8. Preliminary Hazard Analysis and Risk Assessment

8.1 General

The probability of accidents associated with the development and implementation of the project is low, given that the design, operating and control measures adopted by Compass will have the specific aim of their prevention. Similarly, natural events of sufficient magnitude to cause significant damage have a very low probability of occurrence.

General safeguards that will be adopted by Compass include:

- Implementation of emergency response plans (including spill contingency) and procedures for accidents and hazardous events (see Section 9.8.1).
- Induction training and periodic refresher training for all employees on all aspects of safety and site-specific by-laws concerning safety.
- Attention to government statutory compliance, notification and liaison procedures.

Nevertheless, a preliminary hazard assessment has been undertaken to identify and assess the key risks of each major component of the project to people (both project-related and the general public), the mining operation and the environment.

A detailed hazard identification and risk assessment that is consistent with DPIFM's Advisory Note ENG 509 (DBIRD, 2005) in terms of both construction and operation activities will be undertaken before these activities commence [C].

8.2 Risk Identification and Analysis

Hazard identification was based on experience gained by the project team in the development and operation of similar projects in similar environmental and social settings. Qualitative risk analysis was based on the method outlined in Standards Australia HB 203-2004 (Standards Australia, 2004), and took into account both the likelihood and consequence of the various risks. Four levels of risk were identified:

- Extreme—the development of strategies to reduce or mitigate the level of risk is of the highest priority.
- High-high priority; management attention to develop strategies is still required.
- Medium-moderate priority; management responsibility must be specified.
- Low—these risks fall within the bounds of normal project parameters that can be managed by routine procedures and processes.

8.3 Risk Evaluation

The assessment process resulted in the identification and evaluation of 19 risks that warrant particular comment over and above that presented in Chapter 7. These are listed at the end of this chapter in Table 8.1, which also includes mitigative and preventative controls, and the residual risk after taking these controls into account.

No risks were identified in the extreme risk category.

Three risks (all related to fire) were identified in the high-risk category, with another six falling in the medium-risk category. These are discussed below.

8.3.1 Fire (High Risk)

Mining and ore processing operations, including the storage and handling of flammable substances such as those involved in the solvent extraction process at Browns, can lead to the generation of potentially explosive and/or flammable gas emissions. Potential environmental impacts may include breakout of fire into surrounding vegetation, release of significant quantities of air emissions and contaminated runoff from firewater. Other impacts include damage to property and injury, as well as possible plant shutdown.

Similarly, the project may be subjected to bushfire that originates from elsewhere in the area.

Detailed project design will address specific plant and facility design criteria for fire prevention, detection, control and personnel safety requirements [C]. Other measures to reduce this risk are described in the Fire Management Plan (Section 9.8.2) and address matters such as:

- Appropriate induction and training of personnel.
- Procurement of fire equipment adequate for the level of risk identified for the project and regularly maintained and tested to ensure good working order.
- Storage and handling of all substances, including waste, under conditions that minimise the risk of fire, explosion or toxic emissions, with specific measures that address the use of solvent-extraction reagents.
- Implementation of specific procedures for high-risk tasks such as 'hot work' (e.g., welding) and use of chainsaws.
- Liaison (e.g., Northern Territory Bushfire Council) and monitoring (e.g., fire danger ratings).

8.3.2 Pit Flooding (Medium Risk)

The project (and particularly the pit) is located close to the East Finniss River and in an area that receives monsoonal rain. Flooding as a result of an extreme rainfall event and possible flood flow in the river, and/or excessive groundwater inflows, is therefore a possibility that must be considered, although this risk will be minimised by measures such as groundwater level monitoring and ensuring adequate maintenance of pumps (see Table 8.1).

