survey, summarised in Section 7.5).

The shallow soils of the Modification area, coupled with past disturbance from pastoralism and track and fence construction, means that significant *in situ* subsurface cultural deposits are highly improbable.

The Modification area does not contain culturally sensitive landforms such as lunettes or source-bordering sand dunes where subsurface Aboriginal cultural deposits (e.g. burials) have been recorded previously.

A strategy for managing any newly identified Aboriginal objects during the life of the Modification is outlined in Section 10.

9.6 FLEXIBILITY OF THE MODIFICATION DESIGN

The potential area of disturbance associated with the modified Ivanhoe Rail Facility is relatively inflexible. Engineering constraints mean that the components cannot be relocated away from Aboriginal heritage sites to avoid disturbance.

9.7 POTENTIAL CUMULATIVE IMPACTS

The Modification is located within the south-western region of NSW, which contains a number of currently approved or operational mine sites and/or other large-scale infrastructure projects. These existing operations have caused adverse heritage impacts to a range of Aboriginal cultural heritage sites, principally archaeological ones. For the most part, these adverse impacts have been associated with the disturbance or destruction of Aboriginal cultural heritage sites subsequent to archaeological investigation and assessment.

The survey undertaken for this assessment indicate that the types of Aboriginal cultural heritage sites within the Modification area that may be impacted by the Modification generally comprise part of a region-wide distribution of very small open occupation sites including disturbed artefacts and hearths of low scientific significance. Given the low scientific significance of these Aboriginal cultural heritage sites, the cumulative effect that may result from the development of the Modification is considered to be low, and would be mitigated by the ongoing program of archaeological recording/salvage recommended by this assessment.

In terms of cultural values, the Modification is located within an area that has already been heavily modified by past clearing and pastoral activities. The Modification is considered likely to cause few impacts additional to those that have already occurred. On this basis, it is considered that the Modification would not appreciably increase cumulative impacts to Aboriginal heritage in the region.

10 MANAGEMENT STRATEGIES FOR CULTURAL HERITAGE

This section presents proposed strategies for the management of Aboriginal cultural heritage values within the Modification area that may be subject to direct impacts by the construction of the modified Ivanhoe Rail Facility. These recommendations have been developed in consideration of the management approved in the EIS.

10.1 GENERAL RECOMMENDATIONS

10.1.1 Heritage Management Plan

In accordance with Condition 28, Schedule 3 of the Project Development Consent (SSD_5012), a HMP, which outlines the management and mitigation measures for Aboriginal cultural heritage, has been previously prepared for the Project in consultation with the Aboriginal community and the OEH. Tronox should revise the HMP to reflect the results and recommendations of this assessment. The HMP should continue to remain active for the life of the Modified Project and define the tasks, scope and conduct of all Aboriginal cultural heritage management activities. The HMP should be revised in consultation with the local Aboriginal community.

The measures presented below are considered best practice in the mining industry. Their effectiveness and reliability is demonstrated by their continued use and inclusion in management plans and strategies developed in consultation with the RAPs and to the satisfaction of OEH.

10.1.2 Role of the Local Aboriginal Community

Tronox is committed to involving the local Aboriginal community as an integral participant in the management of Aboriginal cultural heritage values in the Modification area. The strategies outlined in this report have incorporated the views of community representatives and the HMP would be prepared in consultation with the local Aboriginal community.

The recording, collection, curation, storage and replacement of moved Aboriginal objects would occur with the invited participation of local Aboriginal community representatives.

10.1.3 Site Management and Cultural Awareness Training

The effective application of the HMP and its strategies will be dependent on an appreciation of its content and function by on-site staff and employees.

It is proposed to provide training to all on-site personnel regarding the HMP strategies relevant to their employment tasks.

10.2 MANAGEMENT OF CULTURAL HERITAGE IN PROXIMITY TO THE DISTURBANCE AREAS

Harm to the twenty-two Aboriginal cultural heritage sites near the proposed disturbance areas for the Modification should be avoided. Temporary barrier/fences should be erected around the sites (a minimum 10 m radius buffer) when works are occurring in their vicinity. At a minimum, these should include star pickets and flagging. These barriers would remain in place throughout the life of the Modified Project.

10.3 MANAGEMENT OF CULTURAL HERITAGE WITHIN THE DISTURBANCE AREA

The Aboriginal cultural heritage sites are five stone artefact sites (with one or three artefacts at each) (RLF29 through to RLF33). This assessment has concluded that these sites are not of high scientific significance.

The area of disturbance for the modified Ivanhoe Rail Facility, which would disturb the Aboriginal cultural heritage sites, is relatively inflexible. Engineering constraints mean that facility components cannot be relocated away from the Aboriginal cultural heritage sites to avoid disturbance. Additionally, any such relocation would not remove threats to the sites from indirect disturbance.

Representatives of the RAPs visited the Aboriginal cultural heritage sites, where options for their management were discussed. Based on the results of these discussions, it is recommended that Tronox arrange collection of the Aboriginal objects prior to the commencement of disturbance activities. Tronox should engage a suitably qualified archaeologist and representatives of the RAPs to record and collect the artefacts. These items should be properly curated and stored at the approved “Keeping Place”. Artefacts should be replaced within rehabilitated areas in consultation with local Aboriginal groups and OEH.

This strategy of recording and collection should also apply to the management of any newly identified Aboriginal cultural heritage items that may be encountered during construction activities.

Examination of the artefacts and their contexts should form an integral part of the recording programme in order to better understand and interpret local and regional patterns of past Aboriginal settlement and resource use. In particular, this could involve investigating lithic technologies and reduction strategies adopted at the Aboriginal cultural heritage sites. These strategies of information collection would complement the salvage programme.

10.4 SUMMARY OF MANAGEMENT RECOMMENDATIONS

Proposed site management strategies for the Aboriginal cultural heritage sites identified during the field survey are summarised in **Table 7**.

Table 7. Proposed Specific Management Strategies for known Aboriginal Cultural Heritage Sites.

Site Name	Type	Summary Scientific Significance	Potential Impacts	Proposed Management Measures
RLF29	Artefact (n=3)	Direct	Total	Collect Aboriginal objects
RLF30	Artefacts (n=1)	Direct	Total	Collect Aboriginal object
RLF31	Artefacts (n=1)	Direct	Total	Collect Aboriginal object
RLF32	Artefacts (n=3)	Direct	Total	Collect Aboriginal objects
RLF33	Artefacts (n=1)	Direct	Total	Collect Aboriginal object

11 SUMMARY RECOMMENDATIONS

Based on the results of this cultural heritage investigation and consultation with representatives of the RAPs the following is recommended:

- The Modification be allowed to proceed because the Modification area would be located in an area where harm to highly significant cultural heritage would be avoided.
- A suitably qualified archaeologist and representatives of the local Aboriginal community should be engaged to record and collect the Aboriginal objects in the Modification area. These items should be properly curated and stored at the approved "Keeping Place". The artefacts should be replaced within rehabilitated areas in consultation with local Aboriginal groups and the NSW Office of Environment and Heritage (OEH).
- In the unlikely event that human skeletal remains are encountered during the course of activities associated with the Modification, all work in that area must cease. Remains must not be handled or otherwise disturbed except to prevent further disturbance. If the remains are thought to be less than 100 years old, the Police or the State Coroner's Office (tel: 02 9552 4066) must be notified. If there is reason to suspect that the skeletal remains are more than 100 years old and Aboriginal, Tronox should contact the OEH's Environmental Line (tel: 131 555) for advice. In the unlikely event that an Aboriginal burial is encountered, strategies for its management would need to be developed with the involvement of the local Aboriginal community.
- Tronox should update the HMP for the Atlas-Campaspe Mine to reflect the results and recommendations of this assessment. The HMP should continue to remain active for the life of the Modified Project and define the tasks, scope and conduct of all Aboriginal cultural heritage management activities. The HMP should be revised in consultation with the local Aboriginal community.
- Tronox should continue to provide training to all on-site personnel regarding the HMP strategies relevant to their employment tasks.
- Tronox should continue to involve the RAPs and any other relevant Aboriginal community groups or members in matters pertaining to the Modification.

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APPENDICES

Appendix 1 Glossary

Appendix 2 Consultation Log

Appendix 3 Correspondence to Aboriginal Community Stakeholders

Appendix 4 Correspondence from Aboriginal Community Stakeholders

Appendix 5 AHIMS Register Search

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APPENDIX 1: GLOSSARY

Archaeological site - A place with evidence of past human activity. This evidence may include Aboriginal and/or historic artefacts, features, structures or organic traces.

Artefact scatter - A surface scatter of Aboriginal or historic cultural material. Scatters of stone artefacts are a common archaeological site type. These scatters may also contain charcoal, discarded animal bones, shell and ochre.

Assemblage - A collection of artefacts from a single archaeological site.

Burial site - A place with a concentration of human remains. Ochre, stone tools, charcoal and grave goods may be associated with burials. Most burial sites are found in sand dunes but dead trees, caves and rock shelters were also used.

Ceremonial ground - Place that may be associated with initiation ceremonies, meetings or sacred rituals. Stone arrangements may be present, including cairns, stone circles or standing slabs of rock.

Chert - A fine-grained opaline rock ranging in color from white to black, but most often grey, brown, grayish brown and light green to rusty red.

Core - A piece of stone from which flakes have been removed. They usually have negative flake scares that have resulted from the removal of flakes.

Cultural material - Any material remains or objects resulting from human activity.

Debitage - Any waste material including flakes and cores produced during the manufacture of chipped stone tools.

Flake - A piece of stone detached from a core that typically displays a striking platform, bulb of percussion and flake scars on the ventral surface.

Flaked piece - Small fragments of stone resulting from the manufacture of stone tools. A striking platform or bulb of percussion may not be evident.

Formalized tools - An artefact that has been deliberately shaped by flaking, retouch or grinding to produce a predetermined tool type.

Ground surface visibility - The amount of bare ground exposed, usually expressed as a percentage.

Hearth - The remains of a campfire containing charcoal, discoloured soil, and possibly, hearthstones, heat retainers or the remains of animals or shellfish cooked and consumed at the campsite.

Hearthstone – Stone cobble placed in a campfire to retain heat for cooking. The types of stone used as hearthstones in western Victoria includes calcrete and sandstone.

Heat retainer - Nodule of baked clay, thought to have been placed in campfires to retain heat for cooking.

in situ - An artefact or other feature that has not been disturbed from its original position.

Mound - Raised areas of earth ranging from 3 to 35m in diameter and from 0.5m to 2m in height. Earth oven material, stone artefacts, food refuse and the remains of hut foundations have been recovered from excavated earth mounds in the central and western parts of Victoria.

Ochre - Soft varieties of the iron oxides goethite, limonite or haematite usually coloured red or yellow and used as pigment for painting.

Quarry - An outcrop of stone or ochre where Aboriginal people have extracted the raw material for use or trade. Stone quarries are identifiable by a dense scatter of broken stone and flakes or consist of pits or hollows where material has been dug out of the ground.

Quartz – A silica mineral resistant to weathering because of its hardness. It is commonplace in the landscape as a consequence.

Quartzite - A metamorphic rock formed by the re-crystallization of quartz.

Retouch - A stone artefact with fine, secondary flaking along one or more edges.

Scarred tree - A tree with a scar on its trunk caused by bark removal.

Shell midden - A surface scatter or heap of discarded shell often with charcoal, animal bones and stone artefacts. Middens may found near coastlines, rivers, creeks, swamps and ancient lakes.

Silcrete - A hard, fine-grained rock composed of silica cement.

Stone feature - Cairns, rock wells, grinding groves, stone structures, fish traps and stone arrangements are examples of stone features.

Stratified deposit - Material that has been laid down over time forming a sequence of events.

Subsurface testing - A method of excavation used for detecting cultural material below the ground surface. Testing is commonly by shovel, trowel or hand auger.

Survey - An inspection of land either by foot or vehicle for the purpose of identifying archaeological sites.

Transect - A predetermined area or a path that directs the course of a survey.

APPENDIX 2: CONSULTATION LOG

DATE	ORGANISATION CONTACTED	HOW CONTACTED	CONTACTED BY	NATURE OF CONSULTATION	TIME
3/28/2019	Kullila Site Consultants*, Michael (Mick) Kelly on behalf of Ngiyampaa people, Balranald Local Aboriginal Land Council*, Ivanhoe Community Working Party*, Muthi Muthi Nations Aboriginal Corporation, National Koorie Site Management, Wakool Indigenous Corporation, Maria Maher, Willandra Lakes 2 Traditional Tribal Groups Elders Council.	Email & Post*	Cristal Mining Australia (now Tronox)	Stage 2 letter notifying the RAPs of the Modification and to provide an opportunity to update their contact details.	
3/28/2019	Barkindji Elders Council and Badger Bates	Post	Cristal Mining Australia (now Tronox)	Stage 2 letter notifying the RAPs of the Modification and to provide an opportunity to update their contact details.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Daniel Kelly	Response to Stage 2 letter indicating that he is the relevant contact regarding any proposed field surveys.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Return Email Service	Returned email received from the Kullila Site Consultants email address (copy of Stage 2 letter). Unable to be delivered. No alternative contact details on file.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Return Email Service	Returned email received from Andrew Rose (from the Ivanhoe Community Working Party) (copy of Stage 2 letter). Unable to be delivered. No alternative contact details on file.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Gary Pappin, Wakool Indigenous Corporation	Gary advised that Daniel Kelly is not associated with the Wakool Indigenous incorporation and requested that he be removed from correspondence.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Return Email Service	Returned email received from the Balranald Local Aboriginal Land Council email address (copy of Stage 2 letter). Unable to be delivered. No alternative contact details on file.	
3/28/2019	Cristal Mining Australia (now Tronox)	Email	Return Email Service	Returned email received from D. Keely (from the Muthi Muthi Nations Aboriginal Corporation) (copy of Stage 2 letter). Unable to be delivered. No alternative contact details on file.	
3/29/2019	Michael (Mick) Kelly on behalf of Ngiyampaa people, Balranald Local Aboriginal Land Council, Ivanhoe Community Working Party, Muthi Muthi Nations Aboriginal Corporation, National Koorie Site Management, Wakool Indigenous Corporation, Maria Maher, Willandra Lakes 2 Traditional Tribal Groups Elders Council.	Email & Post	Cristal Mining Australia (now Tronox)	Stage 3 letter containing information regarding the proposed methodology for the Modification ACHA, an information session to be held in Ivanhoe, and a field survey of the modification area. Comments on the proposed methodology were requested by 3 May 2019.	
3/29/2019	Kullila Site Consultants, Barkindji Elders Council and Badger Bates	Post	Cristal Mining Australia (now Tronox)	Stage 3 letter containing information regarding the proposed methodology for the Modification ACHA, an information session to be held in Ivanhoe, and a field survey of the modification area. Comments on the proposed methodology were requested by 3 May 2019.	
3/29/2019	Balranald Local Aboriginal Land Council	Email	Cristal Mining Australia (now Tronox)	Copy of Stage 2 letter and email resent to updated email address. The first email sent on 28/3/19 was unable to be delivered.	
3/29/2019	Balranald Local Aboriginal Land Council and the Office of Environment and Heritage.	Email	Cristal Mining Australia (now Tronox)	Notification letters detailing the RAPs that were contacted regarding the ACMSP Optimisation Modification (Stage 2 letters).	
3/29/2019	Wakool Indigenous Corporation	Email	Cristal Mining Australia (now Tronox)	Response email indicating that Daniel Kelly was removed as a relevant contact for the Wakool Indigenous Corporation.	
3/29/2019	Cristal Mining Australia (now Tronox)	Email	Office of Environment and Heritage	Response email indicating that the OEH acknowledges that Cristal Mining is continuing consultation for the modification with the RAP's identified in the Project SEARs.	
4/1/2019	Cristal Mining Australia (now Tronox)	Post	Barkindji Elders Council	Stage 2 letter sent back marked 'return to sender' for the reason of 'left address/unknown'.	
4/1/2019	Cristal Mining Australia (now Tronox)	Post	Barkindji Elders Council	Stage 3 letter sent back marked 'return to sender' for the reason of 'left address/unknown'.	
4/3/2019	Cristal Mining Australia (now Tronox)	Email	Office of Environment and Heritage	Indicating that a search of the National Native Title Tribunal website to determine if there are any additional relevant RAPs or if there has been a change in determinations/applications relevant to the Modification.	
4/18/2019	Tara Bruton (member of the Muthi Muthi Nations Aboriginal Corporation)	Email	Tronox	Contacted to ascertain if interested in attending the proposed site survey at the Ivanhoe Rail Facility on 1 May 2019.	
4/18/2019	Tronox	Email	Tara Bruton (member of the Muthi Muthi Nations Aboriginal Corporation)	Indicated that she would not be able to attend the proposed survey of the Ivanhoe Rail Facility on 1 May 2019.	
4/18/2019	Joan Slade (Ivanhoe Community Working Party)	Telephone	Landskape (Dr Matt Cupper)	Called to enquire whether Ms Slade would be interested in attending the proposed field survey on 1 May 2019. Left message with Joan.	
4/18/2019	Landskape (Dr Matt Cupper)	Telephone	Joan Slade (Ivanhoe Community Working Party)	Returned call. Indicated that she was interested in attending the proposed field Survey on 1 May 2019.	
4/20/2019	Tara Bruton (member of the Muthi Muthi Nations Aboriginal Corporation)	Telephone	Tronox	Tara previously contacted Tronox to see if there was heritage survey work at Atlas mine. Tronox contacted Tara to see if she was interested in the heritage survey at Ivanhoe rail facility. Tara declined because she had other work on.	
4/20/2019	Maria Maher	Telephone	Tronox	Responded to phone call from Maria Maher to discuss pay rates proposed to attend consutlation.	

DATE	ORGANISATION CONTACTED	HOW CONTACTED	CONTACTED BY	NATURE OF CONSULTATION	TIME
4/30/2019	Registered Aboriginal Parties	Information Session	Tronox	An information session was held to discuss the Modification and the Proposed Methodology for the ACHA. All RAPs were invited to attend. Representatives from Ivanhoe Community Working Party attended.	
5/1/2019	Registered Aboriginal Parties	Field Survey	Tronox, Landskape	A field survey of the modified Ivanhoe Rail Facility area was undertaken to allow representatives of the RAPs to inspect the area and any Aboriginal Heritage sites which may be located within or in immediate proximity to the area. Representatives from Ivanhoe Community Working Party attended the field survey.	
5/17/2019	Registered Aboriginal Parties	Post/Email	Tronox	Copies of the draft ACHA were provided to the RAPs for review and Comment. Comments on the report were requested by Friday 21 June 2019. Hard copies only were provided to Badger Bates, Arthur Kirby (Barkindji Elders Councils) and Paul Charles (Kulila Site Consultants).	
5/17/2019	Tronox	Email	Return Email Service	Bounced emails received from the Ivanhoe Community Working Party, Ali Maher (National Koorie Site Management), Warren Clarke (Wilandra Lakes 2 Traditional Tribal Groups Elders Council) and Bernadette Pappin (Muthi Muthi Nations Aboriginal Corporation.	
5/17/2019	Ivanhoe Community Working Party, Ali Maher (National Koorie Site Management), Warren Clarke (Wilandra Lakes 2 Traditional Tribal Groups Elders Council) and Bernadette Pappin (Muthi Muthi Nations Aboriginal Corporation.	Email	Tronox	Follow-up email providing the draft ACHA as a downloadable document via a link.	
5/17/2019	Tronox	Email	Return Email Service	Bounced emails again received from Ali Maher (National Koorie Site Management) and Warren Clarke (Wilandra Lakes 2 Traditional Tribal Groups Elders Council).	
5/20/2019	Tronox	Email	Fay Johnstone (Ivanhoe Community Working Party)	Email from Fay indicating she would like a hard copy of the Draft ACHA sent to a postal address.	
5/20/2019	Fay Johnstone (Ivanhoe Community Working Party)	Post	Tronox	Hard copy of the Draft ACHA sent to Fay, as per a request dated 20 May 2019.	
5/20/2019	Tronox	Post	Barkindji Elders Council	Draft ACHA and sent back marked 'return to sender' for the reason of 'left address/unknown'.	

APPENDIX 3: CORRESPONDENCE TO ABORIGINAL COMMUNITY STAKEHOLDERS

STAGE 2 CORRESPONDENCE

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Balranald Local Aboriginal Land Council
Damien Aidon
PO Box 187
BALRANALD NSW 2715

Via Email: ceo.blalc@gmail.com

Dear Damien,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Cristal Mining is seeking environmental approvals under the EP&A Act for a proposed modification to the Project (the Modification).

The Modification would include the following:

- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate longer trains.
- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection.

The Modification would change the approved Ivanhoe Rail Facility surface development area. There would be no change to the approved Atlas-Campaspe Mine surface development area.

As part of the modification request, Cristal Mining will be preparing an Aboriginal Cultural Heritage Assessment to identify ways to avoid or minimise potential harm to Aboriginal objects. The subject area of the Modification and any such application is depicted as the “Indicative Location of Modification” as shown on Figure 2.

Cristal Mining Australia Limited
ABN 60 009 247 858
Gingko Mine via Nob Road Wentworth NSW 2648, Australia
PO Box 444, Broken Hill NSW 2880, Australia
T 61.3.5074.8900 F 61.3.5074.8999
www.cristalmining.com

Community consultation is an important part of this process. In accordance with the requirements as set out in the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010) (Consultation Guidelines) issued by the NSW Office of Environment and Heritage, Cristal Mining is required to conduct a community consultation process with relevant Aboriginal people to assist in the preparation of the Aboriginal Cultural Heritage Assessment. This includes:

- Contacting various government organisations and requesting a list of any Aboriginal persons or groups who may hold cultural knowledge relevant to, or who have a right or interest in, determining the cultural heritage significance of Aboriginal objects and/or places in the "Indicative Location of Modification".
- Writing to the Aboriginal persons or groups identified by the above process to notify them of the Modification and invite them to register an interest in the community consultation process.

Due to your previous involvement in the Aboriginal Cultural Heritage Assessment for the Atlas-Campaspe Mineral Sands Project Environmental Impact Statement, you have been automatically registered for the consultation process associated with the Modification. You do NOT need to contact Cristal Mining to re-register for the Modification.

However, Cristal Mining would appreciate if you could please provide updated contact details for the Modification. Could you please complete the attached form and return to Cristal Mining via the contact details provided below.

Cristal Mining advises that the details of any Aboriginal person or group who registers an interest in the Modification will be forwarded to the NSW Office of Environment and Heritage and the Balranald Local Aboriginal Land Council in accordance with Section 4.1.5 of the Consultation Guidelines, unless they specify that they do not want their details released.

Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

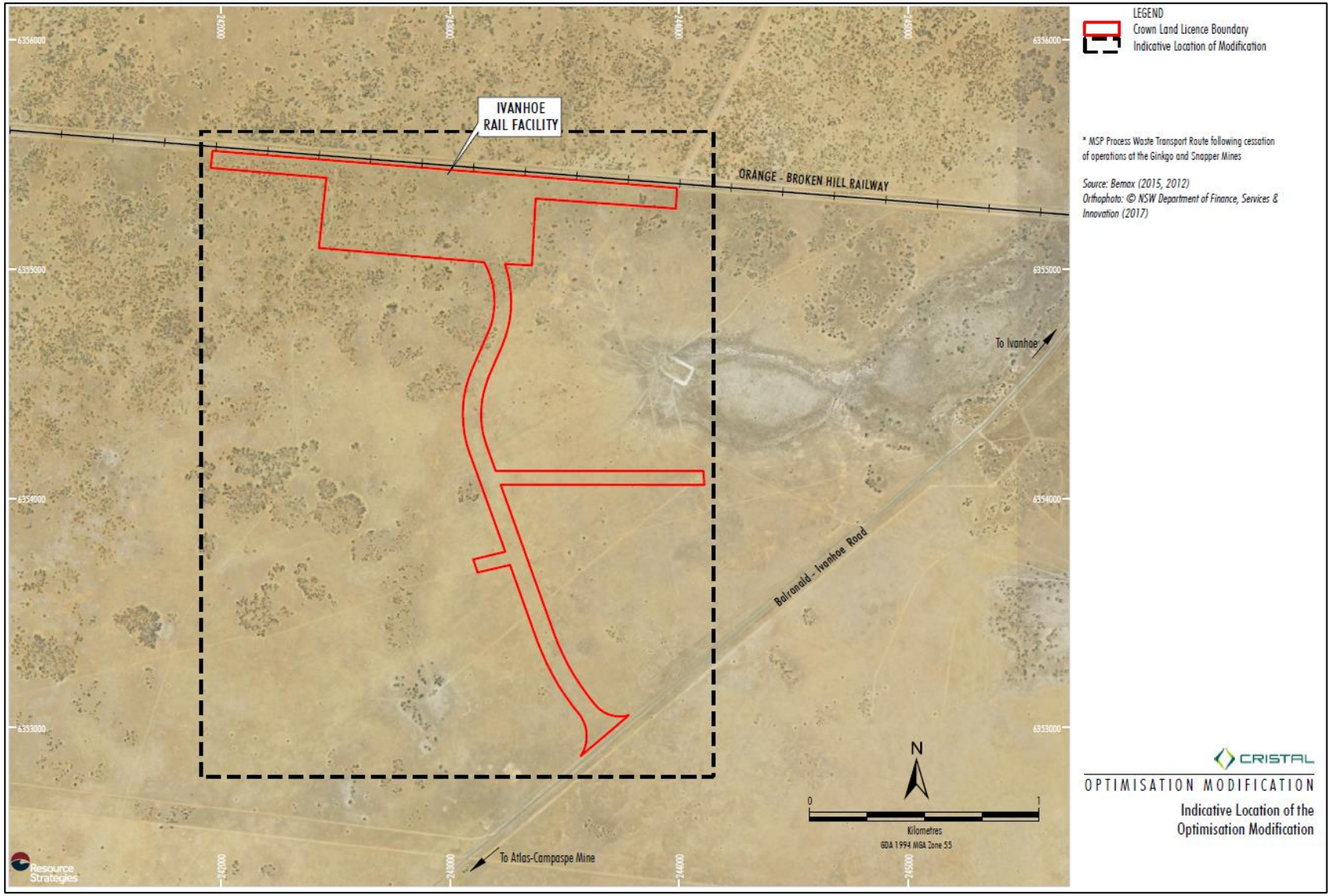
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Ivanhoe Community Working Party
Andrew Rose and Fayne Johnson
PO Box 29
BOURKE NW 2840

Via Email: Andrew.Rose5@dhs.nsw.gov.au, fay.johnstone@det.nsw.edu.au and ivanhoe@mpra.com.au

Dear Andrew and Fayne,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Cristal Mining is seeking environmental approvals under the EP&A Act for a proposed modification to the Project (the Modification).

The Modification would include the following:

- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate longer trains.
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The Modification would change the approved Ivanhoe Rail Facility surface development area. There would be no change to the approved Atlas-Campaspe Mine surface development area.

As part of the modification request, Cristal Mining will be preparing an Aboriginal Cultural Heritage Assessment to identify ways to avoid or minimise potential harm to Aboriginal objects. The subject area of the Modification and any such application is depicted as the “Indicative Location of Modification” as shown on Figure 2.

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Community consultation is an important part of this process. In accordance with the requirements as set out in the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010) (Consultation Guidelines) issued by the NSW Office of Environment and Heritage, Cristal Mining is required to conduct a community consultation process with relevant Aboriginal people to assist in the preparation of the Aboriginal Cultural Heritage Assessment. This includes:

- Contacting various government organisations and requesting a list of any Aboriginal persons or groups who may hold cultural knowledge relevant to, or who have a right or interest in, determining the cultural heritage significance of Aboriginal objects and/or places in the "Indicative Location of Modification".
- Writing to the Aboriginal persons or groups identified by the above process to notify them of the Modification and invite them to register an interest in the community consultation process.

Due to your previous involvement in the Aboriginal Cultural Heritage Assessment for the Atlas-Campaspe Mineral Sands Project Environmental Impact Statement, you have been automatically registered for the consultation process associated with the Modification. You do NOT need to contact Cristal Mining to re-register for the Modification.

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Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

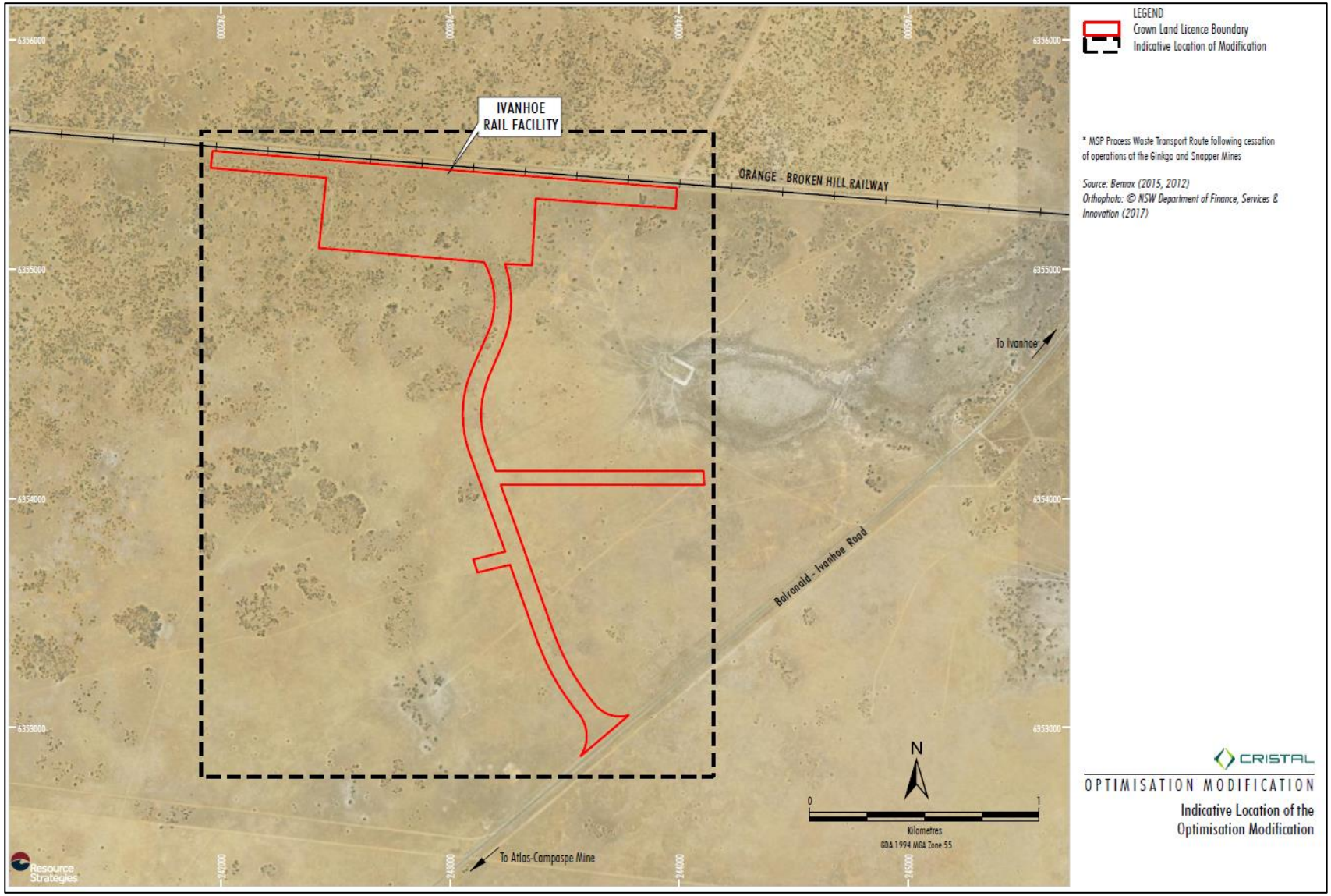
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
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Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Badger Bates
107 Gaffney Lane
BROKEN HIL NSW 2880

Dear Badger,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

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Gingko Mine via Nob Road Wentworth NSW 2648, Australia
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Yours sincerely

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Environmental Manager
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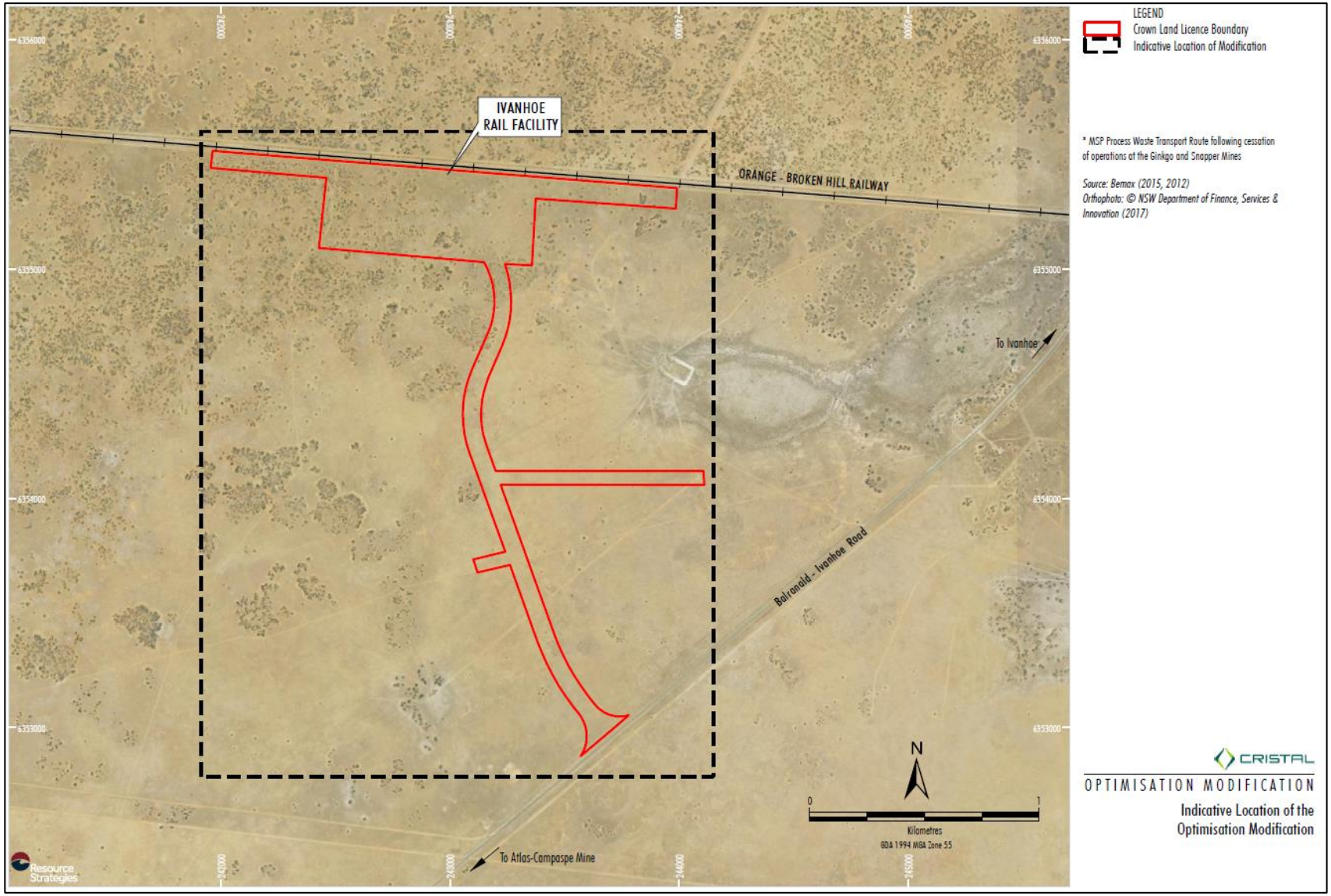

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
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0427 419 273
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Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Barkindji Elders Council
Arthur Kirby
c/- PO Box 87
EUSTON NSW 2737

Dear Arthur,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

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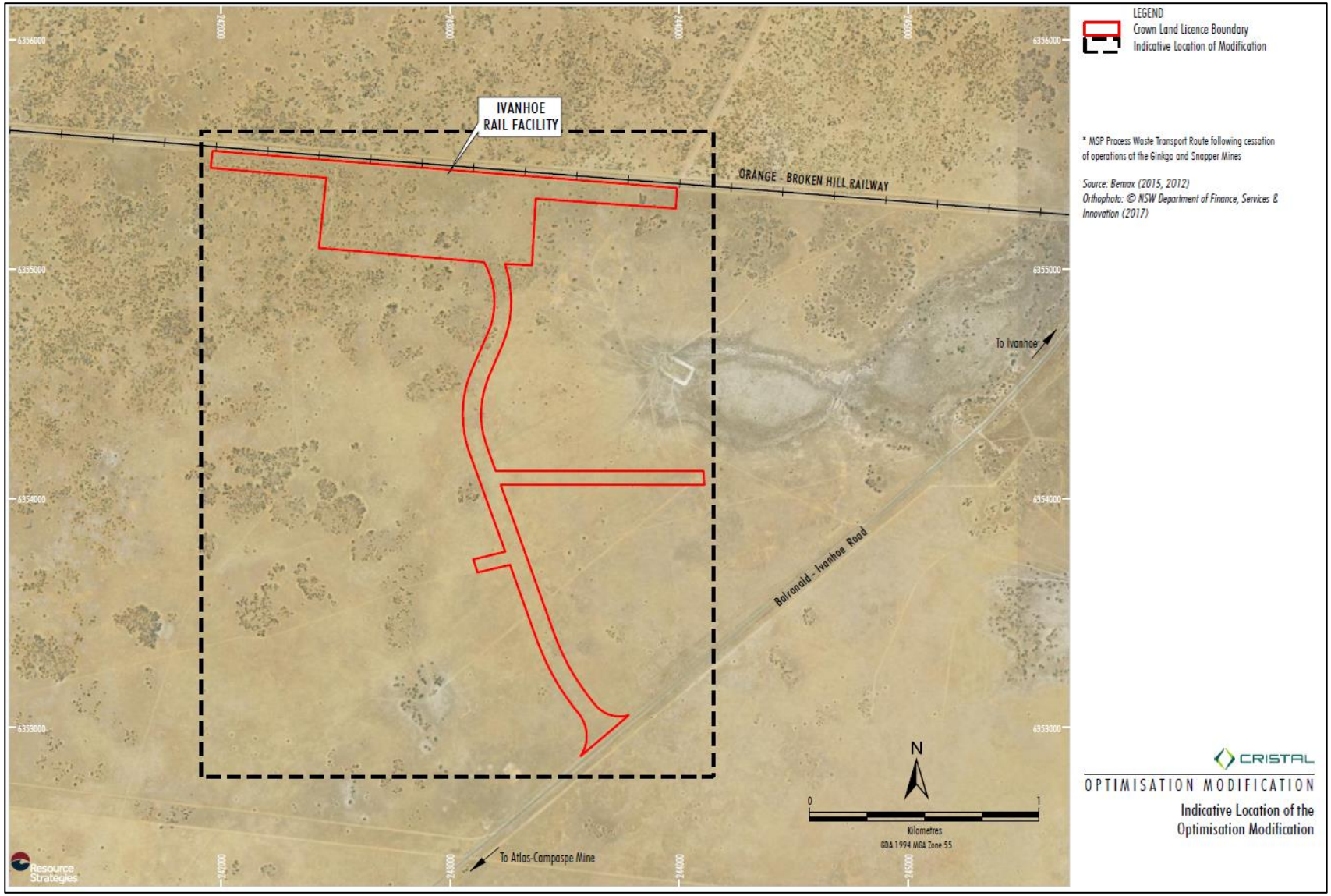

