Pilbara Iron Ore and Infrastructure Project
Stage B

Evaluation of Alternative Rail Routes

prepared for

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TABLE OF CONTENTS

LIST OF FIGURES

1 SUMMARY

In its Public Environmental Review for Stage A of the Pilbara Iron Ore and Infrastructure Project, Fortescue Metals Group Limited (FMG) proposed a north-south rail line linking its proposed mine at Mindy Mindy with Port Hedland.

In Stage B of the project, FMG proposes to construct an east-west rail line providing access from the north-south rail near Mulga Downs to proposed mines at Christmas Creek, Mt Lewin and Mt Nicholas.

This report presents and compares a number of rail routes proposed by FMG and the Department of Conservation and Land Management (CALM).

Seven routes are compared. CALM has suggested a number of routes to Christmas Creek in the belief that they may result in less impact on mulga groves. CALM has also suggested that rather than building a new route through the Chichester Range, FMG should extend the Stage A rail line from Mindy Mindy to Roy Hill, then on to Mt Nicholas, with a rail spur westwards to Christmas Creek.

The routes have been compared by identifying and considering resource access issues, land access issues, engineering and cost issues and environmental issues.

Many of the proposed routes provide inadequate access to current and future resources along the Chichester Range. They would require additional conveyors, roads and stockpiles to access the Cloud Break area, and other potential Chichester resources. They do not meet FMG's objective of providing efficient cost-effective access to resources along the full length of the Chichester Range.

The option of accessing Christmas Creek via Mindy Mindy would lead to much higher greenhouse gas emissions and operating costs throughout the life of the project.

CALM's primary concern is impact on mulga groves, both directly through clearing, and indirectly through rail embankments interrupting sheet flow and potentially causing mulga deaths in shadow areas between culverts. FMG has proposed a number of mitigating actions, including the construction of 300 mm culverts at carefully chosen locations, to ensure continuity of flow as much as possible. FMG is already conducting research on the design of methods to redistribute water downstream of a culvert. Furthermore, FMG will undertake final design so as to reduce direct impacts on mulga, by choosing the best possible route through its preferred corridor.

FMG's preferred route is Route 2 on Figure 1 of this report. This route does have an impact on mulga (which will be mitigated to the maximum possible extent), but it also has the lowest overall land disturbance, provides the best possible access to stranded resources without additional disturbance, does not disturb other significant vegetation types, satisfies engineering constraints, lowers greenhouse gas emissions and lowers operating costs. The long term benefits of this option are significant.

2 INTRODUCTION

2.1 Background

In Stage B of the Pilbara Iron Ore and Infrastructure Project, Fortescue Metals Group Limited (FMG) proposes to construct an east-west rail line from the north-south rail line near Mulga Downs to Mt Nicholas.

This report has been prepared as an Appendix to the Public Environmental Review (PER) for Stage B.

FMG requires a single track rail line to Mt Nicholas, but passing sufficiently close to other potential resources and mines to allow efficient and cost effective mining in the future.

FMG has proposed an "open access" policy, such that its rail infrastructure can be accessed on a commercial basis by others.

FMG understands the need to balance its project and engineering requirements with environmental management requirements. This approach is consistent with Position Statement No.7 of the Environmental Protection Authority (2004), which states that

? *Sound environmental practices and procedures should be adopted by everyone as a basis for sustainability for the benefit of all human beings and the environment today, while considering the environmental, social and economic needs of future generations.*

? *This requires the effective consideration of environmental, social and economic factors in government and other sectors' decision-making processes, with the objective of improving community well-being and the benefit to future generations.*

? *The environmental practices and procedures adopted should be cost-effective and in proportion to the significance of the environmental risks and consequences being addressed.*

Under Principle E (on improved valuation, pricing and incentive mechanisms) Position Statement No.7 says:

? *Established environmental goals should be pursued in the most cost-effective way by establishing incentive structures, including market mechanisms, which enable persons best placed to maximise the benefits or minimise costs to develop solutions to environmental problems.*

The latter is entirely consistent with FMG's goal of providing open infrastructure. The goal is to provide infrastructure to "open up" the eastern Pilbara, so as to minimise future cumulative impact caused by additional rail lines.

In recent meetings, CALM has asked FMG to evaluate alternative rail routes, and in particular to seek to identify routes that would have less potential impacts on mulga groves.

Townley & Associates Pty Ltd was commissioned by FMG to summarise its analysis of alternative rail routes, and to explain how FMG chose its preferred route after modification to reduce impact on mulga groves to the maximum extent possible.

2.2 Objectives

The purpose of this report is to summarise all information on alternative rail routes.

In particular, Townley & Associates Pty Ltd was asked to:

? Review all information available regarding alternative routes.

? Discuss each route, and the viability of each, including disturbance areas (clearing), fuel use (greenhouse gas emissions), engineering requirements (grade, curves, cut and fill) and cost limitations (capital and operating).

? Explain why FMG selected its preferred route, after modification to reduce impact on mulga groves.

? Discuss proposed management measures, especially those designed to manage impacts on mulga groves.

3 REQUIREMENTS, ALTERNATIVES AND ISSUES

3.1 Project Requirements and Business Objectives

FMG's objective is to own and operate iron ore mines and associated infrastructure. Having sought agreement from BHP Billition Iron Ore (BHPBIO) to use its rail infrastructure for transport of iron ore, and having failed to reach such agreement, FMG understands the need not only for rail infrastructure to support its own requirements but also for regional infrastructure designed to help other companies that may otherwise be unable to transport mineral products cost-effectively.

FMG has proposed an "open access" policy, such that its rail infrastructure can be accessed on a commercial basis by others. The policy is based on recognition of the need for transport to and from stranded resources, i.e. mineral resources held by other parties that on their own could not afford to construct their own rail and port infrastructure.

If the proposed infrastructure is not sufficiently close to all of FMG's potential resources, some of FMG's resources could also become stranded in the long term, to the detriment of the company, the state and the nation.

FMG has created a separate corporate entity, The Pilbara Infrastructure Pty Ltd (TPI), with the specific goal of seeking customers to use its rail infrastructure. Open access forms the basis of the company's State Agreement Act, approved by the Government of Western Australia in November 2004: the *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004*.

Although the focus of this report is on Stage B of the Pilbara Iron Ore and Infrastructure Project, specifically the east-west railway, Stage B cannot be considered in isolation from Stage A, i.e. the north-south rail line. Within the Stage B PER, FMG has been proactive in discussing the overlaps and interrelationships between both stages and has dedicated Section 1.6 of the Stage B PER to this discussion.

FMG has submitted a Public Environmental Review (PER) for Stage A of the Pilbara Iron Ore and Infrastructure Project, covering a proposed rail route from Mindy Mindy (100 km northwest of Newman) to Port Hedland. The north-south railway will also be "open access". In other words FMG, through TPI, will also seek customers to use the north-south rail line.

Potential customers for the Stage A north-south rail line include Hope Downs, just to the west of Mindy Mindy, and there may be further potential in this area (see mine sites and resources marked on Figure 1). Potential customers for the Stage B east-west rail line include Hancock Prospecting which holds tenements immediately to the southeast of FMG's Christmas Creek resources (see Figure 1).

The fundamental requirement for Stage B is for rail infrastructure to allow efficient and cost effective transport of iron ore from FMG's proposed iron ore mines in the Chichester Range to the proposed Anderson Point wharf at Port Hedland.

FMG's tenements and potential resources extend along the Chichester Range from White Knight in the west to Mt Nicholas in the east (see Figure 1).

The Stage B PER identifies Christmas Creek, Mt Lewin, Mt Nicholas and Mindy Mindy as mines, but does not identify any other Chichester resources. The other Chichester resources (such as Cloud Break) have not been explored sufficiently to enable inclusion in the PER. FMG understands that in considering the environmental impacts of the proposed project, government authorities are obliged to consider the project described in the PER. However since the *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004* explicitly embraces the concepts of open access and access to stranded resources for the betterment of the State, FMG believes that the alignment of rail infrastructure can and must take into account possible future activities that are not covered by the Stage B PER. This will allow strategic planning of the rail infrastructure to ensure that it can service future developments with as little additional environmental impact as possible.

FMG's requirements include the need to optimise the combined use of the north-south and east-west rail lines, over the life of potential projects in the region, in the context of other issues and constraints.

3.2 Alternative Rail Routes

3.2.1 Access to Christmas Creek, Mt Lewin and Mt Nicholas

FMG has identified several possible routes from the north-south rail line to Mt Nicholas via Christmas Creek and Mt Lewin. In discussion with stakeholders (mainly CALM), other routes have been proposed and considered.

There are an infinite number of possible routes connecting two end points. From an engineering point of view, many are technically feasible. All projects set out to balance a large number of issues and constraints. In terms of cost, the final selection is generally neither the least nor the most expensive option, but a compromise between a number of factors.

It is important to realise the scale of the proposed Pilbara Iron Ore and Infrastructure Project. The length of the proposed rail infrastructure in Stage B alone is of the order of 160 km. Deviations in route that appear to be 1 cm on a map (e.g. on an A4 page) represent many kilometres on the ground. Given that the purpose of rail infrastructure is to provide access, an efficient route must pass within a millimetre or so of where access is needed. Otherwise a significant length of other linear infrastructure (rail spurs, conveyors and roads) may later be needed to reach the primary route.

Seven possible routes to Mt Nicholas sub-parallel to the Chichester Range are described and compared in this report (see Routes 1 to 7 in Figure 1). All routes start somewhere along the Stage A north-south line. Routes 1-6 are the same to the east of Christmas Creek. The routes are as follows:

1. A route running close to the northern shoreline of Fortescue Marsh, as much as possible in the samphire zone, below mulga communities. This route leaves the north-south line at the eastern deviation. It requires a 5 km spur line to Christmas Creek.

2. A route 5-10 kilometres further to the north, just below the Chichester Range. This route also leaves the north-south line at the eastern deviation. The intention is for the final route alignment to be as high as possible in the landscape, just below "headlands" in the breakaway that runs along the Chichester Range.

3. A route that leaves the north-south rail line approximately 30 km north of the eastern deviation. This route meets the gently sloping sediments to the south of the Chichester Range towards the eastern end of the Cloud Break area.

4. A route that traverses higher ground and meets the sediments to the south of the Chichester Range to the northeast of Warrie Camp.

5. A route ~40 km north that joins the gently sloping sediments to the north of Warrie Camp.

6. A route ~40 km north that joins the gently sloping sediments within the Christmas Creek area, passing over some parts of the area to be mined.

7. A route south of the Fortescue Marsh from Mindy Mindy to Roy Hill, and on to Mt Nicholas, with a spur line to Mt Nicholas. All ore from Mt Nicholas, Mt Lewin and Christmas Creek would be transported south to Mindy Mindy, before the journey north to Port Hedland[1].