In addition to disrupting operations and posing a potential risk to the safety of mine employees, such flooding would result in the eventual need to dispose of large volumes of water likely to contain elevated levels of suspended solids and, potentially, PAF material. Unless managed effectively, this could adversely affect downstream environmental values, although this must be evaluated within the context of the already-degraded East Finniss River. Compass therefore proposes to manage this water taking into account the following:

- Discharge of this water into the East Finniss River at high flow is likely to have reduced impacts due to the already-elevated TSS concentrations in top end streams under these conditions and the dilution that is available at high flow.
- Compass will monitor the quality of this water prior to discharge and, if necessary, treat it. Treatment could include flocculant addition, pH adjustment and/or diversion through the main sedimentation trap.

Ongoing geotechnical assessment of pit wall stability and, if necessary, implementation of measures to improve wall stability in case of pit flooding will minimise the likelihood of massive failure of the wall should such flooding occur.

8.3.3 TSF Failure (Medium Risk)

The project is located in an area that has an earthquake hazard risk as measured by the acceleration coefficient of 0.05 to 0.1 (Geoscience Australia, 2005). This means that, in any 50-year period, there is a 90% chance that the peak ground acceleration¹ will not exceed 0.05 to 0.1. This value may be compared to some more seismically active areas of Australia where acceleration coefficients greater than 0.1 apply². Therefore, seismic activity (within the Australian context) in the area, and the associated risk, is considered to be moderate.

No known major active faults, which control the location and occurrence of earthquakes, occur at the project site and the nearest recorded earthquakes to the project area are (Geoscience Australia, 2005):

- A 0 to 2.5 magnitude earthquake approximately 40 km away.
- A 0 to 2.5 magnitude earthquake approximately 70 km away.
- Two 3.5 to 4.5 magnitude earthquakes located 50 to 60 km away.

None of these events would have posed a threat to the security of the TSF.

Nevertheless, the possibility of TSF failure is considered in Appendix 8, where an initial consequence category of High C has been adopted under ANCOLD³ guidelines

¹ Peak ground acceleration is a dimensionless coefficient of acceleration that is used by civil engineers to estimate forces on structures.

 $^{^{2}}$ The higher the value of the coefficient, the higher the risk of earthquake occurrence.

³ Australian National Committee on Large Dams.

(Appendix 8) due to the location of the storage facility next to the plant area and the importance of the TSF to the viability of the overall project. The design of embankment structures to accommodate earthquake loads will be based on ANCOLD Guidelines for Design of Dams for Earthquake, and specific minimum requirements will be met concerning flood requirements, stability under seismic conditions, monitoring and surveillance of performance. An appropriate design earthquake acceleration for a dam having a consequence category of 'High C' would be an annual exceedance probability of around 1 in 1000.

If an earthquake of sufficient magnitude were to occur during operations, the inner slope of the embankment may fail and slide into the TSF. However, this failure is unlikely to extend back to encompass the whole of crest of the embankments and tailing would probably not be released. As the tailing level rises and buttresses the inner embankment slopes, the potential for failure decreases since the tailing provides increased support. Once the TSF is full, failure of inner slopes cannot occur.

The majority of the embankment will be constructed from compacted rockfill, which is relatively resistant to deformations in seismic events, particularly in low-height embankments such as the subject site.

However, should the outer slopes fail, it is possible that the embankment would breach and the less-consolidated tailings could be released. If failure is accompanied by significant rainfall, then tailing solids could be washed into the East Finniss River, with consequent adverse impacts on water quality due to both solids and, possibly, metals. In addition, PAF material that is encapsulated within the embankment could report to downstream watercourses.

It is worth noting that the severe consequences associated with TSF failure in recent years at operations in countries other than Australia are most unlikely to occur at the Browns Oxide Project due to the incorporation of a range of safeguards. These include overall method of embankment construction (i.e., by downstream raising), design and construction of the embankments to be stable up to the design event, controlled discharge of excess water during extreme events (via an emergency spillway), supervision of TSF construction by appropriately qualified personnel, TSF structural inspections, and other measures as detailed in Table 8.1.