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
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Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
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Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

26 March 2019

Michael (Mick) Kelly on behalf of Ngiyampaa people
Michael (Mick) Kelly
C/- Office of Enviornment and Heritage
PO Box 318
BURONGA NSW 2739

Via Email: mick.kelly@environment.nsw.gov.au

Dear Michael,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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Environmental Manager
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0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
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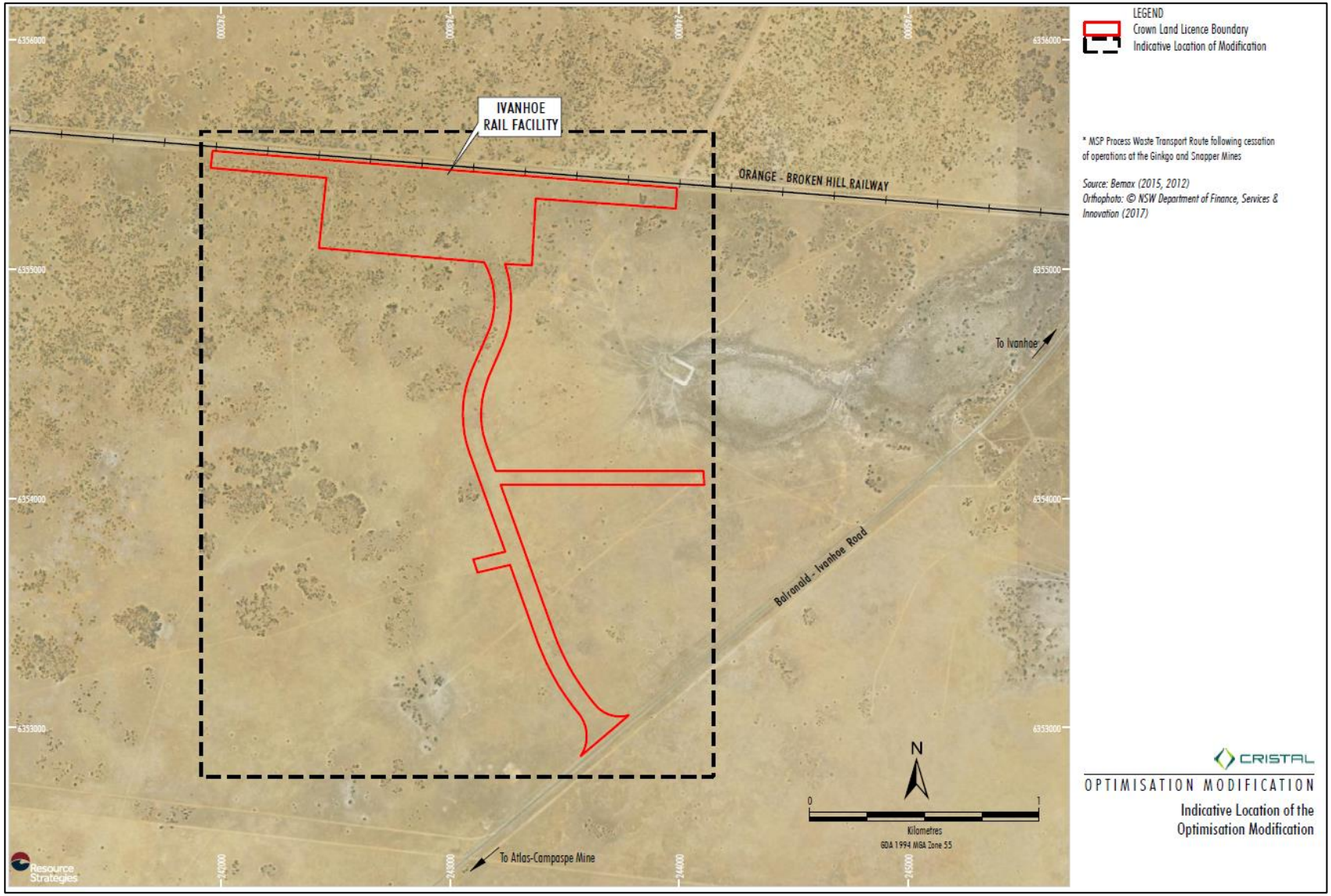

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
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Haakon Nielssen
Environmental Manager
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0427 419 273
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hnielssen@cristal.com

Name	
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Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

National Koorie Site Management
Ali Maher
3 Cuthbert Drive
MOUNT WARRIGAL NSW 2528

Via Email: ali.n.maher@hotmail.com

Dear Ali,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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Yours sincerely

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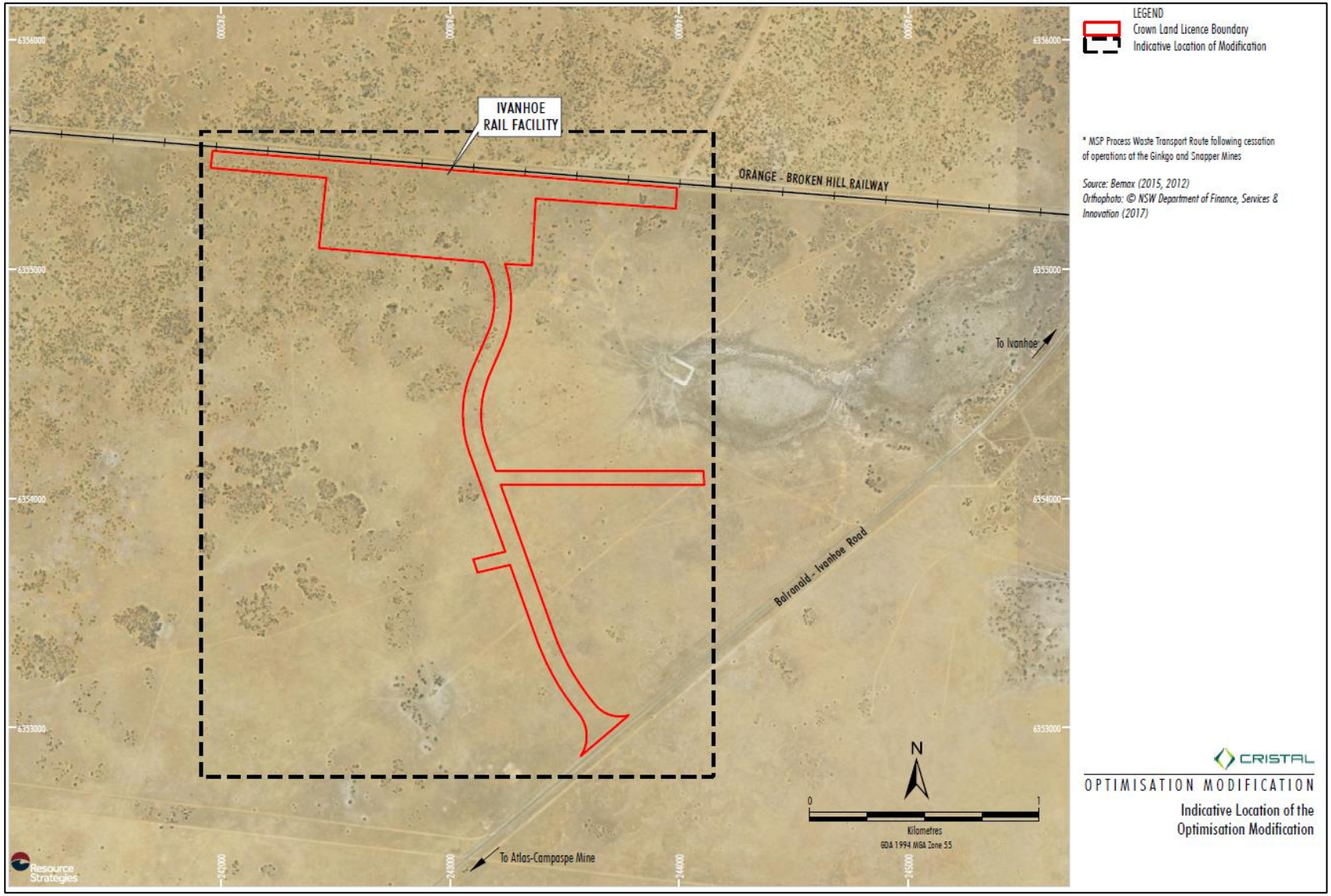

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Haakon Nielssen
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0427 419 273
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Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Kullila Site Consultants
Paul Charles
14 Werrang Road
PRIMBEE NSW 2502

Via Email: kullilasiteconsultants@hotmail.com

Dear Paul,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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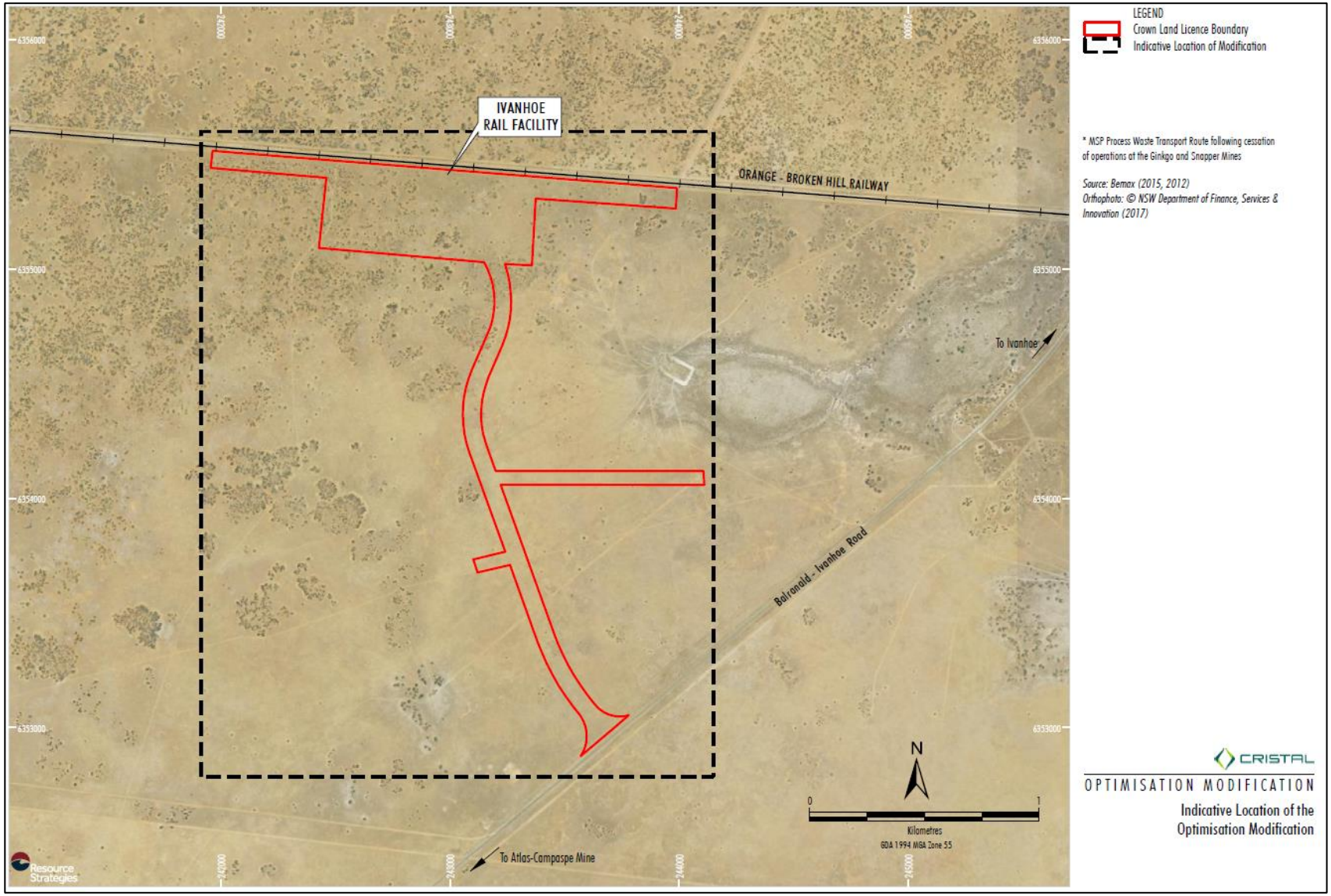

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
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Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Willandra Lakes 2 Traditional Tribal Groups Elders Council
C/- Warren Clarke
PO Box 318
BURONGA NSW 2739

Via Email: warren.clarke@environment.nsw.gov.au

Dear Warren,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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The Modification would include the following:

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- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection.

The Modification would change the approved Ivanhoe Rail Facility surface development area. There would be no change to the approved Atlas-Campaspe Mine surface development area.

As part of the modification request, Cristal Mining will be preparing an Aboriginal Cultural Heritage Assessment to identify ways to avoid or minimise potential harm to Aboriginal objects. The subject area of the Modification and any such application is depicted as the “Indicative Location of Modification” as shown on Figure 2.

Cristal Mining Australia Limited
ABN 60 009 247 858
Gingko Mine via Nob Road Wentworth NSW 2648, Australia
PO Box 444, Broken Hill NSW 2880, Australia
T 61.3.5074.8900 F 61.3.5074.8999
www.cristalmining.com

Community consultation is an important part of this process. In accordance with the requirements as set out in the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010) (Consultation Guidelines) issued by the NSW Office of Environment and Heritage, Cristal Mining is required to conduct a community consultation process with relevant Aboriginal people to assist in the preparation of the Aboriginal Cultural Heritage Assessment. This includes:

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- Writing to the Aboriginal persons or groups identified by the above process to notify them of the Modification and invite them to register an interest in the community consultation process.

Due to your previous involvement in the Aboriginal Cultural Heritage Assessment for the Atlas-Campaspe Mineral Sands Project Environmental Impact Statement, you have been automatically registered for the consultation process associated with the Modification. You do NOT need to contact Cristal Mining to re-register for the Modification.

However, Cristal Mining would appreciate if you could please provide updated contact details for the Modification. Could you please complete the attached form and return to Cristal Mining via the contact details provided below.

Cristal Mining advises that the details of any Aboriginal person or group who registers an interest in the Modification will be forwarded to the NSW Office of Environment and Heritage and the Balranald Local Aboriginal Land Council in accordance with Section 4.1.5 of the Consultation Guidelines, unless they specify that they do not want their details released.

Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

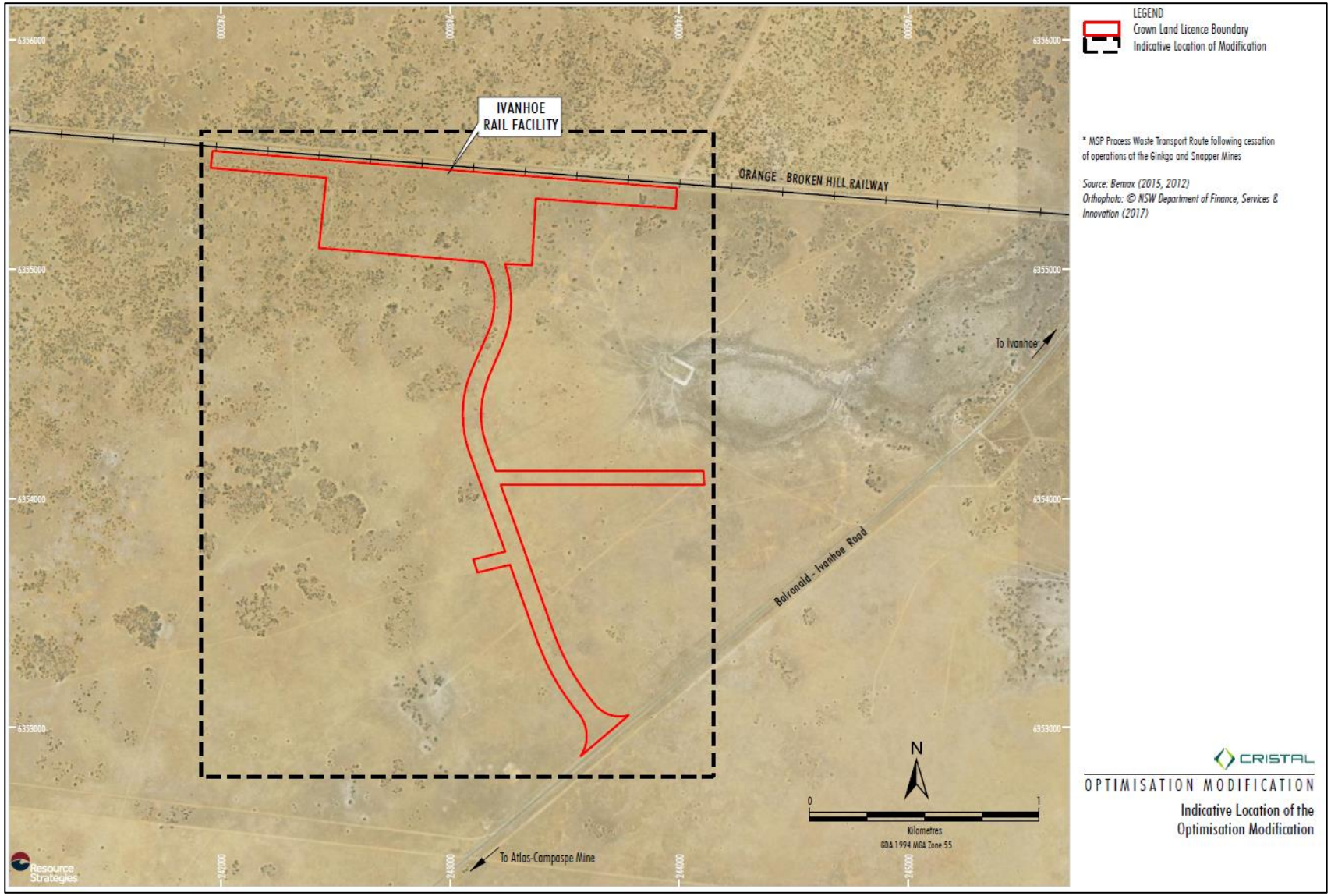
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Muthi Muthi Nations Aboriginal Corporation
Bernadette Pappin
PO Box 210
BALRANALD NSW 2715

Via Email: dkeely@macmildura.org and bpappin@gwahs.health.nsw.gov.au

Dear Bernadette,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Cristal Mining is seeking environmental approvals under the EP&A Act for a proposed modification to the Project (the Modification).

The Modification would include the following:

- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate longer trains.
- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection.

The Modification would change the approved Ivanhoe Rail Facility surface development area. There would be no change to the approved Atlas-Campaspe Mine surface development area.

As part of the modification request, Cristal Mining will be preparing an Aboriginal Cultural Heritage Assessment to identify ways to avoid or minimise potential harm to Aboriginal objects. The subject area of the Modification and any such application is depicted as the “Indicative Location of Modification” as shown on Figure 2.

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www.cristalmining.com

Community consultation is an important part of this process. In accordance with the requirements as set out in the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010) (Consultation Guidelines) issued by the NSW Office of Environment and Heritage, Cristal Mining is required to conduct a community consultation process with relevant Aboriginal people to assist in the preparation of the Aboriginal Cultural Heritage Assessment. This includes:

- Contacting various government organisations and requesting a list of any Aboriginal persons or groups who may hold cultural knowledge relevant to, or who have a right or interest in, determining the cultural heritage significance of Aboriginal objects and/or places in the "Indicative Location of Modification".
- Writing to the Aboriginal persons or groups identified by the above process to notify them of the Modification and invite them to register an interest in the community consultation process.

Due to your previous involvement in the Aboriginal Cultural Heritage Assessment for the Atlas-Campaspe Mineral Sands Project Environmental Impact Statement, you have been automatically registered for the consultation process associated with the Modification. You do NOT need to contact Cristal Mining to re-register for the Modification.

However, Cristal Mining would appreciate if you could please provide updated contact details for the Modification. Could you please complete the attached form and return to Cristal Mining via the contact details provided below.

Cristal Mining advises that the details of any Aboriginal person or group who registers an interest in the Modification will be forwarded to the NSW Office of Environment and Heritage and the Balranald Local Aboriginal Land Council in accordance with Section 4.1.5 of the Consultation Guidelines, unless they specify that they do not want their details released.

Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

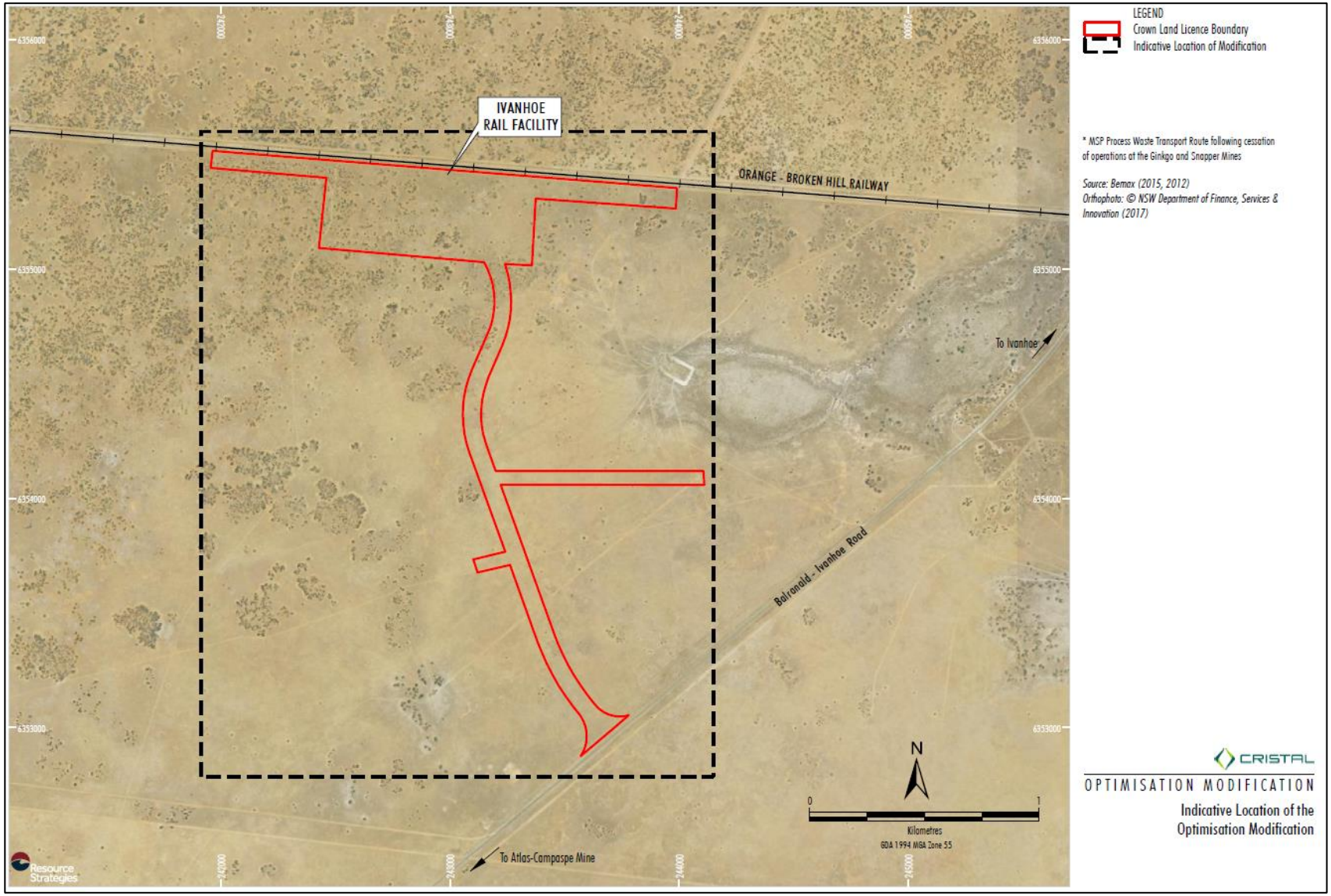
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Wakool Indigenous Corporation
Danny Kelly
Cynthia and Garry Pappin
PO Box 243
BALRANALD NSW 2715

Via Email: danielkelly1952@gmail.com and Wakool.ic@gmail.com

Dear Danny, Cynthia and Garry,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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The Modification would include the following:

- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate longer trains.
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As part of the modification request, Cristal Mining will be preparing an Aboriginal Cultural Heritage Assessment to identify ways to avoid or minimise potential harm to Aboriginal objects. The subject area of the Modification and any such application is depicted as the “Indicative Location of Modification” as shown on Figure 2.

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Due to your previous involvement in the Aboriginal Cultural Heritage Assessment for the Atlas-Campaspe Mineral Sands Project Environmental Impact Statement, you have been automatically registered for the consultation process associated with the Modification. You do NOT need to contact Cristal Mining to re-register for the Modification.

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Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

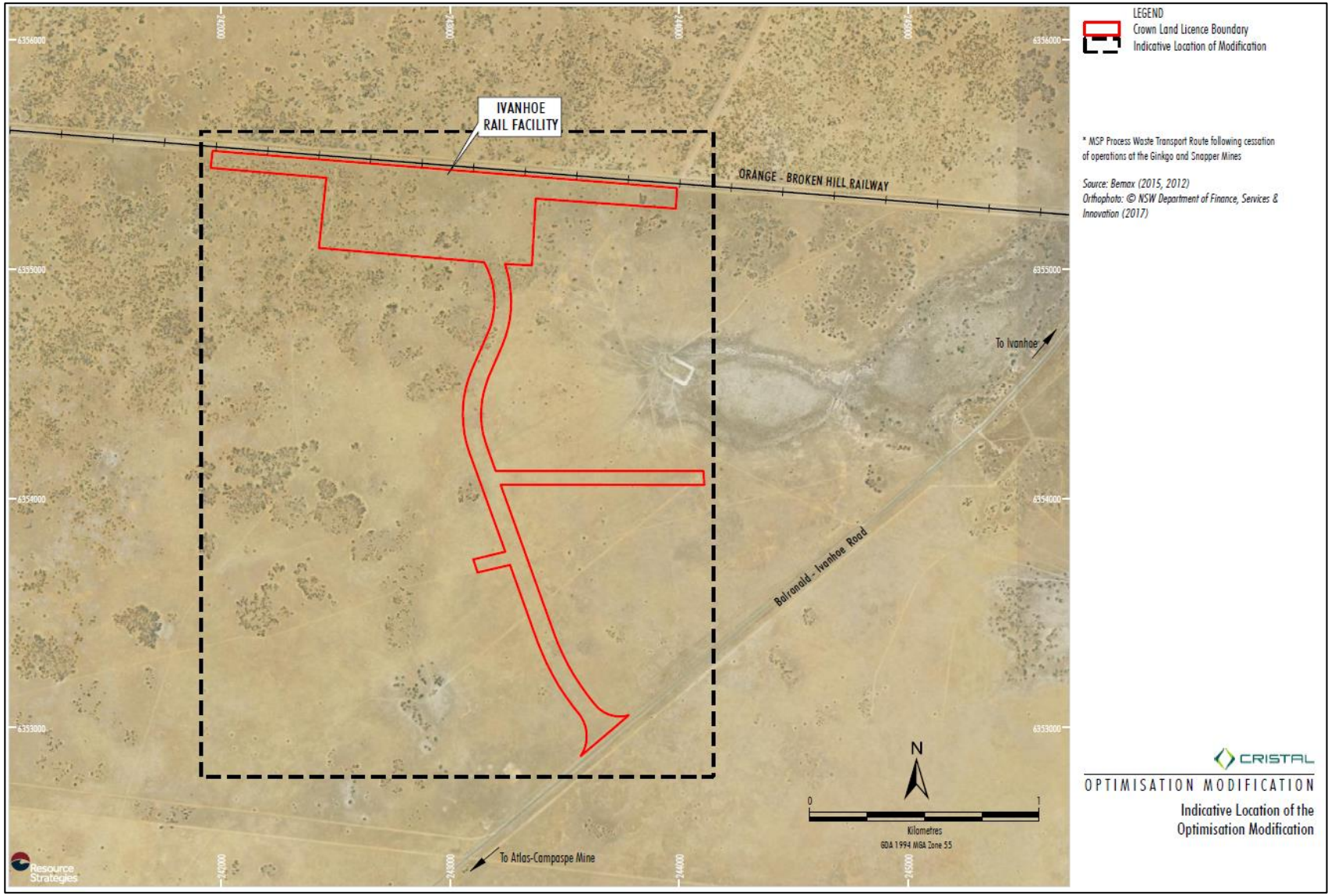
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

28 March 2019

Maria Maher

Via Email: g.m.maher@hotmail.com

Dear Maria,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Should you have any queries regarding your registration, require any further clarification, or wish to discuss the Modification further please do not hesitate to contact Cristal Mining via the following contact details:

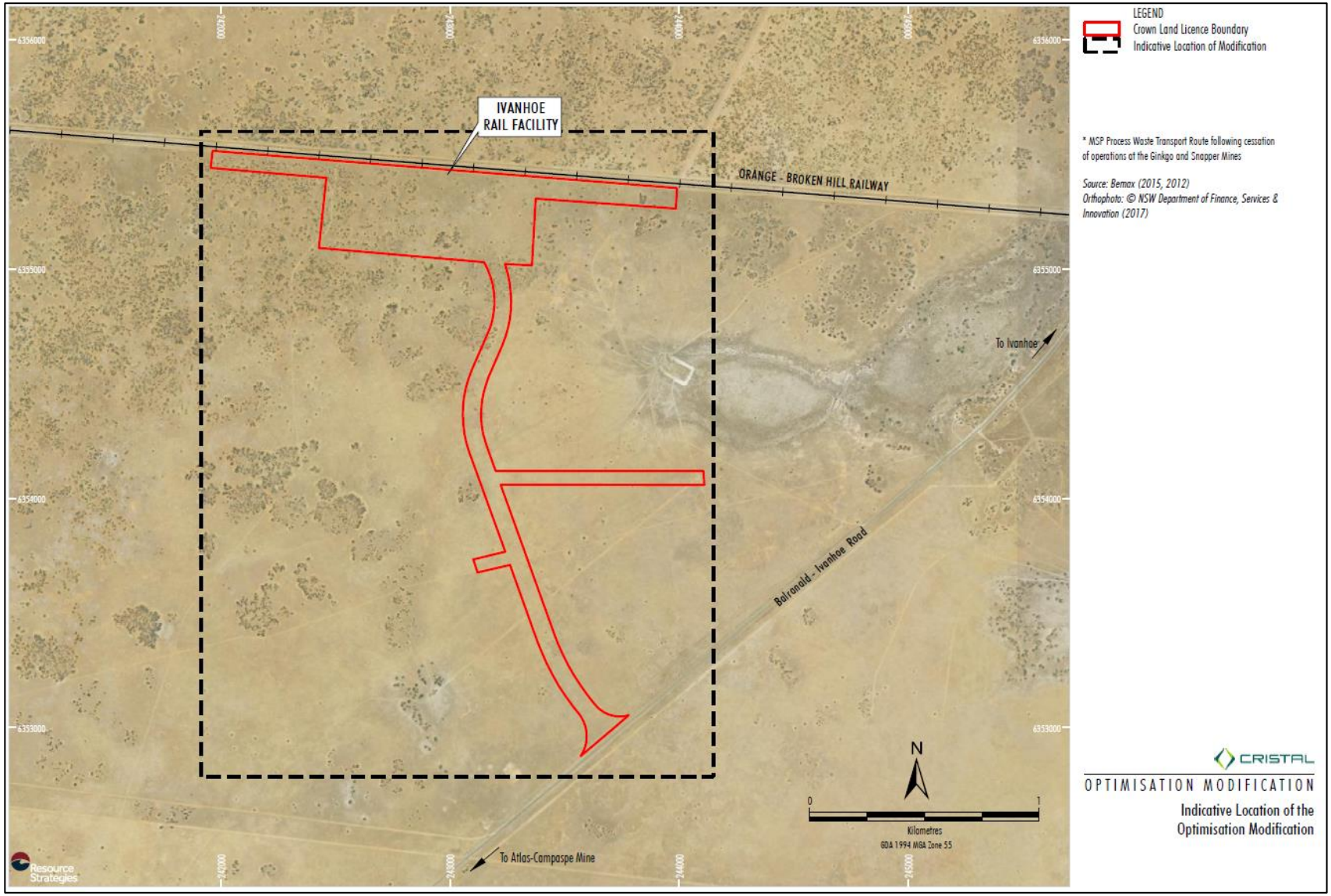
Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

Plan Showing the Regional Location of the Project

Plan Showing "Indicative Location of Modification"



ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION
UPDATED CONTACT DETAILS

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 4032, Mildura VIC 3502
hnielssen@cristal.com

Name	
Registered Aboriginal Party (if different from above)	
Address	
Postal Address (if different from above)	
Telephone Number	
Email Address	

Signed: _____

Date: _____

STAGE 3 CORRESPONDENCE

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Balranald Local Aboriginal Land Council
Damien Aidon
PO Box 187
BALRANALD NSW 2715

Via Email: ceo.blalc@gmail.com

Dear Damien,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe.

Proposed Methodology

Please find enclosed for your review, a copy of the Proposed Methodology for the Aboriginal Cultural Heritage Assessment for the Modification (Enclosure A).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (New South Wales [NSW] Department of Environment, Climate Change and Water, 2010) issued by the NSW Office of Environment and Heritage, we have provided the Proposed Methodology for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the Proposed Methodology.

If you wish to provide input on the following, please provide feedback to Cristal Mining (via the contact details provided at the end of this letter) by **5:00 pm Friday 3 May 2019**:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Modification area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

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All comments received will be taken into consideration as the Methodology is finalised.

Information Session

An information session with all Registered Aboriginal Parties, the consulting archaeologist and Cristal Mining representatives will be held on **Tuesday 30 April 2019** to discuss the Modification and the Proposed Methodology. The information session will be held at the Ivanhoe RSL (51 Columbus Street, Ivanhoe), and will commence at 3:00 pm and conclude at approximately 5:00 pm.

At the information session, Cristal Mining will provide a presentation on the nature and scale of the Modification, an overview of the impact assessment process and will discuss the roles, functions and responsibilities of participants and protocols for the management of any sensitive cultural heritage information.

The information session will also provide Registered Aboriginal Parties with an opportunity to raise any cultural issues or comments/perspectives regarding the Modification or the Proposed Methodology. Note that issues can also be raised at any point during the consultation process.

Light refreshments and drinks will be provided.

Cristal Mining will pay out of pocket travel expenses for Aboriginal representatives, from their home address to the meeting location and return (note that Cristal Mining will pay 75 cents per kilometre, up to a maximum of $300 per Registered Aboriginal Party). Registered Aboriginal Parties seeking to claim payment will need to provide proof of transport and sign a payment declaration form.

Cristal Mining will arrange for payment to be made via direct deposit after the meeting. Bank account details must be supplied to Cristal Mining (with confirmation of details from the bank and/or the Registered Aboriginal Party prior to payment). However, please note that Cristal Mining will not be paying for attendance at the information session.

Can you please indicate whether you are interested in attending the information session by **5:00 pm Friday 12 April 2019** via the contact details provided below.

Field Survey

As part of the Aboriginal Cultural Heritage Assessment for the Modification, Cristal Mining will be facilitating a field survey of the Modification area, to allow representatives of the Registered Aboriginal Parties to inspect the area and any Aboriginal heritage sites which may be located within or in immediate proximity to the area.

Regardless of participation in the surveys, all Registered Aboriginal Parties will be invited by Cristal Mining to attend a site inspection of the Modification area and a selection of the recorded sites following completion of the field surveys.

Please find enclosed the survey application form for completion and return by **5.00 pm Friday 12 April 2019**, for those Registered Aboriginal Parties who are seeking consideration for paid involvement in the field investigation associated with the Modification.

In order to be considered for paid involvement in the field surveys, Registered Aboriginal Parties will need to complete the attached Field Survey Application Form (Enclosure B) and provide it to Cristal Mining by the closing date.

Aboriginal representatives will be selected by Cristal Mining based upon the merits of the application with respect to the selection criteria, which are indicated by the questions in the application form. Applications will be assessed against all criteria including cultural knowledge of the Modification area, the representation of others within the community and experience in providing cultural heritage advice.

Where a response is not received by 5.00 pm Friday 12 April 2019, it will be assumed that you do not wish to seek consideration for paid involvement in the field investigation. Incomplete applications may not be accepted by Cristal Mining. Please note that Cristal Mining reserves the right to request any further information/clarification or supporting documentation from you in respect to your application.

Assistance in the completion of the application form can be provided to you upon request. Please use the contact details provided below.

The field survey is expected to take place on **Wednesday 1 May 2019** (i.e. the day following the Information Session). Further details will be provided to the successful applicants as soon as possible.

Contact Details

To provide any feedback with respect to the Proposed Methodology and/or to indicate your attendance at the information session, please contact Cristal Mining via the following contact details

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION

PROPOSED METHODOLOGY
FOR THE
ABORIGINAL CULTURAL HERITAGE ASSESSMENT

MARCH 2019
Project No. CMA-18-07
Document No. 970715

1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited (CMA), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

1.1 Approved Project

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (Figure 1).

The Project will integrate with currently existing/approved CMA operations in western NSW, including (Figure 1):

- the MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine;
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine; and
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

The Project general arrangements and activities associated with the two main development components of the Project are described in the following sub-sections.