Figure 1 shows the north-south rail line as a corridor 2 km wide. All routes compared in this report are shown as thin lines, although even a line 0.25 mm thick (when this report is plotted at A4 size) represents a corridor more than 200 m wide. The disturbed area along a rail line is expected to average 40 m during construction, depending on local topography and the requirements for cut or fill, and somewhat less after rehabilitation and during operations.

[1] CALM had previously proposed that all ore from Mindy Mindy be transported to Christmas Creek, and then to Port Hedland via one of the proposed routes sub-parallel to the Chichester Range. CALM's most recent correspondence no longer lists this option, which would add significantly to the travel distance from Mindy Mindy to the port. The option will therefore not be considered in this report.

3.2.2 Access to Cloud Break

FMG's Stage B PER does not identify Cloud Break as a future mine. The area is identified by FMG as a potential resource, and FMG has already commenced drilling in this area.

CALM has argued in meetings with FMG that Cloud Break is irrelevant and should not influence decisions about the best route to Christmas Creek and beyond.

In the context of its State Agreement Act and its stated long term objectives, FMG argues that access to Cloud Break should and must be taken into account. FMG's objective is to minimise cumulative environmental impacts in the long term, and to provide the best possible access to all resources, based on the best available information today.

CALM has proposed that access to Cloud Break could best be achieved by conveyors or road. FMG has therefore assessed these options, and the results are presented in this report.

3.3 Issues

Numerous issues influence the choice between different potential rail routes.

These include:

- Resource issues
- Land access issues
- Engineering and cost issues
- Environmental issues

Each of these issues will be addressed below.

3.3.1 Resource issues

There are numerous issues relating to mineral resources, including:

- the requirement for rail to provide access to FMG's iron ore resources,
- the need for rail to provide access to stranded resources held by other companies (e.g. Hancock Prospecting, near Christmas Creek, and Hope Downs, near Mindy Mindy), and
- the need for rail not to be too far from potential mines (to ensure efficient transport from mines to the rail line).

3.3.2 Land access issues

Access issues include:

- the nature of underlying tenure (i.e. pastoral leases),
- the requirement that FMG infrastructure should not interfere with BHPBIO's infrastructure,
- the need to negotiate access to mining tenements held by others,
- the need to negotiate access with traditional owners, and
- the need to avoid or minimise impact on cultural heritage sites.

3.3.3 Engineering and cost issues

The engineering design of rail lines is driven by:

- the need to reduce length[2],
- grade (i.e. slope) requirements, specifically a maximum of 0.33% for travel towards the coast (loaded) and 1.5% for travel inland (empty), and
- curvature of rail lines, to allow fully loaded trains to travel at the maximum possible speed, and to reduce maintenance requirements on wheel bearings etc.

Other engineering issues include:

- the need for suitable foundations from a geotechnical point of view,
- the need to balance cut and fill,
- the desire to source additional fill, if required, from borrow areas within areas that will or may be mined,
- the desirability of crossing creeks and streams higher in the landscape to reduce the size and number of culverts and bridges, and also to reduce potential impact on downstream flows, and
- the need to avoid the possibility of the rail line being flooded, let alone washed out.

[2] Length is the primary determinant of capital costs, ground disturbance, fuel consumption, travel time, cycle time, greenhouse gas emissions and labour costs. Cycle time is the time taken for a round trip of a train, including loading of a train at the mine, travel (loaded) to the port, unloading and return travel (empty) to the mine.

It has been proposed that conveyors or haul roads be used to provide access to some areas, rather than rail. Conveyors and haul roads also have a footprint, and conveyors require a parallel access road.

The net effect of all requirements is reflected in the capital costs for construction, cycle time and operating costs.

3.3.4 Environmental issues

Key environmental issues include:

- proximity to Fortescue Marsh (from the point of view of avoiding flooding of the rail line and also minimising impact on the hydrological regime of the marsh),
- other hydrological issues, such as the impact of linear infrastructure on sheet flow,
- total disturbance of native vegetation,
- disturbance to different vegetation types, in the context of relative abundance of different rangelands classifications, and the condition of the vegetation (i.e. previous impacts of fire, weeds and grazing),
- the spatial distribution of mulga groves and species endemic to the samphire zone around the Fortescue Marsh,
- the occurrence of Declared and Rare Flora, and
- the need to minimise greenhouse gas emissions.

Noise, dust and decommissioning issues are relatively independent of the precise rail route. However noise and dust issues may be greater for conveyors and haul roads providing access to Cloud Break.

CALM perceives fire management to be an important issue. This issue is discussed in the context of fires that have occurred in the past 10 years.

4 ANALYSIS OF ALTERNATIVES

4.1 Approach

This report has been prepared in the knowledge that there are potentially two key views to be considered:

- FMG seeks to construct a rail line that it sees as providing optimal access to known and potential mineral resources, held by FMG and other parties. Access is FMG's primary consideration, rather than cost. This is consistent with FMG's objective of providing open access to its infrastructure and of providing transport for what would otherwise be stranded resources. It is consistent with FMG's obligations under the *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004*. FMG is keen to provide access to potential resources, such as Hancock Prospecting, Cloud Break and other Chichester resources.

- CALM is keen to protect mulga groves, and has proposed routes that avoid some or nearly all impact on mulga groves, but which provide less than optimal access to mineral resources and cause greater overall disturbance and impacts on other significant vegetation types.

The approach taken in this report is to compare alternative routes quantitatively where possible (e.g. disturbance areas, emissions etc.) and qualitatively where quantitative data are not available (e.g. cultural heritage, land access issues etc.). No attempt is made to rank[3] possible routes according to specific potential impacts or to develop a weighted ranking to summarise all potential impacts.

In the following sections, potential issues are simply discussed, for each route being considered. The discussion provides the basis for conclusions.

[3] In the early stages of this analysis, FMG proposed a ranking system to CALM, but CALM indicated a preference for avoiding such a system.

4.2 Resource Issues

All mining tenements near the Chichester Range are shown in Figure 2.

The majority of leases in the Chichester Range are held by FMG. BHPBIO holds exploration leases near the north-south rail line, while Hancock Prospecting holds leases to the southeast of Christmas Creek.

Rio Tinto holds leases to the northeast of Christmas Creek and Mt Lewin, as well as to the west of the north-south line, but in fact the leases are held by many companies.

Resource issues are compared in Table 4.1. A number of key points can be made:

? Route 2 provides the best access to all resources in the Chichester Range. Route 1 would be next best, but being located 5-10 km south would require a spur line to Christmas Creek.

? Routes 3 to 7 do not pass Cloud Break sufficiently close to avoid the need for conveyors or haul roads. Possible routes for conveyors or haul roads are shown in Figure 1: either an 8 km route to Route 3, or in the case of rail Routes 4 to 7, a 25 km route to the north-south rail line, approximately following the route of rail Route 2.

? All of the routes cross areas that may be mineralised, but the depth of mineralisation varies, and in some places it may be possible to avoid sterilisation of resources by moving small sections of rail line at some stage during the life of the project.

Table 4.1 Resource issues

Issue	Route to Christmas Creek and Cloud Break						
	1	2	3	4	5	6	7
Access to FMG resources (Christmas Creek, Cloud Break)	5 km spur required to access Christmas Creek	Direct access to all resources	8 km conveyor or haul road required to access Cloud Break (see Figure 1)	25 km conveyor or haul road required to access Cloud Break (see Figure 1)	25 km conveyor or haul road required to access Cloud Break (see Figure 1)	25 km conveyor or haul road required to access Cloud Break (see Figure 1)	25 km conveyor or haul road required to access Cloud Break (see Figure 1)
Efficient transport of resources	Extra step in materials handling may cause lump product degradation	Minimum use of conveyors	Conveyors or loading and unloading of dump trucks may cause further lump product degradation	Even longer conveyors or loading and unloading of dump trucks may cause further lump product degradation	Even longer conveyors or loading and unloading of dump trucks may cause further lump product degradation	Even longer conveyors or loading and unloading of dump trucks may cause further lump product degradation	Extremely inefficient due to transporting all ore from eastern end of Chichester Range south to Mindy Mindy

4.3 Access and Cultural Heritage Issues

Access depends on exploration and mining tenements (Figure 2), underlying tenure of land (Figure 3), and traditional ownership (Figure 4).

The existence of cultural sites and/or artefacts can also influence access. The Aboriginal Site Register, which is maintained by the Department of Indigenous Affairs (DIA), shows some sites in the vicinity of the proposed routes (Figure 5), but experience in cultural heritage surveys and consultation with traditional owners suggest that many more sites would be found along every route that crosses the Chichester Range. For this reason FMG believes that limiting the rail to one crossing through the Chichester Ranges (at the north-south route only) is preferable, and alternative east-west routes which result in a second crossing (Routes 3, 4, 5 and 6) have a high risk of impacting cultural sites.

Access issues are compared in Table 4.2. A number of key points can be made:

- Route 2 is identified in and covered by the *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004.*
- Routes 5 and 6 cut Hillside Pastoral Lease almost in half. FMG has developed a sound relationship with the holders of this pastoral lease, and has discussed issues with the leaseholders. FMG is not confident that the leaseholders would be in agreement with Routes 5 and 6 as they would have an adverse impact on the way the leaseholders graze their land.
- Route 5 passes almost north-south through the Chichester Range, and in this area is parallel to a route used by Hillside Pastoral Lease to move stock to and from an area they believe to be the best grazing land on the lease (an area the leaseholders have negotiated with CALM to be outside the pastoral lease 2015 exclusion zone). FMG believes that a rail line through this area would inconvenience the leaseholder.
- FMG has a good relationship with the Palyku and Nyiyaparli peoples, two affected groups of traditional owners.
- Intensive consultation with the traditional owners and their legal representative body identified that the initially proposed valley system through the Chichester Range for the north-south route was characterised by numerous extensive rock pools, with associated cultural heritage sites comprising abundant rich cultural heritage material and association developed over continuous occupation dating back to at least 30,000BP (Harry Adams, pers.comm.). At the request of the traditional owners, FMG investigated alternative valley rail alignments through the Chichester Range and proposed the north-south crossing involving a deviation to the east to avoid cultural heritage issues. FMG has reached agreement in principle with the traditional

owners for the north-south route crossing of the Chichester Ranges and an east-west route at the base of the Chichester Ranges (Route 2).