8.3.4 Generation of ARD (Medium Risk)

As indicated in sections 4.9 and 4.10, some of the waste rock is likely to be PAF while the black shale tailing has also been classified as PAF. Geochemical analysis of the material has also identified elevated concentrations of metals such as copper, lead, cobalt and arsenic, that are potentially problematic in terms of the quality of drainage from the TSF.

Successful implementation of the management measures described in sections 4.9 and 4.10, e.g., selective handling and encapsulation of PAF waste rock, and rapid burial of PAF black shale tailing under successive layers of deposited material, will result in a low likelihood of significant volumes of ARD being generated. However, the consequences of ARD (should this occur to a significant extent), particularly as the time period involved could extend beyond mine closure, have resulted in an overall classification of this risk as 'medium' (taking into account the already degraded nature of the East Finniss River).

Management of PAF wastes will therefore be an ongoing, high-priority focus during project development and implementation.

8.3.5 Fuel Leakage/Spillage (Medium Risk)

Spillage of fuels or lubricants, either from routine usage of the fuels or accidental spillage or leakage from, and ruptures of, storage vessels, will have the potential to cause environmental damage.

Minor spillage of fuel and lubricant, such as during vehicle maintenance and refuelling, will be safeguarded against through bunding and a high level of operator training, supplemented by measures such as regular inspections and monitoring. Major spills that result from tank rupture will be contained by bunding, which will be constructed in accordance with the relevant standards and codes (see Section 4.15).

Measures to address hydrocarbon spills/leakages are described in the Waste Management Plan (Section 9.8.7). Any minor spillage at the process plant will be cleaned up by the application of loose sorbent material and disposed of by incineration. Hydrocarbon spills will be reported through the incident reporting management system to Compass management, government authorities and emergency services as required. The response to major spills is described in the Emergency Response Plan (Section 9.8.1).

8.3.6 Chemical Leakage/Spillage (Medium Risk)

Chemical spillage could occur during unloading, transfer to the process feed storage, or mixing.

Major areas containing hazardous materials will be designed to contain spills within the area, in order to prevent the possible mixing of acidic and alkaline materials. All areas subject to possible spills or leakage will be bunded (to collect washdown and rainwater) and will drain to sumps from where the spillage can be returned to the appropriate part of the process.

During the design phase, detailed training manuals will be prepared specifically for the Browns Oxide Project. All workers will be required to undergo formal training before commencing work at the mine or process plant. This will include specific safety training dealing with chemical safety, as well as ensuring familiarity with MSDSs and the more general safety aspects of the operation. Additional specialised training will be provided to operators with specific process or material handling jobs.

Measures to address chemical spills/leakages are described in the Hazardous Materials and Waste Management Plan (Section 9.8.7). Any minor spillage at the process plant will be cleaned up in accordance with MSDS requirements. Chemical spills will be reported through the incident reporting management system to Compass management, government authorities and emergency services as required. The response to major spills is described in the Emergency Response Plan (Section 9.8.1).

8.3.7 Vehicle Collision/Roll-over (Medium Risk)

The potential exists for vehicles bringing reagents, supplies and similar to the site to be involved in an accident. This could result in release of product, hydrocarbons or chemicals with consequent adverse impacts on the environment, and/or injury or fatality.

Contractors will be required to comply with Compass's procedures and the relevant codes and standards for transport, storage and handling of hazardous materials (including emergency response). Similarly, contractors will be required to adhere to Northern Territory road rules.

Fuel trucks will carry equipment necessary to respond to an accident that may result in a spill. In the event that product is spilt during transport, the material will be excavated and recovered as quickly as possible. The General Manager will be notified immediately of spills that occur during transport and Compass will then notify the relevant authorities.

Should fuel or product come into contact with surface drainage, water quality will be monitored to ensure that the area is appropriately remediated, if necessary.

It should be noted that, while a number of risks involve a possible fatality (see Table 8.1), i.e., a severe consequence, only the vehicle collision/roll-over is given a rating greater than 'low'. This reflects the increased likelihood of such an event occurring relative to events such as pit wall failure or explosions.