Atlas-Campaspe Mine

The main activities associated with the development of the Atlas-Campaspe Mine include:

- ongoing exploration activities;
- sequential development and operation of two separate mineral sands ore extraction areas within the Mining Leases;
- use of conventional mobile equipment to mine and place mineral sands ore into dry mining units at a maximum ore production rate of up to 7.2 million tonnes per annum (Mtpa);
- mineral processing infrastructure including the primary gravity concentration unit, salt washing facility and a wet high intensity magnetic separation (WHIMS) circuit;
- mineral concentrate stockpiles and materials handling infrastructure (e.g. towers and stackers);
- progressive backfilling of mine voids with overburden behind the advancing ore extraction areas or in overburden emplacements adjacent to the mine path;
- placement of sand residues and coarse rejects (and MSP process wastes) following mineral processing to either the active mining area (behind the advancing ore extraction area) or in sand residue dams;

- development of a groundwater borefield at the Atlas deposit and localised dewatering systems (bores, spearfields and trenches) at both the Atlas and Campaspe deposits, including associated pump and pipeline systems;
- reverse osmosis plant to supply the salt washing facility and potable water;
- progressive development of water storage dams, sediment basins, pumps, pipelines and other water management equipment and structures;
- administration/office buildings, car parking facilities, workshop and stores;
- on-site accommodation camp;
- sewage treatment plant;
- diesel powered generators, electricity distribution station and associated internal electricity transmission lines;
- site access road, internal access roads and haul roads;
- roadworks along the proposed mineral concentrate transport route to the Ivanhoe Rail Facility;
- transport of mineral concentrates along the mineral concentrate transport route to the Ivanhoe Rail Facility;
- road transport of MSP process waste in sealed storage containers from the Ivanhoe Rail Facility to the Atlas-Campaspe Mine for subsequent unloading, stockpiling and placement behind the advancing ore extraction areas;
- development of soil stockpiles and laydown areas;
- monitoring and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

Ivanhoe Rail Facility

The main activities associated with the construction and operation of the Ivanhoe Rail Facility located approximately 4.5 km south-west of Ivanhoe, will include:

- development of a rail siding for:
  - loading of train wagons with mineral concentrate for rail transport to the MSP via the Orange – Broken Hill railway; and
  - unloading of MSP process waste in sealed storage containers (transported via the Orange – Broken Hill railway) from train wagons;
- site access road and internal haul roads/pavements;
- hardstand areas for mineral concentrate and MSP process waste unloading, stockpiling/sealed container storage and loading;
- a retention basin, drains, pumps, pipelines and other water management equipment and structures;
- site office and car parking facilities;
- extension to existing 11 kilovolt powerline;
- monitoring, landscaping and rehabilitation; and
- other associated minor infrastructure, plant, equipment and activities.

1.2 Optimisation Modification

CMA proposes to modify Development Consent (SSD_5012) to allow for changes to optimise the Project (herein preferred to as the Optimisation Modification or Modification). The Modification would include:

- Increased ore production rate from 7.2 Mtpa to 10.6 Mtpa.
- Addition of conveyors to transfer overburden (haul trucks are currently approved).
- Increased mineral concentrate production from 450,000 tonnes per annum (tpa) to 635,000 tpa.
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day.
- Increased mineral concentrate transport train length (from 600 metres [m] to 800 m) and frequency (from 6 to 8 train movements per week [i.e. 4 arrivals, 4 departures]).
- Extension to the Ivanhoe Rail Facility hardstand area and rail siding to accommodate the longer trains.
- Revised alignment of the Ivanhoe Rail Facility access road and access road intersection.
- Addition of the Ivanhoe Rail Facility bore as a water supply for the Ivanhoe Rail Facility.
- Increased MSP process waste disposal rate from 50,000 tpa to 65,000 tpa.
- Use of other local roads other than the haulage route to access site (i.e. Arumpo Road).
- Addition of an on-site landfill (inside approved surface development area).
- Addition of on-site solar power generation infrastructure (inside the approved surface development area).
- Addition of an airstrip on the site access road (inside the approved surface development area).

The Modification would change the approved Ivanhoe Rail Facility surface development area. The indicative location of additional surface development areas associated with the Modification is provided on Figure 2.

There would be no change to the approved mine site surface development area.

It is proposed that the Modification will be sought under section 4.55(2) of the EP&A Act.

CMA are seeking to engage with the Aboriginal community as part of the preparation for an Aboriginal Cultural Heritage Assessment (ACHA). Consultation with Aboriginal people and communities will be guided by the NSW Office of Environmental and Heritage's (OEH) *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water [DECCW], 2010).

1.3 Structure of this Document

Section 2 of this document describes the previous archaeological investigations undertaken for the approved Project, while Section 3 outlines the Proposed Methodology for the cultural and archaeological assessment of Aboriginal objects, places and/or Aboriginal cultural heritage values within the approved Modification area.

Section 4 outlines the sensitive cultural information management protocol and Section 5 provides further information on the preparation of the ACHA report. Relevant personnel and critical timeframes for the assessment are outlined in Sections 6 and 7, respectively.

2 PREVIOUS ARCHAEOLOGICAL INVESTIGATIONS

A previous Aboriginal Cultural Heritage Assessment was conducted in November 2012 by Niche Environment and Heritage (Niche) on behalf of CMA, for the (now) approved Project.

A total of 100 Aboriginal cultural heritage sites were identified within the Project area and surrounds. This includes 78 Aboriginal cultural heritage sites identified at the Atlas-Campaspe Mine area (including the mineral concentrate transport route) and 22 Aboriginal cultural heritage sites identified at the Ivanhoe Rail Facility area (Niche, 2012).

Aboriginal cultural heritage sites identified within the Project area and surrounds comprise 48 stone artefact scatters, 13 stone artefact scatters with hearths, two stone artefact scatters with hearths and non-human bone, one stone artefact scatter with hearths and freshwater mussel shell, 35 isolated finds of stone artefacts and one culturally modified tree (Niche, 2012).

3 PROPOSED ASSESSMENT METHODOLOGY

The Proposed Methodology for the cultural and archaeological assessment for the ACHA is as follows:

- Conduct a desktop assessment to delineate areas of known and predicted Aboriginal objects, places and/or Aboriginal cultural heritage values, including a detailed review of the previous assessment prepared by Niche (2012).
- Identify the Aboriginal cultural heritage values associated with the relevant area through consulting with Aboriginal people with cultural knowledge or responsibilities for Country in which the Modification occurs, utilising written, oral research and field investigations.
- The conduct of a cultural and archaeological assessment with representatives of local Aboriginal community, to identify Aboriginal objects, places and/or Aboriginal cultural heritage values. The field investigation would be carried out by the project archaeologist with the assistance of Aboriginal representatives.
- Record/document any Aboriginal objects, places and/or Aboriginal cultural heritage values within the relevant area and assessment of their significance with representatives of the Registered Aboriginal Parties (RAPs).
- In consultation with the RAPs, develop recommended management and mitigation measures for Aboriginal objects, places and/or Aboriginal cultural heritage values, including documentation (where relevant) of previous management and mitigation measures described for the approved Project (Niche, 2012).
- Provide a consideration of the potential impacts of the Modification on Aboriginal objects, places and/or Aboriginal cultural heritage values within the Modification area.
- Describe and justify the outcomes and alternatives.
- Document the Aboriginal cultural heritage impact assessment and the recommendations to minimise potential impacts on Aboriginal cultural heritage.
- Provide a copy of the draft ACHA to the RAPs for their review and feedback.
- Documentation of feedback received as part of the cultural assessment from RAPs for presentation in the final ACHA report (subject to the sensitivity of the information provided).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (DECCW, 2010), CMA requests that RAPs provide, where relevant during the conduct of the ACHA, cultural information regarding:

- whether there are any Aboriginal sites/objects of cultural value to Aboriginal people in the relevant area or surrounds; and
- whether there are any places of cultural value to Aboriginal people in the relevant area or surrounds.

This may include places of social, spiritual and cultural value, historic places with cultural significance, and potential places/areas of historic, social, spiritual and/or cultural significance.

4 SENSITIVE CULTURAL INFORMATION – MANAGEMENT PROTOCOL

In the event that a RAP has sensitive or restricted public access information, it is proposed that CMA would manage this information (if provided by the Aboriginal community) in accordance with a sensitive cultural information management protocol.

It is anticipated that the protocol would include making note of and managing the material in accordance with the following key limitations/requirements as advised by the relevant RAP at the time of the information being provided:

- any restrictions on access to the material;
- any restrictions on communication of the material;
- any restrictions on the location/storage of the material;
- any cultural recommendations on handling the material;
- any contextual information;
- any names and contact details of persons authorised by the relevant Aboriginal party to make decisions concerning the Aboriginal material and the degree of authorisation;
- any details of any consent given in accordance with customary law;
- the level of confidentiality to be accorded to the material; and
- any access and use by the RAP, of the cultural information in the material.

All RAPs should be aware of the mandatory OEH requirement that all feedback provided must be documented in the final ACHA, including copies of any submissions received and the proponents response to the issues raised.

5 ABORIGINAL CULTURAL HERITAGE ASSESSMENT

Following consultation on the Proposed Methodology of the cultural and archaeological assessment, and undertaking any required field components, a draft ACHA report will be prepared. The draft ACHA will be provided to all RAPs for their review and comment, and will include:

- details of the Aboriginal objects, places and/or Aboriginal cultural heritage values within the Modification area and how they will be impacted by the Modification;
- details of the consultation undertaken and how comments received at various times were considered; and

- management and mitigation recommendations drawing on information provided by RAPs and the results of the cultural and archaeological assessments.

6 PERSONNEL

Project Archaeologist: Dr Matt Cupper would be the project archaeologist. Matt has a wide range of experience in cultural and natural heritage management and an academic background in archaeology, geology and botany, including a PhD in the palaeoecology and early Aboriginal occupation of the Darling River. His particular area of expertise is the interaction of Aboriginal people and arid ecosystems in the interior of Australia. As a consultant archaeologist he has been engaged in many management and research-oriented studies of the Murray Darling Basin for industry and government. These have included investigation of the cultural heritage of the dunefields of western NSW for petroleum and mineral sands developments, and archaeological surveys of water supply and irrigation infrastructure along the Lachlan, Murray and Darling Rivers.

Aboriginal Field Representatives: It is anticiapted that Aboriginal field representatives would be engaged by CMA for the duration of the cultural heritage field survey (although this number may be subject to change based on the extent of the area requiring survey or due to workplace health and safety constraints). Aboriginal field representatives (including community leaders and Elders attending community consultation meetings) would invoice and, where appropriate, negotiate with CMA directly in relation to engagement for the field surveys. Aboriginal field personnel may be engaged on a rotational basis (e.g. a different team of representatives each day) as required.

7 CRITICAL TIMEFRAMES

Critical timeframes for the ACHA are outlined below:

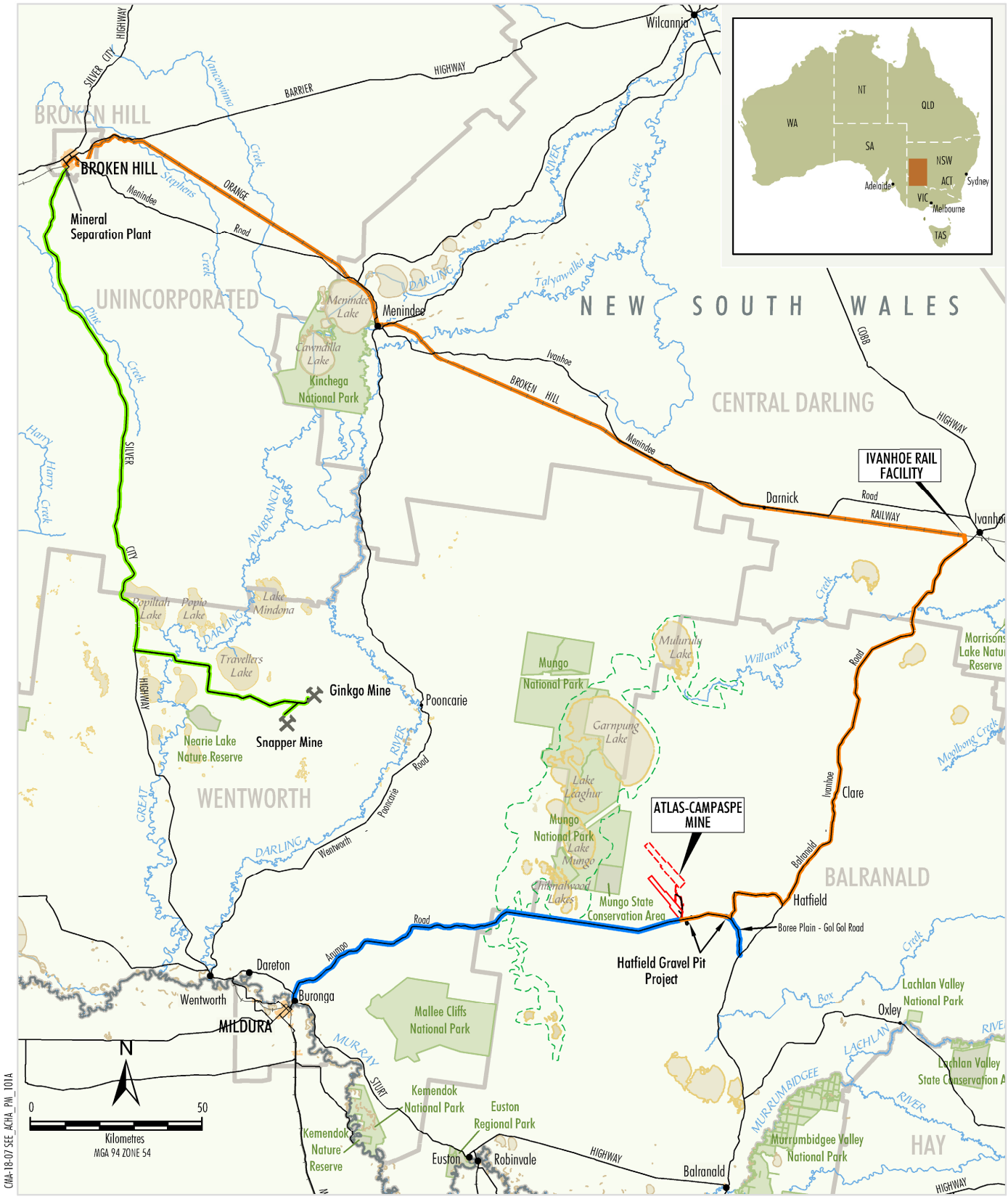
1. Collation of cultural significant information – ongoing throughout process until the end of the draft ACHA review period.
2. Provision of comments on the Proposed Methodology to CMA – April 2019.
3. Field survey – anticipated to occur in April 2019 (noting that survey dates will be confirmed with relevant representatives of the RAPs as required).
4. Provision of a draft ACHA (including proposed management and mitigation measures) to RAPs for review and comment – anticipated to occur April/May 2019 (following field survey).
5. Provision of comments from RAPs on draft ACHA to CMA – anticipated to occur May 2019.
6. Finalise ACHA in consideration of comments received – May 2019.

8 REFERENCES

Niche (2012) *Atlas-Campaspe Mineral Sands Project Aboriginal and Non-Aboriginal Cultural Heritage Assessment.* Report prepared for Cristal Mining Australia Ltd.

Department of Environment, Climate Change and Water (2010) *Aboriginal cultural heritage consultation requirements for proponents 2010*.

FIGURES



CMA-18-07 SEE_ACHA_PM_101A

LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Project Mineral Concentrate Transport Route*
- Proposed Additional Light Vehicle Access Route

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

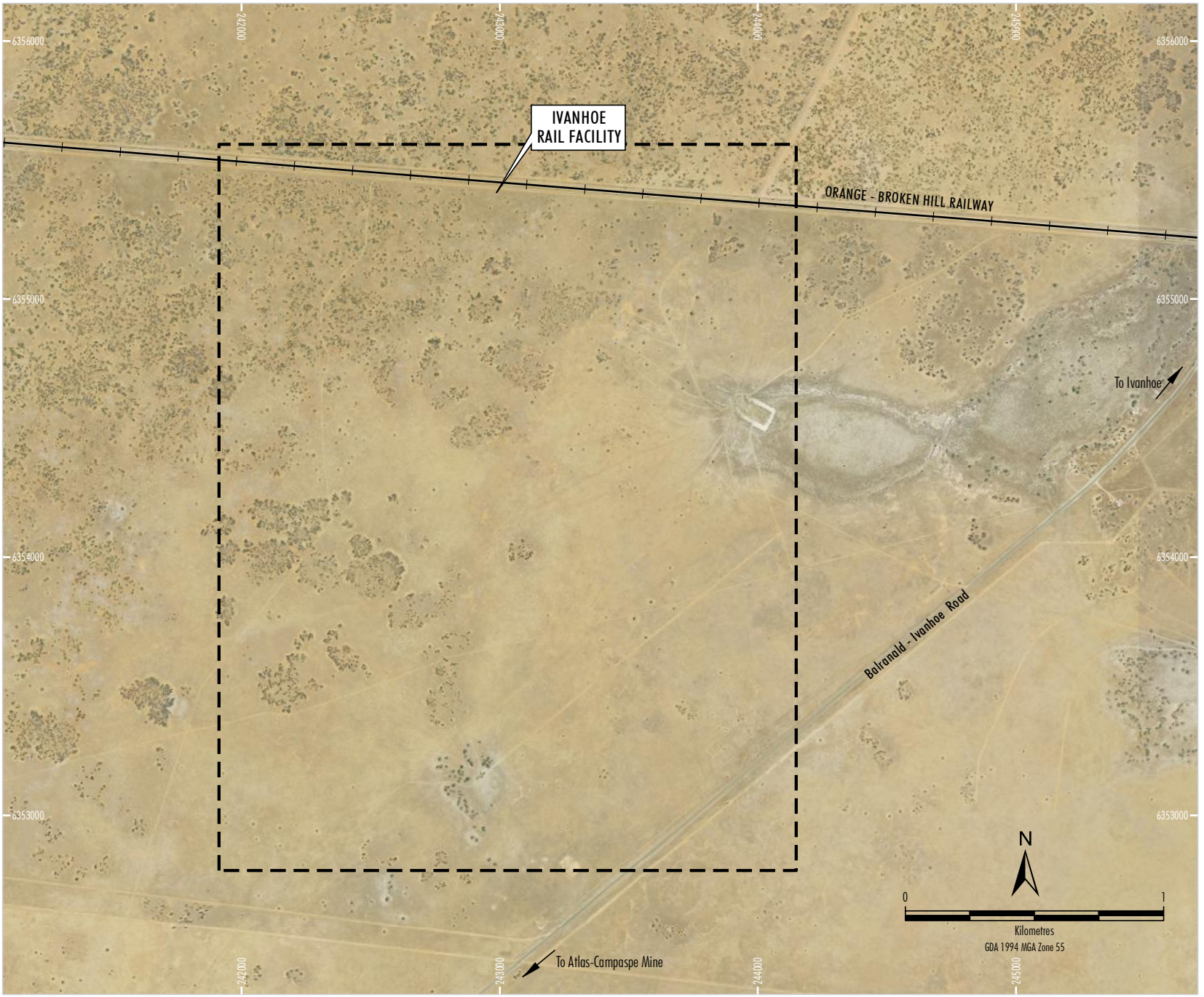
Source: NSW Department of Planning & Environment (2018); DPI-C&L (CLD) (2011) and Bemax (2012)

CRISTAL

ACMSP MODIFICATION

Regional Location

Figure 1



LEGEND
Indicative Location of Modification

Source: Bemax (2015, 2012)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

CRISTAL

OPTIMISATION MODIFICATION

Indicative Location of the Optimisation Modification

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

ENCLOSURE B
FIELD SURVEY ENGAGEMENT APPLICATION FORM

If you wish to be considered for paid participation in any field surveys, please address the following criteria which will be used to determine field survey engagement.

1. Are you a member of a Native Title group?

   ☐ Yes ☐ No

   If yes, please provide further details:

   _____

   _____

2. Are you a member of the following Local Aboriginal Land Council?

   ☐ Balranald

3. Do you have any specific cultural knowledge of the Modification area or of any Aboriginal place(s) or object(s) within it?

   ☐ Yes ☐ No

   If yes, please provide further details:

   _____

   _____

   _____

4. How many adult members does your Registered Aboriginal Party represent?

   _____

5. Please provide documented verification of your response to Question 4 (above) (e.g. please list all adult members).

   _____

   _____

   _____

7. How many years of experience does each of your proposed fieldworker(s) have in Aboriginal cultural heritage surveys? Please provide the corresponding name and projects previously involved in.

_____

_____

_____

_____

_____

8. Does your proposed fieldworker(s) have any specialist skills or knowledge which might assist in the investigation?

☐ Yes ☐ No

If yes, please specify:

_____

_____

_____

9. Is your proposed fieldworker(s) 'fit for duty', including the ability to survey rugged terrain, all day in various weather conditions?

☐ Yes ☐ No

(Please note that Cristal Mining may require a medical certificate if Cristal Mining considers that an individual may not be fit for work).

10. Are your proposed fieldworker(s) willing to undertake random Drug and Alcohol testing (including the provision of mouth swabs and urine samples) at their induction and/or at any time during the field survey?

☐ Yes ☐ No

11. Do you hold the following Certificates of Currency (if yes, please attach them to your application):

☐ Public Liability ☐ Workers Compensation

(Please note that registered groups will need to provide Certificates of Currency for both public liability and workers compensation. Registered individuals will only need to provide a Certificate of Currency for public liability).

Please provide any further details below that you think may be relevant to your selection to participate in the field surveys:

_____

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Responses must be received by 5.00 pm Wednesday 12 April 2019 via the contact details provided below. Please contact Cristal Mining via the contact details below if you require assistance completing this form.

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Ivanhoe Community Working Party
Andrew Rose and Fayne Johnson
PO Box 29
BOURKE NSW 2840

Via Email: fay.johnstone@det.nsw.edu.au and ivanhoe@mpra.com.au

Dear Andrew and Fayne,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe.

Proposed Methodology

Please find enclosed for your review, a copy of the Proposed Methodology for the Aboriginal Cultural Heritage Assessment for the Modification (Enclosure A).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (New South Wales [NSW] Department of Environment, Climate Change and Water, 2010) issued by the NSW Office of Environment and Heritage, we have provided the Proposed Methodology for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the Proposed Methodology.

If you wish to provide input on the following, please provide feedback to Cristal Mining (via the contact details provided at the end of this letter) by **5:00 pm Friday 3 May 2019**:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Modification area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

Cristal Mining Australia Limited
ABN 60 009 247 858
Gingko Mine via Nob Road Wentworth NSW 2648, Australia
PO Box 444, Broken Hill NSW 2880, Australia
T 61.3.5074.8900 F 61.3.5074.8999
www.cristalmining.com

All comments received will be taken into consideration as the Methodology is finalised.

Information Session

An information session with all Registered Aboriginal Parties, the consulting archaeologist and Cristal Mining representatives will be held on **Tuesday 30 April 2019** to discuss the Modification and the Proposed Methodology. The information session will be held at the Ivanhoe RSL (51 Columbus Street, Ivanhoe), and will commence at 3:00 pm and conclude at approximately 5:00 pm.

At the information session, Cristal Mining will provide a presentation on the nature and scale of the Modification, an overview of the impact assessment process and will discuss the roles, functions and responsibilities of participants and protocols for the management of any sensitive cultural heritage information.

The information session will also provide Registered Aboriginal Parties with an opportunity to raise any cultural issues or comments/perspectives regarding the Modification or the Proposed Methodology. Note that issues can also be raised at any point during the consultation process.

Light refreshments and drinks will be provided.

Cristal Mining will pay out of pocket travel expenses for Aboriginal representatives, from their home address to the meeting location and return (note that Cristal Mining will pay 75 cents per kilometre, up to a maximum of $300 per Registered Aboriginal Party). Registered Aboriginal Parties seeking to claim payment will need to provide proof of transport and sign a payment declaration form.

Cristal Mining will arrange for payment to be made via direct deposit after the meeting. Bank account details must be supplied to Cristal Mining (with confirmation of details from the bank and/or the Registered Aboriginal Party prior to payment). However, please note that Cristal Mining will not be paying for attendance at the information session.

Can you please indicate whether you are interested in attending the information session by **5:00 pm Friday 12 April 2019** via the contact details provided below.

Field Survey

As part of the Aboriginal Cultural Heritage Assessment for the Modification, Cristal Mining will be facilitating a field survey of the Modification area, to allow representatives of the Registered Aboriginal Parties to inspect the area and any Aboriginal heritage sites which may be located within or in immediate proximity to the area.

Regardless of participation in the surveys, all Registered Aboriginal Parties will be invited by Cristal Mining to attend a site inspection of the Modification area and a selection of the recorded sites following completion of the field surveys.

Please find enclosed the survey application form for completion and return by **5.00 pm Friday 12 April 2019**, for those Registered Aboriginal Parties who are seeking consideration for paid involvement in the field investigation associated with the Modification.

In order to be considered for paid involvement in the field surveys, Registered Aboriginal Parties will need to complete the attached Field Survey Application Form (Enclosure B) and provide it to Cristal Mining by the closing date.

Aboriginal representatives will be selected by Cristal Mining based upon the merits of the application with respect to the selection criteria, which are indicated by the questions in the application form. Applications will be assessed against all criteria including cultural knowledge of the Modification area, the representation of others within the community and experience in providing cultural heritage advice.

Where a response is not received by 5.00 pm Friday 12 April 2019, it will be assumed that you do not wish to seek consideration for paid involvement in the field investigation. Incomplete applications may not be accepted by Cristal Mining. Please note that Cristal Mining reserves the right to request any further information/clarification or supporting documentation from you in respect to your application.

Assistance in the completion of the application form can be provided to you upon request. Please use the contact details provided below.

The field survey is expected to take place on **Wednesday 1 May 2019** (i.e. the day following the Information Session). Further details will be provided to the successful applicants as soon as possible.

Contact Details

To provide any feedback with respect to the Proposed Methodology and/or to indicate your attendance at the information session, please contact Cristal Mining via the following contact details

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Badger Bates
107 Gaffney Lane
BROKEN HILL NSW 2880

Dear Badger,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe.

Proposed Methodology

Please find enclosed for your review, a copy of the Proposed Methodology for the Aboriginal Cultural Heritage Assessment for the Modification (Enclosure A).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (New South Wales [NSW] Department of Environment, Climate Change and Water, 2010) issued by the NSW Office of Environment and Heritage, we have provided the Proposed Methodology for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the Proposed Methodology.

If you wish to provide input on the following, please provide feedback to Cristal Mining (via the contact details provided at the end of this letter) by **5:00 pm Friday 3 May 2019**:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Modification area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

Cristal Mining Australia Limited
ABN 60 009 247 858
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www.cristalmining.com

All comments received will be taken into consideration as the Methodology is finalised.

Information Session

An information session with all Registered Aboriginal Parties, the consulting archaeologist and Cristal Mining representatives will be held on **Tuesday 30 April 2019** to discuss the Modification and the Proposed Methodology. The information session will be held at the Ivanhoe RSL (51 Columbus Street, Ivanhoe), and will commence at 3:00 pm and conclude at approximately 5:00 pm.

At the information session, Cristal Mining will provide a presentation on the nature and scale of the Modification, an overview of the impact assessment process and will discuss the roles, functions and responsibilities of participants and protocols for the management of any sensitive cultural heritage information.

The information session will also provide Registered Aboriginal Parties with an opportunity to raise any cultural issues or comments/perspectives regarding the Modification or the Proposed Methodology. Note that issues can also be raised at any point during the consultation process.

Light refreshments and drinks will be provided.

Cristal Mining will pay out of pocket travel expenses for Aboriginal representatives, from their home address to the meeting location and return (note that Cristal Mining will pay 75 cents per kilometre, up to a maximum of $300 per Registered Aboriginal Party). Registered Aboriginal Parties seeking to claim payment will need to provide proof of transport and sign a payment declaration form.

Cristal Mining will arrange for payment to be made via direct deposit after the meeting. Bank account details must be supplied to Cristal Mining (with confirmation of details from the bank and/or the Registered Aboriginal Party prior to payment). However, please note that Cristal Mining will not be paying for attendance at the information session.

Can you please indicate whether you are interested in attending the information session by **5:00 pm Friday 12 April 2019** via the contact details provided below.

Field Survey

As part of the Aboriginal Cultural Heritage Assessment for the Modification, Cristal Mining will be facilitating a field survey of the Modification area, to allow representatives of the Registered Aboriginal Parties to inspect the area and any Aboriginal heritage sites which may be located within or in immediate proximity to the area.

Regardless of participation in the surveys, all Registered Aboriginal Parties will be invited by Cristal Mining to attend a site inspection of the Modification area and a selection of the recorded sites following completion of the field surveys.

Please find enclosed the survey application form for completion and return by **5.00 pm Friday 12 April 2019**, for those Registered Aboriginal Parties who are seeking consideration for paid involvement in the field investigation associated with the Modification.

In order to be considered for paid involvement in the field surveys, Registered Aboriginal Parties will need to complete the attached Field Survey Application Form (Enclosure B) and provide it to Cristal Mining by the closing date.

Aboriginal representatives will be selected by Cristal Mining based upon the merits of the application with respect to the selection criteria, which are indicated by the questions in the application form. Applications will be assessed against all criteria including cultural knowledge of the Modification area, the representation of others within the community and experience in providing cultural heritage advice.

Where a response is not received by 5.00 pm Friday 12 April 2019, it will be assumed that you do not wish to seek consideration for paid involvement in the field investigation. Incomplete applications may not be accepted by Cristal Mining. Please note that Cristal Mining reserves the right to request any further information/clarification or supporting documentation from you in respect to your application.

Assistance in the completion of the application form can be provided to you upon request. Please use the contact details provided below.

The field survey is expected to take place on **Wednesday 1 May 2019** (i.e. the day following the Information Session). Further details will be provided to the successful applicants as soon as possible.

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Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Barkindji Elders Council
Arthur Kirby
c/- PO Box 87
EUSTON NSW 2737

Dear Arthur,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

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Proposed Methodology

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If you wish to provide input on the following, please provide feedback to Cristal Mining (via the contact details provided at the end of this letter) by **5:00 pm Friday 3 May 2019**:

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Light refreshments and drinks will be provided.

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Contact Details

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Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Michael (Mick) Kelly on behalf of Ngiyampaa people
Michael (Mick) Kelly
C/- Office of Enviornment and Heritage
PO Box 318
BURONGA NSW 2739

Via Email: mick.kelly@environment.nsw.gov.au

Dear Michael,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

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Cristal Mining Australia Limited
ABN 60 009 247 858
Gingko Mine via Nob Road Wentworth NSW 2648, Australia
PO Box 444, Broken Hill NSW 2880, Australia
T 61.3.5074.8900 F 61.3.5074.8999
www.cristalmining.com

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Cristal Mining Australia Limited
0427 419 273
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hnielssen@cristal.com

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Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

National Koorie Site Management
Ali Maher
3 Cuthbert Drive
MOUNT WARRIGAL NSW 2528

Via Email: ali.n.maher@hotmail.com

Dear Ali,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

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Environmental Manager
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0427 419 273
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Yours sincerely

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Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Kullila Site Consultants
Paul Charles
14 Werrang Road
PRIMBEE NSW 2502

Dear Paul,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

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Cristal Mining Australia Limited
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Yours sincerely

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ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Willandra Lakes 2 Traditional Tribal Groups Elders Council
C/- Warren Clarke
PO Box 318
BURONGA NSW 2739

Via Email: warren.clarke@environment.nsw.gov.au

Dear Warren,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

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Yours sincerely

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ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Muthi Muthi Nations Aboriginal Corporation
Bernadette Pappin
PO Box 210
BALRANALD NSW 2715

Via Email: bpappin@gwahs.health.nsw.gov.au

Dear Bernadette,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

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In order to be considered for paid involvement in the field surveys, Registered Aboriginal Parties will need to complete the attached Field Survey Application Form (Enclosure B) and provide it to Cristal Mining by the closing date.

Aboriginal representatives will be selected by Cristal Mining based upon the merits of the application with respect to the selection criteria, which are indicated by the questions in the application form. Applications will be assessed against all criteria including cultural knowledge of the Modification area, the representation of others within the community and experience in providing cultural heritage advice.

Where a response is not received by 5.00 pm Friday 12 April 2019, it will be assumed that you do not wish to seek consideration for paid involvement in the field investigation. Incomplete applications may not be accepted by Cristal Mining. Please note that Cristal Mining reserves the right to request any further information/clarification or supporting documentation from you in respect to your application.

Assistance in the completion of the application form can be provided to you upon request. Please use the contact details provided below.

The field survey is expected to take place on **Wednesday 1 May 2019** (i.e. the day following the Information Session). Further details will be provided to the successful applicants as soon as possible.

Contact Details

To provide any feedback with respect to the Proposed Methodology and/or to indicate your attendance at the information session, please contact Cristal Mining via the following contact details

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Wakool Indigenous Corporation
Cynthia and Garry Pappin
PO Box 243
BALRANALD NSW 2715

Via Email: Wakool.ic@gmail.com

Dear Cynthia and Garry,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe.

Proposed Methodology

Please find enclosed for your review, a copy of the Proposed Methodology for the Aboriginal Cultural Heritage Assessment for the Modification (Enclosure A).

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (New South Wales [NSW] Department of Environment, Climate Change and Water, 2010) issued by the NSW Office of Environment and Heritage, we have provided the Proposed Methodology for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the Proposed Methodology.

If you wish to provide input on the following, please provide feedback to Cristal Mining (via the contact details provided at the end of this letter) by **5:00 pm Friday 3 May 2019**:

- The nature of the Proposed Methodology.
- Any Aboriginal objects or places of cultural value within the Modification area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

Cristal Mining Australia Limited
ABN 60 009 247 858
Gingko Mine via Nob Road Wentworth NSW 2648, Australia
PO Box 444, Broken Hill NSW 2880, Australia
T 61.3.5074.8900 F 61.3.5074.8999
www.cristalmining.com

All comments received will be taken into consideration as the Methodology is finalised.

Information Session

An information session with all Registered Aboriginal Parties, the consulting archaeologist and Cristal Mining representatives will be held on **Tuesday 30 April 2019** to discuss the Modification and the Proposed Methodology. The information session will be held at the Ivanhoe RSL (51 Columbus Street, Ivanhoe), and will commence at 3:00 pm and conclude at approximately 5:00 pm.

At the information session, Cristal Mining will provide a presentation on the nature and scale of the Modification, an overview of the impact assessment process and will discuss the roles, functions and responsibilities of participants and protocols for the management of any sensitive cultural heritage information.

The information session will also provide Registered Aboriginal Parties with an opportunity to raise any cultural issues or comments/perspectives regarding the Modification or the Proposed Methodology. Note that issues can also be raised at any point during the consultation process.

Light refreshments and drinks will be provided.

Cristal Mining will pay out of pocket travel expenses for Aboriginal representatives, from their home address to the meeting location and return (note that Cristal Mining will pay 75 cents per kilometre, up to a maximum of $300 per Registered Aboriginal Party). Registered Aboriginal Parties seeking to claim payment will need to provide proof of transport and sign a payment declaration form.

Cristal Mining will arrange for payment to be made via direct deposit after the meeting. Bank account details must be supplied to Cristal Mining (with confirmation of details from the bank and/or the Registered Aboriginal Party prior to payment). However, please note that Cristal Mining will not be paying for attendance at the information session.

Can you please indicate whether you are interested in attending the information session by **5:00 pm Friday 12 April 2019** via the contact details provided below.

Field Survey

As part of the Aboriginal Cultural Heritage Assessment for the Modification, Cristal Mining will be facilitating a field survey of the Modification area, to allow representatives of the Registered Aboriginal Parties to inspect the area and any Aboriginal heritage sites which may be located within or in immediate proximity to the area.

Regardless of participation in the surveys, all Registered Aboriginal Parties will be invited by Cristal Mining to attend a site inspection of the Modification area and a selection of the recorded sites following completion of the field surveys.

Please find enclosed the survey application form for completion and return by **5.00 pm Friday 12 April 2019**, for those Registered Aboriginal Parties who are seeking consideration for paid involvement in the field investigation associated with the Modification.

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The field survey is expected to take place on **Wednesday 1 May 2019** (i.e. the day following the Information Session). Further details will be provided to the successful applicants as soon as possible.

Contact Details

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Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

PHONE: +61 3 5074 8900
WEBSITE: www.cristalmining.com
ABN 60 009 247 858

29 March 2019

Maria Maher

Via Email: g.m.maher@hotmail.com

Dear Maria,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION ABORIGINAL CULTURAL HERITAGE ASSESSMENT PROPOSED METHODOLOGY, INFORMATION SESSION AND FIELD SURVEY

Thank you or registering an interest in the Aboriginal consultation process for the Atlas-Campaspe Mineral Sands Project Optimisation Modification (the Modification). As you are aware, the Atlas-Campaspe Mineral Sands Project is being developed by Cristal Mining Australia Ltd (Cristal Mining), which is wholly owned by Cristal Australia Pty Ltd. Cristal Australia Pty Ltd is a wholly-owned subsidiary of The National Titanium Dioxide Company Limited.

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Gingko Mine via Nob Road Wentworth NSW 2648, Australia
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Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited
0427 419 273
PO Box 444, Broken Hill NSW 2880
hnielssen@cristal.com

Yours sincerely

Haakon Nielssen
Environmental Manager
Cristal Mining Australia Limited

ENCLOSURE A

PROPOSED METHODOLOGY FOR THE ABORIGINAL CULTURAL HERITAGE ASSESSMENT FOR THE MODIFICATION

ENCLOSURE B

FIELD SURVEY APPLICATION FORM

STAGE 4 CORRESPONDENCE

17 May 2019

Badger Bates

107 Gaffney Lane

BROKEN HILL NSW 2880

Dear Badger,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification).

Draft Aboriginal Cultural Heritage Assessment

Please find enclosed for your review, a copy of the draft Aboriginal Cultural Heritage Assessment (ACHA) for the Atlas-Campaspe Mineral Sands Project Optimisation Modification.

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010), we have provided the draft ACHA for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the draft ACHA.

If you wish to provide input on the following, please make a submission to Tronox by **5.00 pm Friday 21 June 2019** (via the contact details provided below):

- Identification of issues.
- Any aboriginal objects or places of cultural value within the investigation area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

All comments received will be taken into consideration as the draft ACHA is finalised.

Please submit any feedback regarding the draft ACHA to Tronox via the following contact details by 5.00 pm Friday 21 June 2019:

Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen

Manager Environment AUS-Murray Basin

Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Arthur Kirby
Barkindji Elders Council
c/- PO Box 87
EUSTON NSW 2737

Dear Arthur,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Damien Aidon
Balranald Local Aboriginal Land Council
PO Box 187
BALRANALD NSW 2715

Via email: ceo.blalc@gmail.com

Dear Damien,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Andrew Rose and Fay Johnson
Ivanhoe Community Working Party
PO Box 29
BOURKE NSW 2840

Via email: fay.johnstone@det.nsw.edu.au and ivanhoe@mpra.com.au

Dear Andrew and Fay,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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- Any other factors you consider to be relevant to the heritage assessment.

All comments received will be taken into consideration as the draft ACHA is finalised.

Please submit any feedback regarding the draft ACHA to Tronox via the following contact details by 5.00 pm Friday 21 June 2019:

Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Paul Charles
Kullila Site Consultants
14 Werrang Road
PRIMBEE NSW 2502

Dear Paul,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen

Manager Environment AUS-Murray Basin

Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Maria Maher

Via email: g.m.maher@hotmail.com

Dear Maria,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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Tronox Limited

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Michael (Mick) Kelly
Michael (Mick) Kelly on behalf of Ngiyampaa people
C/- Office of Enviornment and Heritage
PO Box 318
BURONGA NSW 2739

Via email: mick.kelly@environment.nsw.gov.au

Dear Michael,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification).