- In December 2003, FMG commissioned a helicopter Aboriginal cultural heritage constraints survey over the entire proposed project footprint and adjacent areas south of the Yule River. Each of the Native Title Claimant Groups was represented by senior lore men/elders who could "speak for this country". The purpose of the "constraints" survey was to identify any major areas/sites of significance for Aboriginal cultural heritage, whether spiritual, mythological, cultural, lore or thallu ("enrichment/multiplying" sites). In addition to the site (valley system) discussed above, the traditional owners who participated in this helicopter constraints survey indicated significant potential for substantive cultural heritage sites to the east of FMG's Stage A north-south rail line.

- The Aboriginal Site Register contains information over 20,100 Aboriginal sites throughout Western Australia. The Register is held under Section 38 of the State's *Aboriginal Heritage Act 1972*. A recent search of the Register revealed a number of sites near the alternative rail routes, in particular in the vicinity of Routes 3, 4, 5 and 6 where they pass through the Chichester Ranges (Figure 5). Where the informants have requested the site information be kept confidential, the location of the site is censored by placing one or more 2 km square boxes over the extent of the site. As can be seen on Figure 5 there are a number of sites located at the northern end of the alternative rail routes, with fewer to the south. This concentration does not necessarily reflect a concentration of aboriginal activity; rather it may be a reflection of the amount of survey work that has been undertaken in the area.

- Aboriginal sites are often found around natural springs and areas where there is a water source. An investigation of the topographic mapping for the area identified a number of additional springs and water bodies located around the rail alternatives. It is therefore possible that heritage sites may be located at these areas. In addition topographical mapping shows only limited information relating to springs and further investigation is likely to identify numerous additional springs within the Chichester Ranges which may be impacted by alternative routes which result in a second crossing of the Ranges (Routes 3, 4, 5 and 6).

- Based on the geological formation (rock outcrops and stream formations) of the northern slopes of the Chichester Range it is likely that aboriginal heritage sites would be encountered along this area. These areas are not shown in the Aboriginal Site Register as little survey work has been undertaken here. Therefore, if detailed heritage surveys were undertaken for rail alternatives 3, 4, 5 and 6 where they cross the Chichester Range it is likely that heritage sites would be encountered.

- A report on Aboriginal heritage prepared for the Stage B PER and included as Appendix I to the PER (Anthropos Australis, 2004) states that "*The Abydos Plain to the north of the Chichester Range contains an abundance of rock engravings. The valleys of the Chichester Range itself also contain rock engravings. Similar engravings are found elsewhere in the Pilbara notably on the Burrup Peninsula adjacent to the towns of Dampier and Karratha.*" Anthropos Australis has prepared its report in consultation with the Pilbara Native Title Service, a division of Yamatji Marlpa Barna Baba Maaja Aboriginal Corporation, being a Native Title Representative Body under the *Native Title Act (1993)*. Based on this it is likely that Routes 3, 4, 5 and 6 through the Chichester Ranges may encounter rock engraving cultural heritage sites.

- Anthropos Australis (2004) also state that "*There are natural features within the Chichester Range, the Fortescue Plain and the Hamersley Plateau such as the Fortescue Marsh, hills such as Mt Lewin, creeks, springs, claypans, rockholes and rockshelters which the Aboriginal Traditional Owners believe are also the physical manifestations of the ancestral beings. Stories and songs are told today about the travels and exploits of the ancestral beings along the Dreaming Tracks which represent the pathways travelled in the Dreaming."* Again Routes 3, 4, 5 and 6 may impact on these ethnographic (dreaming) features through the Chichester Ranges.

- FMG has already reached agreement with the traditional owners to protect one such ethnographic feature *Millimpirinyha* (The Fortescue Marsh). For this reason Route 1 may be unacceptable due to its proximity to the marsh and unacceptable hydrological impacts (see Section 4.5).

Table 4.2 Access issues

Issue	Route to Christmas Creek and Cloud Break						
	1	2	3	4	5	6	7
Underlying tenure	Crosses Mulga Downs, Marillana, Roy Hill stations	Crosses Mulga Downs, Marillana, Roy Hill stations. *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004* includes this route.	Crosses Mulga Downs, Marillana, Roy Hill stations	Crosses Mulga Downs, Marillana, Roy Hill stations	Crosses Mulga Downs, Marillana, Roy Hill Stations but dissects Hillside Station; adverse impact on stock route from Hillside towards Warrie Camp area	Crosses Mulga Downs, Marillana, Roy Hill Stations but dissects Hillside Station	Crosses Marillana, Roy Hill stations
Traditional owners (Native Title Claimants)	Crosses Native Title Claims by Palyku and Nyiyaparli People	Crosses Native Title Claims by Palyku and Nyiyaparli People. Assessed in detail.	Crosses Native Title Claims by Palyku and Nyiyaparli People	Crosses Native Title Claims by Palyku and Nyiyaparli People	Crosses Native Title Claims by Palyku and Nyiyaparli People	Crosses Native Title Claims by Palyku and Nyiyaparli People	Crosses Native Title Claims by Palyku and Nyiyaparli People
Cultural heritage	FMG has agreed with the traditional owners to avoid and protect *Millimpirinyha* (the Fortescue Marsh)	Agreement in principle with the traditional owners	Potential cultural heritage issues due to second crossing of Chichester Range, rock pools, engravings etc.	Potential cultural heritage issues due to second crossing of Chichester Range, rock pools engravings etc.	Potential cultural heritage issues due to second crossing of Chichester Range, rock pools engravings etc.	Potential cultural heritage issues due to second crossing of Chichester Range, rock pools engravings etc.	Natural features of the Fortescue Plain are potentially ethnographic sites.

4.4 Engineering and Cost Issues

The rail routes compared here have been designed by WorleyParsons Services Pty Ltd using engineering design software known as QUANTM. QUANTM uses topography, a set of desired points along a route and constraints of various kinds to choose an optimal alignment in 3D. The software determines the length of each route, its curvature in plan and along route, and the balance between volumes of cut and fill. It also estimates the capital cost of construction using a schedule of rates, and the footprint in plan, taking into account the depth of cut and height of fill.

FMG has topographic data available at 1 m contours for the area covering Route 2 and parts of the other routes. Outside those areas, spot heights and 20 m contour data are available. While the higher resolution data allow a more accurate design, the available data are sufficient to allow a comparison of options, at the level required for evaluation of alternatives for an Environmental Impact Assessment.

The comparison presented here is based on the assumption that the north-south rail line to Mindy Mindy (covered by the Stage A PER) exists, and that a valid comparison should consider additional infrastructure required to access Christmas Creek, Mt Lewin and Mt Nicholas as part of the current PER and consider access to Cloud Break in the longer term.

Additional infrastructure implies costs (additional to Stage A), land disturbance and other environmental impacts. At the same time, for a valid comparison to be made, operating costs should take into account the combined use of Stage A and Stage B infrastructure, and the actual distances travelled from different mines to Port Hedland.

Capital costs gave been calculated for 7 routes from their junction with the north-south route to Mt Nicholas, and in the case of Route 7, including the spur line to Christmas Creek.

Operating costs have been characterised by analysing travel distance and cycle time[4]. For the purposes of this report, it is assumed that 40 Mtpa of ore will be transported from Christmas Creek, representing an approximate centroid for all resources, with approximately 5 Mtpa transported from Mindy Mindy via the north-south route.

4 Cycle time includes the time taken for loading a train, for travel (loaded) to the port, for unloading at the port and return travel (unloaded) to a mine.

Engineering and cost issues are compared in Tables 4.3 to 4.6.

Construction costs

Table 4.3 compares construction (capital) costs to both Christmas Creek and Mt Nicholas, and shows that:

? Route 2 requires the shortest length of new line, with the exception of Route 7 via Mindy Mindy,

? Routes 1 and 2 cross the Chichester Range at a higher elevation, but the elevation does not influence the efficiency of transport via this route because of the longer straight from Christmas Creek towards the north-south line, to allow trains to gain speed and momentum for the climb,

? The cost of constructing Route 1 is deemed "prohibitive" because it would require a formation at least several metres high almost the full length of Fortescue Marsh,

? Route 7 requires a very high embankment across the Fortescue River floodplain making it more expensive than Routes 2 to 6, and

? Route 2 has the lowest capital cost (CAPEX), due to the shorter length and a relatively short crossing of the Chichester Range (following the crossing for the north-south route)..

Operating costs

Table 4.4 compares operating costs to Christmas Creek, and shows that:

? Routes 3 and 4 are marginally shorter than other routes,

? The round trip travel distance to Christmas Creek is marginally shorter via Routes 3 and 4,

? Route 1 would require an additional locomotive (additional capital and labour costs) due to the steeper initial climb through the Chichester Range,

? Routes 4 to 6 will require an additional locomotive (additional capital and labour costs) because of the relatively short distance from Christmas Creek to the start of the climb over the Chichester Range,

? Routes 4 to 6 result in slower speeds (due the to the slow climb over the Chichester Range), This would negate the advantage of shorter distance, so cycle time and fuel usage would be comparable via all routes other than Route 7,

- Cycle time via Route 7 would be ~4 hours greater[5], and

- Fuel use via Route 7 to Christmas Creek will be ~14 ML greater per annum, about a 35% increase over estimated fuel use for rail transport for the whole project. Routes 1, 4, 5 and 6 would require approximately 2 ML more fuel per annum (a 5% increase).

Steep climbs (as in Routes 1, 4, 5 and 6) can be handled in some circumstances using banker trains, in which an additional locomotive pushes the train up a hill and returns under gravity to a siding to await the next train. FMG would prefer not to use banker trains as they impose operational constraints and add to risk.

Engineering issues

Table 4.5 compares the engineering issues related to cut and fill and borrow areas:

- Routes 1, 2 and 7 share the crossing of the Chichester Range used by the north-south line. The northern half of the crossing is the same, but there would be two climbs in the southern part of the Range to meet at a junction. This is seen as an advantage over multiple crossings.

- Routes 3 to 6 require a completely separate crossing, and this contributes to total disturbance, cumulative environmental impact and cost.

In order to illustrate the impacts of cut and fill, a part of Route 2 has been overlaid on aerial photos in the Chichester Range. Figure 6 shows a mosaic of aerial photos between the deviation in the Stage A north-south route and Christmas Creek. It also shows the location of a number of areas which have been studied in more detail. The areas marked as Sheet 8 and Sheet 9 are provided as Figures 7 and 8.

In Figure 7 (Sheet 8), the rail line is shown crossing the higher part of the Range, with areas of cut shown in pink and fill shown in green. The two lines show the outline of cut and fill, taking into account design slopes of batters. The grid on the Figure is a 200 m grid. The final width of impact can be as low as 10-15 m. The average width of impact during construction for the rail is estimated to be 40 m. Figure 7 shows that when crossing the areas of higher elevation a greater amount of cut is required, increasing the disturbance area and cost.

