ENVIRONMENTAL SCIENCE LANDSCAPE ARCHITECTURE SPATIAL PLANNING

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PO Box 6915
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Dear Sean

RE: FLORA AND VEGETATION IMPACT ASSESSMENT FOR DEWATERING AT FORTESCUE CLOUDBREAK MINE

Background and Introduction

The following is an assessment of the impacts of mine dewatering on flora and vegetation at the Cloudbreak mining operation resulting from Fortescue Metals Group's (FMG's) proposal to increase its water abstraction licence from 15G/L per annum to 40-60G/L per annum. FMG is seeking a Section 45c amendment to its current licence conditions from the EPA to approve this increase.

To facilitate this approval FMG engaged Ecoscape (Australia) Pty Ltd to undertake an assessment of the impacts on flora and vegetation in the Cloudbreak area associated with the proposed increase in mine dewatering and resultant groundwater drawdown. In particular this assessment focused on the impacts of groundwater drawdown on deep rooted groundwater dependent (phreatophytic) vegetation and the mounding impacts on Mulga (*Acacia aneura*) as a result of freshwater re-injection. An assessment of the impacts of dewatering on samphire communities associated with the Fortescue Marsh area is being undertaken by Greg Barrett and Associates.

FMG has proposed that any freshwater derived from the dewatering process not utilised in the "use at source" (e.g. dust suppression etc) or transfer strategies will be re-injected into the borefields to the east and west of the mining area. It is anticipated that up to 70% of the freshwater abstracted during the dewatering process will be re-injected into the borefield.

Methods

The assessment is based on a comprehensive and extensive desktop review of available relevant literature relating to impacts of groundwater drawdown and mounding on phreatophytic tree and plant species and Mulga with a particular focus on the species and communities occurring in the Cloudbreak area. In addition FMG

has provided Ecoscape with a model of the Simulated Regional Groundwater Levels, Drawdown and Mounding for Three Years Dewatering and Injection Operations (FMG 2009). This model has been used in conjunction with the vegetation community mapping taken from the Mattiske Flora and Vegetation Survey report (Mattiske 2005) to provide the basis for the assessment of drawdown and mounding impacts on vegetation from the proposed mining.

The assessment undertaken comprises:

- A comprehensive literature review and desktop assessment of available data
- Data assessment and interpretation, development of conclusions

Data Sources

Relevant information and data sources reviewed as part of this assessment include the following:

- Pilbara Iron and Infrastructure Project Cloud Break Public Environmental Review (PER) (Environ and FMG, 2005), including Appendix C - Hydrogeology Report (Aquaterra Consulting) including digital data interrogation of drawdown predictions, Appendix D - Flora and Vegetation (Mattiske), Appendix F – Likely Impact of Drawdown from the Cloud Break Operations on Vegetation Communities (Barrett, 2005)
- Cloudbreak Hydrogeological Assessment (FMG, 2009)
- Assessing the Cumulative Effects of Water Management by the Mining Industry in Rangeland Environments (URS, 2008)
- Review of Potential Pheatophytic Vegetation in FMG Project Area (Biota, 2004)
- Walters Vegetation of the Earth (Walter, Breckle and Lawlor, 2002)
- Cloudbreak Hydrogeological Assessment (FMG, 2009)
- Marandoo Mine Phase 2 Public Environmental Review (Rio Tinto, 2008)
- Water Flow in Mulga Areas Adjoining Fortescue Marsh (Muller, 2005)
- Marandoo Mulga Monitoring 2000-2007 (Batini, 2008a)
- Report on Coolibah Survey Results on Bruce Flat, Marandoo (Batini, 2008b)
- Flora and Vegetation on the Cloudbreak and White Knight Leases (Mattiske, 2005)
- Flora and Vegetation of Fortescue Marshes (Mattiske, 2007)
- Coordinated research programme on saline agriculture (Ahmad, 1988)
- Pilbara Mulga Study Stage 1 (Fortech, 1999)