Draft Aboriginal Cultural Heritage Assessment

Please find enclosed for your review, a copy of the draft Aboriginal Cultural Heritage Assessment (ACHA) for the Atlas-Campaspe Mineral Sands Project Optimisation Modification.

In accordance with the *Aboriginal cultural heritage consultation requirements for proponents 2010* (NSW Department of Environment, Climate Change and Water, 2010), we have provided the draft ACHA for your review and feedback. Your feedback may include the identification of issues or areas of cultural significance that may be used to affect, inform or refine the draft ACHA.

If you wish to provide input on the following, please make a submission to Tronox by **5.00 pm Friday 21 June 2019** (via the contact details provided below):

- Identification of issues.
- Any aboriginal objects or places of cultural value within the investigation area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

All comments received will be taken into consideration as the draft ACHA is finalised.

Please submit any feedback regarding the draft ACHA to Tronox via the following contact details by 5.00 pm Friday 21 June 2019:

Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen

Manager Environment AUS-Murray Basin

Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Bernadette Pappin
Muthi Muthi Nations Aboriginal Corporation
PO Box 210
BALRANALD NSW 2715

Via email: bpappin@gwahs.health.nsw.gov.au

Dear Bernadette,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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If you wish to provide input on the following, please make a submission to Tronox by **5.00 pm Thursday 20 June 2019** (via the contact details provided below):

- Identification of issues.
- Any aboriginal objects or places of cultural value within the investigation area, or issues of cultural significance, that you are aware of.
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Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen

Manager Environment AUS-Murray Basin

Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Ali Maher
National Koorie Site Management
3 Cuthbert Drive
MOUNT WARRIGAL NSW 2528

Via email: ali.n.maher@hotmail.com

Dear Ali,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

Cynthia and Garry Pappin
Wakool Indigenous Corporation
PO Box 243
BALRANALD NSW 2715

Via email: Wakool.ic@gmail.com

Dear Cynthia and Garry,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Tronox Limited (Tronox). Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

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Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

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ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

17 May 2019

C/- Warren Clarke

Willandra Lakes 2 Traditional Tribal Groups Elders Council

PO Box 318

BURONGA NSW 2739

Via email: warren.clarke@environment.nsw.gov.au

Dear Warren

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

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Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen
Manager Environment AUS-Murray Basin
Tronox Limited

TRONOX

ATTACHMENT 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

20 May 2019

Fay Johnstone
Ivanhoe Community Working Party
PO Box 50
IVANHOE NSW 2878

Dear Auntie Fay,

RE: ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION - DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT (HARD COPY)

As requested in your correspondence dated 20 May 2019**,** please find enclosed for your review a hard copy of the draft Aboriginal Cultural Heritage Assessment (ACHA) for the Atlas-Campaspe Mineral Sands Project Optimisation Modification.

If you wish to provide input on the following, please make a submission to Tronox by **5.00 pm Friday 21 June 2019** (via the contact details provided below):

- Identification of issues.
- Any aboriginal objects or places of cultural value within the investigation area, or issues of cultural significance, that you are aware of.
- Any restrictions or protocols you may consider necessary in relation to any information of sensitivity that you may provide.
- Any other factors you consider to be relevant to the heritage assessment.

All comments received will be taken into consideration as the draft ACHA is finalised.

Please submit any feedback regarding the draft ACHA to Tronox via the following contact details by 5.00 pm Friday 21 June 2019:

Tronox
Haakon Nielssen
375-381 Benetook Ave, Mildura VIC 3500
Mobile: 0427 419 273
Email: haakon.nielssen@tronox.com

Yours sincerely,

Haakon Nielssen

Manager Environment AUS-Murray Basin

Tronox Limited

ENCLOSURE 1

ATLAS-CAMPASPE MINERAL SANDS PROJECT OPTIMISATION MODIFICATION – DRAFT ABORIGINAL CULTURAL HERITAGE ASSESSMENT

APPENDIX 4: CORRESPONDENCE FROM ABORIGINAL COMMUNITY STAKEHOLDERS

From: Fay Johnstone <>
Sent: Monday, 20 May 2019 8:39 AM
To: Haakon Nielssen <>
Subject: Re: Atlas-Campaspe Mineral Sands Project Optimisation Modification - Draft ACHA

Morning Haakon, Please send me a draft hard copy of the ACHA to PO Box 50 Ivanhoe 2878 Please.

Auntie Fay

Fay Johnstone
Aboriginal Education Officer
Ivanhoe Central School

From: Haakon Nielssen <>
Sent: Friday, 17 May 2019 3:59 PM
To: Fay Johnstone;
Subject: Atlas-Campaspe Mineral Sands Project Optimisation Modification - Draft ACHA

Dear Andrew and Aunty Fay,

Please see attached correspondence regarding the draft Aboriginal Cultural Heritage Assessment (ACHA) for the Atlas-Campaspe Mineral Sands Project Optimisation Modification. The draft ACHA can be downloaded at the following link: https://resourcestrategies.sharefile.com/d-sa718ed1fb1b47e08

Please advise if you would like a hardcopy of the draft ACHA provided to a postal address.

Please do not hesitate to contact me if you have any queries.

Regards,

Haakon Nielssen
Manager Environment
AUS-Murray Basin
www.tronox.com

TRONOX
A Brighter Future – From the Ground Up

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APPENDIX 5: AHIMS REGISTER SEARCH

AHIMS Web Services (AWS)
Search Result

Purchase Order/Reference : Ivanhoe

Client Service ID : 419820

LandSkape - Natural & Cultural Heritage Management

P O Box 246
Merbein Victoria 3505

Attention: Matt Cupper

Email: landskape@telstra.com

Date: 10 May 2019

Dear Sir or Madam:

AHIMS Web Service search for the following area at Datum :GDA, Zone : 55, Eastings : 208000 - 306000, Northings : 6310000 - 6390000 with a Buffer of 1000 meters, conducted by Matt Cupper on 10 May 2019.

The context area of your search is shown in the map below. Please note that the map does not accurately display the exact boundaries of the search as defined in the paragraph above. The map is to be used for general reference purposes only.

A search of the Office of the Environment and Heritage AHIMS Web Services (Aboriginal Heritage Information Management System) has shown that:

51	Aboriginal sites are recorded in or near the above location.
0	Aboriginal places have been declared in or near the above location. *

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Ivanhoe

Client Service ID : 419820

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
41-2-0014	Mossgiel 1	GDA	55	279145	6317372	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
41-2-0015	Mossgiel 2	GDA	55	279143	6317316	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
41-2-0016	Mossgiel 3	GDA	55	279168	6317276	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
33-4-0001	Ivanhoe Rd 1	GDA	55	259518	6346939	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
33-4-0002	Ivanhoe Rd 2	GDA	55	259537	6347003	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
33-4-0003	Ivanhoe Rd 3	GDA	55	259433	6347200	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly					**Permits**		
41-2-0023	Wilderness Area 7	GDA	55	302580	6319111	Open site	Valid	Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly,Mr.Mark Brettschneider					**Permits**		
41-2-0024	Wilderness Area 8	GDA	55	304511	6319640	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly,Mr.Mark Brettschneider					**Permits**		
41-2-0025	Wilderness Area 9	GDA	55	303002	6321721	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly,Mr.Mark Brettschneider					**Permits**		
41-2-0026	Wilderness Area 10	GDA	55	302615	6322348	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly,Mr.Mark Brettschneider					**Permits**		
41-2-0027	Wilderness Area 11	GDA	55	302649	6322765	Open site	Valid	Artefact : -, Hearth : -		
	Contact Searle	**Recorders**	Mr.Michael Kelly,Mr.Mark Brettschneider					**Permits**		
41-1-0241	WNP IF1	GDA	55	239828	6329745	Open site	Valid	Artefact : -		
	Contact Searle	**Recorders**	OzArk Environmental and Heritage Management					**Permits**		
41-1-0242	GOS IF1	GDA	55	231498	6324113	Open site	Valid	Artefact : -		
	Contact Searle	**Recorders**	OzArk Environmental and Heritage Management					**Permits**		
41-1-0243	GOS OS1	GDA	55	229927	6322281	Open site	Valid	Artefact : -		
	Contact Searle	**Recorders**	OzArk Environmental and Heritage Management					**Permits**		
41-1-0001	Mossgiel;	AGD	55	257848	6317309	Open site	Valid	Burial : -	Burial/s	
	Contact	**Recorders**	ASRSYS					**Permits**		
41-2-0002	Mossgiel;	AGD	55	272477	6317449	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	ASRSYS					**Permits**		
41-2-0003	Mossgiel Tank;	AGD	55	272442	6321106	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	ASRSYS					**Permits**		

Report generated by AHIMS Web Service on 10/05/2019 for Matt Cupper for the following area at Datum :GDA, Zone : 55, Eastings : 208000 - 306000, Northings : 6310000 - 6390000 with a Buffer of 1000 meters. Additional Info : Identify Aboriginal objects in study area. Number of Aboriginal sites and Aboriginal objects found is 51

This information is not guaranteed to be free from error omission. Office of Environment and Heritage (NSW) and its employees disclaim liability for any act done or omission made on the information and consequences of such acts or omission.

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
41-2-0004	Holey Box Well;	AGD	55	265885	6337505	Open site	Valid	Artefact : -	Open Camp Site	605
	Contact	**Recorders**	ASRSYS					**Permits**		
41-2-0005	Contour 100;	AGD	55	302752	6322254	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	Mr.M Harris					**Permits**		
41-2-0006	Wilderness Rabbits;	AGD	55	302645	6322510	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	Mr.M Harris					**Permits**		
41-2-0007	Warringah Tree;	AGD	55	303002	6318880	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	
	Contact	**Recorders**	Mr.M Harris					**Permits**		
41-2-0010	Wilderness 3	AGD	55	303288	6320829	Open site	Valid	Hearth : 1, Artefact : -		
	Contact T Russell	**Recorders**	Mr.Pat Faulkner					**Permits**		
41-2-0012	Wirringa 1	AGD	55	300680	6320690	Open site	Valid	Artefact : 6, Hearth : 1		
	Contact T Russell	**Recorders**	Mr.Pat Faulkner					**Permits**		
41-2-0013	Wirringa 2	AGD	55	302040	6320220	Open site	Valid	Hearth : -, Artefact : -		
	Contact T Russell	**Recorders**	Mr.Pat Faulkner					**Permits**		
33-4-0005	Ivanhoe RLF6	GDA	55	245522	6355587	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Mr.Jamie Reeves					**Permits**		
33-4-0006	Ivanhoe RLF7	GDA	55	243707	6353654	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0007	Ivanhoe RLF 8	GDA	55	243668	6353753	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0008	Ivanhoe RLF 9	GDA	55	243586	6354064	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0009	Ivanhoe RLF 10	GDA	55	243398	6354485	Open site	Valid	Art (Pigment or Engraved) : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0010	Ivanhoe RLF 11	GDA	55	243462	6354855	Open site	Valid	Artefact : 1, Hearth : 1, Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0011	Ivanhoe RLF 12	GDA	55	243290	6354506	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		

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AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Ivanhoe

Client Service ID : 419820

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
33-4-0012	Ivanhoe RLF 13	GDA	55	243215	6354362	Open site	Valid	Artefact : 1, Hearth : 1, Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0013	Ivanhoe RLF 14	GDA	55	243319	6354068	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0014	Ivanhoe RLF 15	GDA	55	243326	6353952	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0015	Ivanhoe RLF 16	GDA	55	243487	6353679	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0016	Ivanhoe RLF 17	GDA	55	243337	6355144	Open site	Valid	Artefact : 1, Hearth : 1, Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0017	Ivanhoe RLF 18	GDA	55	243006	6355048	Open site	Valid	Artefact : 1, Hearth : 1, Potential Archaeological Deposit (PAD) : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0018	Ivanhoe RLF 19	GDA	55	243426	6355275	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0019	Ivanhoe RLF 20	GDA	55	243372	6354954	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0020	Ivanhoe RLF 21	GDA	55	243345	6354857	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0021	Ivanhoe RLF 22	GDA	55	243283	6354883	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0022	Ivanhoe RLF 23	GDA	55	243119	6354817	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0023	Ivanhoe RLF 24	GDA	55	243157	6354953	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0024	Ivanhoe RLF 25	GDA	55	243567	6355036	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
33-4-0025	Ivanhoe RLF 26	GDA	55	243736	6355069	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		

Report generated by AHIMS Web Service on 10/05/2019 for Matt Cupper for the following area at Datum :GDA, Zone : 55, Eastings : 208000 - 306000, Northings : 6310000 - 6390000 with a Buffer of 1000 meters. Additional Info : Identify Aboriginal objects in study area. Number of Aboriginal sites and Aboriginal objects found is 51

This information is not guaranteed to be free from error omission. Office of Environment and Heritage (NSW) and its employees disclaim liability for any act done or omission made on the information and consequences of such acts or omission.

AHIMS Web Services (AWS)

Extensive search - Site list report

Your Ref/PO Number : Ivanhoe

Client Service ID : 419820

SiteID	SiteName	Datum	Zone	Easting	Northing	Context	Site Status	SiteFeatures	SiteTypes	Reports
33-4-0026	Ivanhoe RLF 27	GDA	55	243836	6355094	Open site	Valid	Artefact : 1		
	Contact	**Recorders**	Niche Environment and Heritage,Ms.Clare Anderson					**Permits**		
41-3-0022	Pebble Mound	AGD	55	304588	6319583	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	Mr.M Harris					**Permits**		
33-5-0002	Canoble;Blake's Waterhole;	AGD	55	286740	6355992	Open site	Valid	Ceremonial Ring (Stone or Earth) : -, Modified Tree (Carved or Scarred) : -	Bora/Ceremonial,Carved Tree	
	Contact	**Recorders**	David Bell					**Permits**		
33-5-0004	Kajuligah 2;	AGD	55	276300	6383400	Open site	Valid	Modified Tree (Carved or Scarred) : -	Scarred Tree	
	Contact	**Recorders**	J Brickhill					**Permits**		
33-5-0005	Kajuligah_1;	AGD	55	276100	6383900	Open site	Valid	Artefact : -	Open Camp Site	
	Contact	**Recorders**	J Brickhill					**Permits**		
41-1-0244	94MStru37/38	GDA	55	221944	6315505	Open site	Valid	Artefact : -		
	Contact	**Recorders**	Mrs.Angela Besant,Insite Heritage Pty Ltd					**Permits**		

Report generated by AHIMS Web Service on 10/05/2019 for Matt Cupper for the following area at Datum :GDA, Zone : 55, Eastings : 208000 - 306000, Northings : 6310000 - 6390000 with a Buffer of 1000 meters. Additional Info : Identify Aboriginal objects in study area. Number of Aboriginal sites and Aboriginal objects found is 51

This information is not guaranteed to be free from error omission. Office of Environment and Heritage (NSW) and its employees disclaim liability for any act done or omission made on the information and consequences of such acts or omission.

APPENDIX 6: AHIMS SITE CARDS

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

AHIMS site ID: 33-4-0031 **Date recorded:** 10-06-2019

Site Location Information

Site name: Ivanhoe Rail Load Facility 29 (RLF29)

Easting: 242862 **Northing:** 6355330 **Coordinates must be in GDA (MGA)**

Horizontal Accuracy (m): 5

Zone: 55 **Location method:** Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Dr.	Cupper	Matt

Organisation: Landskape

Address: 178 Midgen Flat Road Broken Head 2481

Phone: 0408006690 **E-mail:** landskape@telstra.com

Site Context Information

Land Form Pattern: Undulating Plain **Land Use:** Farming Low Intensity

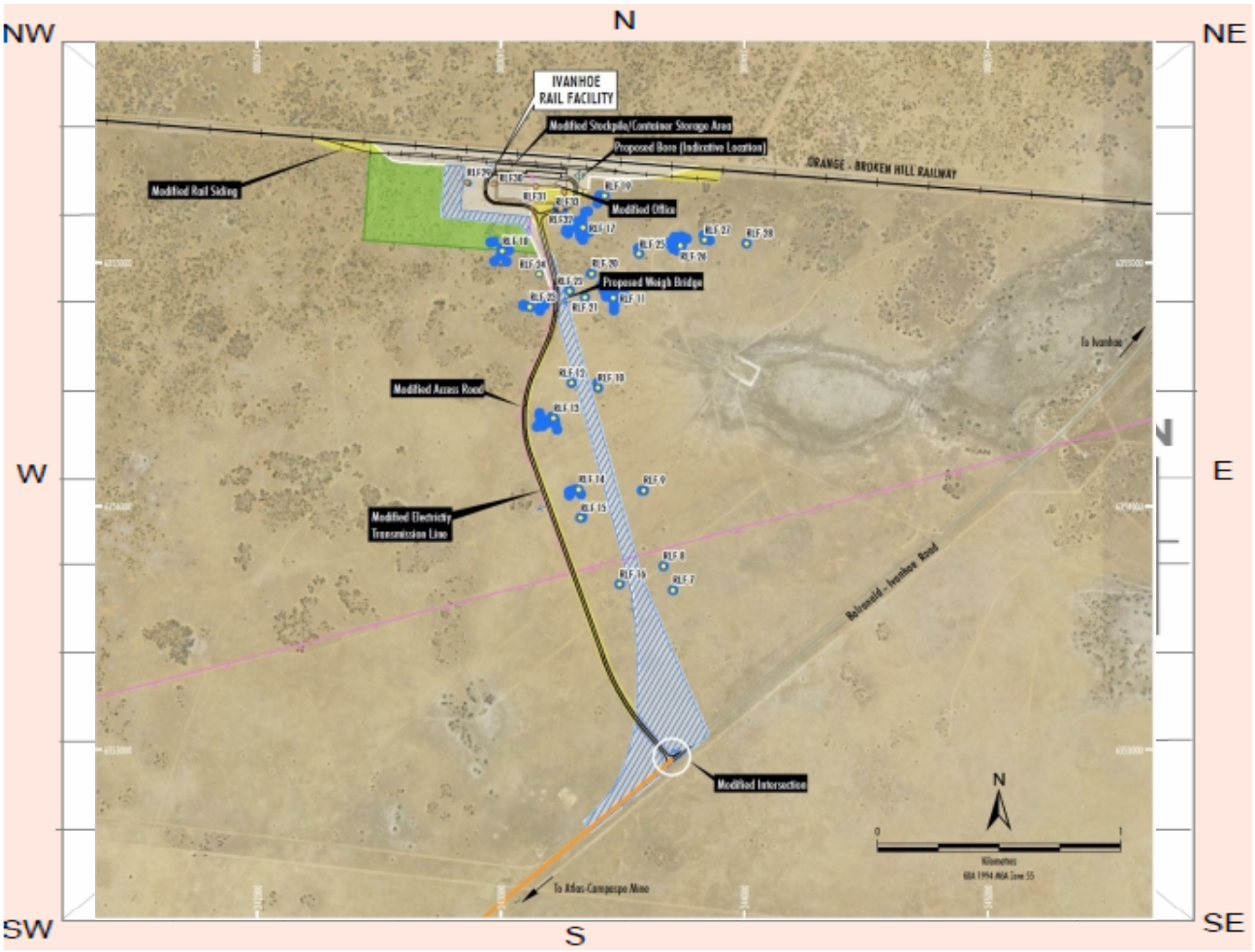
Land Form Unit: Plain **Vegetation:** Isolated clumps of trees

Distance to Water (m): 2000 **Primary Report:** Cupper, M. (2019). Altas Campaspe Heritage Assessment.

How to get to the site: Site is located approximately 1 km north of Balranald Road and west of railway line.

Other site information:

Site location map



Site contents information

open/closed site: Open

Site condition: Erosion

Features:

		Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1.	Artefact	3	5	5				

Description:

2 silcrete angular fragments, 1 silcrete flake.

Features:

		Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.								

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
4.							

Description:

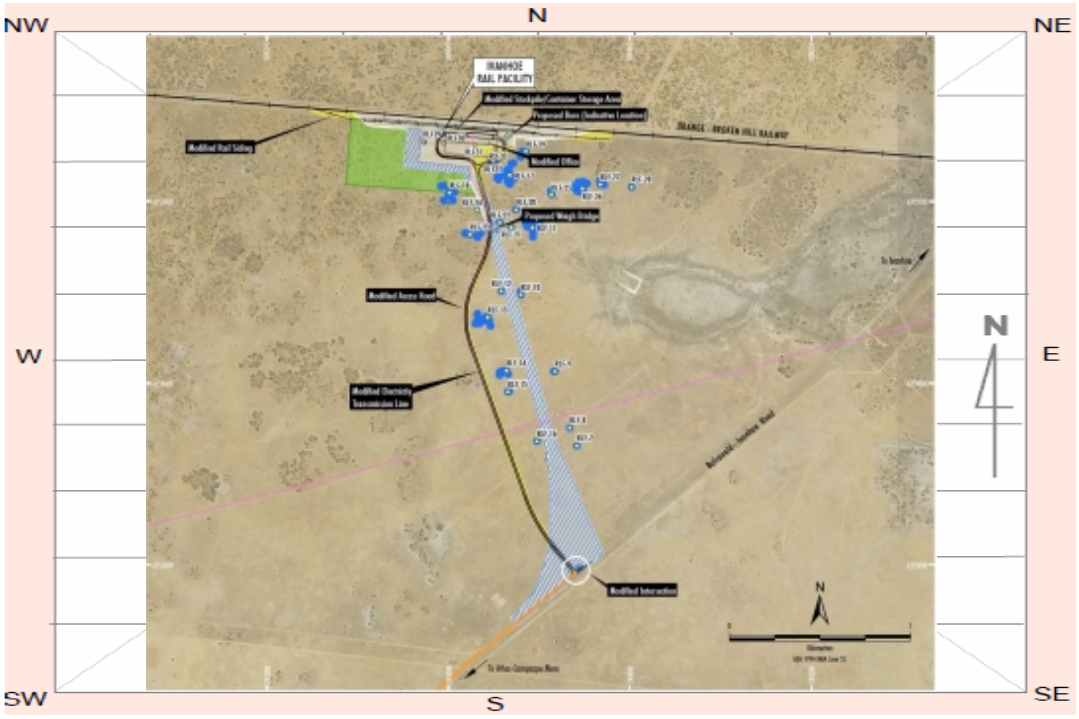
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
5.							

Description:

Other Site Info:

Site plan



Site photographs

Description: RLF29

Description:

Description:

Description:

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

Title **Surname** **First name**

Organisation:

Address:

Phone: **E-mail:**

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

AHIMS site ID: 33-4-0030 **Date recorded:** 10-06-2019

Site Location Information

Site name: Ivanhoe Rail Load Facility 30 (RLF30)

Easting: 242971 **Northing:** 6355324 **Coordinates must be in GDA (MGA)**

Horizontal Accuracy (m): 5

Zone: 55 **Location method:** Non-Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Dr.	Cupper	Matt

Organisation: Landskape

Address: 178 Midgen Flat Road Broken Head 2481

Phone: 0408006690 **E-mail:** landskape@telstra.com

Site Context Information

Land Form Pattern: Undulating Plain **Land Use:** Farming Low Intensity

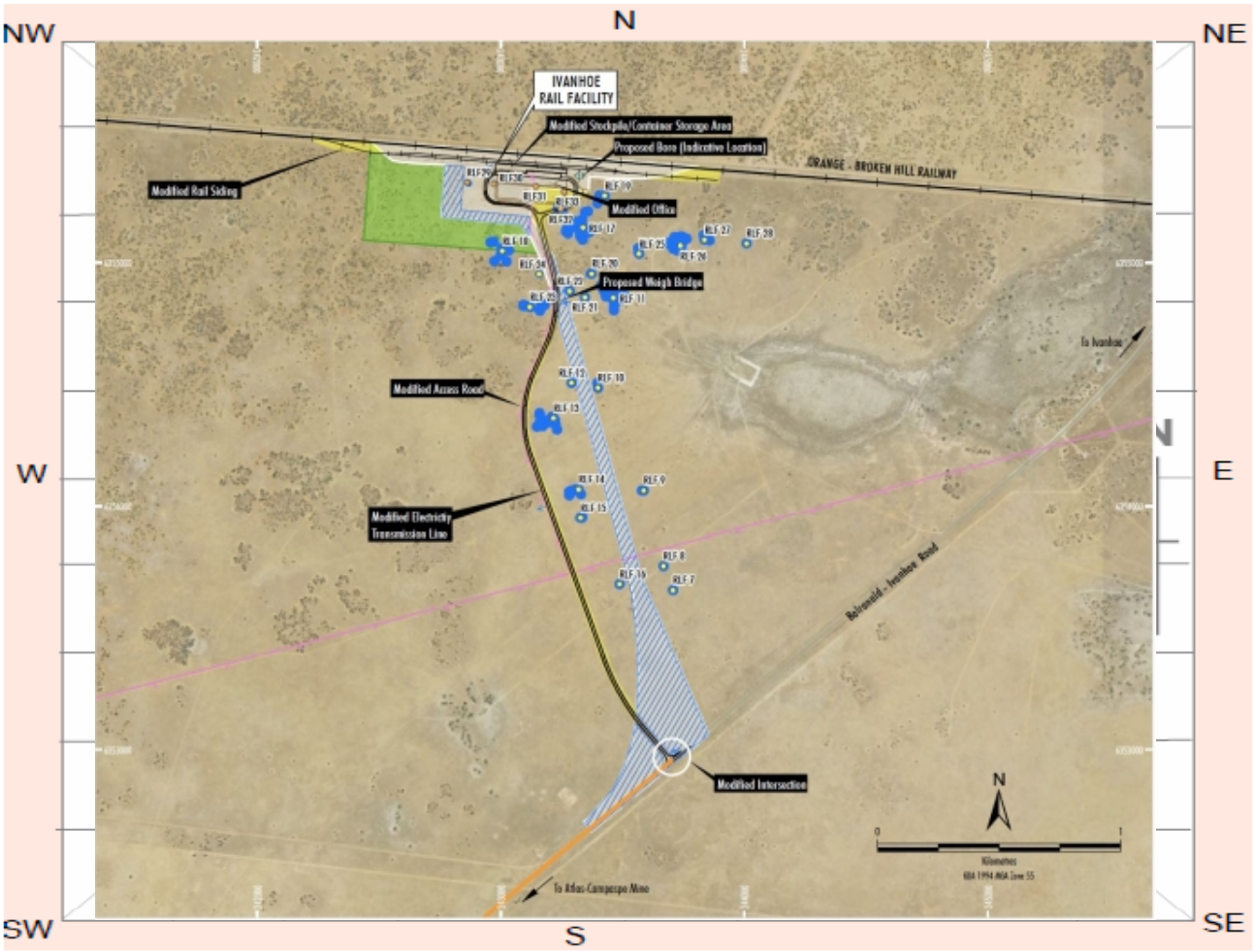
Land Form Unit: Plain **Vegetation:** Isolated clumps of trees

Distance to Water (m): 2000 **Primary Report:** Cupper, M. (2019). Altas Campaspe Heritage Assessment.

How to get to the site: Site is located approximately 1 km north of Balranald Road and west of railway line.

Other site information:

Site location map



Site contents information

open/closed site: Open

Site condition: Erosion

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1. Artefact	1	1	1				

Description:

1 silcrete flake.

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
4.							

Description:

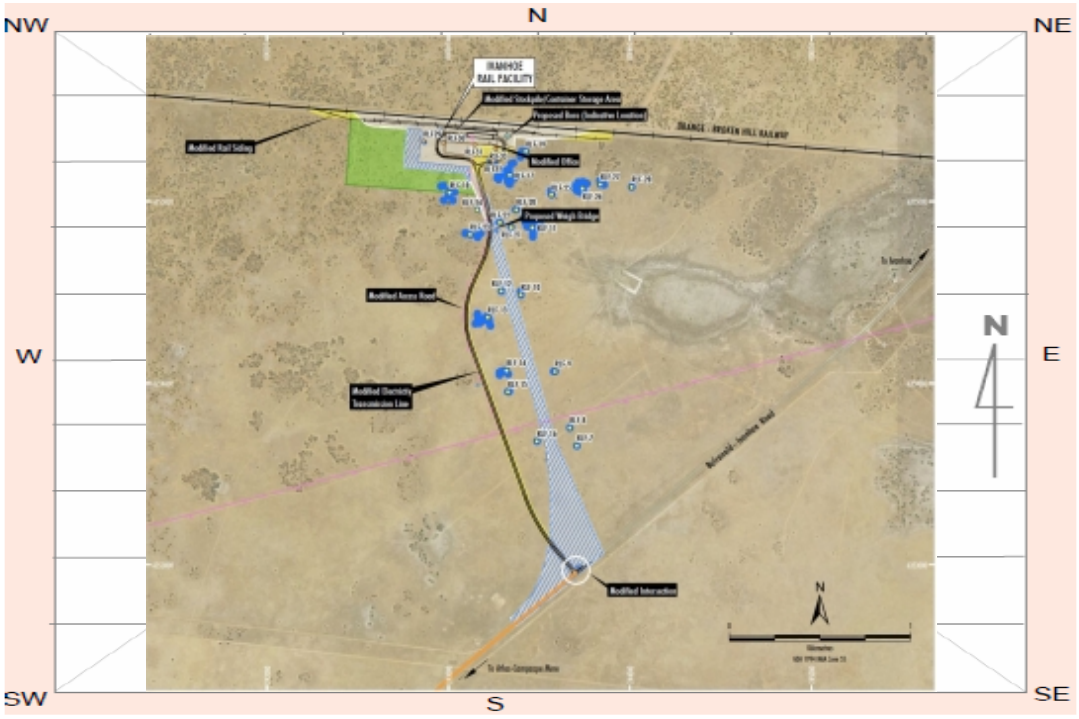
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
5.							

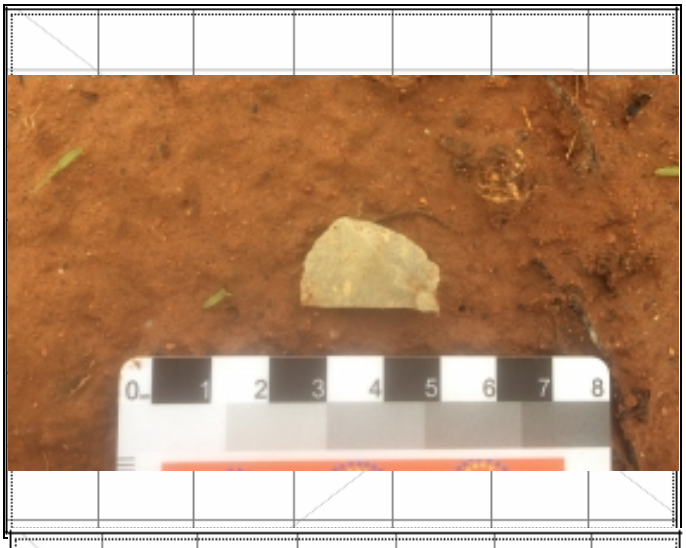
Description:

Other Site Info:

Site plan



Site photographs



Description: RLF30

Description:

Description:

Description:

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

Title **Surname** **First name**

Organisation:

Address:

Phone: **E-mail:**

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

AHIMS site ID: 33-4-0029 **Date recorded:** 10-06-2019

Site Location Information

Site name: Ivanhoe Rail Load Facility 31 (RLF31)

Easting: 243143 **Northing:** 6355314 **Coordinates must be in GDA (MGA)**

Horizontal Accuracy (m): 5

Zone: 55 **Location method:** Non-Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Dr.	Cupper	Matt

Organisation: Landskape

Address: 178 Midgen Flat Road Broken Head 2481

Phone: 0408006690 **E-mail:** landskape@telstra.com

Site Context Information

Land Form Pattern: Undulating Plain **Land Use:** Farming Low Intensity

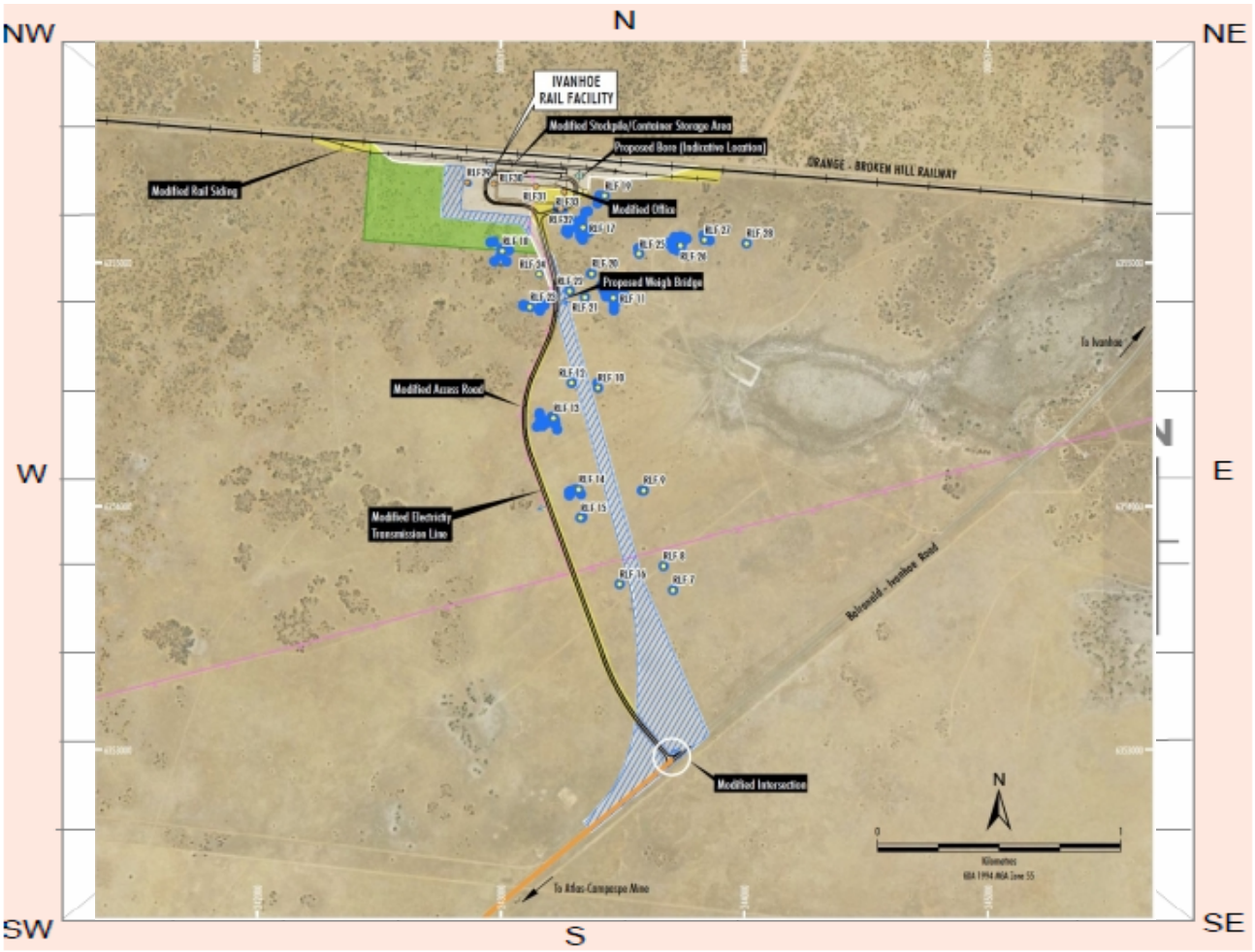
Land Form Unit: Plain **Vegetation:** Isolated clumps of trees

Distance to Water (m): 2000 **Primary Report:** Cupper, M. (2019). Altas Campaspe Heritage Assessment.

How to get to the site: Site is located approximately 1 km north of Balranald Road and west of railway line.

Other site information:

Site location map



Site contents information

open/closed site: Open

Site condition: Erosion

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1. Artefact	1	1	1				

Description:

1 silcrete angular fragment.

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
4.							

Description:

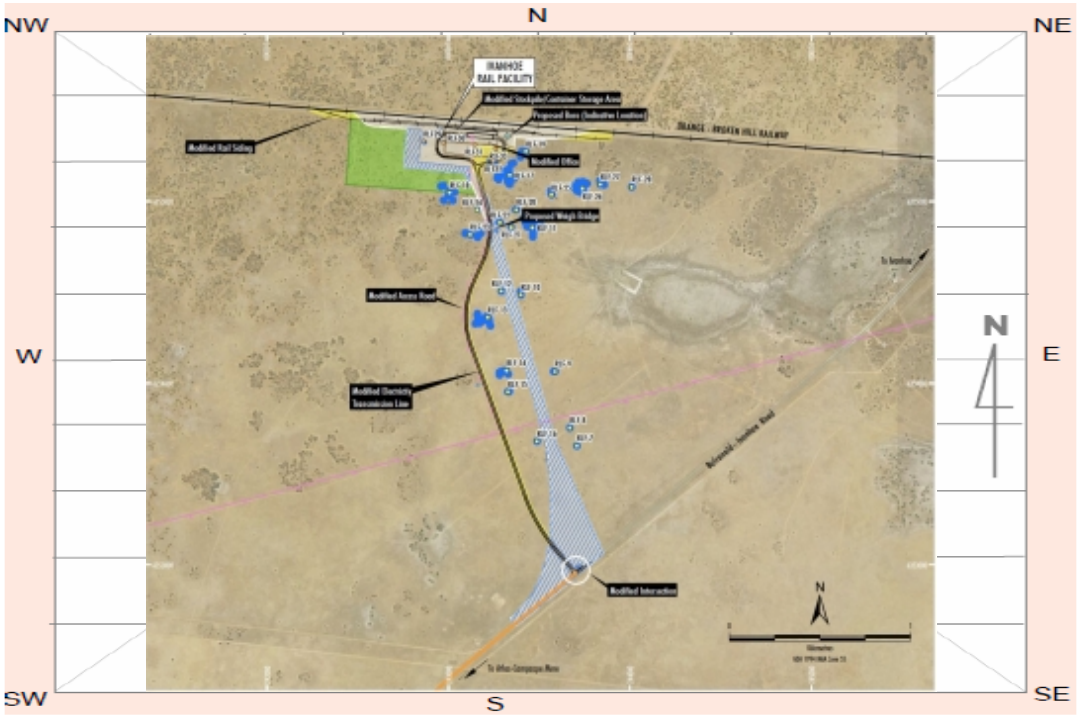
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
5.							