Figure 8 (Sheet 9) is further towards Cloud Break, and shows what may be largest area of fill along Route 2. The footprint becomes as wide as 70-80 m.

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5 This should be seen in the context of a cycle time of about 24 hours, of which 12 hours is travel time and 12 hours is loading and unloading. The additional 3.8 hours is consistent with increased fuel use of about 35%.

The Figures are intended to illustrate the engineering issues associated with crossing the Chichester Range. FMG sees advantages in minimising both the number of crossings and the cumulative length of such impact within the Chichester Range.

The borrow areas in Table 4.5 describe the likely areas that will require disturbance to obtain material for the alternative routes. As Route 1 is located in a potential flood area and the geotechnical characteristics of the area are not ideal for a rail (soft ground), a high rail embankment will have to be constructed. The material for this embankment will be sourced from within the vicinity of the rail and may impact on the Marsh. An opportunity exists to obtain the fill for Route 2 from within areas that will be mined in the future, thereby minimising disturbance for this alternative. Due to the location of Routes 3, 4, 5 and 6, borrow pits will have to be constructed to the north of the Chichester Ranges and therefore areas would be impacted that would otherwise not be disturbed. Due to the location of Route 7, across the Fortescue River flood plain, a large rail embankment would be required. The materials for this embankment would need to be sourced from within the flood plain and there could be hydrological and potential erosion impacts associated with these large borrow pits.

Conveyors to Cloud Break

Table 4.6 compares methods of access to Cloud Break, specifically the possibility of using conveyors with Routes 3 to 7 with the fact that Routes 1 and 2 would not need additional linear infrastructure.

- Route 3 would require a conveyor 8 km long (see Figure 1) to access Cloud Break. The conveyor would run from Cloud Break northeast to Route 3. This option would also require either a siding or a rail loop in the Chichester Range adjacent to Route 3, to allow loading of trains.

- Routes 4 to 7 would require a conveyor 25 km (see Figure 1), running northwest from Cloud Break, essentially along the same line as the Route 2 rail line. It would also require either a siding or rail loop adjacent to the north-south route.

- Routes 1 and 2 would require either a siding or rail loop in the vicinity of Cloud Break.

- The siding or rail loop would in every case have similar impact, although rail infrastructure in the Chichester Range (with Routes 3 to 7) would have greater disturbance due to cut and fill.

- The additional capital costs for conveyors and associated infrastructure are in the range $3-5M per kilometre.

- When added to the capital cost of the rail routes themselves, Route 2 is clearly the least expensive option.

- Operating costs of conveyors are high, and every option that includes conveyors to access Cloud Break will have higher operating costs than an option without conveyors.

Haul roads to Cloud Break

Table 4.7 compares the option of using haul roads to access Cloud Break.

- The capital costs of haul roads are modest, but their footprint is greater, up to 50 or 60 m during operations.
- The annual operating costs for short distances of road haulage are extremely large. A fleet of road trains is required (at additional capital cost), and many drivers would be required to operate the fleet (with associated issues related to risk, health and safety).
- Routes 1 and 2 would not require road transport of this kind.

Table 4.3 Capital costs (CAPEX) to Christmas Creek and Mt Nicholas

Issue	Route to Christmas Creek, Mt Lewin and Mt Nicholas						
	1	2	3	4	5	6	7
Length of new rail line (from Stage A line to Christmas Creek, Mt Lewin and Mt Nicholas) (km)	175 (from bend in Chichester Range)	171 (from bend in Chichester Range)	194 (from "start point"[6])	192 (from "start point")	214 (from "start point")	201 (from "start point")	149 (from bend near Mindy Mindy)
Elevation[7] (mAHD)	516	516	469	482	472	487	516
Capital cost[8] (from Stage A line to Christmas Creek, Mt Lewin and Mt Nicholas) ($M)	Prohibitive	126-150	147-191	153-199	235-305	175-227	242-315

6 Start point is at (704325mE, 7577190mN).

7 In the cases of Routes 1, 2 and 7, the highest elevation of the crossing is on the Stage A north-south line.

8 Based on a best estimate cost, increasing by up to 15% for Route 2 and 30% for all other routes.

Table 4.4 Operating costs (OPEX) to Christmas Creek

Issue	Route to Christmas Creek, Mt Lewin and Mt Nicholas						
	1	2	3	4	5	6	7
Travel distance from "start point" to Christmas Creek (km)	119	120	111	109	131	118	232
Additional cycle time to Christmas Creek relative to fastest cycle time (h)	0	0	0	0	0	0	4
Additional fuel usage per annum relative to lowest fuel use (ML)	~ 2	0	0	~ 2	~ 2	~ 2	~ 14
Additional rail equipment required	Additional locomotive needed			Additional locomotive needed			

Table 4.5 Engineering issues

Issue	Route to Christmas Creek, Mt Lewin and Mt Nicholas						
	1	2	3	4	5	6	7
Additional complete crossings of Chichester Range	0	0	1	1	1	1	0
Cut and fill[9]	Cut and fill required for ~15 km between junction with north-south line and footslopes, then fill the full length of Fortescue Marsh	Cut and fill required for ~25 km between junction with north-south line and footslopes	Cut and fill required for ~30 km between junction with north-south line and footslopes	Cut and fill required for ~40 km between junction with north-south line and footslopes	Cut and fill required for ~30 km between junction with north-south line and footslopes	Cut and fill required for ~40 km between junction with north-south line and footslopes	Fill required across Fortescue River flood plain
Borrow areas	Very large borrow areas would be needed, potentially impacting the Fortescue Marsh	Any excess fill could potentially come from borrow areas that may later be mined in the Cloud Break area	Excess fill most likely to come from borrow areas that would otherwise not be impacted	Excess fill most likely to come from borrow areas that would otherwise not be impacted	Excess fill most likely to come from borrow areas that would otherwise not be impacted	Excess fill most likely to come from borrow areas that would otherwise not be impacted	Large borrow areas would be needed, potentially impacting the Fortescue Marsh

[9] The distances over which cut and fill would be required can be envisaged in Figure 10 which shows topography based on spot heights.

Table 4.6 Access to Cloud Break by conveyor

Issue	Route to Christmas Creek, Mt Lewin, Mt Nicholas and Cloud Break						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Additional infrastructure to access Cloud Break	None	None	Conveyor 8 km long and access road	Conveyor 25 km long to Stage A rail line and access road	Conveyor 25 km long to Stage A rail line and access road	Conveyor 25 km long to Stage A rail line and access road	Conveyor 25 km long to Stage A rail line and access road
Additional capital cost[10] to access Cloud Break ($M)	0	0	28-36	91-118	91-118	91-118	91-118
Total capital cost[6] (Stage A to Christmas Creek, Mt Lewin, Mt Nicholas and Cloud Break) ($M)	Prohibitive	126-150	175-227	244-317	326-424	266-346	333-433
Additional distance, fuel to Cloud Break	None	None	More due to conveyor (8 km)	More due to conveyor (25 km)	More due to conveyor (25 km)	More due to conveyor (25 km)	More due to conveyor (25 km)

10 Estimated cost with +30% contingency.

Table 4.7 Access to Cloud Break by haul roads

Issue	Route to Christmas Creek, Mt Lewin, Mt Nicholas and Cloud Break						
	1	2	3	4	5	6	7
Additional infrastructure to access Cloud Break	None	None	8 km haul road	25 km haul road	25 km haul road	25 km haul road	25 km haul road
Additional capital cost[11] to access Cloud Break ($M)	0	0	7-9	18-23	18-23	18-23	18-23
Operating cost per annum to access Cloud Break[12] ($M)	0	0	36	111	111	111	111
Number of road trains required	0	0	31	95	95	95	95
Number of drivers required	0	0	89	272	272	272	272

11 Estimated cost with +30% contingency.

12 Estimated based on 45 Mpta ore from Cloud Break, by extraploating costs estimated by GHD in Mindy Mindy Concept Study.

4.5 Environmental Issues

4.5.1 Environmental baseline and impacts

Before summarising environmental issues associated with proposed routes, it is useful to see where the routes lie in a regional context.

Geomorphology and topography

Figures 9 and 10 show alternative rail routes superimposed on LANDSAT thematic imagery and topography (based on spot heights). Together these images allow some features of the region to be visualised, including the shape of the Chichester Range, its footslopes and the extent of Fortescue Marsh and the Fortescue River floodplain.

Hydrology

General features of the regional drainage system are shown by Aquaterra (2004). The Fortescue River flows northwest towards Fortescue Marsh. A number of streams flow southwards crossing the proposed rail route between Christmas Creek and Mt Nicholas. Other smaller streams discharge across the gentle slopes to the south of the Chichester Range (forming sheet flow), and are closely linked to the occurrence of mulga groves in this area.

Figure 11 illustrates the fact that the Chichester Range is heavily dissected by small streams. This Figure is shown at a larger scale than other Figures in this report, partly because the data on which this Figure is based are not available along the full length of the Chichester Range, but also to allow the structure of the stream network to be seen. The Figure also shows the locations of Sheets 8 and 9 (Figures 7 and 8).

Vegetation

The Pilbara Rangelands Survey Project has carried out land systems mapping for the rangelands in the east Pilbara (Figure 12). FMG has completed detailed surveys along Route 2 (Biota Environmental Science Pty Ltd, 2004), but rangelands data are used here to ensure an equal basis for comparison.

<u>Mulga</u>

CALM has expressed particular interest in areas of mulga, particularly along the southern footslopes of the Chichester Range. Table 4.8 summarises the impact of different rail routes on mulga communities. All of the routes disturb mulga, with Route 5 having the lowest overall disturbance of 205 ha. Route 1 has the highest overall disturbance of mulga (334 ha), followed by Route 2 (306 ha).

Of the 6 land systems containing mulga in Table 4.8, some may have more conservation value than others. In particular, the Cowra Land System

(RGECWA, impacted by Route 1) is very small (just over 20,000 ha) with only six occurrences, all fringing the Fortescue Marsh.

In addition, while larger in size, the following land systems are restricted to the region:

- Fan (RGEFAN, impacted by Route 7) - Fan LS - restricted to the Weeli Wolli delta and another area associated with the Fortescue River to the south;
- Marillana (RGEMRA, impacted by Route 7) - only two occurrences, both restricted to the Fortescue Marsh area;
- Jamindie (RGEJAM, impacted by all Routes) - main occurrences are around the Marsh; and
- Washplain (RGEWSP, impacted by all Routes) - restricted to the eastern end of the Fortescue Valley.