- An Inventory and Condition Survey of the Pilbara region, Western Australia. Technical Bulletin No. 92, (Department of Agriculture, 2004)

- Biodrainage - Principles, Experiences and Applications (Heuperman *et al,* 2002)

Regional Hydrogeology

Groundwater movement within the Cloudbreak area is primarily driven by rainfall recharge on the elevated flanks of the Fortescue Valley and the surrounding Chichester Ranges. This movement drives the flow of groundwater in a southerly direction towards the Fortescue Marshes. Depth to groundwater along the flanks of the Fortescue Valley is typically 20m or more (at the end of the dry season). Data collected and provided by FMG from monitoring bores (shallow and deep) within the proposed drawdown area and to the south, west and east of the area indicates that levels range from 0.08m near the Fortescue Marsh to 21.58m along the flanks of the Fortescue Valley (see attached Map 1).

Predicted Groundwater Drawdown Modelling

In February 2009, FMG prepared a model of the predicted drawdown of groundwater levels associated with the proposed increase in mine dewatering at Cloudbreak. The model also included the predicted increase in groundwater levels associated with the re-injection of freshwater derived from dewatering into borefields to the east and west of the mining areas and saline water to the south of the mine area. The model simulation of the Cloudbreak three year mine plan provided the following results (FMG, 2009):

- Dewatering volumes both fresh and saline will increase from the current 30,000kL/d to 160,000 kL/d by mid 2010, before declining to 130,000 kL/d
- Re-disposal of the dewater to re-injection borefields will result in minimal change to groundwater levels near the Marsh
- Dewatering will result in drawdown of up to 34m (in mine pit)
- Mounding of groundwater into the re-injection borefields will result in water level rises of up to 8m at point of recharge

Impacts of Phreatophytic Vegetation

By overlaying FMG's simulated regional groundwater levels model drawdown contours over the Mattiske (2005) vegetation mapping only one community dominated by vadophytic (vegetation that utilises water in the unsaturated zone above the watertable) to weakly phreatophytic vegetation (species that rely on consistent access to the watertable) was identified within the drawdown zone as potentially being adversely impacted over the three year dewatering period:

1. Open Woodland of *Eucalyptus victrix*, *Eucalyptus camaldulensis* var. *obtusa* with pockets of *Acacia coriacea* subsp. *pendens* over *Grevillea wickhamii* subsp. *aprica, Petalostylis labicheoides*, *and Acacia tumida* over *Triodia longiceps, Chrysopogon*

fallax, Themeda triandra and *Aristida* species. This community is associated with creek and drainage lines within the assessment area (see attached Map 1).

Several areas within the drawdown "area of influence" in the vicinity of the Cloudbreak mine supporting this community occur (predominantly to the immediately north, northwest and northeast of the Cloudbreak mine). Coolibah (*Eucalyptus victrix*) and River Red Gum (*Eucalyptus camaldulensis*), which are dominant components of this community, are both vadophytic to weakly phreatophytic (Coolibah) and phreatophytic (River Red Gum) species but the extent to which they are phreatophytic is dependent on local groundwater conditions. However, while Coolibah may utilise groundwater when available, it is not necessarily reliant on it for survival and reproduction. The root system structure of Coolibah is closely related to the local hydrological condition of an area (Rio Tinto, 2008), is tolerant to long periods without flooding or readily available water (Muir Environmental, 1995) and has a dimorphic root system, with extensive, dense superficial root system spreading beyond the width of the tree canopy with one or several tap roots, which are known to be not well developed (Adams *et al,* 2005).