Description:

Other Site Info:

Site plan



Site photographs

Description: RLF31

Description:

Description:

Description:

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

Title **Surname** **First name**

Organisation:

Address:

Phone: **E-mail:**

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

AHIMS site ID: 33-4-0028 **Date recorded:** 10-06-2019

Site Location Information

Site name: Ivanhoe Rail Load Facility 32 (RLF32)

Easting: 243246 **Northing:** 6355220 **Coordinates must be in GDA (MGA)**

Horizontal Accuracy (m): 5

Zone: 55 **Location method:** Non-Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Dr.	Cupper	Matt

Organisation: Landskape

Address: 178 Midgen Flat Road Broken Head 2481

Phone: 0408006690 **E-mail:** landskape@telstra.com

Site Context Information

Land Form Pattern: Undulating Plain **Land Use:** Farming Low Intensity

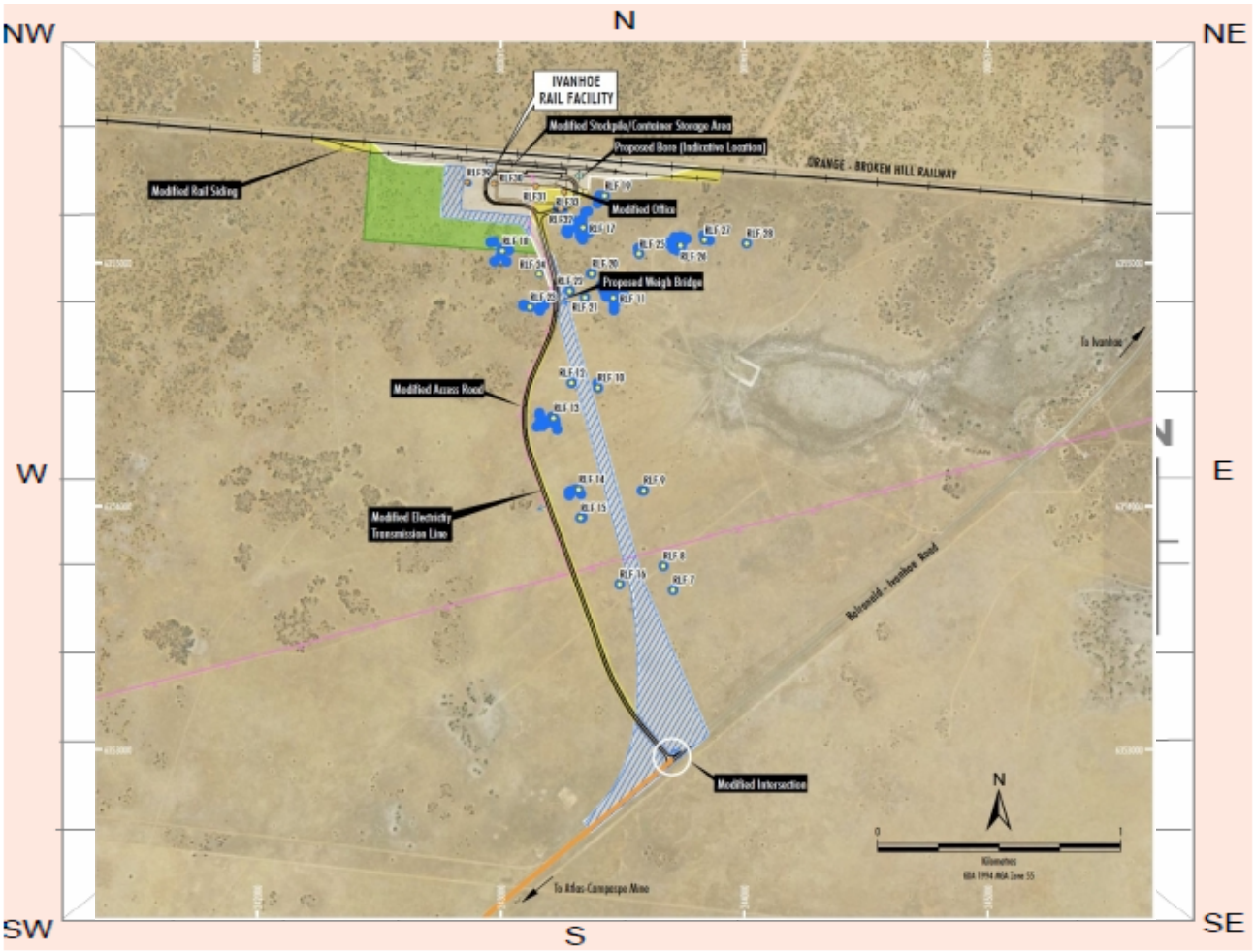
Land Form Unit: Plain **Vegetation:** Isolated clumps of trees

Distance to Water (m): 2000 **Primary Report:** Cupper, M. (2019). Altas Campaspe Heritage Assessment.

How to get to the site: Site is located approximately 1 km north of Balranald Road and west of railway line.

Other site information:

Site location map



Site contents information

open/closed site: Open

Site condition: Erosion

Features:

		Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1.	Artefact	3	10	10				

Description:

3 silcrete angular fragments.

Features:

		Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.								

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
4.							

Description:

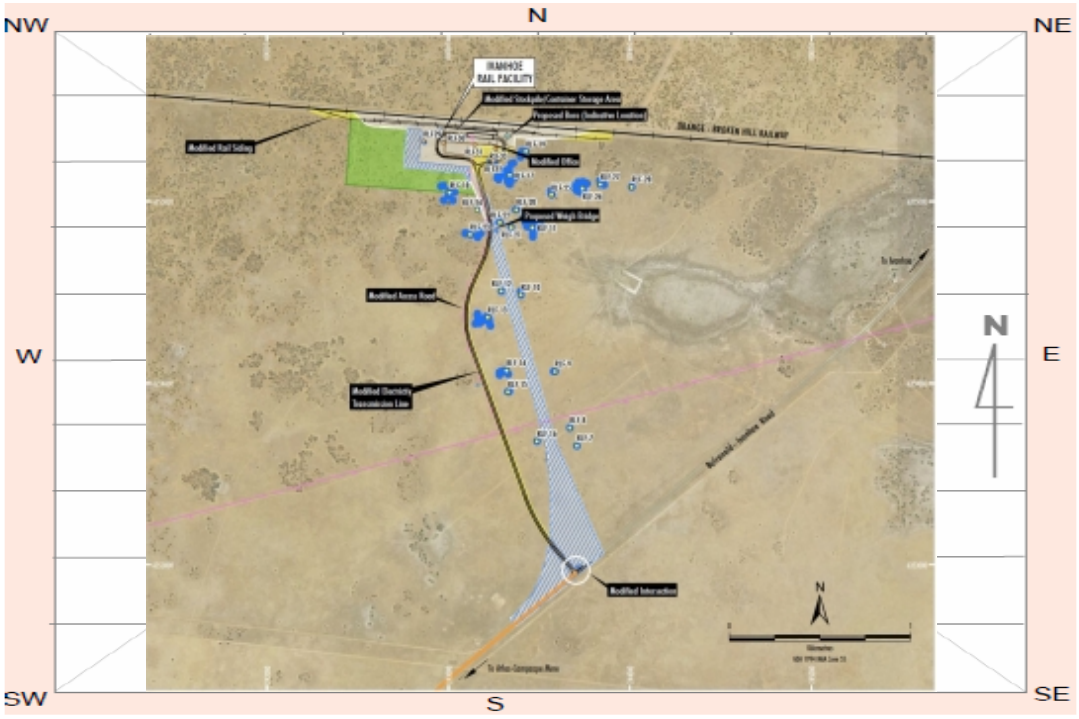
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
5.							

Description:

Other Site Info:

Site plan



Site photographs

Description: RLF32

Description:

Description:

Description:

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

Title **Surname** **First name**

Organisation:

Address:

Phone: **E-mail:**

Aboriginal Site Recording Form

AHIMS Registrar
PO Box 1967, Hurstville 2220 NSW

AHIMS site ID: 33-4-0027 **Date recorded:** 10-06-2019

Site Location Information

Site name: Ivanhoe Rail Load Facility 33 (RLF33)

Easting: 243260 **Northing:** 6355292 **Coordinates must be in GDA (MGA)**

Horizontal Accuracy (m): 5

Zone: 55 **Location method:** Non-Differential GPS

Recorder Information

(The person responsible for the completion and submission of this form)

Title	Surname	First name
Dr.	Cupper	Matt

Organisation: Landskape

Address: 178 Midgen Flat Road Broken Head 2481

Phone: 0408006690 **E-mail:** landskape@telstra.com

Site Context Information

Land Form Pattern: Undulating Plain **Land Use:** Farming Low Intensity

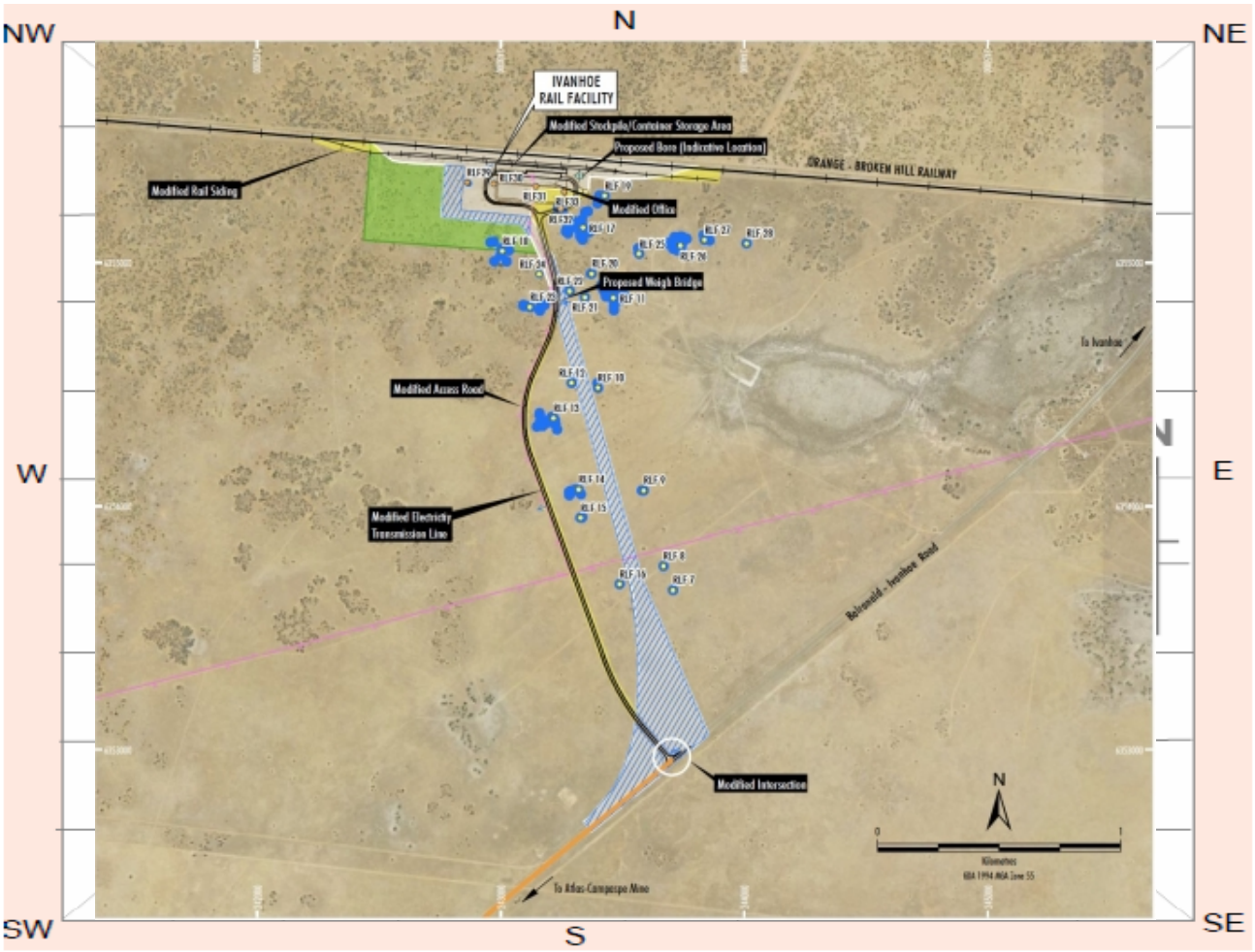
Land Form Unit: Plain **Vegetation:** Isolated clumps of trees

Distance to Water (m): 2000 **Primary Report:** Cupper, M. (2019). Altas Campaspe Heritage Assessment.

How to get to the site: Site is located approximately 1 km north of Balranald Road and west of railway line.

Other site information:

Site location map



Site contents information

open/closed site: Open

Site condition: Erosion

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
1. Artefact	1	1	1				

Description:

1 silcrete angular fragment.

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
2.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
3.							

Description:

Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
4.							

Description:

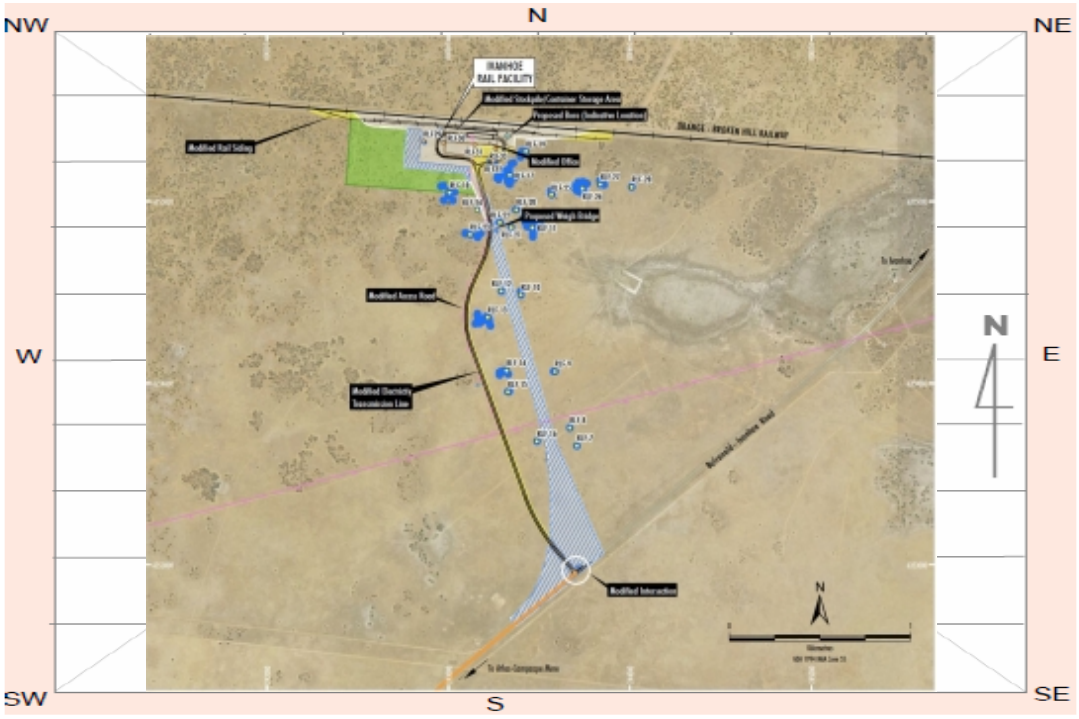
Features:

	Number of features	Length of feature(s) extent (m)	Width of feature (s) extent (m)	Scarred Trees: Scar Depth (cm)	Scarred Trees: Regrowth (cm)	Scarred Trees: Scar shape	Scarred Trees: Tree Species
5.							

Description:

Other Site Info:

Site plan



Site photographs

Description: RLF33

Description:

Description:

Description:

Site restrictions

Do you want to Restrict this site?:

Restriction type: Gender General Location

Why is this site restricted?:

Further information contact

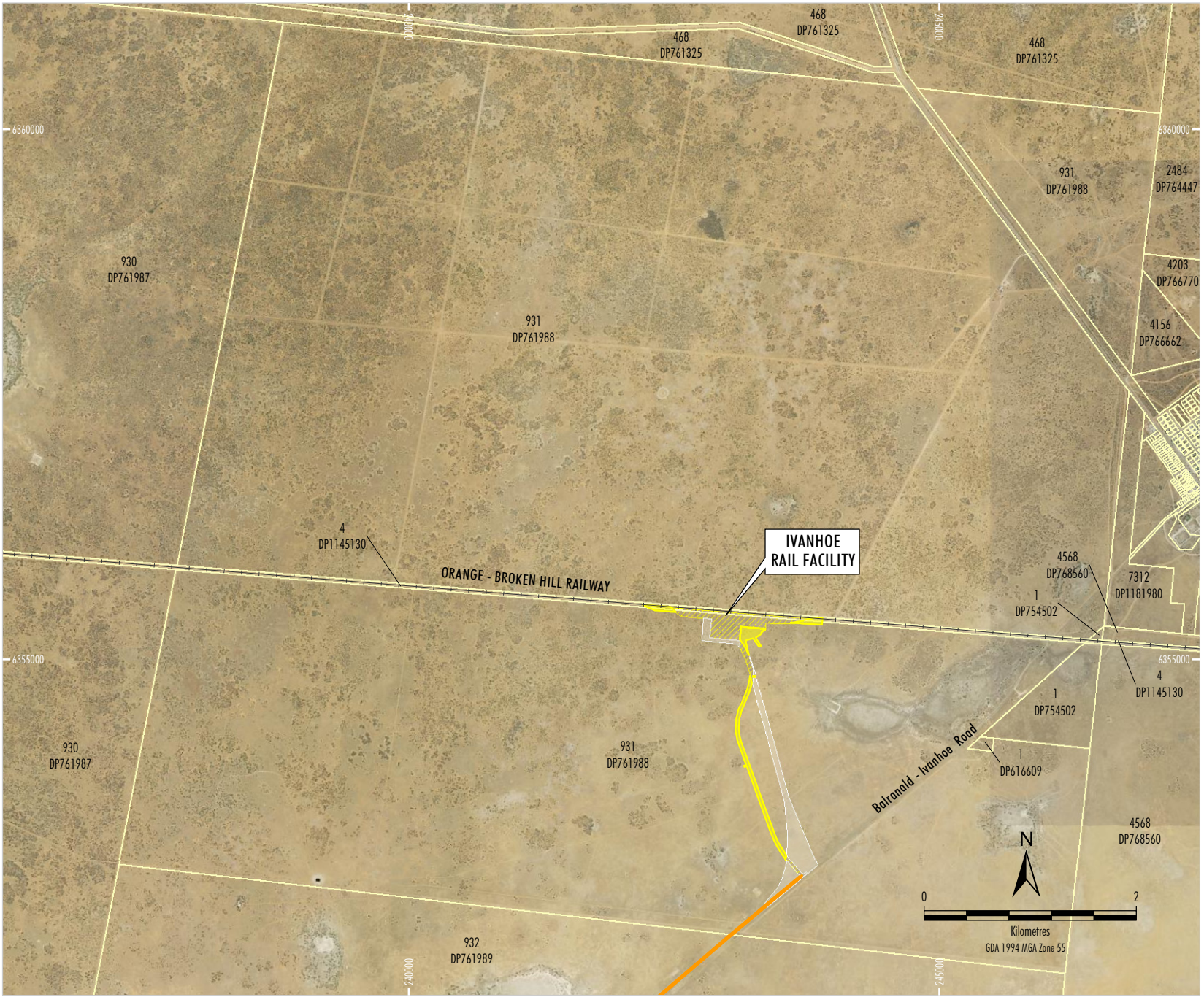
Title **Surname** **First name**

Organisation:

Address:

Phone: **E-mail:**

APPENDIX 7: CADASTRE INFORMATION


LEGEND
Approved Surface Development Area Required
Additional Surface Development Area
Approved Surface Development Area not Required
Approved Mineral Concentrate Transport Route*
* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines
Source: Cristal Mining Australia (2012); Tronox (2019) and Landskape (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)
IVANHOE RAIL FACILITY
ORANGE - BROKEN HILL RAILWAY
Balranald - Ivanhoe Road
468 DP761325
930 DP761987
931 DP761988
932 DP761989
4 DP1145130
1 DP754502
1 DP616609
4568 DP768560
7312 DP1181980
2484 DP764447
4203 DP766770
4156 DP766662
6360000
6355000
240000
245000
N
0
2
Kilometres
GDA 1994 MGA Zone 55
TRONOX
OPTIMISATION MODIFICATION
Cadastral Information
Figure A7-1

APPENDIX F

GROUNDWATER REVIEW

ATLAS-CAMPASPE MINERAL SANDS PROJECT

OPTIMISATION MODIFICATION

APPENDIX F

GROUNDWATER REVIEW

TRONOX

TRONOX MINING AUSTRALIA LIMITED

ATLAS-CAMPASPE MINERAL SANDS PROJECT
OPTIMISATION MODIFICATION

GROUNDWATER REVIEW

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Attachment B AQTESOLV Predictive Analyses

1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) is being developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019. Development Consent (SSD_5012) for the Project was issued under the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW and 270 km south-east of Broken Hill, NSW (Figure 1). The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km to the south-west of the township of Ivanhoe (Figure 1).

Product (mineral concentrates) generated as a result of operations at the Atlas-Campaspe Mine will be trucked to the Ivanhoe Rail Facility for transfer to train wagons, which will then be railed to the existing Broken Hill Mineral Separation Plant (the MSP) (Figure 1).

The Project will integrate with currently existing/approved Tronox operations in western NSW, including (Figure 1):

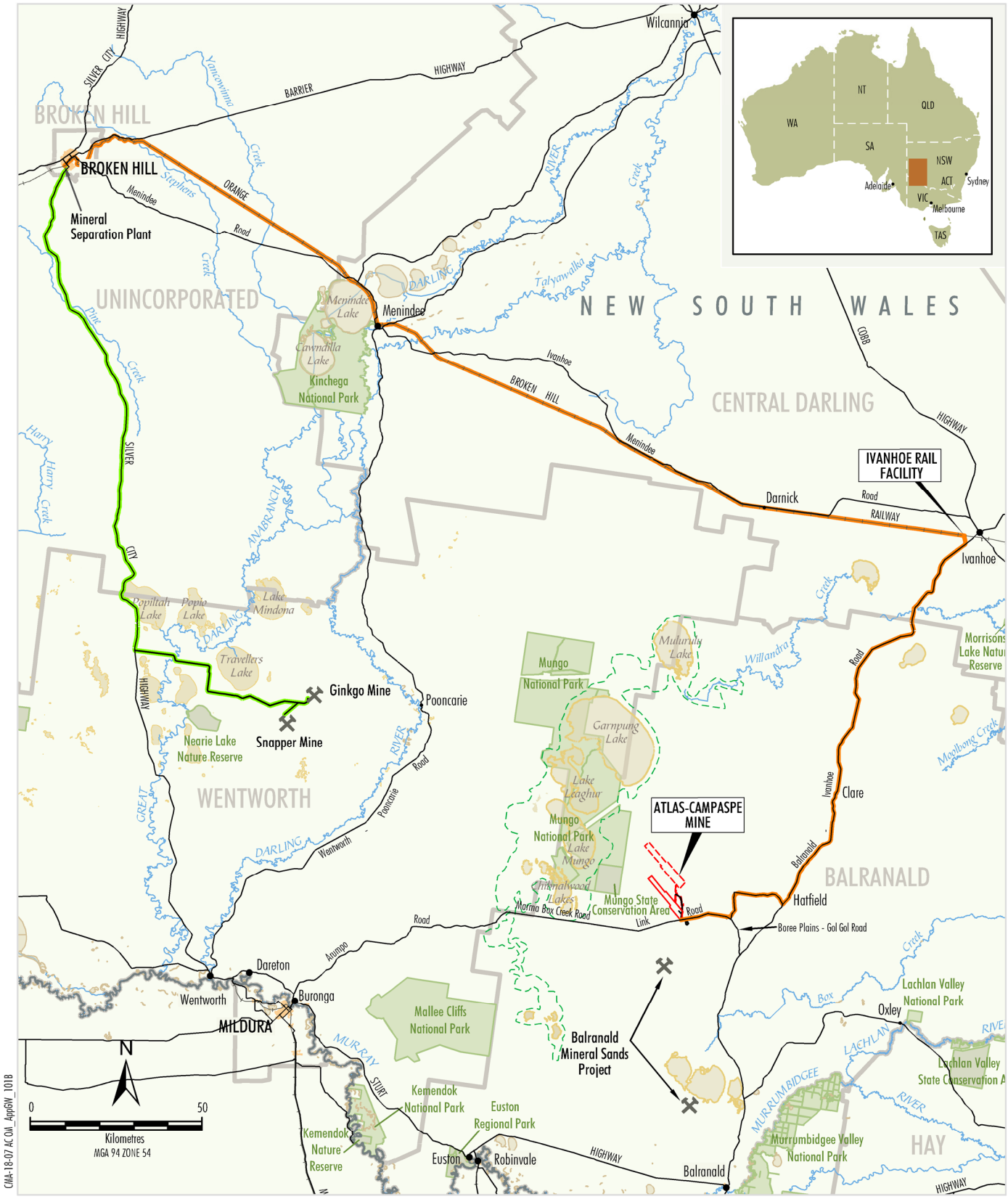
- The MSP – located in Broken Hill approximately 270 km north-west of the Atlas-Campaspe Mine
- Snapper Mine – located approximately 105 km to the west of the Atlas-Campaspe Mine
- Ginkgo Mine – located approximately 100 km to the west of the Atlas-Campaspe Mine.

This Groundwater Review has been prepared to support the application to modify Development Consent (SSD_5012) for the Project.

1.1 OVERVIEW OF THE MODIFICATION

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would include:

- Increased mineral concentrate production from 546,000 tonnes per annum (tpa) to 665,000 tpa;
- Increased mineral concentrate transport from 450,000 tpa to 665,000 tpa;
- Increased mineral concentrate transport truck trips from 24 per day to 35 per day;



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LEGEND

- National Park, Regional Park or State Conservation Area
- Willandra Lakes Region World Heritage Area
- Local Government Area Boundary
- Mining Lease Boundary (ML 1767)
- Mining Lease Application Boundary (MLA)
- Existing Mineral Concentrate Transport Route and MSP Process Waste Transport Route
- Approved Mineral Concentrate Transport Route*

Source: © NSW Department of Finance, Services & Innovation (2018); Cristal Mining Australia (2012)

TRONOX

OPTIMISATION MODIFICATION

Regional Location

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines.

Figure 1

- Increased mineral concentrate transport train length (from 600 metres [m] to 920 m) and frequency (from six to eight train movements per week [i.e. four arrivals, four departures]);
- Increased MSP process waste disposal from 50,000 tonnes per annum (tpa) to 65,000 tpa;
- The option to use an overland conveyor to transfer overburden in addition to haul trucks;
- The relocation of the Atlas-Campaspe Mine accommodation camp;
- The option to develop on-site solar power generation infrastructure at the Atlas-Campaspe Mine to supplement diesel generator sets;
- Development of an emergency airstrip at the Atlas-Campaspe Mine;
- Construction and operation of a telecommunications tower at the Atlas-Campaspe Mine;
- Extension to the Ivanhoe Rail Facility hardstand area;
- Extension of the Ivanhoe Rail Facility rail siding and addition of a passing siding;
- A revised alignment of the Ivanhoe Rail Facility access road and access road intersection;
- A groundwater supply bore for the Ivanhoe Rail Facility; and
- The use of local roads other than the road haulage route by Project-related light vehicles to access site.

There would be no change to the following key components of the approved Project due to the Modification:

- Mine path or mine life;
- Mining method;
- Mineral concentration methods;
- Overburden and ore extraction rate;
- Sand residue, coarse reject and process waste placement management;
- Annual maximum water supply/demand;
- Rehabilitation works;
- Biodiversity offset area; or
- Workforce.

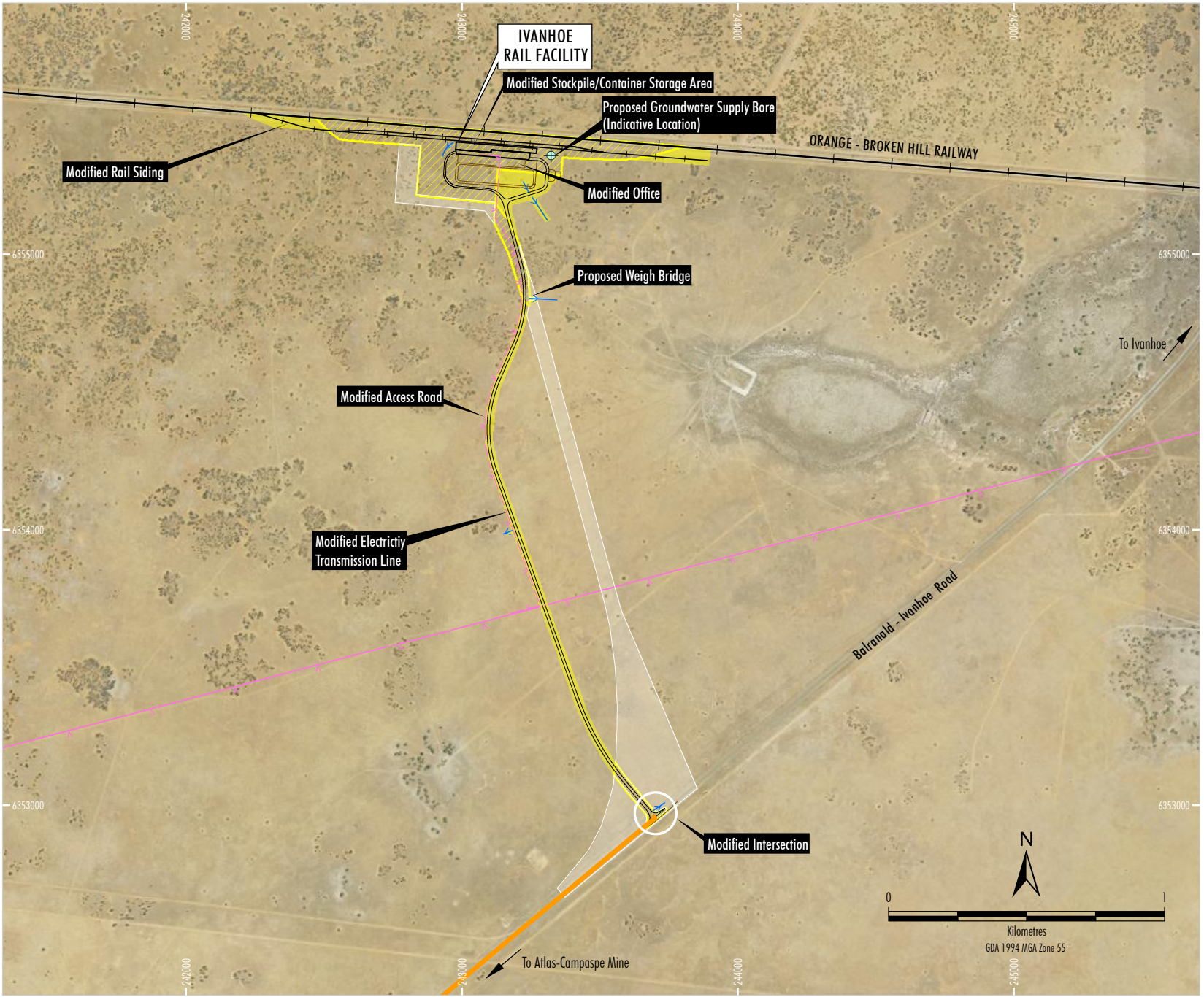
A detailed description of the Modification is provided in the main text of the Modification Report.

As the Modification would not have a significant change to the potential groundwater impacts at the Atlas-Campaspe Mine, this Groundwater Review focusses on the potential groundwater impacts associated with the proposed Ivanhoe Rail Facility groundwater supply bore.

1.2 IVANHOE RAIL FACILITY GROUNDWATER SUPPLY BORE

The Modification includes the installation of a groundwater supply bore at the Ivanhoe Rail Facility (Figure 2). The water would be utilised at the Ivanhoe Rail Facility for wash down purposes and dust suppression on the access road and mineral concentrate stockpiles.

The groundwater supply bore would provide up to approximately 60 million litres per year (ML/yr) (1.9 litres per second [L/s]) over the Project life. The bore would be designed to provide a peak demand of up to about 5 L/s.



LEGEND

- Approved Surface Development Area Required
- Additional Surface Development Area
- Approved Surface Development Area not Required
- Approved Mineral Concentrate Transport Route*
- Existing Electricity Transmission Line

* MSP Process Waste Transport Route following cessation of operations at the Ginkgo and Snapper Mines

Source: Cristal Mining Australia (2012); Tronox (2019)
Orthophoto: © NSW Department of Finance, Services & Innovation (2017)

TRONOX

OPTIMISATION MODIFICATION

Modified Ivanhoe Rail Facility
General Arrangement

Figure 2

CMA-18-07 AC OM_App GW_201B

2 HYDROGEOLOGICAL SETTING

A description of the hydrogeological setting at the Ivanhoe Rail Facility is provided in this section based on the following sources:

- Murray Basin Hydrogeological Map Series.[1]
- Lachlan Fan/Ivanhoe Block Steady State Groundwater Model.[2]
- Lower Lachlan Groundwater Model.[3]
- NSW Government PINNEENA Groundwater Database.[4]
- Bureau of Meteorology (BOM) Australian Groundwater Explorer.[5]
- Bore census of local groundwater use (Attachment A). [6]
- Regional topographic data.
- Anecdotal information from local drilling contractor.

The Lower Lachlan Groundwater Model provides the most recent hydrogeological assessment of the area, and calibrated parameters from this model have been used as the primary source for the groundwater assessment.

2.1 TOPOGRAPHY AND DRAINAGE

The Ivanhoe Rail Facility is located within the Willandra Creek catchment in the Lachlan River basin. Willandra Creek is an effluent creek of the lower Lachlan River which terminates in a series of lignum swamps and intermittent lakes in the Benanee basin south-west of Ivanhoe[7]. Flows into Willandra Creek are primarily controlled by Willandra Weir on the Lachlan River, and like most unregulated streams in western NSW experience long periods of no flow interspersed with rare flows of varying magnitude.

There are no permanent surface water bodies in the Ivanhoe area.

1. Australian Geological Survey Organisation (AGSO) and Bureau of Mineral Resources, Geology and Geophysics (BMR) (1991-1994) Murray Basin Hydrogeological Map Series 1:250,000 *Map Sheets, Mildura, Balranald, Pooncarie, Manara, Hay and Booligal*
2. Kellet, J. R. (1997) *Lachlan Fan / Ivanhoe Block Steady State Groundwater Model*. Australian Geological Survey Organization, Canberra.
3. Mampitiya, D. (2010) *Lower Lachlan Groundwater Model*. NSW Office of Water, April 2010.
4. NWS Department of Industry (2014) PINNEENA 10.1,
5. <www.bom.gov.au/water/groundwater/explorer/>
6. Tronox (2019) *Ivanhoe Rail Facility Bore Census.*
7. Green, D., Petrovic, J., Moss, P., And Burrell, M. (2011) *Water resources and management overview – Lachlan catchment. NSW Office of Water, Sydney*.

The Ivanhoe Rail Facility area is relatively flat lying and sparsely vegetated, characterised by stabilised sand dunes and Native Grassland/Sparse Acacia/Chenopod Shrubs and Belah-Rosewood/Acacia Woodland vegetation communities (Australian Museum Business Services, 2013). The landform at the Ivanhoe Rail Facility is flat at approximately 100 metres Australian Height Datum (m AHD).

2.2 RAINFALL AND EVAPORATION

The climate in the Ivanhoe area is semi-arid with low and sporadic rainfall and high evaporation. Annual rainfall at Ivanhoe is both low (average 306 millimetres [mm]) as well as highly variable (minimum 69 mm and maximum 880 mm).[8]

Average areal actual evapotranspiration has been estimated by the BOM to be about 300 millimetres per year (mm/year) for data obtained from 1961 to 1990.[9] The average areal potential evaporation is estimated by the BOM to be about 1,200 mm/yr, and the average point potential evapotranspiration is indicated to be about 2,100 mm/yr.

The thin surficial Quaternary sediments (Section 2.4) are quite variable in terms of infiltration potential including both clayey and sandy layers. The Shepparton Formation tends to be clayey, reducing the potential for infiltration, while the Calivil Sands include a mixture of sand and clay.

2.3 LAND USE

Contemporary land use in the vicinity of the Ivanhoe Rail Facility is dominated by agricultural activities (low intensity grazing) and the Orange – Broken Hill railway. The township of Ivanhoe is located approximately 4.5 km to the north-east of the Ivanhoe Rail Facility.

2.4 STRATIGRAPHY AND LITHOLOGY

The stratigraphy of the Ivanhoe area is described below in descending order. [10]

- Surficial Quaternary sediments (alluvial, evaporite, calcrete, aeolian).
- The Tertiary-Quaternary Shepparton Formation (TQs) is a thin fluvio-lacustrine deposit comprising clay, silty clay and sand with lenses of coarse sand and gravel, and minor aeolian reworked material.
- The Pliocene Calivil Formation (Tpc) is primarily a fluvio-lacustrine sand deposit and is expected to be the water table aquifer at the site.

8. BOM Climaet Data Online. Ivanhoe Post Office Station 049019. 1884—2016. < http://www.bom.gov.au/climate/averages/tables/cw_049019.shtml>
9. BOM *Average Annual and Monthly Evapotranspiration*. Website: <http://www.bom.gov.au/jsp/ncc/climate_averages/evapotranspiration/index.jsp?maptype=1&period=an>
10. Brown, C.M. and Stephenson, A.E. (1991). *Geology of the Murray Basin, Southeastern Australia*. Bureau of Mineral Resources, Australia. Bulletin 235.

- The Tertiary Renmark Group (Ter) comprises sands and clays and is a significant aquifer in the region.

- The Cretaceous Monash Formation (Kl) includes sands, sandstone, siltstone and shale, with minor coal.

- The Devonian basement rock includes sandstones and metasediments.

At the Ivanhoe Rail Facility site, potential groundwater targets include sand zones within the Calivil Formation and Renmark Group and possibly in the deeper Monash Formation.

The geological log for NSW Government monitoring bore GW036919, located approximately 4.4 km to the north-east of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3) is reproduced in Table 1.

Based on the drilling log for GW036919, it is expected that reasonable water yields could be obtained at a depth of about 50 m to 70 m. The Lower Lachlan Groundwater model indicates the Renmark Group Aquifer is between about 38 m and 84 m depth. The Renmark Group Aquifer is the target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore.

2.5 LICENSING

The Ivanhoe Rail Facility is located within the Lower Lachlan Alluvium Groundwater Source (GS30) as defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* under the NSW *Water Management Act, 2000*. It is noted that the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* has been published on the NSW Department of Industry website and is scheduled to commence on 1 July 2019. The Ivanhoe Rail Facility remains in the Lower Lachlan Alluvium Groundwater Source under the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*.

The long-term annual extraction limit stipulated in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Lower Lachlan Alluvium Groundwater Source, in addition to basic landholder rights, is 108,000 ML/yr and is fully allocated. The majority of water use in the Lower Lachlan Alluvium Groundwater Source is along the Lachlan River, and in the eastern portion of the catchment, where water quality is good.

Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source for the Ivanhoe Rail Facility. In accordance with Condition 24, Schedule 3 of Development Consent (SSD_5012), Tronox will hold sufficient water entitlements under the NSW *Water Management Act, 2000* for all stages of the Project.