The above land systems containing mulga are shown in Figure 13. Of these land systems, the one which is impacted the most by all rail routes is Jamindie (RGEJAM). To place the impact of each rail route in context, the fraction of the total Jamindie land system (207,601 ha) that would be impacted by each route is shown below as a percentage below:

Land system	**Route 1**	**Route 2**	**Route 3**	**Route 4**	**Route 5**	**Route 6**	**Route 7**
RGEJAM disturbed (ha)	119	297	253	197	200	138	123
% of total RGEJAM land system	0.06	0.14	0.12	0.09	0.10	0.07	0.06

Other significant vegetation

In addition to mulga, a number of other vegetation types would be impacted by the various rail alternatives. Disturbance of different land systems (other than those containing mulga) is shown in Table 4.9, based on a 40 m wide corridor around each route. This analysis was performed by Mattiske Consulting Pty Ltd, and supporting information is provided in Appendix A to this report.

Of the land systems in Table 4.9, the following are particularly small and would probably support restricted vegetation types:

- Black (RGEBLK impacted by Routes 5 and 6) – 17,023 ha in size, although more frequent in occurrence than Narbung, comprises linear rocky ridges that are isolated and sporadic - different ridges would likely support different vegetation types, given their geographic separation.
- White Springs (RGEWHS impacted by Routes 5 and 6) – 26,563 ha in size and restricted to plains north of the Chichester Range, contains cracking clay vegetation.

- Adrian (RGEADR impacted by Route 7) – 23,494 ha in size and associated with the Fortescue Marsh / Fortescue River system east of the Marsh.

- Narbung (RGENAB, impacted by Route 7) – 15,957 ha in size, has only two occurrences in the Pilbara and is restricted to the Fortescue Marsh area. It presumably supports different vegetation to the surrounds or would not have been distinguished as a separate Land System.

These land systems are depicted with the 7 rail alternatives in Figure 14.

In addition, whilst larger land systems than those above, the following systems are restricted to the region:

- River (RGERIV impacted by Routes 5 and 6) - major river systems which are restricted to the major rivers in the area.

- Bonney (RGEBNY impacted by Route 6) - isolated occurrences in the Pilbara, the occurrences impacted by Route 6 are well separated from the remainder and may support distinct vegetation.

- Coolibah (RGECOB impacted by Route 7) restricted to the Fortescue River floodplains.

- Urandy (RGEURY impacted by Route 7) restricted to the Fortescue Plains sub-region.

- Marsh (impacted by Route 1) contains Fortescue Marsh samphires and species which are known to be restricted to this area.

- Turee (RGETUR impacted by all tracks) - virtually all on the northern side of the Fortescue Marsh, contains cracking clay vegetation and some mulga.

The above land systems are shown in Figure 15. Of these land systems, the one which is impacted the most by all rail routes is Turee (RGETUR). To place the impact of each rail route in context, the fraction of the total Turee land system (58,084 ha) that would be impacted by each route is shown as a percentage below:

Land system	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6	Route 7
RGETUR disturbed (ha)	194	148	144	126	133	116	168
% of total RGETUR land system	0.33	0.25	0.25	0.22	0.23	0.20	0.29

Table 4.8 Impact on mulga communities (based on rangelands mapping, areas in ha)

Land system	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6	Route 7
Plains fringing the Marsh land system and supporting snakewood and mulga shrublands with some halophytic undershrubs (RGECWA)	206	-	-	-	-	-	-
Hardpan plains and gilgai plains supporting groved mulga shrublands and minor tussock grasslands (RGEFAN)	-	-	-	-	-	-	29
Stony hardpan plains and rises supporting groved mulga shrublands, occasionally with spinifex understorey (RGEJAM)	119	297	253	197	200	138	123
Gravelly plains with large drainage foci and unchannelled drainage tracts supporting snakewood shrublands and grassy mulga shrublands (RGEMRA)	-	-	-	-	-	-	62
Alluvial wash plains with prominent internal drainage foci supporting snakewood and mulga shrublands with halophytic low shrubs (RGENAB)	-	-	-	-	-	-	62
Hardpan plains supporting groved mulga shrublands (RGEWSP)	9	9	8	8	9	8	7
TOTAL DISTURBANCE - LAND SYSTEMS CONTAINING MULGA (ha)	**334**	**306**	**261**	**205**	**209**	**146**	**283**

Table 4.9 Disturbance of vegetation other than mulga, for alternative rail routes (based on rangelands mapping, areas in ha)

Land system	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6	Route 7
Stony plains and low silcrete hills supporting hard spinifex grasslands (RGEADR)	-	-	-	-	-	-	17
Linear ridges of dolerite or basalt supporting hard spinifex grasslands, with unvegetated rock piles along summits (RGEBLK)	-	-	-	-	2	2	-
Low rounded hills and undulating stony plains supporting soft spinifex grasslands (RGEBNY)	-	-	-	-	-	18	-
Flood plains with weakly gilgaied clay soils supporting coolibah woodlands with tussock grass understorey (RGECOB)	-	-	-	-	-	-	18
Hills and ridges of sandstone and dolomite supporting shrubby hard and soft spinifex grasslands (RGECPN)	-	-	-	6	3	3	3
Sandplains and occasional dunes supporting shrubby hard spinifex grasslands (RGEDIV)	120	120	120	120	120	120	173
Rugged granitic hills supporting shrubby hard and soft spinifex grasslands (RGEGRC)	-	-	37	38	60	60	-
Stony plains and occasional tor fields based on granite supporting hard and soft spinifex grasslands (RGEMAC)	-	-	84	89	198	198	-
Hills, ridges, plateaux remnants and breakaways of metasedimentary and sedimentary rocks supporting hard spinifex grasslands (RGEMCK)	29	28	19	131	29	68	15
Lake beds and flood plains subject to regular inundation supporting samphire shrublands, salt water couch grasslands and halophytic shrublands (RGEMSH)	27	-	-	-	-	-	-
Rugged jaspilite plateaux, ridges and mountains supporting hard spinifex grasslands (RGENEW)	21	52	73	68	22	25	12
Active flood plains and major rivers supporting grassy eucalypt woodlands, tussock grasslands and soft spinifex grasslands (RGERIV)	-	-	-	-	4	4	-
Low limonite mesas and buttes supporting soft spinifex (and occasionally hard spinifex) grasslands (RGEROB)	-	-	2	5	2	2	-
Basalt hills, plateaux, lower slopes and minor stony plains supporting hard spinifex (and occasionally soft spinifex) grasslands (RGEROC)	-	-	38	38	56	41	-

Land system	Route 1	Route 2	Route 3	Route 4	Route 5	Route 6	Route 7
Hills and ridges of greenstone and chert and stony plains supporting hard and soft spinifex grasslands (RGETLG)	-	-	8	8	24	24	-
Stony alluvial plains with gilgaied and non-gilgaied surfaces supporting tussock grasslands and grassy shrublands (RGETUR)	194	148	144	126	133	116	168
Stony plains, alluvial plains and drainage lines supporting shrubby soft spinifex grasslands (RGEURY)	-	-	-	-	-	-	7
Basalt upland gilgai plains supporting tussock grasslands and minor hard spinifex grasslands (RGEWON)	-	-	-	8	-	-	4
Stony gilgai plains supporting tussock grasslands and hard spinifex grasslands (RGEWHS)	-	-	-	-	6	6	-
Basalt upland gilgai plains supporting tussock grasslands and minor hard spinifex grasslands (RGEWON)	-	-	-	-	17	9	-
TOTAL DISTURBANCE - LAND SYSTEMS NOT CONTAINING MULGA (ha)	**391**	**348**	**525**	**637**	**676**	**696**	**417**

Flora

While all native flora are protected under the *Wildlife Conservation Act 1950-1979*, some species are assigned an additional level of conservation significance based on the number of known populations and the perceived threats to these populations (Table 4.10). Species of the highest conservation significance are designated Declared Rare Flora (DRF) (either extant or presumed extinct). Species that appear to be rare or threatened, but for which there are insufficient data to properly evaluate their conservation significance, are assigned to one of four Priority flora categories.

Table 4.10 Categories of conservation significance for flora species (Atkins 2004)

Declared Rare Flora - Extant Taxa. Taxa that have been adequately searched for and are deemed to be in the wild either rare, in danger of extinction or otherwise in need of special protection.
Declared Rare Flora - Presumed Extinct. Taxa which have not been collected, or otherwise verified, over the past 50 years despite thorough searching, or of which all known wild populations have been destroyed more recently.
Priority 1 - Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations which are under threat.
Priority 2 - Poorly Known Taxa. Taxa which are known from one or a few (generally <5) populations, at least some of which are not believed to be under threat.
Priority 3 - Poorly Known Taxa. Taxa which are known from several populations, at least some of which are not believed to be under threat.
Priority 4 - Rare Taxa. Taxa which are considered to have been adequately surveyed and which whilst being rare, are not currently threatened by any identifiable factors.

In addition, some flora species are listed as triggers for Federal referral under the *Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act 1999)*. In the Pilbara, only the two DRF species (*Lepidium catapycnon* and *Thryptomene wittweri*) are currently listed under the *EPBC Act 1999*.

A search of CALM's Threatened (Declared Rare) and Priority Flora database and the Western Australian Herbarium Specimen database was commissioned for the area bounded by 20°00' - 23°00'S and 118°00' - 121°00'E. This search yielded 275 location records of 68 taxa. However, this search was of a very large area, and only 6 records were near the alternative rail routes:

? *Bulbostylis burbidgeae* (Priority 3) recorded 2 km south of Route 6,

? *Abutilon trudgenii* (Priority 3) located 0.3 km south of Route 6,

? *Goodenia stellata* (Priority 4) located 4.5 km southwest of Routes 5 and 6,

? *Eremophila spongiocarpa* (Priority 1) located 6 km southwest of Route 1, and

? *Eremophila youngii* subsp. *lepidota* (Priority 4) recorded 0.7 km south and 3.5 km north of Route 7.

FMG has mapped Route 2 in detail and six priority species were found:

? Priority 1 species: *Eremophila pilosa*

? Priority 3 species: *Abutilon trudgenii* ms., *Goodenia nuda*, *Hibiscus brachysiphonius*, *Sida* sp. Wittenoom (W.R. Barker 1962) and *Themeda* sp. Hamersley Station (M.E.Trudgen 11431).

With the exception of *Eremophila pilosa*, all of the Priority flora species recorded from the FMG Stage B rail corridor and mine areas have also been recorded during the Hope Downs rail corridor surveys and/or FMG Stage A rail corridor survey (Biota 2004).

FMG will make efforts to avoid these species during selection of final alignment and detailed project design. However it should be noted that for the routes through the Chichester Ranges (3 – 6) there would be less flexibility in the final alignment to avoid populations of such species, due to topographical constraints.

Fire history

The region is not immune to fire. Most fires are caused by lightning strikes, but could potentially be caused by anthropogenic causes.