A characteristic of River Red Gum is the rapid development of an extensive, dense and deep taproot system that extends down towards zones of higher water supply (Bren, 1991). The surface root system of a mature river red gum extends at least 20 m in the horizontal direction (Dexter 1967) and greater than 10 m vertically (Davies 1953). River Red Gums can opportunistically alternate between different sources of water (i.e. ground or surface water) depending on which are most energetically favourable at the time. River Red Gum is generally (including at Cloudbreak) associated with riparian systems and is typically found where the depth to groundwater varies between 1m and 3m (Dames & Moore, 1984).

Depth to groundwater along the flanks of the Fortescue Valley, which includes the area of the community with which these species is associated, is typically no more than 22m (at the end of the dry season). Along drainage lines the long term average depth to groundwater is significantly less (i.e. 12-15m). Over the course of their lifespan phreatophytic species such as Coolibah and River Red Gum are regularly subject to volatile groundwater levels often experiencing short and long term variations in levels of more than 10m. For the purpose of this assessment, a conservative decline in groundwater levels beyond the 20m level was set as the threshold at which the health of Coolibah and River Red Gum dominated communities were potentially adversely impacted. While drawdown resulting in an increase in depth to groundwater beyond 20m may result in adverse impacts on these species, most of the areas dominated by these species are predicted to experience a drawdown significantly less than the 20m threshold and as a consequence are unlikely to be adversely affected. Additionally, the areas where this community will be potentially adversely impacted by increased dewatering are generally located within areas proposed for mining and will be cleared prior to commencement of mining (see attached Map 1).

Impacts on Mulga Communities

Mulga (*Acacia aneura*) dominated vegetation communities in the Cloudbreak area are close to the northern extent of the species natural range. Mulga communities are considered to be primarily at risk from fire, grazing and climate change (Fortech 1999). Any alteration to surface water flow (e.g. water shadow effects resulting from construction of adjacent linear infrastructure such as roads or railways) is also known

to have an adverse impact on Mulga health. Mulga is a long-lived species (up to 250 years) but only grows where both summer and winter rainfall is expected and where water is generally a limiting factor for growth. In general Mulga is intolerant to periods of inundation, but the degree to which it is intolerant is largely dependent on its position in the landscape. Mulga monitoring on Mt Bruce Flats near Marandoo indicated that the majority of Mulga deaths recorded during the 2000-2007 monitoring period were a result waterlogging following a significant rainfall event during March 2006 (Batini, 2008b).

By overlaying FMG's simulated regional groundwater levels model drawdown contours over the Mattiske (2005) vegetation mapping within the drawdown zone, three Mulga dominated vegetation communities were identified as potentially being impacted by mounding impacts over the indicative three year dewatering (and re-injection) period. These are:

1. Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia citrinoviridis, Acacia pruinocarpa* over *Acacia tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax, Stemodia viscosa, Blumea tenella, Themeda triandra* and species of *Triodia* and *Aristida*. This community is mapped as being associated with creeks and drainage lines (see attached Map 1).

2. Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia tetragonophylla, Acacia tenuissima, Grevillea wickhamii* subsp. *aprica, Psydrax latifolia* over *Dodonaea petiolaris* and species of *Triodia* and *Aristida.* This community is mapped as being associated with the flats and broad plains at the base of the Chichester Ranges and in the Fortescue Valley (see attached Map 1).

3. Low Open Woodland of *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia xiphophylla, Acacia victoriae* over *Acacia tetragonophylla, Psydrax latifolia* and *Psydrax suaveolens* over *Ptilotus obovatus* var. *obovatus* and mixed Chenopod species of *Maireana* and *Sclerolaena.* This community is mapped as being associated with the flats and broad plains at the base of the Chichester Ranges and in the Fortescue Valley (see attached Map 1).