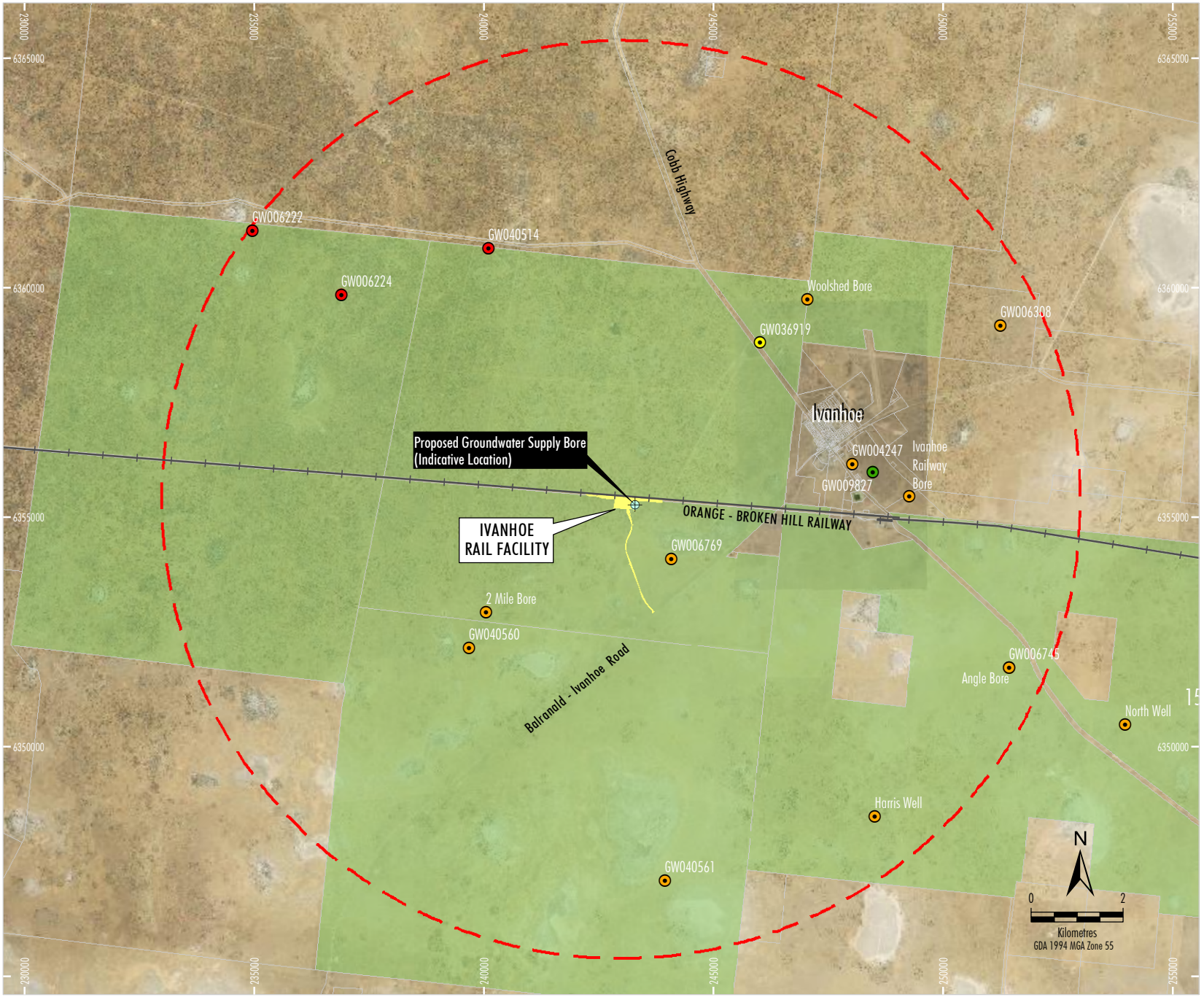

LEGEND
Bore Census Area (10 km Buffer)
Modified Surface Development Area - Ivanhoe Rail Facility
Leaseholder Consulted
Groundwater Bore Intended Purpose
Stock
Domestic
Monitoring
Not In Use
Source: © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019).
Orthophoto: © NSW Department of Finance, Services & Innovation (2019)
Proposed Groundwater Supply Bore (Indicative Location)
IVANHOE RAIL FACILITY
ORANGE - BROKEN HILL RAILWAY
Cobb Highway
Balranald - Ivanhoe Road
Ivanhoe
GW006222
GW040514
GW006224
Woolshed Bore
GW036919
GW006308
GW004247
Ivanhoe Railway Bore
GW009827
GW006769
2 Mile Bore
GW040560
GW006745
Angle Bore
North Well
Harris Well
GW040561
280000
285000
290000
295000
300000
305000
6365000
6360000
6355000
6350000
N
0
2
Kilometres
GDA 1994 MGA Zone 55
TRONOX
OPTIMISATION MODIFICATION
Ivanhoe Rail Facility Bore Census Results
Figure 3
CMA-18-07_EIS_App_GW_201C

Table 1. GW036919 Geological Record.

Depth (m)		Lithology
From	To	
0	3	Sandy clay; red-brown, grading to clayey sand with nodular calcrete
3	5.5	Silcrete/ferricrete; massive, red-brown, yellow-brown and pale grey, very hard drilling
5.5	16	Sandstone; coarse, soft, white-grey, sub-rounded, moderately sorted, quartz, with some thin hard silcrete bands
16	21	Sandstone; coarse, soft, white, slightly clayey, sub-rounded, poorly sorted, quartz, with white pigmentation due to kaolinitic matrix and grain coatings
21	23	Sandstone; banded white and pale pink-grey, soft, clayey, coarse, (with quartz, sub-angular, poorly sorted, 10% opaque and frosted grains) and minor white kaolinitic bands
23	26	Clay & sand; interbedded, clay, kaolinitic, white, and sand, weakly cemented, medium to coarse, quartz, sub-rounded, poorly sorted, with some pink-grey sand beds and pink pigmentation, possibly due to chamosite grain coatings
26	31	Sand & sandy clay; sand, medium, clayey, white-grey, with bands of sandy clay, white, kaolinitic, with minor pink-grey fine sand grains in 29-31m
31	32	Sandy clay & clayey sand; interbedded, sandy clay, pink-grey and pale grey, and clayey sand, fine
32	33	Silty clay; yellow-brown, with thin dark grey-brown clay bands and some pale grey fine sand beds
33	35	Sandy clay; grey, with some yellow-brown, weakly ferruginised clayey, fine sand bands
35	37	Clay; mottled, pale grey and yellow-brown, with a trace of fine sand bands
37	39	Sand; fine, clayey, yellow-grey
39	41	Silty clay & clayey sand; interbedded, silty clay, pale grey, and clayey sand, fine, with minor yellow-grey clayey fine sand bands
41	42	Sandy clay; dark grey
42	43	Sandy clay; pale brown-grey, with fine to medium sand, in bands
43	44	Sandy clay; mottled, pale grey and yellow-brown, with fine sand bands
44	45	Clay; dark grey with minor bronze, possibly pyritic fine sand bands
45	47	Silty clay; pale grey, with yellow-brown fine sand bands
47	49	Sandy clay; plastic, slightly carbonaceous, dark grey
49	51	Silty clay; pale grey, with fine sand bands, and minor yellow-brown mottles
51	61	Sand & sandy clay; interbedded, sand, fine, yellow-grey, and sandy clay, pale grey, with a trace of thin, black, carbonaceous clay bands
61	62	Sandy clay & sand; sandy clay, mottled, plae grey and yellow-brown, and sand, in beds, medium, sub-angular to sub-rounded, poorly sorted, quartz
62	72	Sand; sand, coarse, sub-rounded, very poorly sorted, quartz, pale brown, and clay, in bands throughout, but mostly in 62-64m and 71-72m
72	91	Mudstone; pale blue-grey, very softy, with minor fine sand bands throughout and trace of brown carbonaceous clay bands
91	92	Sandstone; fine, pale grey, becoming hard
92	95	Sandstone; core, mostly massive, pale grey quartzose sandstone (quartz grains, sub-rounded to sub-angular, poorly sorted). diffuse dark grey carbonaceous zone 92.4-92.55m with the carbonaceous material appearing entirely in the matrix

Sand zones highlighted in grey.

2.6 GROUNDWATER BORE CENSUS

A bore census in the vicinity of the Ivanhoe Rail Facility was conducted by Tronox in April 2019 (Attachment A). The bore census covered a 10 km radial buffer around the Ivanhoe Rail Facility groundwater supply bore (or approximately 314 square kilometres) and included a review of NSW Government records and consultation with surrounding landholders.

The bore census confirmed the existence of 10 groundwater bores. The closest groundwater bore is located approximately 2 km south-east of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3).

Of the 10 groundwater bores, seven were confirmed to be in use and three are not in use (Attachment A). The purposes of the seven groundwater bores in use included (Figure 3):

- monitoring (one bore); and
- stock (six bores).

The lack of active bores in the region is understandable given the poor quality of the groundwater (Section 2.9).

2.7 GROUNDWATER DEPENDENT ECOSYSTEMS

There are currently no high priority groundwater dependent ecosystems (GDEs) identified in the Lower Lachlan Alluvium Groundwater Source defined in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* or the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* under the NSW *Water Management Act, 2000* within which the Ivanhoe Rail Facility is located.

The *Groundwater Dependent Ecosystems Atlas* (BOM, 2019) identifies potential GDEs at locations of dry lake beds, which occasionally capture rainfall run-off, in the vicinity of the Ivanhoe Rail Facility as having a low potential for groundwater interaction.[11] As these surface features are disconnected from the groundwater table, which is located approximately 30 m below ground level, it is considered that they are not groundwater dependent.

Notwithstanding, *NSW State Groundwater Dependent Ecosystems Policy* (Department of Land and Water Conservation, 2002) recognises the four Australian GDE types (Hatton and Evans, 1998) that can be found in NSW, namely:

- Terrestrial vegetation;
- Baseflows in streams;
- Aquifer and cave ecosystems; and
- Wetlands.

11. Bureau of Meteorology, Groundwater Dependent Ecosystems Atlas. <http://www.bom.gov.au/water/groundwater/gde/map.shtml> accessed March 2019.

The *Risk Assessment Guidelines for Groundwater Dependent Ecosystems* (NSW Office of Water [NOW], 2012) also identifies four above ground ecosystems that are considered GDEs, as follows:

- Groundwater dependent wetlands;
- Baseflow streams (surface water ecosystems);
- Estuarine and near shore marine ecosystems; and
- Phreatophytes – groundwater dependent terrestrial ecosystems.

No GDEs are considered to be present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore.

2.8 BASELINE GROUNDWATER LEVEL DATA

NSW Government monitoring bore GW036919 is located about 3 km north-west of Ivanhoe and approximately 4.4 km NE of the proposed Ivanhoe Rail Facility groundwater supply bore (Figure 3). The surface level is approximately RL 89 m AHD. It is a nested pair monitoring bore and the upper bore screen is indicated to be set at 39 m to 45 m depth (about RL 44 m to RL 50 m AHD) in sandy-clay and clayey sand zone (possibly the base of the Calivil Formation). The lower bore screen is indicated to be set at about 58 m to 70 m depth (RL 19 m to RL 31 m AHD) in a section with fine to coarse sand bands (likely within the Renmark Group Aquifer).

Hydrographs for the shallow (s) and deep (d) standpipes at GW036919 are shown in Figure 4.

The water levels in the two bores are very similar, and have risen by only about 0.1 m, over 20 years since construction, indicating stable groundwater conditions (Figure 4).

It is likely that the shallow screen is poorly connected to the regional aquifer(s) as the geological log indicates the screen was placed in a sandy clay zone. This could explain the slow recovery of about 0.2 m since construction in 1995, to a relatively stable level since 2002 (Figure 4).

Since 2003 the groundwater levels in both standpipes have been fairly stable. The fluctuation in levels is very small and likely primarily due to changes in atmospheric pressure at the time of readings. The difference in level between the two standpipes is about 2 cm and may indicate a small upward gradient, or inaccuracy in measurements. There is a very small long-term trend of rising water level of about 0.1 m in the lower standpipe between 1995 and 2015 (Figure 4).

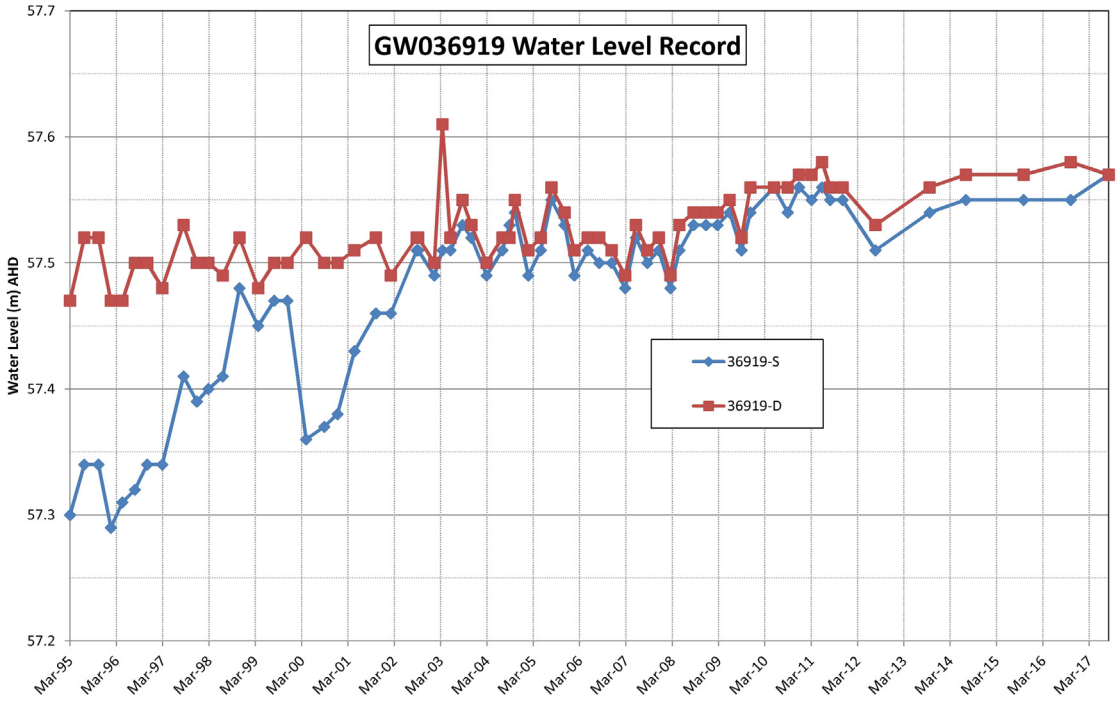


Figure 4. GW036919 Groundwater Level Records.

2.9 BASELINE GROUNDWATER CHEMISTRY DATA

Groundwater salinity mapping of the region (Murray Darling Basin Authority, 2008) indicates salinity of about 10,000 milligrams per litre (mg/L).

This elevated salinity is consistent with the limited groundwater use in the Ivanhoe area (Section 2.6).

2.10 RAINFALL RECHARGE

Based on studies of chlorine input from rainfall, Kellet (1997) indicates that recharge varies from about 0.1% to 1.0% of rainfall, with the lowest infiltration over the western mallee of about 0.1 mm/year. Kellet (1997) estimated recharge across the Riverine Plain and Willandra Lakes depression to be up to 1.8 mm/year, with recharge of up to 3 mm/year along the Murray River boundary area (Kellet, 1997).

Mampitiya (2010) used a recharge rate of 1% of rainfall, which is equivalent to about 3 mm/year over the western part of the current groundwater model area, which overlaps with the Lower Lachlan Groundwater Model. Mampitiya (2010) noted that:

> *"Potential evaporation exceeds annual rainfall by a ratio of nearly 5:1 in the model area. Therefore, much of the rain received in the area is likely to evaporate before significant surface ponding, infiltration and runoff. Clay rich topsoil has a very low permeability resulting in low deep drainage from rainfall. The water table in most parts of the study area is about 25 m below ground level. All of these factors indicate that the model area is generally experiencing dry conditions and relatively low rates of rainfall recharge. Monitoring bore hydrographs do not indicate any noticeable response to rainfall, not even for sporadic high intensity events."*

2.11 HYDROGEOLOGICAL PARAMETERS

Hydrogeological parameters from the Lower Lachlan Groundwater Model for the proposed bore location are provided in Table 2.

Table 2. Hydrogeological Parameters.

	m AHD	K (m/d)	SY%	Ss	Leakance (1/d)
Surface	83.07				
Shepparton	69.97	1	7.24		1.14E-04
Calivil	45.06	13.4		1.00E-04	9.73E-05
Renmark	-1.33	15.61		1.00E-04	

Levels for base of formation.
K: Horizontal Hydraulic Conductivity
SY: Specific Yield
Ss: Specific Storage
Leakance: Measure of flow between layers.

3 GROUNDWATER MODEL

3.1 GROUNDWATER MODEL CONCEPTUALISATION

The conceptual understanding of the regional groundwater regime is based on the Lower Lachlan Groundwater Model and a review of existing hydrogeological data (Section 2).

The Lower Lachlan Groundwater Model indicates a relatively flat regional groundwater gradient flowing to the west at about 1 vertical (V) to 4,500 horizontal (H). The groundwater table in the vicinity of the Ivanhoe Rail Facility is approximately 32 m below ground level and generally sits in the Calivil Formation. The hydrographs in Figure 4 indicate relatively stable water level conditions, which is matched by the Lower Lachlan Groundwater Model simulated water levels.

Given these hydrogeological conditions and an assumed uniform confined aquifer the pumping effect from the proposed Ivanhoe Rail Facility water supply bore would be a localised symmetric cone.

3.2 MODEL SOFTWARE AND COMPLEXITY

An analytical model (axi-symmetric analytical methods for leaky confined aquifers) has been used to simulate the drawdown from the proposed Ivanhoe Rail Facility groundwater supply bore. The model type is considered appropriate given:

- The hydrogeological conditions at the Ivanhoe Rail Facility (i.e. uniform confined aquifer, with a very low regional gradient) as discussed in Section 3.1.
- The limited groundwater use in the vicinity of the Ivanhoe Rail Facility (Section 2.6).
- The expected limited drawdown associated with the proposed Ivanhoe Rail Facility groundwater supply bore.

Analysis has been carried out using AQTESOLV software (Duffield, G.M., 2007), using the Hantush solution for leaky confined aquifers.

The use of an analytical model is also consistent with the Murray-Darling Basin Commission (MDBC) Guideline. Under the MDBC Guideline, a "*simple model*" is considered appropriate to "*predict the long term drawdown due to abstractions from a proposed water supply bore*" (e.g. the proposed Ivanhoe Rail Facility groundwater supply bore). The MDBC Guideline states that the complexity of a "*simple model*" is "*basic*" and "*often uses analytical modelling approach*".

The use of an analytical model is also consistent with Australian Groundwater Modelling (AGM) Guideline. Based on Table 2-1 (Model confidence level classification) of the AGM Guideline, as the model is required to provide predictions of *"long-term impacts of proposed developments in low-value aquifers"*, a "Class 1" model is appropriate. The AGM Guideline states that the confidence level of the "Class 1" model is low. The confidence level of the model could be considered to be low as the parameters adopted in the model ae based on the Lower Lachlan Groundwater Model which has been carried out over a very large region, with minimal specific information for the Ivanhoe location. While the confidence in the model predictions could be low, the consequence of likely variance in those predictions is also low, given the low value of the aquifer and the significant distance to any receiving environment or groundwater users.

Given the above, the use of AQTESOLV software (Duffield, G.M., 2007), using the Hantush solution for leaky confined aquifers, is considered appropriate for the Ivanhoe Rail Facility groundwater supply bore.

3.3 IVANHOE RAIL FACILITY WATERSUPPLY BORE SCENARIO

The Modification includes the installation of a groundwater supply bore at the Ivanhoe Rail Facility (Figure 2). The groundwater supply bore would provide up to approximately 60 ML/yr (1.9 L/s) over the Project life (a 20 year period has been adopted for the model).

3.4 PARAMETERS ADOPTED

The following parameters for the Renmark Group Aquifer from the Lower Lachlan Groundwater Model (Section 2.10) have been adopted in the model:

- Hydraulic Conductivity (K)=15.6 m/d.
- Aquifer Thickness(B)=46 m.
- Specific Storage (Ss)=0.0001.
- Leakance from Calivil=9.7E-5 1/d.

3.5 MODEL RESULTS

The predicted maximum drawdown after 20 years at the Ivanhoe Rail Facility groundwater supply bore and 10 m, 20 m and 100 m from the bore is presented in Table 3.

Table 3 also includes the results of a sensitivity analysis that was carried out by varying several of the parameters by one order of magnitude. The Specific Storage (Ss) and Leakance parameters were not sensitive and were only varied towards the maximum case direction. Two values for the productive aquifer thickness (B) were considered based on the geological log for GW036919 (i.e. 11 m – Table 1) and the aquifer thickness adopted in the Lower Lachlan Groundwater Model (i.e. 46 m).

Table 3. Modelled Groundwater Drawdown After 20 Years at Radial Distances.

Scenario	K (m/d)	B (m)	T (m^2/d)	Ss	Leakance (1/d)	Maximum Drawdown			
						@Bore	10m	20m	100m
1	15.6	46	724	0.0001	9.7e-5	19cm	4cm	2cm	-
2	1.56	46	72.4	0.0001	9.7e-5	190cm	40cm	20cm	-
3	15.6	11	172	0.0001	9.7e-5	80cm	17cm	9cm	-
4	1.56	11	17.2	0.0001	9.7e-5	790cm	170cm	85cm	2cm
5	1.56	11	17.2	0.00001	9.7e-5	790cm	170cm	85cm	2cm
6	1.56	11	17.2	0.0001	9.7e-6	790cm	170cm	85cm	2cm
7	156	11	1717	0.0001	9.7e-5	8cm	2cm	1cm	-

K: Horizontal Hydraulic Conductivity

B: Aquifer Thickness.

T: Transmissivity

Ss: Specific Storage

The results show that drawdowns are low, stabilises quickly and are not significant beyond 100 m.

Comparison was made to the pumping test results for Bore AB1 in the Calivil/Loxton-Parilla Formation at the Atlas-Campaspe Mine site, which showed a similar characteristic to the drawdown curves (at a higher flow rate).

4 ASSESSMENT OF POTENTIAL IMPACTS

4.1 AQUIFER DRAWDOWN

Extraction of groundwater from the Ivanhoe Rail Facility groundwater supply bore would form a localised groundwater sink. As described in Section 3.5, the maximum predicted drawdown is low, stabilises quickly and is not significant beyond 100 m (i.e. predicted maximum drawdown 100 m from the bore is 2 cm) (Figure 5).

4.2 GROUNDWATER USERS

The closest groundwater bore to the proposed Ivanhoe Rail Facility groundwater supply bore is located approximately 2 km to the south-east (Section 2.6). The drawdown at this bore due to the proposed Ivanhoe Rail Facility groundwater supply bore is predicted to be negligible.

4.3 GROUNDWATER QUALITY

Given the limited drawdown impact of the proposed Ivanhoe Rail Facility groundwater supply bore and the poor (saline) quality of the groundwater resource, there is expected to be no significant change in groundwater quality as a result of the Modification.

4.4 GROUNDWATER DEPENDENT ECOSYSTEMS

As there are no GDEs present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore and the limited predicted drawdown, no impacts on GDEs are expected as a result of the Modification.

4.5 CUMULATIVE IMPACTS

As there are no significant groundwater users in the vicinity of the proposed Ivanhoe Rail Facility groundwater supply bore and the limited predicted drawdown, no cumulative impacts are expected as a result of the Modification.

4.6 CONSIDERATION OF THE AQUIFER INTERFERENCE POLICY

The Aquifer Interference Policy (AIP) has been developed by the NSW Government as a component of the NSW Government's *Strategic Regional Land Use Policy*. The AIP applies state wide and details water licence and impact assessment requirements.

The stated objective of the AIP is to ensure equitable water sharing between various water users and proper licensing of water that is taken by aquifer interference activities to ensure that the take is accounted for in the water budget and water sharing arrangements.

Water Source

The AIP requires all water taken by aquifer interference activities to be accounted for within the extraction limits set by the relevant Water Sharing Plan. The Water Sharing Plan relevant to the Ivanhoe Rail Facility is the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*.

The draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*, which has been published on the NSW Department of Industry website (Section 2.5) would become the relevant Water Sharing Plan for the Ivanhoe Rail Facility when it comes into force.

Licensing Requirements

The *Water Management Act, 2000* makes it an offence to "take" water without a water licence or in accordance with a lawful exemption.

The AIP states that all water taken by aquifer interference activities needs to be accounted for within the extraction limits set by the relevant water sharing plan.

As described in Section 2.5, Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the proposed Ivanhoe Rail Facility groundwater supply bore. Tronox therefore has adequate licences available to account for the proposed take of water associated with the Ivanhoe Rail Facility groundwater supply bore (i.e. 60 ML/yr).

Minimal Impact Considerations

The AIP establishes minimal impact considerations for groundwater categories of both 'highly productive' and 'less productive' groundwater. 'Highly productive groundwater' is defined by the AIP as groundwater which (NOW, 2012):

> *…is defined in this Policy as a groundwater source that is declared in the Regulations and will be based on the following criteria:*
>
> *a) has total dissolved solids of less than 1,500 mg/L, and*
>
> *b) contains water supply works that can yield water at a rate greater than 5 L/sec.*

The AIP further groups groundwater in to categories (e.g. alluvial, porous rock).

The target aquifer for the proposed Ivanhoe Rail Facility groundwater supply bore (i.e. the Renmark Group Aquifer) is considered to be a 'less productive' alluvial aquifer, due to its high salinity, in accordance with the AIP. Table 4 provides an assessment of the watertable, water pressure and water quality minimal impact considerations.

The Modification would have "minimal impact" (as defined by the AIP) (Table 4).

Table 4. Less Productive Alluvial Aquifer – Minimal Impact Considerations

Level 1 Minimal Impact Consideration	Assessment
Water Table 1. *Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic "post-water sharing plan" … variations, 40m from any:* (a) *high priority groundwater dependent ecosystem; or* (b) *high priority culturally significant site; listed in the schedule of the relevant water sharing plan; or* *A maximum of a 2m decline cumulatively at any water supply work unless make good provisions should apply.*	There are no high priority GDEs listed in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* or the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*. There are no high priority culturally significant sites listed in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* or the *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*. Predicted drawdown at all privately-owned bores would be less than 2 m. There are no other relevant water supply works. **Complies with Level 1 minimal impact considerations.**
Water Pressure 1. *A cumulative pressure head decline of not more than 40% of the "post-water sharing plan"… pressure head above the base of the water source to a maximum of a 2m decline, at any water supply work.* 2. *If the predicted pressure head decline is greater than requirement 1. above, then appropriate studies are required to demonstrate to the Minister's satisfaction that the decline will not prevent the longterm viability of the affected water supply works unless make good provisions apply.*	Predicted water pressure decline at all privately-owned bores would be less than 2 m. There are no other relevant water supply works. **Complies with Level 1 minimal impact considerations.**

Level 1 Minimal Impact Consideration	Assessment
<u>*Water Quality*</u> *(a) Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40m from the activity; and* *(b) No increase of more than 1% per activity in long-term average salinity in a highly connected surface water source at the nearest point to the activity. Redesign of a highly connected … surface water source that is defined as a "reliable water supply"… is not an appropriate mitigation measure to meet considerations 1.(a) and 1.(b) above.* (c) *No mining activity to be below the natural ground surface within 200m laterally from the top of high bank or 100m vertically beneath (or the three dimensional extent of the alluvial material - whichever is the lesser distance) of a highly connected surface water source that is defined as a "reliable water supply"*	Negligible impacts on groundwater quality are expected and therefore no change to the beneficial use category of the groundwater source. <u>There are no highly connected surface water sources in the vicinity of the Ivanhoe Rail Facility.</u> <u>No mining activities are proposed at the Ivanhoe Rail Facility.</u> **Complies with Level 1 minimal impact considerations.**

4.7 CONSIDERATION OF THE WATER SHARING PLAN FOR THE LOWER LACHLAN GROUNDWATER SOURCE 2003

Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* relates to the management of local impact on the groundwater resource. An assessment against the relevant provisions of Division 3 of Part 10 is provided in Table 5.

Section 4.41(1) of the NSW *Environmental Planning and Assessment Act, 1979* provides that water use approvals under section 89, water management work approvals under section 90 (which include water supply work approvals), or an activity approval (excluding an aquifer interference approval) under section 91 of the *Water Management Act, 2000* are not required for an approved State Significant Development Project. Therefore, restrictions set out in clause 36 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* do not apply to a bore approved as part of the Project. Notwithstanding the above, clause 36 is still considered in Table 5.

The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*.

Table 5. Management of Local Impact Considerations

Requirement	Assessment
36 Extraction interference between neighbouring bores	
1. To minimise interference between extraction under different access licences in this groundwater source, extraction from a water supply work (bore) nominated by an access licence will not be permitted within: *(a) 1,000 metres of another water supply work (bore) nominated by an access licence authorised to extract up to, and including, 10 ML/day,* *(b) 2,000 metres of another water supply work nominated by an access licence authorised to extract greater than 10 ML/day, and up to and including 15 ML/day, and* *(c) 3,000 metres of another water supply work nominated by an access licence authorised to extract greater than 15 ML/day.*	Extraction from the proposed Ivanhoe Rail Facility groundwater supply bore would be less than 10 ML/day. No groundwater bores are located within 1,000 m of the proposed Ivanhoe Rail Facility groundwater supply bore.
37 Water level management	
1. The Minister may declare that, in order to protect water levels within this groundwater source, local access rules are to apply in a defined area known as a local impact area. …	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 37 is not applicable to any dealing for the proposed Ivanhoe Rail Facility groundwater supply bore.
38 Water quality management	
1. The beneficial uses of this groundwater source based on the Australian and New Zealand Environment and Conservation Council Water Quality Guidelines 2000, and the National Health and Medical Research Council Raw Water for Drinking Purposes Guidelines 1996, are raw water for drinking supplies, and agriculture water.	Negligible impacts on groundwater quality are expected and therefore no change to the beneficial use category of the groundwater source. Clauses 38(1) and 38(2) are therefore not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.
2. Water quality decline will be deemed unacceptable if extraction is likely to cause water quality to decline to a lower beneficial use class.	
3. The Minister may declare that, in order to protect water quality within this groundwater source, local access rules are to apply in a defined area known as a local impact area.	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 38(3) is not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.

Requirement	Assessment
39 Protection of groundwater dependent ecosystems and Aboriginal cultural heritage values	
(1) Extraction of groundwater from a new or replacement water supply work (bore) is excluded: *(a) for works nominated by an access licence, within 200 metres of high priority groundwater dependent ecosystems, or where impact may occur on Aboriginal cultural heritage values,* *(b) for those exercising basic landholder rights, within 100 metres of high priority groundwater dependent ecosystems, or where impact may occur on Aboriginal cultural heritage values, and* *(c) within 40 metres of any river for any works.*	There are no high priority GDEs listed in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*. There are no high priority culturally significant sites listed in the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*. There is no river in the vicinity of the Ivanhoe Rail Facility groundwater supply bore.
40 Protection of aquifer integrity	
(1) The Minister may declare that, in order to protect the integrity of the aquifers within this groundwater source, local access restrictions are to apply in a defined area known as a local impact area.	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within a local impact area, therefore clause 40 is not applicable to any dealing for the Ivanhoe Rail Facility groundwater supply bore.

4.8 CONSIDERATION OF THE DRAFT WATER SHARING PLAN FOR THE LACHLAN ALLUVIAL GROUNDWATER SOURCES 2019

Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* relates to rules for granting water supply work approvals.

As noted in Section 2.5, the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019* is scheduled to commence on 1 July 2019. Notwithstanding, an assessment against the relevant provisions of Part 9 is provided in Table 6.

Table 6. Rules for Water Supply Work Approvals

Requirement	Assessment
40 - Rules to minimise interference between water supply works	
(2) A water supply work approval must not be granted or amended in the Lower Lachlan Groundwater Source if located within: *(d) 400 metres of a water supply work located on another landholding that is authorised to take water from the same groundwater source for basic landholder rights only, or* *(e) 200 metres from the boundary of the landholding on which the water supply work is located, unless the owner of the landholding adjoining the boundary has provided consent in writing, or* *(f) 600 metres of a water supply work that is nominated by a local water utility access licence or a major utility access licence to take water from the same groundwater source, unless the holder of the local water utility access licence or major utility access licence has provided consent in writing, or* *(g) 500 metres of a Government observation or monitoring bore, or* *(h) 1,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take up to and including 2,000 ML/year, or* *(i) 2,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take between 2,000 ML/year and 3,000ML/year, or* *(j) 3,000 metres of a water supply work located on another landholding within the same groundwater source that is authorised to take over 3,000ML/yr*	No water supply works are located within 600 m of the proposed Ivanhoe Rail Facility groundwater supply bore. The proposed Ivanhoe Rail Facility groundwater supply bore is not located within 200 m of the boundary of the relevant landholding (i.e. Lot 931, DP761988). No Government observation or monitoring bores are located within 500 m of the proposed Ivanhoe Rail Facility groundwater supply bore. No water supply works are located on another landholding within 3,000 m of the proposed Ivanhoe Rail Facility groundwater supply bore which are authorised to take up to 3,000 ML/yr or over.

Requirement	Assessment
41 Rules for water supply works located near contamination sources	
(1) A water supply work approval must not be granted or amended if the water supply work is located: *(a) within 500 metres of a contamination source listed in Schedule 1, or* *(b) within 250 metres of the edge of a plume associated with a contamination source listed in Schedule 1, or* *(c) between 250 metres and 500 metres from the edge of a plume associated with a contamination source listed in Schedule 1, unless the Minister is satisfied that no drawdown will occur within 250 metres of that plume.*	The proposed Ivanhoe Rail Facility groundwater supply bore is not located within 500 m of a contamination source or the plume associated with a contamination source listed in Schedule 1.
42 Rules for water supply works located near groundwater-dependent ecosystems	
(2) A water supply work approval must not be granted or amended for the following water supply works: *(a) a water supply work that is located within 40 metres of the top of the high bank of a river,* *(b) a water supply work for basic landholder rights that is located within 100 metres of any other high priority groundwater-dependent ecosystem shown on the GDE Map,* *(c) a water supply work, other than solely for basic landholder rights, that is located within 200 metres of any other high priority groundwater-dependent ecosystem shown on the GDE Map*	There is no river in the vicinity of the Ivanhoe Rail Facility groundwater supply bore. There are no high priority GDEs listed in the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019.*
43 Rules for water supply works located near groundwater-dependent culturally significant areas	
(1) A water supply work approval must not be granted or amended if located within: *(a) 100 metres of a groundwater-dependent culturally significant area, for a water supply work that will be used take water for basic landholder rights only, or* *(b) 200 metres of a groundwater-dependent culturally significant area, for a water supply work that is intended to be nominated by an access licence.*	There are no groundwater-dependent culturally significant areas listed in the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019.*

5 RECOMMENDED MANAGEMENT AND MONITORING PROGRAMME

5.1 GROUNDWATER MANAGEMENT PLAN

A Groundwater Management Plan has been prepared for the Project in accordance with Condition 26(f), Schedule 3 of Development Consent (SSD_5012). The Groundwater Management Plan includes:

- Groundwater assessment criteria and associated trigger levels;
- Groundwater monitoring program;
- Plan to respond to Groundwater assessment criteria exceedances; and
- Program to validate the groundwater model.

It is recommended that the Groundwater Management Plan be revised to incorporate the Ivanhoe Rail Facility groundwater supply bore.

5.2 MONITORING

The revised Groundwater Management Plan should include the following additional monitoring:

- Meteorological data from the existing Atlas-Campaspe Mine automated weather station and from the BOM site at Ivanhoe.
- Groundwater level at the Ivanhoe Rail Facility groundwater supply bore (quarterly).
- Groundwater quality (Electrical Conductivity (EC), pH, standard anions and cations, and metals) at the Ivanhoe Rail Facility groundwater supply bore (quarterly).

5.3 COMPENSATORY WATER SUPPLY

Conditions 25, Schedule 3 of Development Consent (SSD_5012) state the following:

Compensatory Water Supply

The Applicant shall provide a compensatory water supply to any landowner or leaseholder of privately-owned land whose water supply is adversely and directly impacted (other than an impact that is negligible) as a result of the development, in consultation with NOW, and the satisfaction of the Secretary.

The compensatory water supply measures must provide an alternative long term supply of water that is equivalent to the loss attributed to the development.

The extent of adverse impact on water supply must be investigated in accordance with the procedures outlined in Condition 4 of Schedule 5. The compensatory water supply measures must provide an alternative long term supply of water that is equivalent to the loss attributable to the project. Equivalent water supply should be provided (at least on an interim basis) within 24 hours of the loss being identified, unless otherwise agreed with the landowner/leaseholder.

If the Applicant and landowner/leaseholder cannot agree on the measures to be implemented, or there is a dispute about the implementation of these measures, then either party may refer the matter to the Secretary for resolution.

If the Applicant is unable to provide an alternative long term supply of water, then the Applicant shall provide alternative compensation to the satisfaction of the Secretary.

In the unlikely event that a leaseholder's water supply is adversely and directly impacted (other than an impact that is negligible) as a result of the Ivanhoe Rail Facility groundwater supply bore, Tronox would provide a compensatory water supply in accordance with Conditions 25, Schedule 3 of Development Consent (SSD_5012).

5.4 GROUNDWATER MODEL VALIDATION AND REVIEW

The groundwater model should be used as a management tool for the periodic review and calibration of predicted groundwater drawdown from the Ivanhoe Rail Facility groundwater supply bore during the life of the Project.

Revised outputs from the groundwater model will be reported periodically over the life of the Project. In the event that the actual groundwater drawdown levels exceed the predicted groundwater drawdown levels over the life of the Project, the groundwater model will be further refined using any new data available to characterise the aquifer system.

5.5 GROUNDWATER LICENSING

Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the Ivanhoe Rail Facility.

In accordance with Condition 24, Schedule 3 of Development Consent (SSD_5012), Tronox will hold sufficient water entitlements under the NSW *Water Management Act, 2000* for all stages of the Project.

6 GROUNDWATER MODEL LIMITATIONS

The predictive ability of groundwater modelling is generally related to the availability of geological and hydrogeological data (i.e. knowledge) of the area. Given the remote location of the site, substantial historic datasets are not available. Notwithstanding, sensitivity variations were modelled for conservative (i.e. maximum case) conditions (Section 3.5) to identify an envelope of maximum potential limit of impact. Given the conservative nature of the assessment undertaken in this report, the model accuracy is expected to be adequate for the required purpose of assessing the range of potential impacts surrounding the proposed Ivanhoe Rail Facility groundwater supply bore.

7 CONCLUSIONS

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project. The Modification would include the installation of a groundwater supply bore at the Ivanhoe Rail Facility that would provide up to approximately 60 ML/yr (1.9 L/s) over the Project life.