Figure 16 shows fires that have occurred during the last 10 years, mapped by CALM based on satellite imagery. Each year could be shown as a different map, and animating such a sequence of maps shows that multiple fires have occurred in some places. Routes 2 and 3 cross an area in the Cloud Break area that burned out in 1999 and 2000, i.e. in successive years.

CALM has reported that vegetation south of the Fortescue Marsh has been less impacted by fire than vegetation to the north (Stephen van Leeuwen, pers.comm.). However, the fire history records show that in the last 10 years, the north of the Fortescue Marsh has had more frequent larger fires than the southern area.

Weeds and priority species

During mapping of the Route 2 corridor and mine sites, Biota Environmental Sciences Pty Ltd also mapped occurrences of weeds and priority species. Figure 17 shows these occurrences.

Thirteen species of introduced flora were recorded from the FMG Project area in the detailed surveys conducted by Biota. None of these are listed as a Declared Plant for the Pilbara under the *Agriculture and Related Resources Protection Act 1979*. The 13 weed species recorded are largely common and widespread species of the Pilbara region:

- Ruby dock **Acetosa vesicaria*
- Kapok **Aerva javanica*
- Mexican poppy **Argemone ochroleuca* subsp*. ochroleuca*
- Beggar's ticks **Bidens bipinnata*
- Buffel grass **Cenchrus ciliaris*
- Birdwood grass **C. setigerus*
- Feathertop Rhodes grass or Windmill grass **Chloris virgata*
- The cucurbid **Citrullus colocynthis*
- Awnless Barnyard grass **Echinochloa colona*
- Spiked Malvastrum **Malvastrum americanum*
- Whorled pigeon grass **Setaria verticillata*
- Indian weed **Sigesbeckia orientalis*
- Common sowthistle **Sonchus oleraceus*

Within the survey area, several creeklines that were substantially degraded by invasion from Buffel grass **Cenchrus ciliaris*, and occasional other areas that were heavily weed infested or heavily grazed (see below), were considered to be in poor to very poor condition. Many of the mulga groves contained Beggars ticks **Bidens bipinnata*. However groves with dense infestations of Beggars ticks had a relatively high cover of native grasses and other features indicating integrity (see scale in Fortech, 1999, as referenced by Biota, 2004). This suggests that this particular weed species has not had a major effect on vegetation structure (Biota, 2004).

North of the Marsh, it is likely that the valleys and lower lying flood plains are more heavily infested by weeds than the elevated areas of the ranges due to the inaccessibility to cattle and vehicles (which are weed transport mechanisms).

CALM have indicated (Stephen van Leeuwen, pers.comm.) that the area south of the Marsh is also impacted by weed invasion.

Grazing and vegetation condition

Observations along the footslopes of the Chichester Range (Libby Mattiske, pers.comm.) suggest that the mulga grove communities are affected by grazing. This is in accordance with communications with pastoralists, that indicate much of the area north of the Fortescue Marsh is prime grazing land.

Much of the area has been grazed for nearly 100 years (since the pastoral stations were established), but some areas have been affected more than others. The plains surrounding the Fortescue Marsh and valley areas within the ranges are subject to higher grazing pressure than the elevated areas of the ranges, due to inaccessibility to cattle.

The Biota (2004) survey of Route 2 and the proposed mining areas found that the vegetation of the low stony hills habitats of the sections of the Chichester and Hamersley Ranges within the study area were generally in very good to excellent condition. These areas are not preferred grazing habitat for stock, and the stony, relatively dry substrates also tend to discourage germination and growth of weed species. It is therefore likely that vegetation along all routes through the low stony hills of the Chichesters (Routes 3, 4, 5 and 6) is also in very good to excellent condition.

The Biota (2004) survey identified that there were some obviously heavily grazed areas along Route 2, mainly adjacent to stock watering points, which tended to coincide with heavy Buffel grass infestations. The clayey plains of the Fortescue Valley are highly productive from a pastoral perspective. The dense Mulga vegetation of the clayey plains, and dense Mulga and other vegetation of creeklines, provide both forage and shelter for stock, which tend to concentrate the effects of grazing and trampling in such habitats. In addition, these mesic (moist) environments are more favourable for germination and growth of weed species, which may also be spread by stock movement and/or encouraged by grazing (Biota, 2004).

Overall Biota (2004) found that majority of vegetation types identified along Route 2 and in mining areas were of at least moderate conservation value (only those vegetation types substantially degraded by Buffel grass and/or grazing were considered to have low conservation value).

Agriculture WA expects to complete mapping of vegetation condition in the area in January 2005, and this mapping will provide a useful additional source of information.

4.5.2 Comparison of alternative rail routes

Environmental issues are compared in Tables 4.11 to 4.15.

Total disturbance is addressed in Table 4.11:

- Route 2 has the least total disturbance, especially taking into account the impact of conveyors (or other forms of access to Cloud Break, such as haul roads).
- Routes 3 to 6 through the Chichester Range result in significantly more total disturbance.

Hydrological issues are addressed in Table 4.12:

- Route 1 would be significantly more difficult than others from a water management point of view. Being low in the landscape, the embankment required for Route 1 would impede throughflow and require bigger culverts.

- Routes 3 to 6 that have a complete second crossing of the Chichester Range are likely to have greater impacts on drainage within the Range, and will certainly require many diversion channels and culverts in areas of cut and fill, respectively.

- Route 7 would effectively dam the Fortescue River upstream of Fortescue Marsh.

- Route 2, requires the most management of sheet flow into mulga groves (along 44 km of rail). FMG believes that this can be managed as described in Section 5 and discussed in further detail within the Stage B PER.

Impact on vegetation types is addressed in Table 4.13 (see also Figures 12 to 15):

- Route 1 has the greatest impact on mulga communities.

- Route 2 has the second greatest impact on mulga communities in total and the greatest impact on groved mulga, but disturbs only 0.14% of the Jamindie land system and 0.2% of such communities within the Chichester Footslopes mulga vegetation unit, as defined in the FMG Stage B PER.

- Routes 3 to 7 all have impacts on mulga communities.

- Route 1 impacts a mulga-containing land system which is very small, with only six occurrences (the Cowra Land system).

- Route 7 impacts two mulga-containing land systems that are restricted to the region (the Fan and Marillana land systems).

- Routes 5 and 6 impact two particularly small non-mulga land systems which may support restricted vegetation (Black and White Springs land systems) and also impacts River land systems which are restricted to the region.

- Route 7 impacts two small non-mulga land systems which may have restricted vegetation within them (Adrian and Narbung), the Coolibah land system which is restricted to the Fortescue River floodplains and the Urandy land system which is restricted to the southern edge of the Fortescue Plains.

? Route 6 impacts the Bonney land system which has isolated occurrences in the Pilbara and due to isolation near route 6, may support distinct vegetation.

? Route 1 impacts the Marsh land system which contains Fortescue Marsh samphires and species which are known to be restricted to this area.

? All routes impact the Turee land system (restricted to the region) to a similar extent, although the final alignment of the rail can be designed to take into account the location of cracking clay vegetation within the corridor.

The importance of vegetation condition and grazing history is highlighted in Table 4.14 (see also Figures 16 and 17):

? Routes 1 and 2 were subject to fires in the Cloud Break area in 1999 and 2000.

? Route 6 passes through a part of Hillside Pastoral Lease that was subject to a large fire in 1997.

? The vegetation crossed by all routes north of the Fortescue Marsh (Routes 1 – 6) has been subject to more fires in the last 10 years than that crossed by Route 7 (south of the Marsh).

? Weed invasion was found by FMG during its detailed surveys of Route 2 and the proposed mines.

? The area crossed by Route 7 is also reported to be subject to weed invasion.

? Routes crossing higher elevations (Routes 3 – 6) are likely to be subject to less weed invasion and grazing pressure in the elevated areas due to inaccessibility – therefore these areas may be more pristine.

? The lowlands around Fortescue Marsh and the foothills of the Chichester Range have been grazed for about 100 years.

Greenhouse gas emissions are addressed in Table 4.15:

? Overall greenhouse gas emissions during the life of the rail infrastructure will be dominated by the length (and to a lesser extent curvature, alignment and elevation) of the rail line and conveyors.

? Route 7 would increase fuel use and greenhouse gas emissions by about 35%.

? Use of haul roads to transport ore from Cloud Break would cause an increase in emissions during the mining of Cloud Break.

Table 4.11 Total disturbance

Issue	Route to Christmas Creek, Mt Lewin, Mt Nicholas and Cloud Break						
	1	2	3	4	5	6	7
Overall Land disturbance[13]	725	654	786	842	885	842	700
Additional land disturbance[14] due to conveyors, access roads, laydown areas etc. to access Cloud Break (ha)	0	0	8	25	25	25	25
Total land disturbance (Stage A to Mt Nicholas and Cloud Break, including conveyors etc.) (ha)	725	654	794	867	910	867	725

13 This area is based on a 40 m corridor along the full length of each route, including rail loops and spur lines as shown in Figure 1.

14 This area is based on a 10 m corridor along each conneyor route, inlcluding an access road. It does not include the area of rail sidings or loops required in every case at Christmas Creek, and either at Cloud Break or the rail route to which a conveyor would carry ore from Cloud Break. Note that haul roads would result in additional disturbance 5-10 times larger, due to the much greater width of a haul road.

Table 4.12 Hydrological issues

Issue	Route to Christmas Creek, Mt Lewin, Mt Nicholas and Cloud Break						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Hydrological impacts in Chichester Range	Least additional impact	Least additional impact	Impacts on drainage patterns along a complete crossing of Chichester Range	Impacts on drainage patterns along a complete crossing of Chichester Range	Impacts on drainage patterns along a complete crossing of Chichester Range	Impacts on drainage patterns along a complete crossing of Chichester Range	Not applicable
Hydrological impacts on mulga groves	Higher risk from point of view that flows needing to pass through culverts would be greater; risk of flooding	Culverts required to pass flow and re-establish sheet flow along 44.4 km of linear infrastructure	Culverts required to pass flow and re-establish sheet flow along 30.3 km of linear infrastructure	Culverts required to pass flow and re-establish sheet flow along 9.5 km of linear infrastructure	Culverts required to pass flow and re-establish sheet flow along 5.2 km of linear infrastructure	Culverts required to pass flow and re-establish sheet flow along 5.3 km of linear infrastructure	Culverts required to pass flow and re-establish sheet flow in areas where mulga groves could be affected
Hydrological impacts on Fortescue Marsh and Fortescue River	Closest to Marsh, with consequent risks	Negligible impacts	Negligible impacts	Negligible impacts	Negligible impacts	Negligible impacts	Effectively dams Fortescue River over 3 km wide floodplain

Table 4.13 Impact on vegetation types

Issue	Route to Christmas Creek						
	1	2	3	4	5	6	7
Summary of Vegetation types	Samphire zone and fringing mulga above Fortescue Marsh	Mulga groves and grasslands, plus other communities in Chichester Range	Mulga groves and grasslands, plus other communitie s in Chichester Range	Mulga groves and grasslands, plus other communitie s in Chichester Range	Mulga groves and grasslands, plus other communities in Chichester Range	Mulga groves and grasslands, plus other communities in Chichester Range	Mulga groves between Roy Hill and Christmas Creek
Direct impact on mulga (including conveyors etc.) (ha)	334	306	261	205	209	146	283
Direct impact on mulga groves (including conveyors etc.) (ha)	128	306	261	205	209	146	159
Impacts on small land systems (LS) (with potentially restricted vegetation)	Impacts Cowra (small mulga-containing LS) and Marsh (samphire-containing LS surrounding the Fortescue Marsh)	None	None	None	Impacts Black (isolated and sporadic LS) and White Springs (LS which contains cracking clay) - both small non-mulga LS likely to contain restricted vegetation	Impacts Black (isolated and sporadic LS) and White Springs (LS which contains cracking clay) - both small non-mulga LS likely to contain restricted vegetation	Impacts two small non-mulga LS: Adrian (associated with Fortescue Marsh and River) and Narbung (only 2 occurrences in Pilbara) - likely to contain restricted vegetation.