Mulga is dependent on the basal sheet or surface flow of water rather than groundwater resources. Mulga communities in the Cloudbreak area are predominantly well vegetated groves and sparse intergroves that occur on the contour, although some Mulga areas are associated with creeks and drainage lines. Topographical position allows for surface overland flows to be intercepted by the intergroves which enables water harvesting to occur. Root studies of Mulga indicate that the majority of their root system is concentrated in the top 30cm of the soil profile (Fortech 1999), extending laterally, rather than vertically, to a depth of generally no greater than 2m (Walter *et al,* 2002). This supports the generally accepted scientific view that Mulga is reliant on harvesting water from the unsaturated zone above the watertable rather than being dependent on a groundwater source for its survival and reproduction. As a consequence Mulga is unlikely to be adversely impacted by the predicted drawdown impacts on groundwater levels resulting from increased mine dewatering at Cloudbreak.

Mulga dominated communities mapped at the base of the southern Chichester Ranges are considered unlikely to be tolerant of their root systems being saturated for a moderate period of time. However Mulga in closer proximity to the Fortescue Marsh, where the groundwater levels are closer to the surface and the soil more

prone to saturation, is likely to be exhibit a greater level of tolerance to waterlogging of their root system (Stephen van Leeuwin, pers.comm, 2009).

Groundwater level monitoring data collected from the Cloudbreak borefield indicates that predicted mounding impacts associated with re-injection of freshwater into the borefield is unlikely to result in any significant adverse impacts on Mulga. Although there were fewer bores within the mounding zone of influence than there were within the balance of the Cloudbreak area, bore monitoring data indicates that predicted increased groundwater levels resulting from mounding will not result in saturation of the root zone of Mulga (based on Mulga root zones extending to a depth of 2m) occurring within the Cloudbreak area.

The Mulga community associated with the creek and drainage lines (i.e. Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia citrinoviridis, Acacia pruinocarpa* over *Acacia tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax, Stemodia viscosa, Blumea tenella, Themeda triandra* and species of *Triodia* and *Aristida*) is likely to be tolerant of periods of inundation given its low topographical position in the landscape and being subject to periods of inundation following significant rainfall and creekline flow events.

The root systems of Mulga are specifically adapted to obtain water from the thin surface soil layer allowing it to exploit the moisture from even minor rainfall events (Greig 1992; Burnside *et al*. 1995; Wickens 1998; Brearley 2000). Consequently any increase in salt levels in this layer would be expected to affect water uptake. Field trials on the tolerance of different plant species and varieties in Pakistan in 1988 indicated that the root zone of Mulga (associated with 50% green matter yield reduction) is tolerant of salinity (EC_e) levels of up to 9.5 dS/m (Ahmad, 1988). According to FMG's Cloudbreak Hydrogeological Assessment (FMG, 2009) saline groundwater abstracted during dewatering operations will be partially disposed of by re-injection at the saline front. This strategy will minimise expansion of the groundwater drawdown cone towards the saline groundwater and reduces the potential for both saline intrusion and upconing. Therefore there are unlikely to be any adverse impacts on the health of Mulga dominated communities as a result in salinisation of Mulga root zones in the Cloudbreak area from re-injection of saline dewater.

Summary Conclusions

Data from monitoring bores along the flanks of the Fortescue Valley and the base of the southern Chichester Ranges, which includes the majority of the assessment area, demonstrate that the groundwater levels within the assessment area range from approximately 0.8m adjacent to the Fortescue Marsh to 21.58m in the vicinity of the proposed mining pits. Therefore, other than for *Eucalyptus victrix* and *Eucalyptus camaldulensis* Woodland in the immediate vicinity of the drawdown areas (i.e. areas where predicted depth to groundwater will be at more than 20m) where there is the potential for temporary adverse impacts on tree health, it is unlikely that the dewatering from the proposed mining areas will result in any significant adverse impacts on the phreatophytic components of the vegetation communities surrounding the proposed mining areas. The areas where potential adverse impacts may occur generally coincide with the proposed mine pit areas and the associated vegetation will be cleared prior to mining.