This Groundwater Review has assessed the potential groundwater impacts associated with the proposed Ivanhoe Rail Facility groundwater supply bore and concluded the following:

- The maximum predicted drawdown is low and is not significant beyond 100 m (i.e. predicted maximum drawdown 100 m from the bore is 2 cm);
- There is expected to be no significant change in groundwater quality as a result of the proposed groundwater bore;
- The closest groundwater bore to the proposed Ivanhoe Rail Facility bore is located approximately 2 km to the south-east and the drawdown at this bore due to the proposed IRF bore is predicted to be negligible;
- There no GDEs present within the locality of the proposed Ivanhoe Rail Facility groundwater supply bore and therefore no impacts on GDEs are expected;
- There are no significant groundwater users in the vicinity of the proposed Ivanhoe Rail Facility groundwater supply bore and therefore no cumulative impacts are expected;
- The proposed IRF groundwater supply bore would have “minimal impact” as defined in the NSW AIP;
- The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant management of local impact considerations in Division 3 of Part 10 of the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003*;
- The proposed Ivanhoe Rail Facility groundwater supply bore would meet relevant rules for granting water supply work approvals in Part 9 of the draft *Water Sharing Plan for the Lachlan Alluvial Groundwater Sources 2019*;
- Tronox has obtained a total of 100 share components (units or million litres) in the Lower Lachlan Alluvium Groundwater Source under the *Water Sharing Plan for the Lower Lachlan Groundwater Source 2003* for the proposed Ivanhoe Rail Facility groundwater supply bore and therefore has adequate licences available to account for the proposed take of water associated with the Ivanhoe Rail Facility groundwater supply bore (i.e. 60 ML/yr); and

- It is recommended that the Groundwater Management Plan be revised to incorporate the Ivanhoe Rail Facility groundwater supply bore and include the following additional monitoring:
  - Meteorological data from the existing Atlas-Campaspe Mine automated weather station and from the BOM site at Ivanhoe.
  - Groundwater level at the Ivanhoe Rail Facility groundwater supply bore (quarterly).
  - Groundwater quality (EC, pH, standard anions and cations, and metals) at the Ivanhoe Rail Facility groundwater supply bore (quarterly).

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Attachment A

Ivanhoe Rail Facility Bore Census

ATLAS-CAMPASPE OPTIMISATION MODIFICATION

IVANHOE RAIL FACILITY GROUNDWATER BORE CENSUS REPORT

MAY 2019
Project No. CMA 18-07
Document No. Version 1
ID: 00975426

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1 INTRODUCTION

The Atlas-Campaspe Mineral Sands Project (the Project) operates in accordance with Development Consent (SSD_5012) issued under Part 4 of the New South Wales (NSW) *Environmental Planning and Assessment Act 1979* (EP&A Act) in 2014.

The Project includes the development of a mineral sands mining operation (herein referred to as the Atlas-Campaspe Mine), together with the construction and operation of a rail loadout facility located near the township of Ivanhoe (herein referred to as the Ivanhoe Rail Facility).

The Atlas-Campaspe Mine is located approximately 80 kilometres (km) north of Balranald, NSW, and approximately 270 km south-east of Broken Hill, NSW. The Ivanhoe Rail Facility is located approximately 135 km north-east of the Atlas-Campaspe Mine, and is approximately 4.5 km south-west of the township of Ivanhoe.

The Project is being Developed by Cristal Mining Australia Limited, which will be renamed Tronox Mining Australia Limited (Tronox) on 25 July 2019.

Tronox proposes to modify Development Consent (SSD_5012) for the Project to allow for changes to optimise the Project (herein referred to the Optimisation Modification or Modification). The Modification would, among other things, include the installation of a groundwater bore at the modified Ivanhoe Rail Facility.

This report presents the findings of a groundwater bore census conducted by Tronox for the area surrounding the Ivanhoe Rail Facility. The findings of the Bore Census will assist in understanding groundwater use within the vicinity of the Ivanhoe Rail Facility.

2 CENSUS AREA

The Bore Census Area consists of a 10 km radial buffer centred on the Ivanhoe Rail Facility (the Bore Census Area). The Bore Census Area covers approximately 314 square kilometres (km^2).

The Bore Census Area includes the town of Ivanhoe, while the remainder of land in the Bore Census Area is dominated by agricultural land uses (predominantly grazing). Groundwater use within the Bore Census Area is understood to be sparse and primarily used for domestic and agricultural purposes.

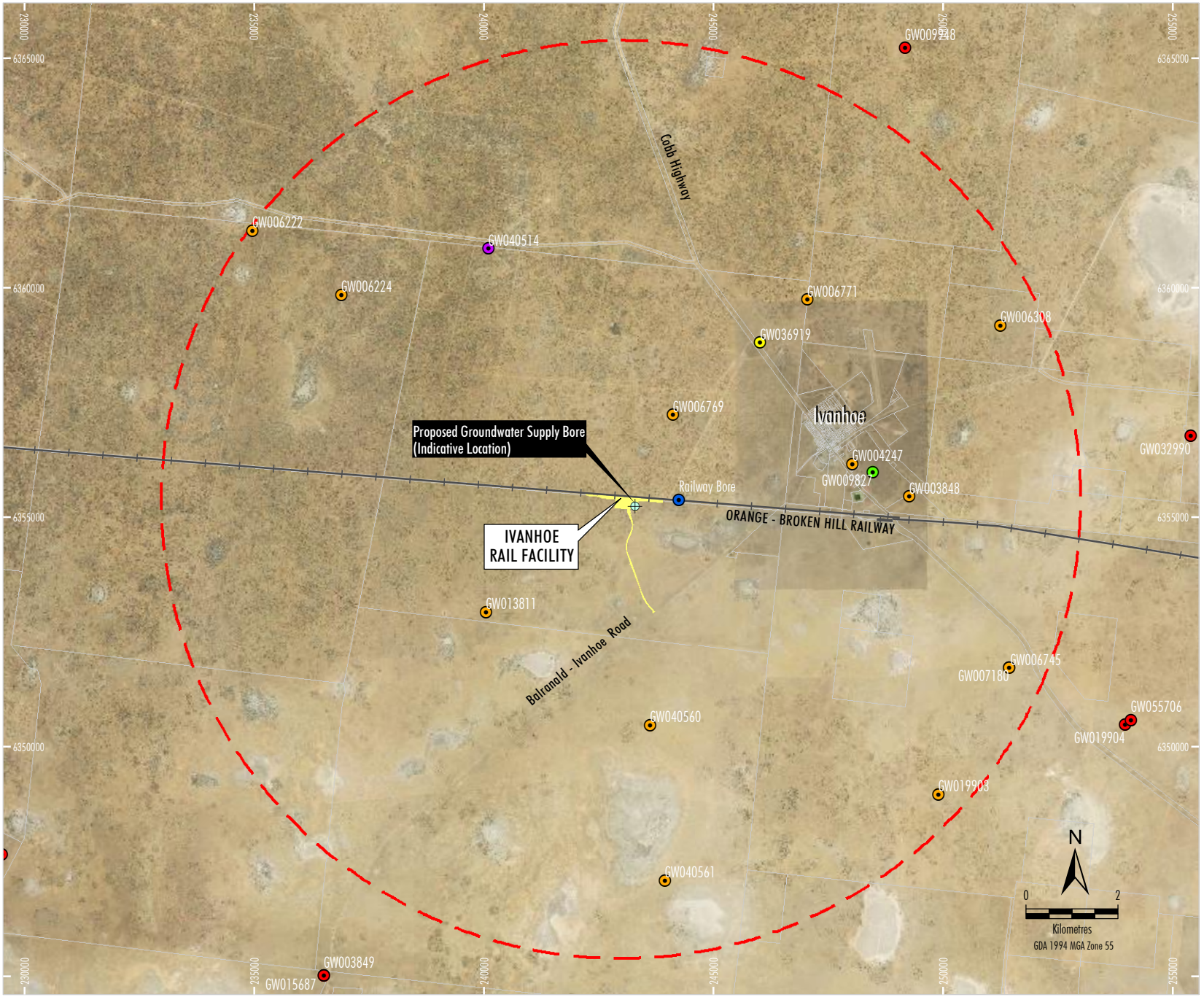
3 DESKTOP ANALYSIS

A desktop analysis was undertaken to identify any potential groundwater bores within the Bore Census Area. The sources of information reviewed for the desktop analysis are described in Sections 3.1–3.3. Potential groundwater bores identified during the desktop analysis are shown on Figure 1.

3.1 WATERNSW GROUNDWATER DATABASE

Registered groundwater bores within the Bore Census Area were identified through a search of the WaterNSW 'Real-time Data' database (WaterNSW, 2019) to provide a basis for consultation with relevant landholders and/or leaseholders in the Bore Census Area.

16 registered groundwater bores (Appendix A) were identified through the WaterNSW groundwater database within the Bore Census Area (Figure 1).



LEGEND

- Bore Census Area (10 km Buffer)
- Modified Surface Development Area - Ivanhoe Rail Facility

NSW Pineena Groundwater Database

- Stock
- Domestic
- Monitoring
- Irrigation
- Groundwater Bore outside Bore Census Area

Topographic Mapping

- Potential Bore

Source: Tronox (2019), © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019). Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX

OPTIMISATION MODIFICATION

Potential Groundwater Bores Identified by Desktop Anaylsis

Figure 1

CMA-18-07_BC_203C

The following intended purposes were attributed to the registered groundwater bores in the Bore Census Area (Figure 1):

- Monitoring (one bore).
- Domestic (one bore).
- Irrigation (one bore).
- Stock (13 bores).

3.2 AERIAL IMAGERY AND TOPOGRAPHIC MAPPING

The Bore Census Area was investigated for infrastructure typically associated with groundwater bores such as windmills, wells and pumps, through an analysis of current and historical NSW Government Topographic Mapping (SIX Maps) (NSW Department of Finance Services and Innovation, 2019). Each identified location was then validated via high-resolution aerial imagery (Google Earth and Six Maps) to confirm the presence of a potential groundwater bore.

The Railway Bore (Figure 1) was identified on topographic mapping as a potential additional bore within the Bore Census Area. No registered bore details are available for the Railway Bore and no infrastructure could be located through aerial imagery. Further, consultation with the leaseholder (Richard Gates) did not indicate that the groundwater bore exists. For the purposes of this Bore Census, the Railway Bore is taken to not exist at the location shown on Figure 1, and is not referred to further in this report.

3.3 PREVIOUS REPORTS

It is understood that the Bore Census Area has not been subject to any recent groundwater studies.

4 CONSULTATION

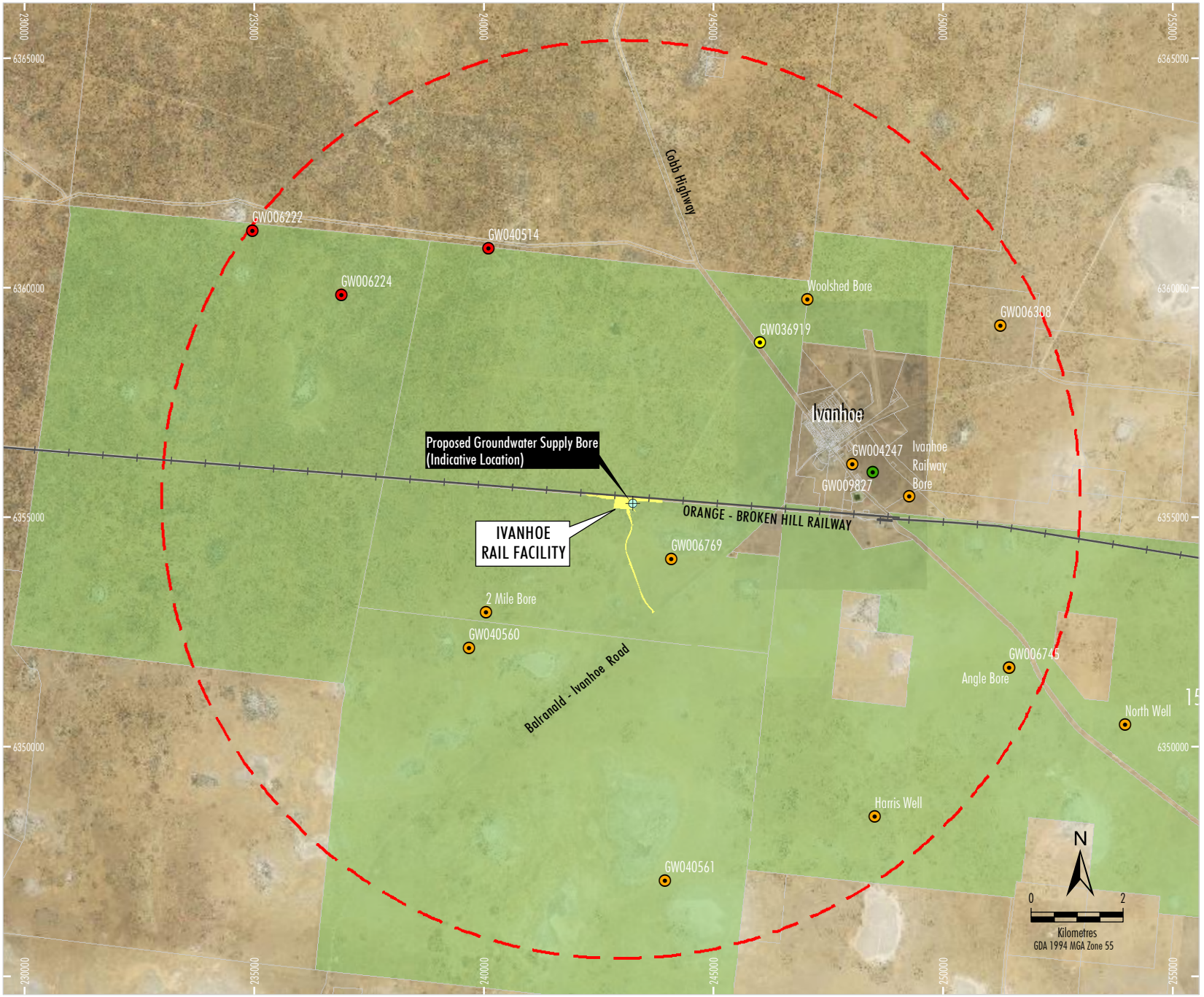
The leaseholders/landholders of the Lots/DP's within the Bore Census Area were identified through a tenure search to provide contact details for consultation purposes. Seven Lots/DP's containing registered groundwater bores were identified within the Bore Census Area. The leaseholders of four lots (Richard Gates and Gregory Turner) were contacted to validate the location of any groundwater bores identified on their properties from the desktop analysis (Section 3) and to provide any further information (i.e. depth to water, pumping rate, etc.) where possible.

The following landholders/leaseholders did not participate in the consultation process:

- Robert Newnham.
- The State of NSW.

Details of 10 of the 16 registered groundwater bores identified in the Bore Census Area were able to be verified through consultation with Richard Gates and Gregory Turner[1]. Approximately 70% (219 km^2) of the Bore Census Area was accounted for through consultation with the leaseholders (Figure 2). Details of six bores identified in the Bore Census Area (Section 3) were unable to be verified through consultation with the relevant landholders/leaseholders.

[1] Gregory Turner provided information on an additional two bores (namely GW019904 and GW055706) located outside the Bore Census Area (Appendices B and C). Gregory Turner also provided information on one bore (GW004247) located on land owned by the State of NSW.



LEGEND

- Bore Census Area (10 km Buffer)
- Modified Surface Development Area - Ivanhoe Rail Facility
- Leaseholder Consulted

Groundwater Bore Intended Purpose

- Stock
- Domestic
- Monitoring
- Not In Use

Source: © NSW Department of Finance, Services & Innovation (2019), WaterNSW (2019).
Orthophoto: © NSW Department of Finance, Services & Innovation (2019)

TRONOX

OPTIMISATION MODIFICATION

Ivanhoe Rail Facility Bore Census Results

Figure 2

CMA-18-07_BC_201B

5 BORE CENSUS RESULTS SUMMARY

A summary of the Bore Census findings are presented below. Detailed results are provided in Appendix C.

Through consultation with the relevant leaseholders, and the WaterNSW groundwater database (for bores that were not able to be verified with the relevant landholder/leaseholder), the 16 registered bores identified within the Bore Census Area were defined as either:

- in use (i.e. currently accessing groundwater) (13 bores); or
- not in use (i.e. not currently accessing groundwater or not capable of accessing groundwater i.e. collapsed) (three bores).

As described in Section 4, the details of six bores in the Bore Census Area were unable to be verified with the relevant landholder/leaseholder. This Bore Census conservatively assumes these bores are in use (Figure 2 and Appendix C). The Bore Census Database (Appendix C) therefore adopts the information from the relevant WaterNSW Works Summary for these six bores (Appendix A).

Of the 10 verified groundwater bores located in the Bore Census Area, the location of three groundwater bores was corrected during consultation and verified through aerial imagery (Sections 3.2 and 4), namely:

- GW006769;
- GW040560; and
- GW019903.

Information provided by the relevant leaseholders and/or WaterNSW Works Summaries indicated that the 13 groundwater bores defined as ‘in-use’ are drilled to the following depths:

- 30 – 50 meters below ground level (mbgl) (three bores)
- 51 – 70 mbgl (six bores)
- >71 mbgl (two bores)
- No depth recorded (two bores).

6 REFERENCES

WaterNSW (2019) *Real-time water data.*
Website: https://realtimedata.waternsw.com.au/
Dates Accessed: 24 April to 8 May 2019

NSW Department of Finance Services and Innovation (2019) *Spatial Information Exchange (SIX Maps).*
Website: https://six.nsw.gov.au/content/about
Dates Accessed: 24 April to 8 May 2019

APPENDIX A

WATERNSW WORKS SUMMARIES

WaterNSW
Work Summary

GW003848

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Other Govt

Commenced Date: **Final Depth:** 54.90 m
Completion Date: 01/12/1943 **Drilled Depth:** 54.90 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** 3001-7000 ppm
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	TS&CR 66171
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6355456.000 **Latitude:** 32°54'37.5"S
Elevation Source: (Unknown) **Easting:** 249265.000 **Longitude:** 144°19'08.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.50	52.10	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
38.10	38.40	0.30	(Unknown)	30.50		0.10			
51.80	54.80	3.00	Consolidated	30.50		0.63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	1.22	1.22	Driller	(Unknown)	
1.22	4.27	3.05	Clay	Clay	
4.27	6.10	1.83	Sandstone	Sandstone	
6.10	7.92	1.82	Sand	Sand	
7.92	9.75	1.83	Sand Hard	Sand	
9.75	12.19	2.44	Sandstone Soft	Sandstone	
12.19	13.72	1.53	Sandstone Solid	Sandstone	
13.72	17.68	3.96	Sand Coarse Dry	Sand	
17.68	21.34	3.66	Sand	Sand	
21.34	22.56	1.22	Sandstone	Sandstone	
22.56	28.65	6.09	Sand	Sand	
28.65	29.87	1.22	Sandstone	Sandstone	
29.87	33.22	3.35	Sand	Sand	
33.22	36.58	3.36	Pipe Clay	Clay	
36.58	38.10	1.52	Clay	Clay	
38.10	38.40	0.30	Sand Water Supply	Sand	
38.40	51.82	13.42	Clay	Clay	
51.82	54.86	3.04	Sandstone Soft Water Supply	Sandstone	

Remarks

30/06/1982: PWP 66 ADJACENT IVANHOE RAILWAYSTATION
02/11/1987: RAILWAY BORE IVANHOE

***** End of GW003848 *****

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WaterNSW
Work Summary

GW004247

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore open thru rock
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 63.70 m
Completion Date: 01/06/1909 **Drilled Depth:** 63.70 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** Good Stock
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	TSR 1418
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6356164.000 **Latitude:** 32°54'13.5"S
Elevation Source: (Unknown) **Easting:** 248024.000 **Longitude:** 144°18'21.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	47.50	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
15.80	17.00	1.20	(Unknown)						
27.00	27.00	0.00	(Unknown)						
34.70	34.90	0.20	(Unknown)						
37.60	38.40	0.80	(Unknown)						
40.20	40.80	0.60	(Unknown)						
47.50	49.30	1.80	(Unknown)	26.20		0.63			
54.90	54.90	0.00	(Unknown)						

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.66	3.66	Clay Hard Gypsum	Clay	
3.66	4.57	0.91	Pebbles White Red	Gravel	
4.57	14.94	10.37	Sand White Very Fine Some Cemented Layers	Sand	
14.94	15.85	0.91	Sandstone Hard Cemented	Sandstone	
15.85	17.98	2.13	Drift Coarse Soak Water Supply	Sand	
17.98	24.99	7.01	Sand Drift Pink	Sand	
24.99	25.60	0.61	Clay Sandy	Clay	
25.60	26.82	1.22	Pipe Clay White	Clay	
26.82	26.97	0.15	Sand Drift Water Supply	Sand	
26.97	28.04	1.07	Clay Yellow Sandy	Clay	
28.04	30.78	2.74	Clay Yellow	Clay	
30.78	31.09	0.31	Ironstone Rusty Nodular	Ironstone	
31.09	32.92	1.83	Clay White Yellow	Clay	
32.92	34.44	1.52	Clay White	Clay	
34.44	34.90	0.46	Sand Drift Water Supply	Sand	
34.90	35.20	0.30	Sandstone Yellow Hard	Sandstone	
35.20	35.51	0.31	Clay Yellow Sandy	Clay	
35.51	36.12	0.61	Clay	Clay	
36.12	37.03	0.91	Clay White	Clay	
37.03	37.34	0.31	Sandstone Nodular	Sandstone	
37.34	37.64	0.30	Sand Drift	Sand	
37.64	40.69	3.05	Clay Sandy	Clay	
40.69	40.84	0.15	Sand Drift Water Supply	Sand	
40.84	41.15	0.31	Stones Hard Nodular	Gravel	
41.15	43.89	2.74	Clay Sandy	Clay	
43.89	44.50	0.61	Clay	Clay	
44.50	45.11	0.61	Pipe Clay	Clay	
45.11	47.55	2.44	Pipe Clay White	Clay	
47.55	49.38	1.83	Sand Drift Water Supply	Sand	
49.38	49.99	0.61	Clay White	Clay	
49.99	54.86	4.87	Sand Drift	Sand	
54.86	59.13	4.27	Clay Sandy Some Very Hard Water Supply	Clay	
59.13	60.05	0.92	Clay Sandy	Clay	
60.05	61.26	1.21	Clay White	Clay	
61.26	63.70	2.44	Clay Dark Blue	Clay	

Remarks

09/05/1979: ADJACENT IVANHOE ASTRON. STATION
09/05/1979: ABADONED HOLE CLOSEBY WITH CASSTUCK IN SWELLING CLAY

***** End of GW004247 *****

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WaterNSW
Work Summary

GW006222

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/08/1937
Final Depth: 32.60 m
Drilled Depth: 32.60 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Poor Stock
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 2851
Licensed:			

Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6361248.000
Easting: 234962.000
Latitude: 32°51'17.5"S
Longitude: 144°10'04.5"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	30.50	152			
1	1	Opening	Screen	29.60	32.60			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	27.40	0.00	(Unknown)	19.20		0.86			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.61	0.61	Loam Red	Loam	
0.61	5.49	4.88	Clay Light Reddish	Clay	
5.49	6.71	1.22	Clay Grey Gypsum	Clay	
6.71	8.23	1.52	Clay Light Yellow	Clay	
8.23	9.14	0.91	Clay White Hard Slippery	Clay	
9.14	10.97	1.83	Clay Grey Hard Crumbly	Clay	

10.97	14.63	3.66	Sandstone Grey	Sandstone	
14.63	17.98	3.35	Clay Light Yellow	Clay	
17.98	19.20	1.22	Sand White	Sand	
19.20	20.12	0.92	Sandstone	Sandstone	
20.12	20.73	0.61	Clay Yellow	Clay	
20.73	21.95	1.22	Clay Dark Coloured	Clay	
21.95	22.56	0.61	Clay Light Yellow Sandy	Clay	
22.56	27.43	4.87	Sand Yellow Fine	Sand	
27.43	32.61	5.18	Drift Yellow Fine Water Supply	Invalid Code	
32.61	32.63	0.02	Clay Yellow Hard	Clay	

***** End of GW006222 *****

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WaterNSW
Work Summary

GW006224

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/07/1937
Final Depth: 86.30 m
Drilled Depth: 86.30 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Stock
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 2851
Licensed:			

Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6359850.000
Easting: 236899.000
Latitude: 32°52'04.5"S
Longitude: 144°11'17.5"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	83.80	152			
1	1	Opening	Screen	83.20	86.20	76		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
27.40	27.40	0.00	Unconsolidated						
39.60	39.60	0.00	Unconsolidated						
74.10	74.10	0.00	Unconsolidated						
86.30	86.30	0.00	Unconsolidated	26.80		0.82			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Loam Red	Loam	
0.91	4.57	3.66	Clay Light Grey	Clay	
4.57	9.75	5.18	Sand White Coarse	Sand	

9.75	10.97	1.22	Clay Light Grey Soft	Clay	
10.97	12.80	1.83	Sandstone Hard	Sandstone	
12.80	14.33	1.53	Clay Black Yellow Dark Sandy	Clay	
14.33	17.07	2.74	Clay Light Grey Yellow	Clay	
17.07	18.29	1.22	Clay White Sandy	Clay	
18.29	21.34	3.05	Clay Yellow	Clay	
21.34	23.16	1.82	Sand Red	Sand	
23.16	27.43	4.27	Clay Yellow	Clay	
27.43	32.00	4.57	Clay Purple Water Bearing	Clay	
32.00	32.61	0.61	Clay White	Clay	
32.61	34.14	1.53	Clay Grey Crumbly	Clay	
34.14	36.27	2.13	Clay Red	Clay	
36.27	36.88	0.61	Clay Black White Red	Clay	
36.88	37.80	0.92	Clay White Soft	Clay	
37.80	39.62	1.82	Drift White	Invalid Code	
39.62	51.82	12.20	Drift Red Water Bearing	Invalid Code	
51.82	54.86	3.04	Drift Yellow	Invalid Code	
54.86	60.96	6.10	Sand Grey Coarse	Sand	
60.96	61.87	0.91	Clay White Soft	Clay	
61.87	62.48	0.61	Clay Light Grey	Clay	
62.48	74.07	11.59	Drift White Coarse Water Bearing	Invalid Code	
74.07	79.25	5.18	Clay Soft Light Coloured	Clay	
79.25	82.30	3.05	Clay White Drift	Clay	
82.30	86.26	3.96	Drift White Fine Water Supply	Invalid Code	
0.00	0.91	0.91	Clay Green Yellow	Clay	

***** End of GW006224 *****

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WaterNSW
Work Summary

GW006308

Licence: | **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Supply Obtained
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: | **Final Depth:** 54.90 m
Completion Date: 01/01/1938 | **Drilled Depth:** 54.90 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: | **Standing Water Level (m):**
GWMA: | **Salinity Description:** 10001-14000 ppm
GW Zone: | **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 6614
Licensed:			

Region: 70 - Lachlan | **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER | **Grid Zone:** | **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) | **Northing:** 6359174.000 | **Latitude:** 32°52'38.5"S
Elevation Source: (Unknown) | **Easting:** 251251.000 | **Longitude:** 144°20'28.5"E

GS Map: - | **MGA Zone:** 55 | **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	54.90	127			
1	1	Opening	Screen	51.80	54.80			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
44.20	44.20	0.00	Unconsolidated						
53.30	54.80	1.50	(Unknown)	35.10					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.10	6.10	Loam	Loam	
6.10	42.67	36.57	Sand Red Coarse	Sand	
42.67	44.20	1.53	Sandstone White	Sandstone	
44.20	50.29	6.09	Clay Red White Water Bearing	Clay	
50.29	53.34	3.05	Clay White	Clay	

53.34	54.86	1.52	Drift Fine Water Bearing	Invalid Code	

***** End of GW006308 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW006745

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 41.10 m
Completion Date: 01/11/1940 **Drilled Depth:** 41.20 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** 3001-7000 ppm
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 283
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6351719.000 **Latitude:** 32°56'40.5"S
Elevation Source: (Unknown) **Easting:** 251439.000 **Longitude:** 144°20'28.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	39.00	127			
1	1	Opening	Screen	35.10	38.10			1	Copper Alloy

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Soil Gibbers	Soil	
0.30	1.83	1.53	Clay	Clay	
1.83	2.44	0.61	Clay Sandy	Clay	
2.44	25.60	23.16	Sandstone Gravel	Sandstone	
25.60	32.61	7.01	Sandstone	Sandstone	
32.61	32.92	0.31	Clay Sandy	Clay	
32.92	35.05	2.13	Clay	Clay	
35.05	38.71	3.66	Drift Clay Bands Water Bearing	Invalid Code	
38.71	41.15	2.44	Drift Water Supply	Invalid Code	

Remarks

30/06/1982: WHEN YIELD DROPPED IN 1944 R/C ATTEMPT ABAND DVE SCRN

***** End of GW006745 *****

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WaterNSW
Work Summary

GW006769

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status: Needs Reconditioning
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 46.90 m
Completion Date: 01/01/1941 **Drilled Depth:** 80.20 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** Salty
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 3339
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6357235.000 **Latitude:** 32°53'35.5"S
Elevation Source: (Unknown) **Easting:** 244122.000 **Longitude:** 144°15'52.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Backfill	Backfill	46.90	80.10	127			
1	1	Casing	Withdrawn	0.00	0.00	127			
1	1	Casing	Threaded Steel	0.00	46.90	152			

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
46.90	46.90	0.00	Unconsolidated						
53.60	56.00	2.40	Unconsolidated						
64.60	65.20	0.60	Unconsolidated						
70.10	70.70	0.60	Unconsolidated						
73.80	74.40	0.60	Unconsolidated						
80.20	80.20	0.00	(Unknown)	28.00					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	46.94	46.94	Water Bearing	(Unknown)	
46.94	48.16	1.22	Clay Sandy	Clay	
48.16	53.64	5.48	Clay	Clay	
53.64	56.08	2.44	Drift Water Bearing	Invalid Code	
56.08	59.13	3.05	Clay Very Sandy	Clay	
59.13	64.62	5.49	Clay	Clay	
64.62	65.23	0.61	Clay Porous Water Bearing	Clay	
65.23	70.10	4.87	Clay	Clay	
70.10	70.71	0.61	Clay Porous Water Bearing	Clay	
70.71	73.76	3.05	Clay Sandy	Clay	
73.76	74.37	0.61	Sandstone Water Bearing Wash	Sandstone	
74.37	79.55	5.18	Clay Very Sandy	Clay	
79.55	80.16	0.61	Clay	Clay	
80.16	80.18	0.02	Drift Water Bearing	Invalid Code	

Remarks

30/06/1982: R/C 23/1/42-DEEPENED TO 80.2M-WATER WORSE-SEE CAS 2&3

***** End of GW006769 *****

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WaterNSW
Work Summary

GW006771

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 53.00 m
Completion Date: 01/02/1942 **Drilled Depth:** 53.00 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** Good
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 4578
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6359746.000 **Latitude:** 32°52'16.5"S
Elevation Source: (Unknown) **Easting:** 247048.000 **Longitude:** 144°17'47.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	53.00	127			
1	1	Opening	Screen	51.50	53.00	76		1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
38.40	38.40	0.00	(Unknown)			0.04			
40.80	40.80	0.00	Consolidated			0.06			
53.00	53.00	0.00	(Unknown)	35.10					

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.30	0.30	Soil Clayey	Soil	
0.30	1.22	0.92	Clay Kopi (copi)	Clay	
1.22	2.74	1.52	Clay	Clay	
2.74	4.57	1.83	Clay Pebbles/pebbly	Clay	
4.57	7.01	2.44	Clay Gravel	Clay	
7.01	20.73	13.72	Sandstone	Sandstone	
20.73	23.16	2.43	Clay	Clay	
23.16	27.13	3.97	Clay Sandy	Clay	
27.13	28.65	1.52	Sandstone	Sandstone	
28.65	33.53	4.88	Sandstone Clayey	Sandstone	
33.53	38.10	4.57	Clay	Clay	
38.10	38.40	0.30	Sandstone	Sandstone	
38.40	40.23	1.83	Clay Sandy	Clay	
40.23	40.84	0.61	Sandstone Water Supply	Sandstone	
40.84	44.20	3.36	Clay Sandy	Clay	
44.20	49.38	5.18	Clay	Clay	
49.38	53.04	3.66	Drift Water Supply	Invalid Code	

***** End of GW006771 *****

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WaterNSW
Work Summary

GW007180

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK
Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private
Commenced Date:
Completion Date: 01/02/1946
Final Depth: 47.90 m
Drilled Depth: 47.90 m
Contractor Name: (None)
Driller:
Assistant Driller:
Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good Stock
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 283
Licensed:			

Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6351719.000
Easting: 251439.000
Latitude: 32°56'40.5"S
Longitude: 144°20'28.5"E
GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	44.80	127			Suspended in Clamps
1	1	Opening	Screen	44.80	47.80			1	

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
37.90	38.10	0.20	(Unknown)						
44.80	44.80	0.00	(Unknown)	28.30		0.38			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	6.10	6.10	Loam	Loam	
6.10	13.72	7.62	Sand Dry Coarse	Sand	
13.72	16.76	3.04	Sandstone Grey	Sandstone	
16.76	18.29	1.53	Sand Dry Coarse	Sand	
18.29	19.20	0.91	Sandstone	Sandstone	

19.20	19.81	0.61	Clay White Sand Seams	Clay	
19.81	22.25	2.44	Sandstone White	Sandstone	
22.25	34.44	12.19	Sand Dry Very Coarse	Sand	
34.44	35.05	0.61	Clay Grey	Clay	
35.05	37.49	2.44	Clay Yellow	Clay	
37.49	37.95	0.46	Clay White	Clay	
37.95	38.10	0.15	Drift Water Bearing	Invalid Code	
38.10	38.40	0.30	Clay Grey	Clay	
38.40	42.98	4.58	Sand Clay Bands	Sand	
42.98	47.85	4.87	Sand Drift Water Supply	Sand	

***** End of GW007180 *****

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WaterNSW
Work Summary

GW009827

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): DOMESTIC

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 46.90 m
Completion Date: 01/08/1951 **Drilled Depth:** 46.90 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** Fair
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	TS&CR 9781
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6355990.000 **Latitude:** 32°54'19.5"S
Elevation Source: (Unknown) **Easting:** 248471.000 **Longitude:** 144°18'38.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	43.00	127			
1	1	Opening	Screen	43.00	46.00	89		1	Copper Alloy

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
30.50	32.30	1.80	(Unknown)	30.50					
40.20	42.30	2.10	(Unknown)	30.50					
45.70	46.90	1.20	(Unknown)	30.50		0.38			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.66	3.66	Loam	Loam	
3.66	7.62	3.96	Clay	Clay	
7.62	10.36	2.74	Sandstone Limestone	Sandstone	
10.36	13.41	3.05	Sandstone Clay Bands	Sandstone	
13.41	28.65	15.24	Sand Dry Gravel	Sand	
28.65	35.66	7.01	Sand Drift Clay Bands Water Bearing	Sand	
35.66	46.02	10.36	Clay Sandy Bands Water Supply	Clay	
46.02	46.94	0.92	Drift Water Supply	Invalid Code	
0.00	3.66	3.66	Limestone Stones	Limestone	
3.66	7.62	3.96	Ironstone Rock	Ironstone	

***** End of GW009827 *****

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WaterNSW
Work Summary

GW013811

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date: **Final Depth:** 51.80 m
Completion Date: 01/01/1959 **Drilled Depth:** 51.80 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:** Stock
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 3339
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6352935.000 **Latitude:** 32°55'51.5"S
Elevation Source: (Unknown) **Easting:** 240047.000 **Longitude:** 144°13'11.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	51.20	127			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
29.90	30.20	0.30	Unconsolidated	28.00		0.13			
32.00	32.30	0.30	Unconsolidated	28.00		0.13			
37.80	38.10	0.30	Consolidated	28.00		0.13			
40.80	42.30	1.50	Unconsolidated	27.40		0.25			
50.90	51.80	0.90	(Unknown)	27.40		0.63			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	3.05	3.05	Clay Red	Clay	
3.05	3.35	0.30	Gypsum	Gypsum	
3.35	25.60	22.25	Clay Grey Sand	Clay	
25.60	28.96	3.36	Clay Yellow	Clay	
28.96	29.87	0.91	Clay Yellow Sand	Clay	
29.87	30.18	0.31	Clay Sand Water Supply	Clay	
30.18	32.00	1.82	Clay Yellow Sand	Clay	
32.00	32.31	0.31	Clay Sand Water Supply	Clay	
32.31	35.36	3.05	Clay Yellow Sand	Clay	
35.36	36.58	1.22	Clay Yellow	Clay	
36.58	37.80	1.22	Clay Yellow Sand	Clay	
37.80	38.10	0.30	Sandstone Grey Water Supply	Sandstone	
38.10	39.62	1.52	Drift Grey	Invalid Code	
39.62	40.84	1.22	Clay Yellow	Clay	
40.84	42.37	1.53	Drift Grey Water Supply	Invalid Code	
42.37	50.29	7.92	Clay Yellow	Clay	
50.29	50.90	0.61	Sandstone Yellow	Sandstone	
50.90	51.82	0.92	Sandstone Drift Water Supply	Sandstone	

***** End of GW013811 *****

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WaterNSW
Work Summary

GW019903

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private

Commenced Date:
Completion Date: 01/06/1962
Final Depth: 55.80 m
Drilled Depth: 55.80 m

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 283
Licensed:			

Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6348967.000
Easting: 249898.000
Latitude: 32°58'08.5"S
Longitude: 144°19'26.5"E

GS Map: -
MGA Zone: 55
Coordinate Source: PR.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	-0.30	53.20	152			Suspended in Clamps
1	1	Opening	Screen	52.10	54.80	102		1	A: 0.25mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
39.60	55.10	15.50	(Unknown)	29.30		0.94			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Sand	Sand	
0.91	3.35	2.44	Clay Grey	Clay	
3.35	4.27	0.92	Gravel	Gravel	
4.27	16.76	12.49	Sand	Sand	
16.76	18.29	1.53	Sandstone	Sandstone	
18.29	39.62	21.33	Clay	Clay	

39.62	55.17	15.55	Sand Water Supply	Sand	
55.17	55.47	0.30	Clay	Clay	
55.47	55.78	0.31	Sand	Sand	

Remarks

30/06/1982: 1M OF STONES PLACED IN BASE OF HOLE

***** End of GW019903 *****

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WaterNSW
Work Summary

GW019904

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK
Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private
Commenced Date:
Completion Date: 01/06/1962
Final Depth: 49.40 m
Drilled Depth: 49.40 m
Contractor Name: (None)
Driller:
Assistant Driller:
Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 283
Licensed:			

Region: 70 - Lachlan
River Basin: 425 - DARLING RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6350488.000
Easting: 253965.000
Latitude: 32°57'22.5"S
Longitude: 144°22'04.5"E
GS Map: -
MGA Zone: 55
Coordinate Source: PR.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	Threaded Steel	0.00	46.30	152			Suspended in Clamps

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
43.60	43.60	0.00	Unconsolidated						
46.30	46.30	0.00	Unconsolidated	32.00		0.76			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	0.91	0.91	Topsoil	Topsoil	
0.91	5.49	4.58	Clay Red	Clay	
5.49	13.41	7.92	Clay Grey	Clay	
13.41	32.31	18.90	Clay Sandy	Clay	
32.31	41.45	9.14	Clay	Clay	
41.45	41.76	0.31	Sand	Sand	

41.76	49.38	7.62	Clay	Clay	

***** End of GW019904 *****

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WaterNSW
Work Summary

GW036919

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): MONITORING BORE

Work Type: Bore - Nested (2)
Work Status: Manual Observations,Monthly
Construct.Method: Rotary Mud
Owner Type: NSW Office of Water

Commenced Date: **Final Depth:** 95.00 m
Completion Date: 20/08/1991 **Drilled Depth:**

Contractor Name: DWR GROUNDWATER DRILLING
Driller: Gerard Anthony Smit
Assistant Driller:

Property: **Standing Water Level (m):** 30.360
GWMA: **Salinity Description:**
GW Zone: **Yield (L/s):** 1.500

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	YELTY	931//761988
Licensed:			

Region: 85 - Far West **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 89.33 m (A.H.D.) **Northing:** 6358808.000 **Latitude:** 32°52'46.1"S
Elevation Source: (unknown) **Easting:** 246017.000 **Longitude:** 144°17'06.9"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** Surveyed

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	52.00	200			Rotary Mud
1		Annulus	Waterworn/Rounded	0.00	52.00	200	100		Q:1.000m3
1		Backfill	Backfill	51.00	52.00	200			
1	1	Casing	Steel	-1.20	1.80	200			Cemented, Driven into Hole
1	1	Casing	Pvc Class 12	-1.00	51.00	100			
1	1	Opening	Slots - Diagonal	39.00	45.00	100		1	Sawn, PVC Class 12, SL: 200.0mm, A: 1.50mm
2		Hole	Hole	0.00	92.00	200			Rotary Mud
2		Hole	Hole	92.00	95.00	100			Other
2		Annulus	Waterworn/Rounded	40.00	95.00	100			Q:2.000m3
2		Backfill	Backfill	76.00	95.00				
2	2	Casing	Steel	-1.20	1.80	200			Cemented
2	2	Casing	Pvc Class 12	-1.00	76.00	100			
2	2	Opening	Slots - Diagonal	58.00	70.00	100		2	Sawn, PVC Class 12, SL: 200.0mm, A: 1.50mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
39.00	45.00	6.00	Unknown	30.56		0.50			
58.00	70.00	12.00	Unknown	30.36		1.50			

Remarks

13/10/2008: Nat Carling, 13-Oct-2008: Updated RL's & coordinates, based in info provided in State Water Survey database, provided by Jim Salmon.
31/03/2011: Karla Abbs, 31-Mar-2011: Entered geology log

***** End of GW036919 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW040514

Licence:
Licence Status:

Authorised Purpose(s):
Intended Purpose(s): IRRIGATION

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date:
Final Depth:
Drilled Depth:

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 3339
Licensed:			

Region: 70 - Lachlan
River Basin: 412 - LACHLAN RIVER
Area/District:
CMA Map: 7732
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6360860.000
Easting: 240099.000
Latitude: 32°51'34.5"S
Longitude: 144°13'21.5"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Remarks

06/11/2009: Reviewed data - nothing to update.