Issue	Route to Christmas Creek						
	1	2	3	4	5	6	7
Impacts on land systems (LS) (restricted to the region)	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley - contains mulga). In addition impacts the Marsh LS containing restricted samphire spp.	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley - contains mulga)	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley - contains mulga)	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley - contains mulga)	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley -contains mulga). In addition impacts the River LS restricted to major river systems.	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley -contains mulga). In addition impacts the River LS restricted to major river systems and the Bonney LS with isolated occurrences in the Pilbara.	Impacts Turee LS (cracking clay and some mulga) and Washplain LS (restricted to Fortescue Valley -contains mulga). In addition impacts several other LS restricted to the region: Coolibah, Fan, Marillana and Urandy.

Table 4.14 Vegetation condition

Issue	Route to Christmas Creek						
	1	2	3	4	5	6	7
Fire history	Fires in 1999 and 2000 burnt the same area near Cloud Break. Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. 10 year history intersects scattered areas of this route.	Fires in 1999 and 2000 burnt the same area near Cloud Break. Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. 10 year history intersects scattered areas of this route.	Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. 10 year history intersects scattered areas of this route.	Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. 10 year history intersects scattered areas of this route.	Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. 10 year history intersects large area of the northern portion of this route.	Areas burnt to the west of Christmas Creek, near Roy Hill, and near Mt Nicholas. Large area burnt in Chichester Range in 1997. 10 year history intersects a large area of this route.	Areas burnt near Roy Hill, and near Mt Nicholas. 10 year history intersects only a small area of this route.
Weed invasion	Weed invasion likely due to long term grazing	Weed invasion. FMG survey found 13 species, with heavy infestation in creeklines	Less weed invasion likely in Chichester Range due to inaccessibility, but weed invasion in footslopes.	Less weed invasion likely in Chichester Range due to inaccessibility, but weed invasion in footslopes.	Less weed invasion likely in Chichester Range due to inaccessibility, but weed invasion in footslopes. Stock route to Warrie Camp likely to more infested.	Less weed invasion likely in Chichester Range due to inaccessibility, but weed invasion in footslopes.	Weed invasion likely due to long term grazing

Issue	Route to Christmas Creek						
	1	**2**	**3**	**4**	**5**	**6**	**7**
Grazing history	Area grazed for approximately 100 years.	Area grazed for approximately 100 years.	Foothills grazed for approximately 100 years, but higher elevation areas likely to be less affected due to inaccessibility.	Foothills grazed for approximately 100 years, but higher elevation areas likely to be less affected due to inaccessibility.	Foothills grazed for approximately 100 years, but higher elevation areas likely to be less affected due to inaccessibility.	Foothills grazed for approximately 100 years, but higher elevation areas likely to be less affected due to inaccessibility.	Area grazed for approximately 100 years.

Table 4.15 Greenhouse gas emissions

<table>
<tr><th rowspan="2">Issue</th><th colspan="7">Route to Christmas Creek</th></tr>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th></tr>
<tr><td>Additional fuel use[15] relative to Route 4 and greenhouse gas emissions (to/from Christmas Creek)</td><td colspan="6">All comparable due to comparable distance and cycle time</td><td>Additional 14 ML/y diesel fuel, hence 35% increase in tCO_{2e}/y greenhouse gas emissions for life of project</td></tr>
<tr><td>Greenhouse gas emissions due to land clearing</td><td colspan="7">Negligible relative to fuel use</td></tr>
<tr><td>Greenhouse gas emissions (Cloud Break, via conveyors)</td><td>0</td><td>0</td><td>Increase relative to Routes 1 and 2 without conveyors</td><td colspan="4">Even larger increase relative to Routes 1 and 2 without conveyors, for life of Cloud Break</td></tr>
<tr><td>Greenhouse gas emissions (Cloud Break, via haul roads)</td><td>0</td><td>0</td><td>Very large increase due to fleet of 31 road trains</td><td colspan="4">Very large increase due to fleet of 95 road trains, for life of Cloud Break</td></tr>
</table>

15 See Table 4.3. Fuel use is approximate and based on average use for the whole project. During final design, simulators would be used to simulate the way a train would be powered over the Chichester Range, thus allowing more realistic estimates of fuel use. To be compared with 40 ML/y diesel fuel use for rail transport for the whole project.

4.6 Preferred Rail Route

During the process of considering alternatives, FMG has taken into account environmental, engineering and economic issues, and will continue to do so.

FMG is aware and understands CALM's desire to minimise direct and indirect impacts on mulga groves. Since length of line is the primary determinant of capital and operating costs, as well as land disturbance and greenhouse gas emissions, length becomes a key parameter in any comparison. Other key parameters include proximity to currently known and future resources.

Through the *Railway and Port (The Pilbara Infrastructure Pty Ltd) Agreement Act 2004*, FMG now has an obligation to provide open access to its rail infrastructure, and to provide infrastructure that will provide access to stranded resources in the area.

The route that maximises access to resources while minimising overall environmental impacts is Route 2. This is FMG's preferred route.

Rail route 2 between the north-south line and Mt Nicholas will require clearing of 306 ha of mulga groves. When compared with the total area of mulga in the Chichester Range and footslopes, this is 0.5% of the total mulga in this area (FMG Stage B PER).

Rail route 2:

- provides best access to FMG's known and potential resources,
- provides best access to potential stranded resources held by other parties,
- provides greater likelihood that materials for embankment construction can be sourced from likely mine areas,
- has operating costs per tonne (fuel, labour, wear and tear etc., but excluding depreciation of capital costs) that are almost as low as any other option,
- has the lowest capital costs (such costs influencing the costs that will be charged by TPI to all parties accessing the rail line),
- has the least total disturbance,
- affects areas of mulga and mulga groves, but often obliquely, so that water management may not be as difficult as CALM may have anticipated (refer to Section 5),
- has been subject to multiple fires, weed infestation and grazing (and is therefore not pristine) - this has been considered by Biota (2004) in determining vegetation conservation value, and FMG has committed to

avoiding significant vegetation types and flora where possible (Stage B PER), and

? has greenhouse gas emissions for transport from all areas along the Chichester Range that are as low as any other option.

Each of the other routes has disadvantages:

? Route 1 would require a large embankment that would impede flows and present risks to the Fortescue Marsh, affects the largest area of mulga and mulga groves, and is prohibitively expensive.

? Route 3 requires a second crossing of the Chichester Range (with more cut and fill, hydrological impacts and cultural heritage risks), does not provide optimal access to Cloud Break area (it would require conveyors and/or roads), has larger total disturbance than Route 2 without significant decreases in impacts to mulga, and results in significant CAPEX and OPEX increases.

? Route 4 requires a long second crossing of the Chichester Range (with more cut and fill, hydrological impacts and cultural heritage risks), does not provide optimal access to Cloud Break area (it would require conveyors and/or roads), has larger total disturbance than Route 2, requires an additional locomotive to accelerate a train up the Chichester Range from Christmas Creek and results in significant CAPEX and OPEX increases.

? Route 5 requires a second crossing of the Chichester Range (with more cut and fill, hydrological impacts and cultural heritage risks), does not provide optimal access to Cloud Break area (it would require conveyors and/or roads), has larger total disturbance than Route 2, disturbs additional significant vegetation types, and requires an additional locomotive to accelerate a train up the Chichester Range from Christmas Creek. It also splits the Hillside Pastoral Lease in two, would adversely affect stock movement along a stock route and results in significant CAPEX and OPEX increases.

? Route 6 requires a second crossing of the Chichester Range (with more cut and fill, hydrological impacts and cultural heritage risks), does not provide optimal access to Cloud Break area (it would require conveyors and/or roads), has larger total disturbance than Route 2, disturbs additional significant vegetation types, and requires an additional locomotive to accelerate a train up the Chichester Range from Christmas Creek. It also splits the Hillside Pastoral Lease in two and results in significant CAPEX and OPEX increases.

? Route 7 would add 35% to fuel use and greenhouse gas emissions for most of the project life, does not provide optimal access to Cloud Break area (it would require conveyors and/or roads), has larger total disturbance than Route 2 and disturbs additional significant vegetation types. The route would be very expensive, as embankments would effectively dam the Fortescue River floodplain.

Route 2 provides the best balance between project and engineering requirements and environmental management requirements, consistent with the policy outlined in Position Statement No.7 of the Environmental Protection Authority (2004).

5 PROPOSED MANAGEMENT MEASURES

FMG understands and has adopted a hierarchy of controls, aiming first to avoid, second to minimise, third to mitigate and finally to manage the environmental impacts of the proposed rail routes.

CALM has encouraged FMG to place a high priority on the potential impacts on mulga groves. FMG considers cumulative disturbance to be important, as well as other environmental impacts such as greenhouse gas emissions, and disturbance to natural hydrological flows. The focus of this section is on management of impacts on mulga communities, especially mulga groves, but also includes reference to other impacts.

FMG has undertaken to select the final route along the corridor of its preferred Route 2:

- to avoid impact on mulga along Christmas Creek and Kondy Creek, and
- to align with less dense areas of mulga groves.

FMG will soon define an 800 m wide corridor rather than a 2 km corridor, to give more certainty during the next stages of design and stakeholder consultation.