A gradual drawdown in groundwater levels will allow the root growth of weakly phreatophytic species such as Coolibah and strongly phreatophytic species such as River Red Gum to adapt and harmonise with the rate of drawdown and recharge

events. Ecoscape understands that the majority of the proposed dewatering (and re-injection of freshwater) at Cloudbreak is proposed to occur during the initial year and then stabilise over the following two years (Willis-Jones, pers. comm. 2009). It is during this initial year of dewatering, when the rate of drawdown is at predicted to be at its highest, that there is the greatest potential for adverse impacts on the health of phreatophytic vegetation, Coolibah trees in particular.

Mulga dominated plant communities within the Cloudbreak area are dependent on basal sheet flow of water rather than groundwater resources. Therefore predicted groundwater drawdown associated mine dewatering is unlikely to result in any adverse impacts on Mulga.

The proposed re-injection of excess freshwater harvested from the mine dewatering process to the east and west of the dewatering zone will result in localised mounding resulting in increases in groundwater levels of up to 8m. While Mulga is generally intolerant of having its root zone saturated for any more than a short period of time, particularly those communities in a higher topographical position in the landscape, the predicted rise in groundwater levels resulting from mounding occurring beneath Mulga communities is not expected to result in the saturation of the root zone of Mulga. Therefore according to the simulated drawdown and mounding model, there is unlikely to be any adverse impacts on the health of Mulga dominated communities in the Cloudbreak area.

While root zones of Mulga has been shown to be tolerant to salinity levels of up to 9.5 dS/m, there are unlikely to be any adverse impacts on the health of Mulga dominated communities in the Cloudbreak area due to salinisation resulting from re-injection of saline dewater.

This completes Ecoscapes assessment of drawdown and mounding impacts on vegetation and flora associated with the proposed increased in mine dewatering at Cloudbreak.

Yours sincerely,
ECOSCAPE (AUSTRALIA) PTY LTD

Shaun Grein
Principal Environmental Scientist

attachments

References
Map 1 Simulated Groundwater Levels, Drawdown, Mounding and Mattiske Vegetation Mapping