***** End of GW040514 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW040560

Licence: **Licence Status:**

Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date: **Final Depth:**
Completion Date: **Drilled Depth:**

Contractor Name: (None)
Driller:
Assistant Driller:

Property: **Standing Water Level (m):**
GWMA: **Salinity Description:**
GW Zone: **Yield (L/s):**

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 2853
Licensed:			

Region: 70 - Lachlan **CMA Map:** 7732
River Basin: 412 - LACHLAN RIVER **Grid Zone:** **Scale:**
Area/District:

Elevation: 0.00 m (A.H.D.) **Northing:** 6350470.000 **Latitude:** 32°57'14.5"S
Elevation Source: (Unknown) **Easting:** 243622.000 **Longitude:** 144°15'26.5"E

GS Map: - **MGA Zone:** 55 **Coordinate Source:** GD.,ACC.MAP

Remarks

06/11/2009: Reviewed data - nothing to update.

***** End of GW040560 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW040561

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK

Work Type: Bore
Work Status:
Construct.Method:
Owner Type:

Commenced Date:
Completion Date: 19/06/1992
Final Depth:
Drilled Depth:

Contractor Name: (None)
Driller:
Assistant Driller:

Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description:
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MANARA	invalid code	WLL 2853
Licensed:			

Region: 70 - Lachlan
CMA Map: 7732
River Basin: 412 - LACHLAN RIVER
Area/District:
Grid Zone:
Scale:

Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6347087.000
Easting: 243944.000
Latitude: 32°59'04.5"S
Longitude: 144°15'35.5"E

GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1		Hole	Hole	0.00	5.50	0			(Unknown)
1	1	Casing		0.00	0.00				

Remarks

06/11/2009: Reviewed data - nothing to update.
16/08/2013: Nat Carling, 16-Aug-2013; Added hole (based on deepest water level reading) & casing details, to enable data migration to HydstraGW.

***** End of GW040561 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

WaterNSW
Work Summary

GW055706

Licence:
Licence Status:
Authorised Purpose(s):
Intended Purpose(s): STOCK
Work Type: Bore
Work Status:
Construct.Method: Cable Tool
Owner Type: Private
Commenced Date:
Completion Date: 01/09/1981
Final Depth: 7.60 m
Drilled Depth: 76.20 m
Contractor Name: (None)
Driller:
Assistant Driller:
Property:
GWMA:
GW Zone:
Standing Water Level (m):
Salinity Description: Good Stock
Yield (L/s):

Site Details

Site Chosen By:

	County	Parish	Cadastre
Form A:	MOSSGIEL	invalid code	WLL 283
Licensed:			

Region: 70 - Lachlan
CMA Map: 7732
River Basin: 412 - LACHLAN RIVER
Area/District:
Grid Zone:
Scale:
Elevation: 0.00 m (A.H.D.)
Elevation Source: (Unknown)
Northing: 6350583.000
Easting: 254093.000
Latitude: 32°57'19.5"S
Longitude: 144°22'09.5"E
GS Map: -
MGA Zone: 55
Coordinate Source: GD.,ACC.MAP

Construction

Negative depths indicate Above Ground Level; C-Cemented; SL-Slot Length; A-Aperture; GS-Grain Size; Q-Quantity; PL-Placement of Gravel Pack; PC-Pressure Cemented; S-Sump; CE-Centralisers

Hole	Pipe	Component	Type	From (m)	To (m)	Outside Diameter (mm)	Inside Diameter (mm)	Interval	Details
1	1	Casing	P.V.C.	0.00	73.50	114			Suspended in Clamps
1	1	Opening	Screen	73.20	76.20	81		1	Stainless Steel, A: 0.25mm

Water Bearing Zones

From (m)	To (m)	Thickness (m)	WBZ Type	S.W.L. (m)	D.D.L. (m)	Yield (L/s)	Hole Depth (m)	Duration (hr)	Salinity (mg/L)
36.60	41.20	4.60	Unconsolidated	31.40					
73.20	76.20	3.00	Unconsolidated	31.40		3.03			

Drillers Log

From (m)	To (m)	Thickness (m)	Drillers Description	Geological Material	Comments
0.00	7.62	7.62	Clay	Clay	
7.62	32.00	24.38	Clay Sandy	Clay	
32.00	36.58	4.58	Clay Variegated	Clay	
36.58	41.15	4.57	Sand Fine Dirty	Sand	
41.15	57.91	16.76	Clay Sandy	Clay	

57.91	64.01	6.10	Clay	Clay	
64.01	73.15	9.14	Clay Sandy	Clay	
73.15	76.20	3.05	Sand Water Supply	Sand	

***** End of GW055706 *****

Warning To Clients: This raw data has been supplied to the NSW Office of Water by drillers, licensees and other sources. The NOW does not verify the accuracy of this data. The data is presented for use by you at your own risk. You should consider verifying this data before relying on it. Professional hydrogeological advice should be sought in interpreting and using this data.

APPENDIX B

LANDHOLDER/LEASEHOLDER CONSULTATION SUMMARY

Appendix B
Landholder Consultation

Ground Water ID	Local Bore Name	Lot	DP	Consultee	Bore Census Findings		
					Status	Location	TDS/Pumping Rate
GW004247	GW004247	56	DP767383	Gregory Turner	In Use.	Confirmed	Unknown
GW006222	GW006222	930	DP761987	Gregory Turner	Not in use.	Confirmed	-
GW006224	GW006224	930	DP761987	Gregory Turner	Not in use.	Confirmed	-
GW006769	GW006769	931	DP761988	Richard Gates	In Use.	Incorrect Location. Corrected to 32551745 S, 144154795 E	4500ppm/ 800G/hr (3,637L/hr).
GW006771	Woolshed Bore	931	DP761988	Richard Gates	In Use.	Confirmed	8000ppm/ 700G/hr (3182L/hr)
GW013811	2 Mile Bore	931	DP761988	Richard Gates	In Use.	Confirmed	4500pm/ 800G/hr (3,671L/hr).
GW036919	GW036919	931	DP761988	Richard Gates	In Use.	Confirmed	-
GW040514	GW040514	931	DP761988	Richard Gates	Not in use.	Confirmed	-
GW040560	GW040560	932	DP761989	Gregory Turner	In Use.	Aerial imagery indicates the bore is incorrectly located and should be relocated to to 32561646 S, 144125645 E	6000ppm
GW019903	Harris Well	4568	DP768560	Gregory Turner	In Use.	Aerial imagery indicates the bore is incorrectly located and should be relocated to 32583832 S, 144185438 E.	1000 to 1200ppm.
GW019904	North Well	4568	DP768560	Gregory Turner	In Use	Confirmed	1000 to 1200ppm.
GW055706	Osbornes Bore	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	In Use	Aerial imagery indicates the bore is incorrectly located and should be relocated to 32581418 S, 144234570 E.	1000 to 1200ppm.
GW006745	GW006745	4568	DP768560	Gregory Turner	Leaseholder did not discuss bore.		
GW007180	Angle Bore	4568	DP768560	Gregory Turner	Leaseholder did not discuss bore.		
GW040561	GW040560	932	DP761989	Gregory Turner	Leaseholder did not discuss bore.		
GW003848	Ivanhoe Railway Bore	56	DP767383	The State of New South Wales	No consultation with landholder.		
GW009827	GW009827	56	DP767383	The State of New South Wales	No consultation with landholder.		
GW006308	GW006308	2140	DP765875	RI, AR Hiscock and MV and LJ Newnham	Leaseholder unable to be contacted.		

TDS = Total dissolved solids

APPENDIX C

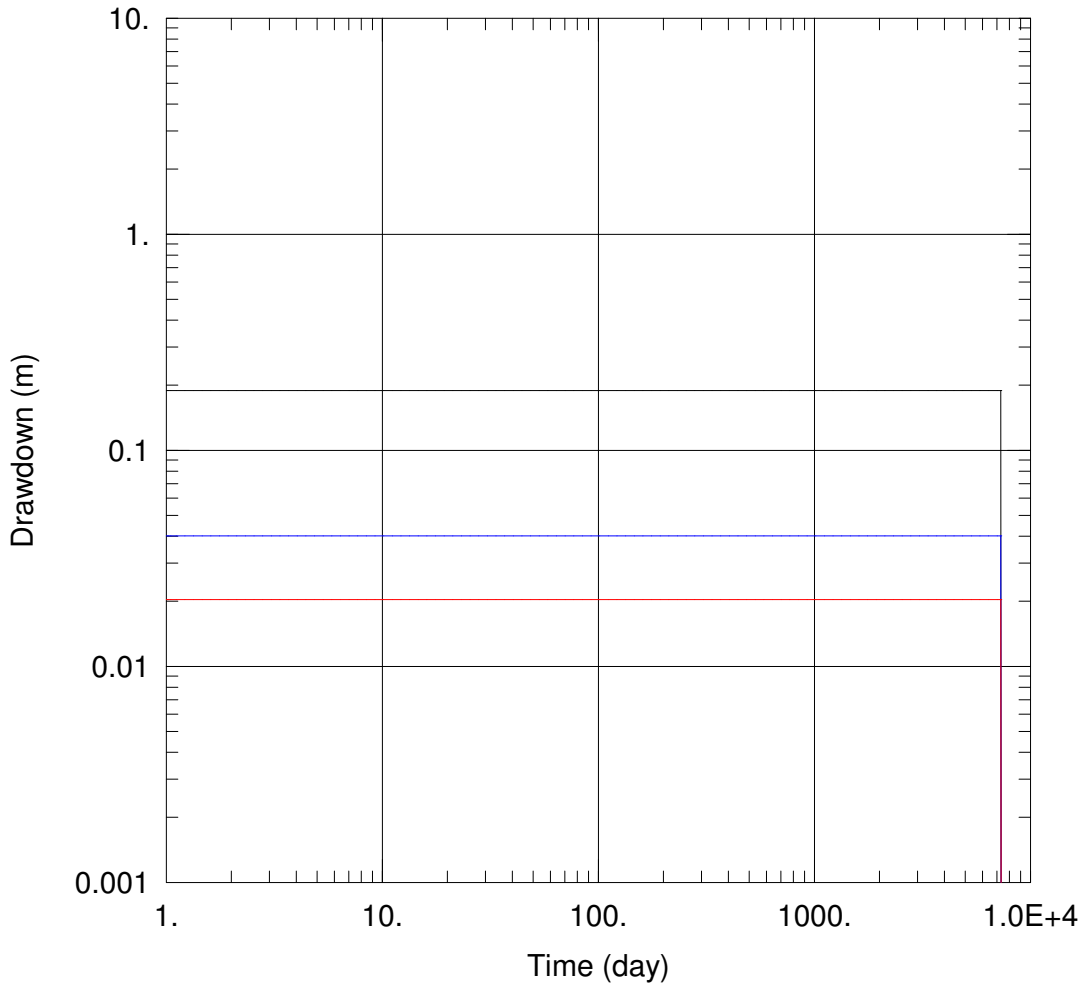
GROUNDWATER BORE CENSUS DATABASE

Appendix C
Groundwater Bore Census Database

Groundwater ID	Local Bore Name	Easting	Northing	Zone (MGA 94)	Lot	DP	Ownership	Intended Purpose	Bore Census Status	SWL (m)	Depth Drilled (m)	Date Drilled
GW003848	Ivanhoe Railway Bore	249265	6355456	55	56	DP767383	The State of New South Wales	Stock	In Use	-	54.9	1/12/1943
GW004247	GW004247	248024	6356164	55	56	DP767383	The State of New South Wales	Stock	In Use	-	63.7	1/06/1909
GW009827	GW009827	248471	6355990	55	56	DP767383	The State of New South Wales	Domestic	In Use	-	46.9	1/08/1951
GW006222	GW006222	234962	6361248	55	930	DP761987	Graham Holbrook Turner and Judith Mary Turner	Stock	Not In Use	-	32.6	1/08/1937
GW006224	GW006224	236899	6359850	55	930	DP761987	Graham Holbrook Turner and Judith Mary Turner	Stock	Not In Use	-	86.3	1/07/1937
GW006769	GW006769	244084	6354091	55	931	DP761988	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	80.2	1/01/1941
GW006771	Woolshed Bore	247048	6359746	55	931	DP761988	Richard Darel Gates and Joanne Dee Gates	Stock	In Use	-	53	1/02/1942
GW013811	2 Mile Bore	240047	6352935	55	931	DP761988	Richard Darel Gates and Joanne Dee Gates	Stock	In Use	-	51.8	1/01/1959
GW036919	GW036919	246017	6358808	55	931	DP761988	Richard Darel Gates and Joanne Dee Gates	Monitoring Bore	In Use	30.36	95	20/08/1991
GW040514	GW040514	240099	6360860	55	931	DP761988	Richard Darel Gates and Joanne Dee Gates	Irrigation	Not In Use	-	-	-
GW040560	GW040560	239676	6352156	55	932	DP761989	Gregory James Turner	Stock	In Use	-	-	-
GW006308	GW006308	251251	6359174	55	2140	DP765875	Robert Ian, Andrew Robert Hiscock and Mark Vivian, Lee Jane Newnham	Stock	In Use	-	54.9	1/01/1938
GW006745	GW006745	251439	6351719	55	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	41.2	1/11/1940
GW007180	Angle Bore	251439	6351719	55	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	47.9	1/02/1946
GW019903	Harris Well	249898	6348967	55	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	55.8	1/06/1962
GW040561	GW040561	243944	6347087	55	932	DP761989	Gregory James Turner	Stock	In Use	-	-	19/06/1992
GW019904	North Well	253965	6350488	55	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	49.4	1/06/1962
GW055706	Osbornes Bore	256633	6348961	55	4568	DP768560	Graham Holbrook Turner and Judith Mary Turner	Stock	In Use	-	76.2	1/09/1981
Key												
	Verified by Leaseholder											
	Outside Bore Census Area											

Attachment B

AQTESOLV Predictive Analyses



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

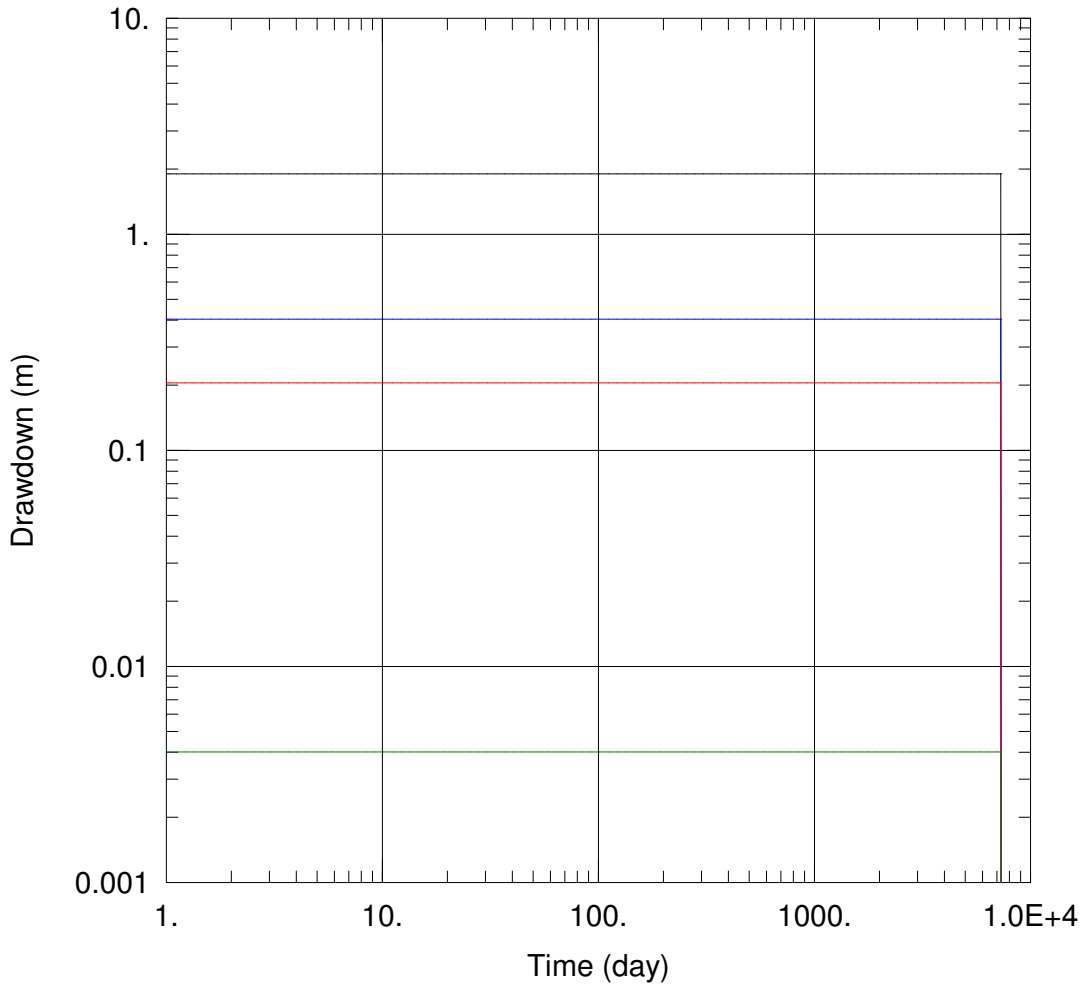
Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 724. m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}

S = 0.0001
ß'/r = 9.16E-5 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

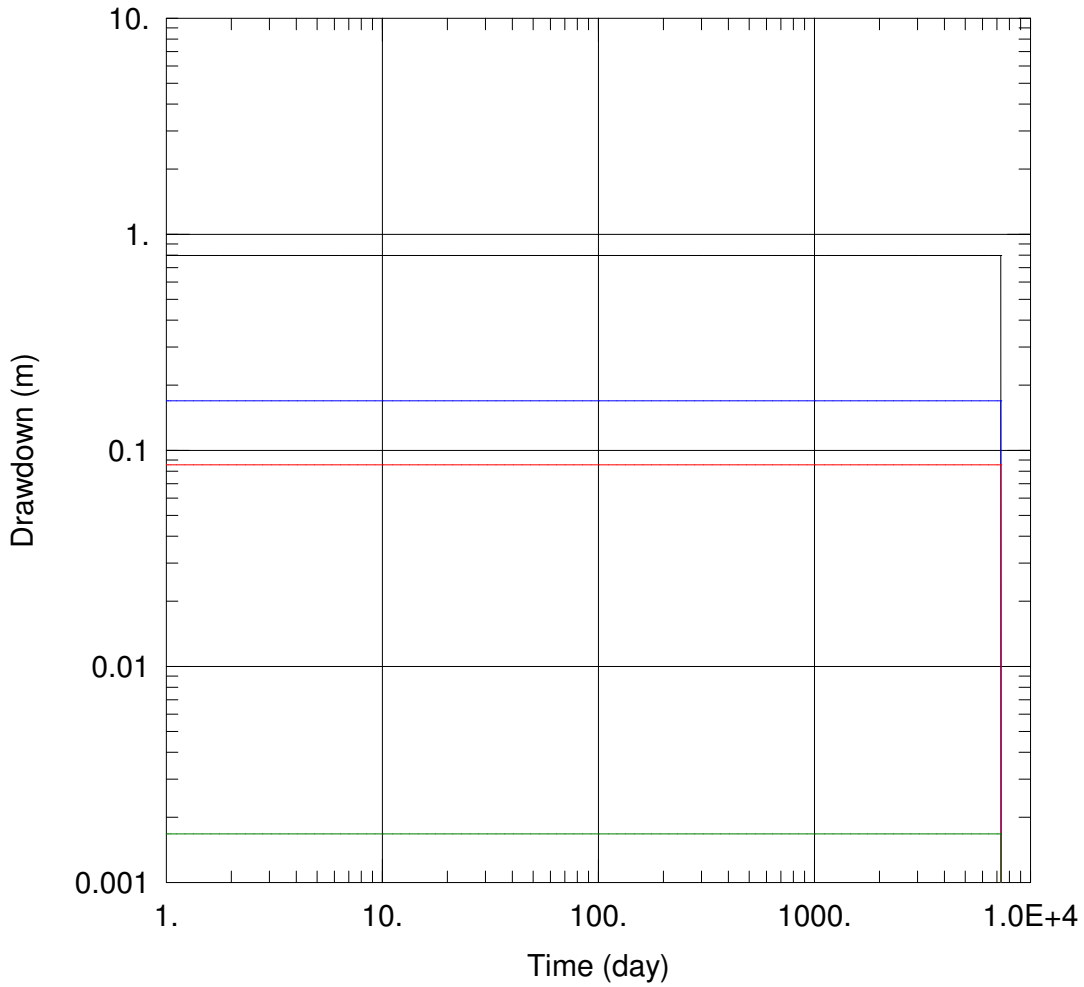
Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 71.81 m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}

S = 0.0001
ß'/r = 0.000291 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

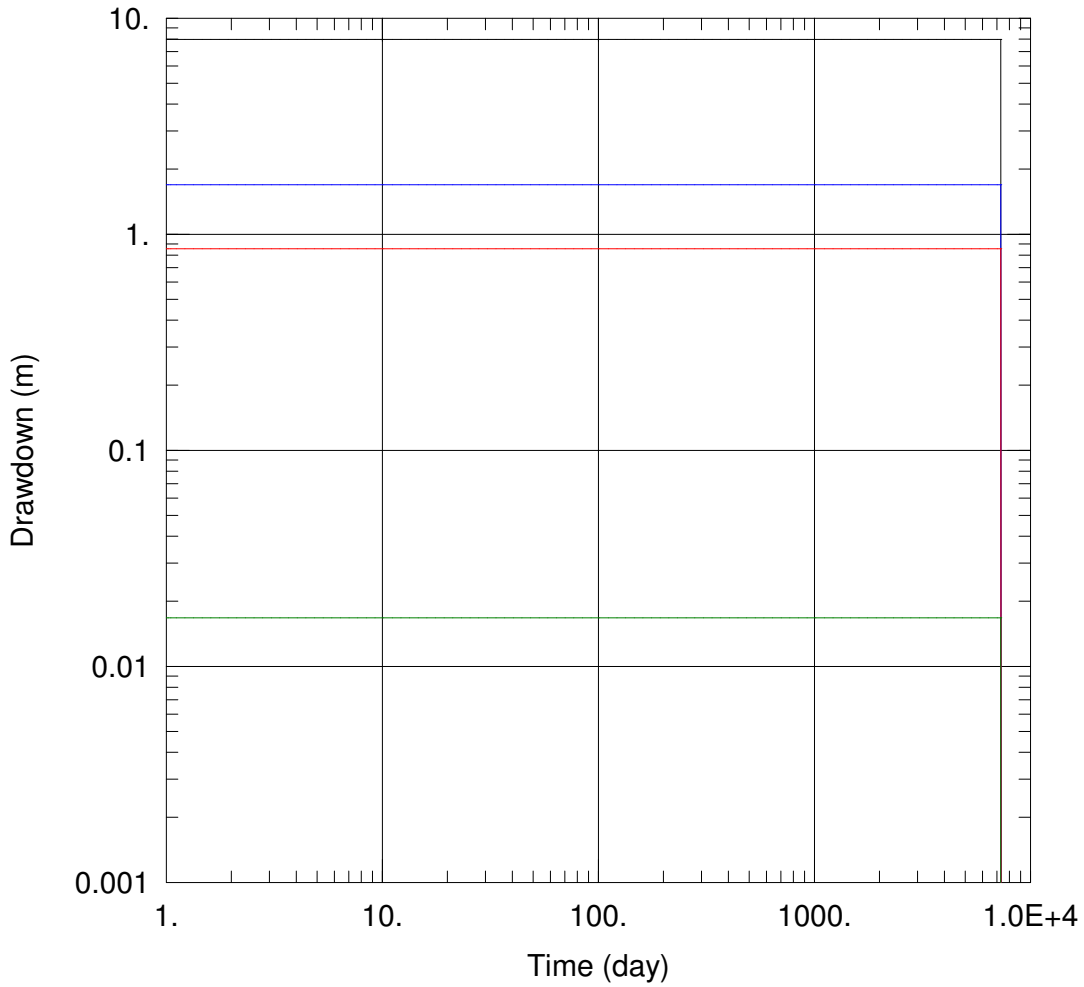
Observation Wells

Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 171.7 m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}
S = 0.0001
ß'/r = 0.000188 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

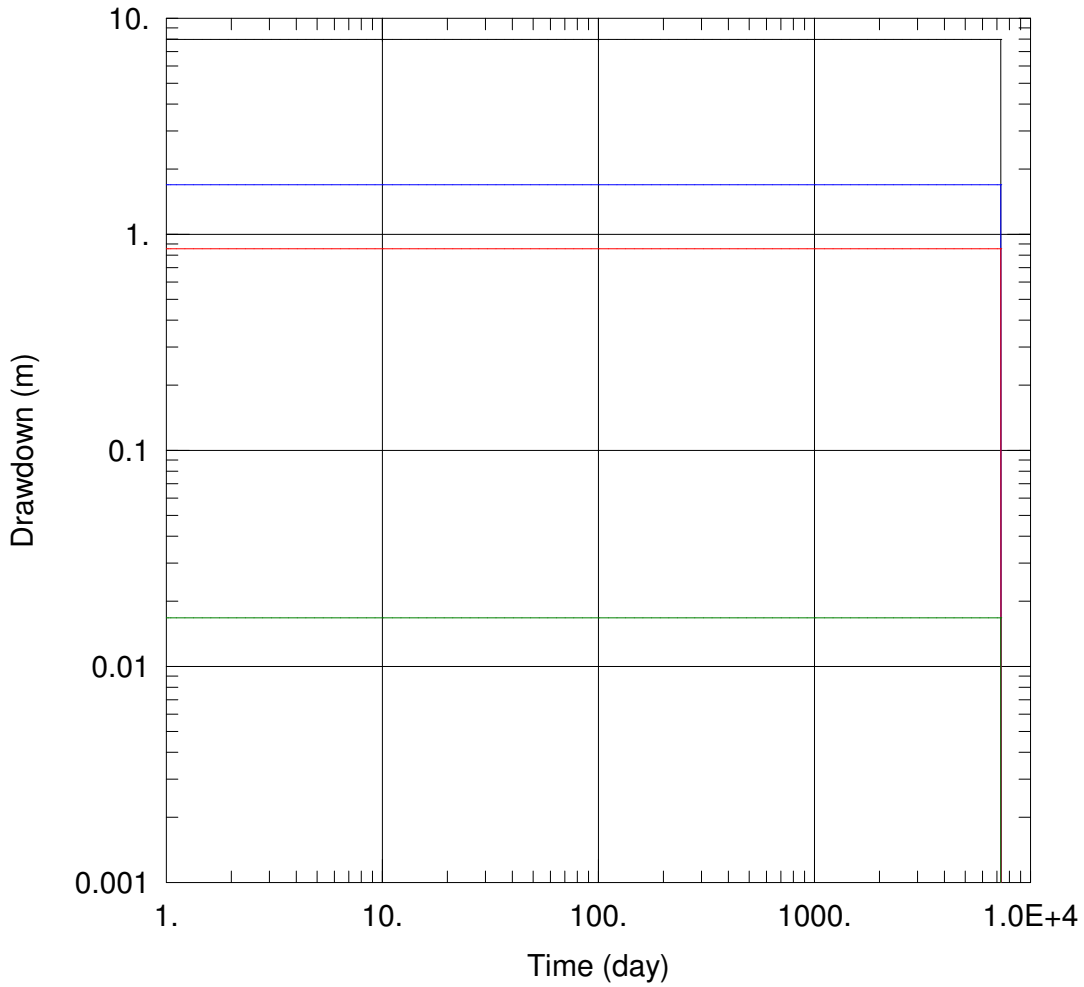
Observation Wells

Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 17.17 m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}
S = 0.0001
ß'/r = 0.000595 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

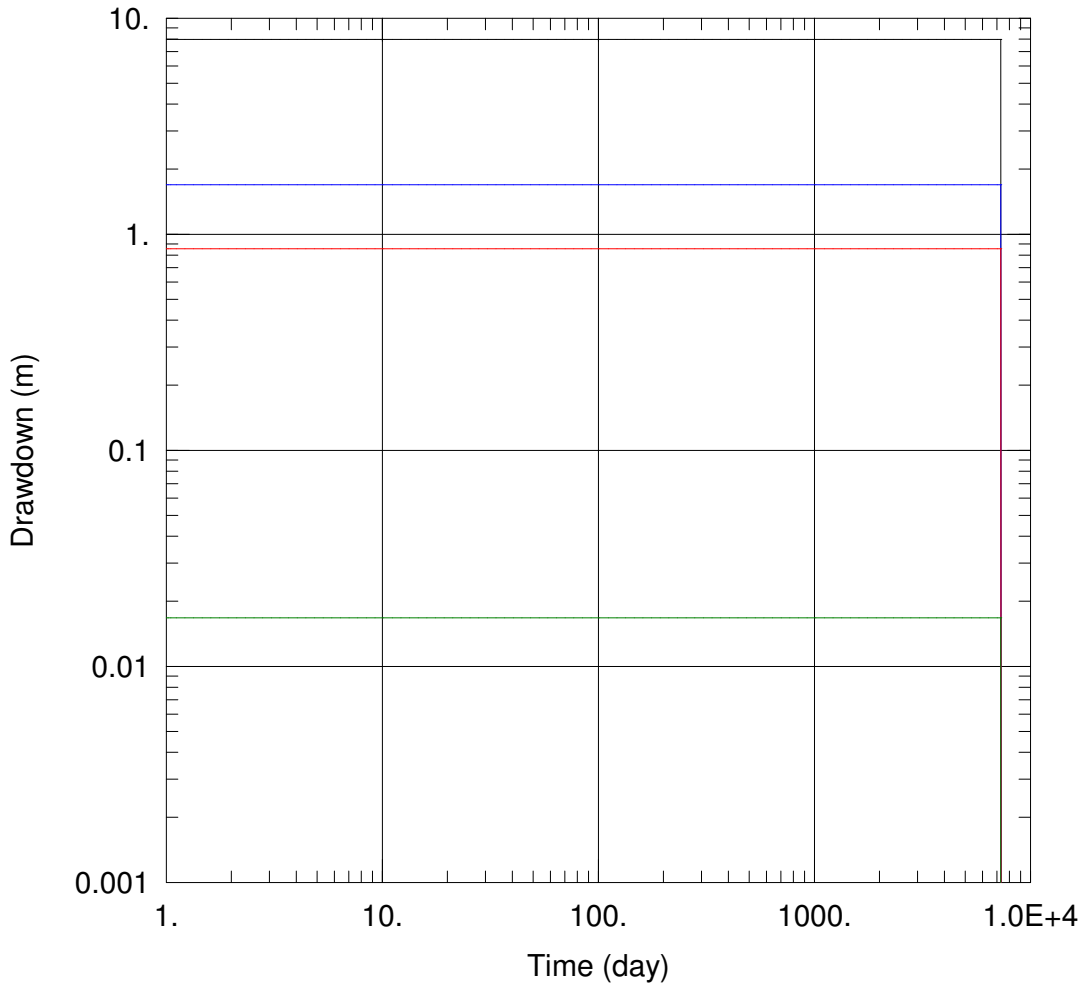
Observation Wells

Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 17.17 m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}
S = 1.0E-5
ß'/r = 0.00188 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

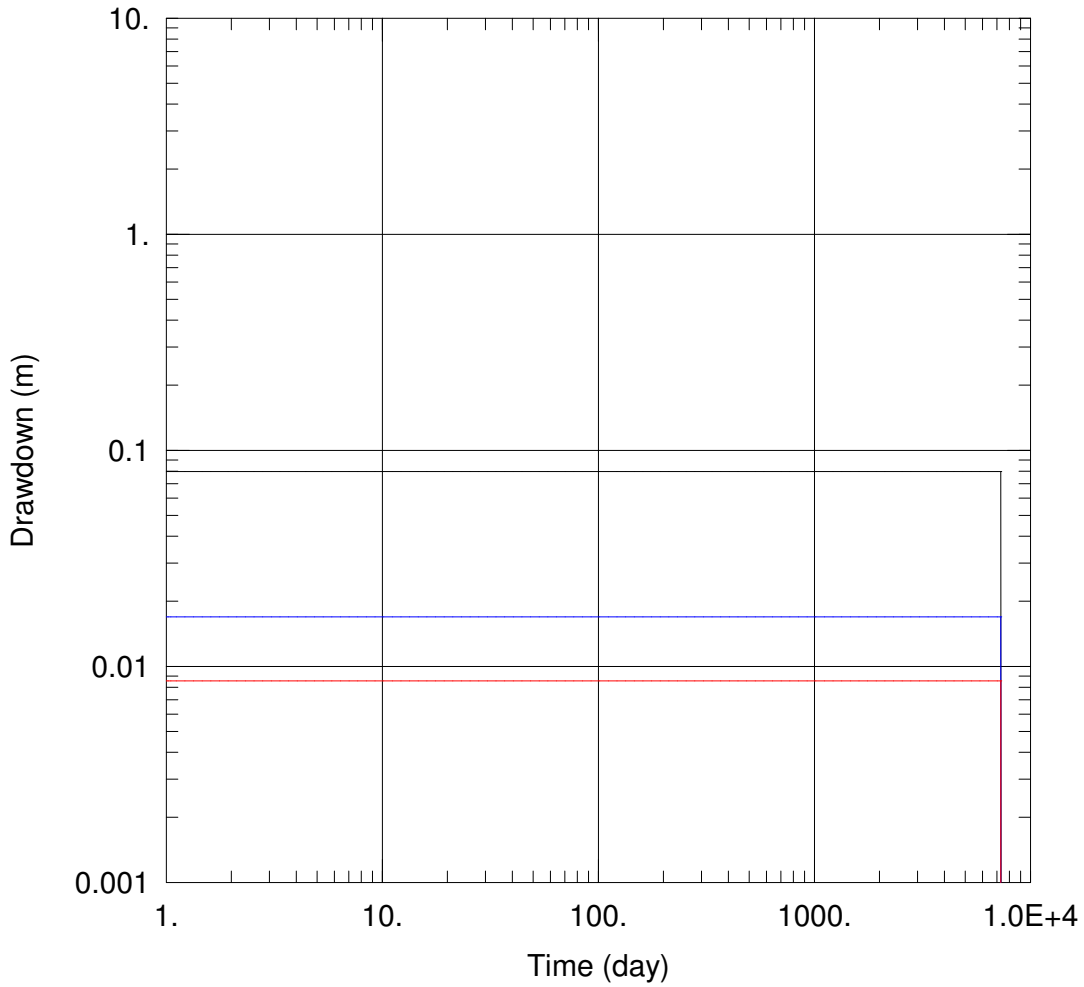
Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 17.17 m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}

S = 0.0001
ß'/r = 0.000188 m^{-1}
ß"/r = 0. m^{-1}



IVANHOE RAIL SIDING BORE

AQUIFER DATA

Saturated Thickness: 11. m
Aquitard Thickness (b'): 10. m
Anisotropy Ratio (Kz/Kr): 0.1
Aquitard Thickness (b"): 20. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
IV1	243126	6355388

Observation Wells

Well Name	X (m)	Y (m)
▫ IV1	243126	6355388
▫ +10	243136	6355388
▫ +20	243146	6355388
▫ +100	243226	6355388

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 1717. m^2/day
1/B' = 0.0401 m^{-1}
1/B" = 0. m^{-1}

S = 1.0E-5
ß'/r = 5.95E-5 m^{-1}
ß"/r = 0. m^{-1}