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Mine Component	Hazard	Hazard No.	Incident/Event	Potential Consequence/Impacts	Mitigation and Prevention Measures	Potential Offsite Impact?	Qualitative Risk
Mine pit	Pit wall failure	F .	Failure due to seismic activity, geotechnical instability or groundwater pressure.	Injury/fatality. Disruption to operations.	Material constrained to the confines of the pit. Design of pits slopes, bench heights and berms. Stability monitoring, e.g., pins, ongoing geotechnical and hydrological review. Dewatering, i.e., control of water behind pit walls.	°Z	Low
	Flooding	1.2	Pit floods as a result of extreme rainfall or flood event, excessive groundwater inflows or failure of dewatering system.	Disruption to operations. Large volume of water requiring disposal. Contaminated pit water enters watercourse. Pit wall instability.	Weather monitoring. Groundwater level monitoring. River/pit water level monitoring. Maintenance of pumps. Stability monitoring, e.g., pins, ongoing geotechnical and hydrological review.	Yes	Medium
	ARD	د ن	ARD is generated as a result of exposure of reactive sulfides in pit wall/floor.	Contaminated pit water enters watercourse.	No mining of primary ore. Pumping pit water to main sedimentation dam for use in the process plant. Treatment prior to discharge from main sedimentation dam. Rapid flooding of pit on closure.	Yes	Low
	Mobile mining equipment collisions or rollover	1.4	Accident involving single, multiple vehicles or pedestrians.	Injury/fatality.	Operator induction and training. Flashing lights. Reversing horns. Night lighting.	°Z	Low

Table 8.1 Preliminary hazard analysis

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8. Preliminary Hazard Analysis and Risk Assessment

Mine Component	Hazard	Hazard No.	Incident/Event	Potential Consequence/Impacts	Mitigation and Prevention Measures	Potential Offsite Impact?	Qualitative Risk
Mine pit (cont'd)	Post-closure pit wall failure into flooded pit	1.5	Post-closure failure of pit wall results in water in the already flooded pit overtopping the walls.	Contaminated pit water enters watercourse.	Pit wall and berm design. Post-closure pit water quality monitoring.	Yes	Low
TSF and associated infrastructure	Embankment failure	2.1	Failure due to seismic activity, overtopping embankment/spillway results in release of tailing solids and liquid.	Exposure of PAF material in embankment walls with subsequent oxidation and onset of acid conditions. Tailing solids and/or contaminated water enters watercourse.	Downstream construction of embankment raises. TSF structural inspections. Daily decant level monitoring. Supervision by qualified engineer during construction. Development of detailed TSF operating procedures. Development of contingency plans. Engineered capping on closure.	Yes	Medium
	Tailing pipeline failure	2.2	Failure due to seismic activity, structural failure or heavy equipment damage.	Release of tailing slurry to vegetation. Release of tailing slurry to watercourse.	Bunding. Emergency containment ponds. Monitoring pipeline flow. Development of contingency plans.	Yes	Low
	ARD	2.3	Significant volumes of ARD are generated from waste rock (placed in the TSF embankment) and/or tailing.	Contaminated water enters watercourse.	Encapsulation of PAF material in TSF embankment. Minimal atmospheric exposure of PAF tailing during operations. Engineered capping on closure. Monitoring.	Yes	Medium

Table 8.1 Preliminary hazard analysis (cont'd)

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	Poten Offsi Impae	Yes	Yes	Υes
(2)	Mitigation and Prevention Measures	Location of stockpile. Appropriate dumping practices. Drainage control. Development of recovery plan.	Bunding. Monitoring pipeline flow. Monitoring tank levels. Development of contingency plans.	Compliance with standards for the storage and handling of explosives and flammable material, including: - Buffer zones. - Fire detection requirements. - Fire control equipment. - Ignition free zones. Specific measures for the use of solvent-extraction reagents. Regular maintenance and testing of fire equipment. Regular fire response training. Development of fire management plan and emergency response plan.
	Potential Consequence/Impacts	Smothering of vegetation. Surface water contamination.	Release of process water, hydrocarbons or other chemical. Surface/ground water contamination. Fire or explosion.	Escape of fire into surrounding vegetation. Release of air emissions. Contaminated runoff from firewater enters watercourse. Injury/fatality.
	Incident/Event	Failure due to seismic activity or changed material properties (e.g., moisture content).	Exceedance of design criteria.	Ignition of flammable material.
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	Hazard	Stockpile failure	Tank or pipeline rupture or breach	Fire and explosion
	Mine Component	Stockpiles	Process plant	Process plant and magazine