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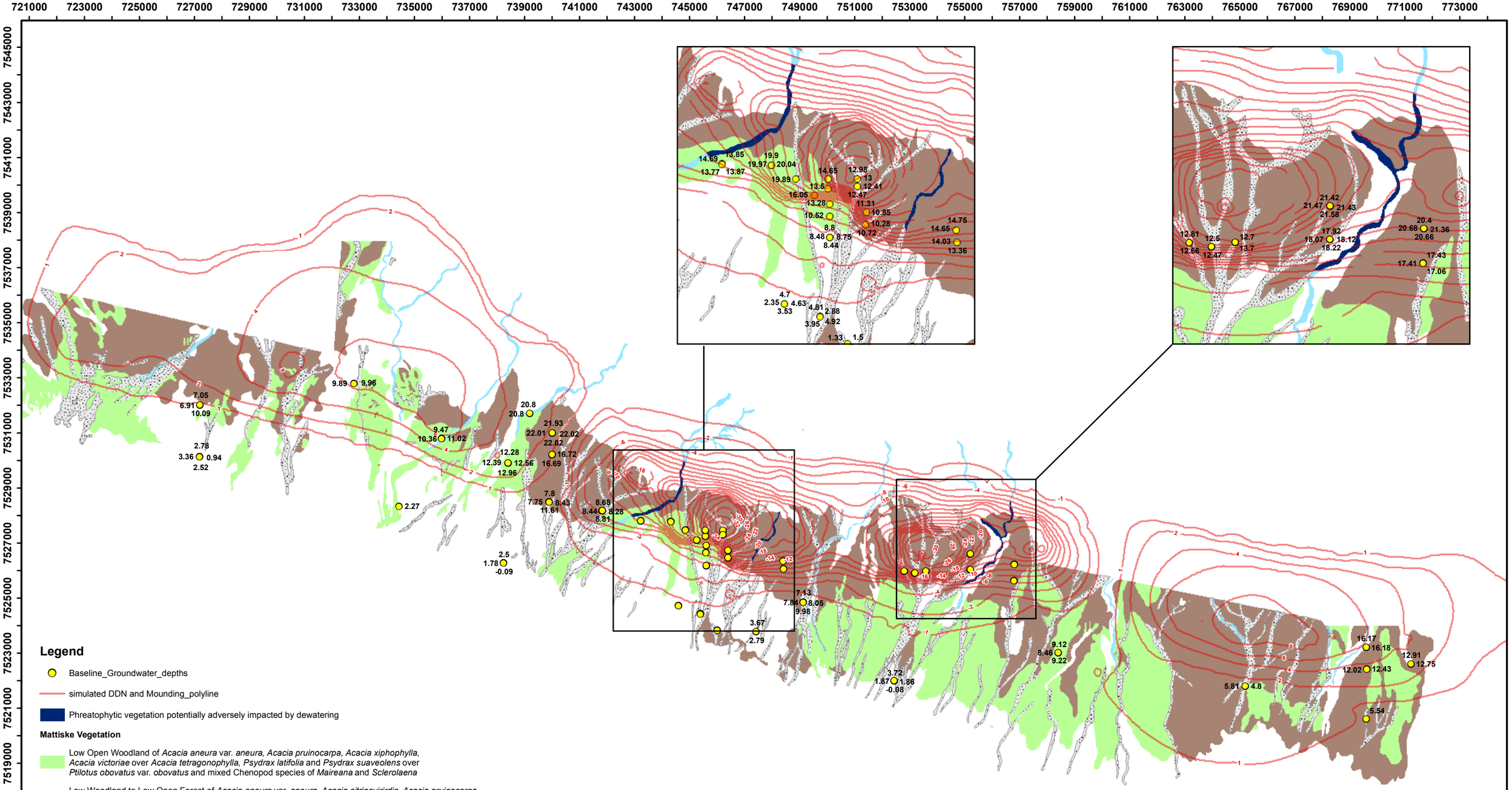

Legend

- Baseline_Groundwater_depths
- simulated DDN and Mounding_polyline
- Phreatophytic vegetation potentially adversely impacted by dewatering

Mattiske Vegetation

- Low Open Woodland of *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia xiphophylla, Acacia victoriae* over *Acacia tetragonophylla, Psydrax latifolia* and *Psydrax suaveolens* over *Ptilotus obovatus* var. *obovatus* and mixed Chenopod species of *Maireana* and *Sclerolaena*
- Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia citrinoviridis, Acacia pruinocarpa* over *Acacia tetragonophylla* and *Psydrax latifolia* over *Chrysopogon fallax, Stemodia viscosa, Blumea tenella, Themeda triandra* and species of *Triodia* and *Aristida* (Unlikely to be impacted by mounding)
- Low Woodland to Low Open Forest of *Acacia aneura* var. *aneura, Acacia pruinocarpa, Acacia tetragonophylla, Acacia tenuissima, Grevillea wickhamii subsp. aprica, Psydrax latifolia* over *Dodonaea petiolaris* and species of *Triodia* and *Aristida*
- Open Woodland of *Eucalyptus victrix, Eucalyptus camaldulensis* var. *obtusa* with pockets of *Acacia coriacea subsp. pendens* over *Grevillea wickhamii subsp. aprica, Petalostylis labicheoides, Acacia tumida* over *Triodia longiceps, Chrysopogon fallax, Themeda triandra* and *Aristida* species

Sources: Drawdown Data (FMG, 2009), Vegetation Data (Mattiske, 2005), all other data (FMG, 2009)
Projection: Transverse_Mercator GDA_1994_MGA_Zone_50

Flora & Vegetation IA for Dewatering at Cloudbreak

Map 1 — **Simulated Groundwater Levels, Drawdown Mounding and Mattiske Vegetation Mapping**

May 2009

prepared for Fortescue Metals Group

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