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Mine Component	Hazard	Hazard No.	Incident/Event	Potential Consequence/Impacts	Mitigation and Prevention Measures	Potential Offsite Impact?	Qualitative Risk
Confined spaces	Irrespirable atmosphere	9	Entering confined space without appropriate safety equipment.	Injury/fatality. Mill shut-down.	Standard procedures for operating in confined spaces.	No	Low
Chemical storage and handling facilities Maintenance facilities	Fire and explosion	7.1	Ignition of flammable material.	Escape of fire into surrounding vegetation. Release of air emissions. Contaminated runoff from firewater. Injury/fatality.	Minimal flammable material to be stored on site. Other measures as described for hazard no. 5.	Yes	High
	Fuel leakage/spillage	7.2	Spillage during tanker unloading or leakages from tanks.	Fire and explosion. Soil contamination. Surface water contamination. Groundwater contamination.	Regular inspection of tanks, pipes, connections and bunds. Soil and groundwater monitoring. Operator training. Spill response training. Spill response training. Spill response training and located in appropriate areas. Development of waste management plan. Development of emergency response plan (including spill contingency).	Yes	Medium

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Mine Component	Hazard	Hazard No.	Incident/Event	Potential Consequence/Impacts	Mitigation and Prevention Measures	Potential Offsite Impact?	Qualitative Risk
Chemical storage and handling facilities Maintenance facilities (cont'd)	Chemical leakage/spillage	7.3	Spillage during unloading, transfer to process feed storage or mixing.	Release of chemical resulting in surface water and ground contamination. Release of gases.	Storage that prevents possible mixing of acidic and alkaline materials. Bunding with washdown and runoff collection systems. Use of appropriate protective clothing during handling. Operator training for mixing and use of chemicals. Spill response training. Management in accordance with MSDS. Development of waste management plan. Development of emergency response plan (including spill contingency).	Yes	Medium
Services	Powerlines	ω	Mobile equipment contact with powerlines.	Fire. Injury/fatality.	Overhead lines marking and signage.	Yes	Low
Transport activities	Vehicle collision or roll-over	σ	Road accident.	Release of product, hydrocarbons or chemicals to the environment. Fire or explosion. Injury/fatality.	Compliance with appropriate statutory standards for the transport of hazardous materials. Adherence to speed limits (where applicable) and road rules.	Yes	Medium

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Mine Component	Hazard	Hazard No.	Incident/Event	Potential Consequence/Impacts	Mitigation and Prevention Measures	Potential Offsite Impact?	Qualitative Risk
Transport activities (cont'd)					Develop emergency response plan (including spill contingency). Trim roadside vegetation to increase line of sight. Maintenance schedule for all vehicles.		
Entire mine site	Fire	10.1	Fire started within the project area or entering the project area from offsite.	Disruption to operations. Vegetation damage. Explosion. Release of air emissions. Contaminated runoff from firewater. Injury/fatality.	Weather monitoring. UHF communications on site. Fire extinguishers on board all vehicles. Other measures as described for hazard nos. 5 and 7.1.	Yes	High
	Flooding	10.2	Flooding caused by extreme rainfall event and/or flood flows in the East Finniss River (and its tributaries).	Disruption to operations. Injury/fatality. Large volume water requiring disposal.	Weather monitoring. Groundwater level monitoring. Maintenance of pumps. River/pit water level monitoring.	Yes	Low

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