Apart from direct impacts on mulga groves by clearing, FMG has committed to managing potential disruption to sheet flow by:

- moving the rail alignment as far north as possible, i.e. as near as possible to headlands in the breakaway, so that surface flow is intercepted in defined channels, where it can be more easily captured and re-distributed,
- constructing 300 mm culverts at regular intervals, to allow flow to pass through the rail formation (see Aquaterra Consulting, 2004), and
- designing and constructing sheetflow redistribution systems to help to re-establish sheet flow downstream of the rail formation, where required to support downstream mulga groving.

The above management measures are discussed in more detail within the FMG Stage B PER.

To further explore the potential impact on mulga groves resulting from FMG's preferred route (Route 2), it instructive to overlay FMG's current design along its preferred Route 2 on aerial photographs and detailed contour maps. WorleyParsons Services Pty Ltd has used QUANTM to design this route, taking into account design criteria for grade and curves and a desire to balance cut and fill.

Figures 18 to 24 show the preferred Route 2 overlain on aerial photographs randomly selected along the western two thirds of the route to Mt Nicholas, in the area that has been mapped as mulga groving. In each case the blue lines show the footprint of the rail formation (cut or fill), which is of the order of 5 - 7 m wide. The footprint is wider in areas of cut or fill. The Figures show that:

- the rail route does not follow the contour, but crosses many slopes obliquely (leading to lesser impacts on sheetflow than initially perceived by CALM). That is, the rail route is often oblique to the alignment of mulga groves, making it easier to manage surface flows to redistribute water downgradient of the rail formation,

- many areas mapped at a regional scale as mulga groves are relatively sparsely vegetated, and

- there appears to be considerable opportunity for fine tuning the rail alignment to further reduce direct and impacts on mulga groves, by crossing areas with sparse or no mulga as much as possible.

Aerial photos show that mulga groves are in some cases dense in the lower parts of the footslopes and in other cases relatively sparse lower in the landscape. This tends to suggest that a simple generalisation, e.g. that the best rail route would be high or low in the landscape, may not apply.

FMG's analysis to date suggests that while it is possible to choose a route reasonably close the breakaway at the northern end of the footslopes, it is not possible to choose a route that hugs the breakaway along its full length. Such a route would require much larger volumes of cut and fill, without necessarily having less impact on mulga groves.

This report outlines the process FMG has undertaken to avoid, minimise, mitigate and manage impacts, and in its Stage B PER, FMG has undertaken to continue doing so during final design, construction and operations.

6 REFERENCES

Anthropos Australis (2004), Summary of Aboriginal Heritage, prepared for Stage B PER, December.

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Fortescue Metals Group Limited (2004), Pilbara Iron Ore & Infrastructure Project: East-West Railway and Mine Sites, Environmental Scoping Document (Stage B) (Assessment No. 1520), October.

7 ACKNOWLEDGEMENTS

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Several representatives of CALM attended three meetings at FMG during the course of preparation of this report: Norm Caporn, George Watson, Stephen van Leeuwen and Daniel Coffey. Their feedback is gratefully acknowledged.

Two meetings were also attended by representatives of EPA: Juliet Cole and Douglas Betts, respectively.

FIGURES

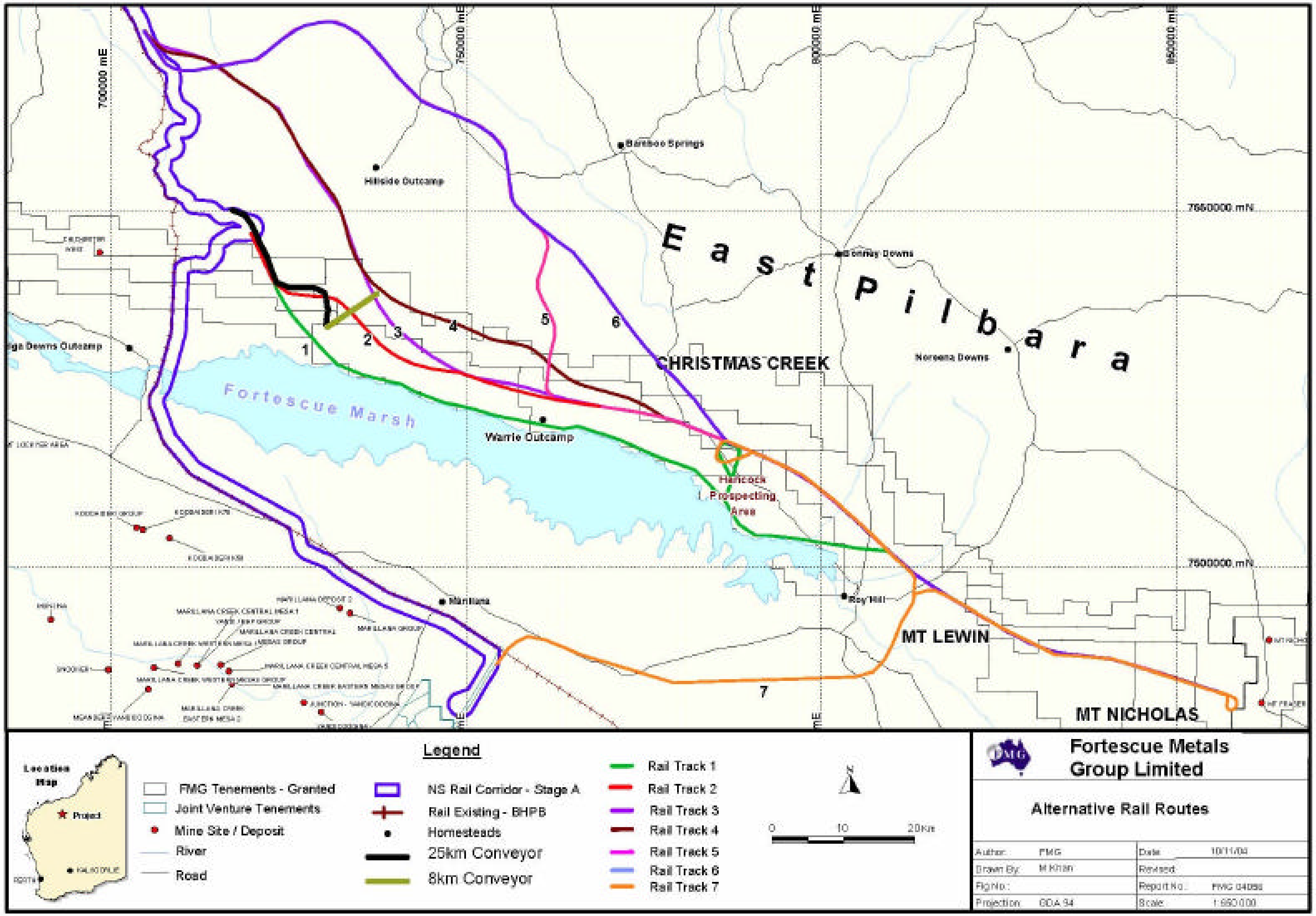

Figure 1 Alternative rail routes and possible conveyors or haul roads

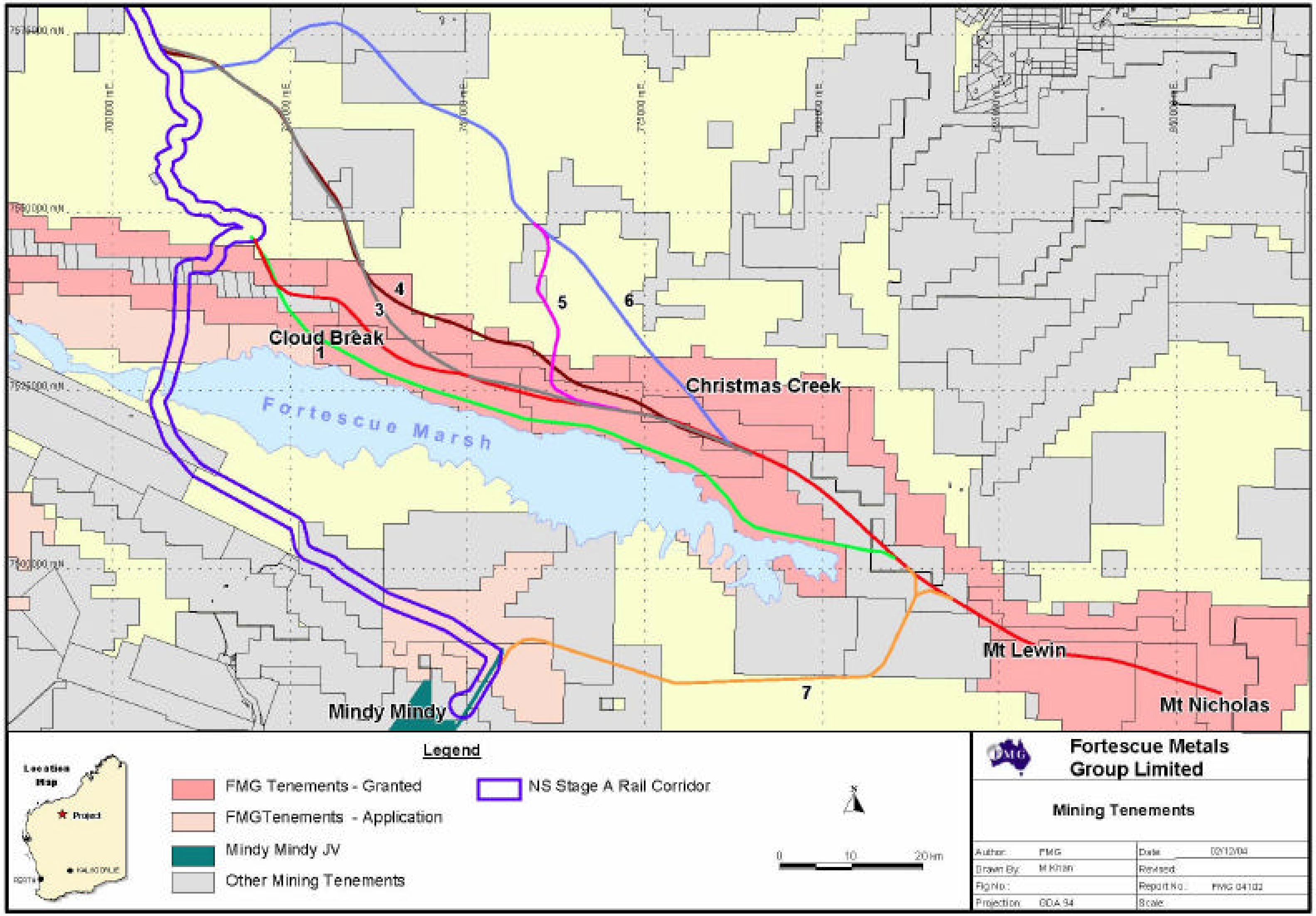

Figure 2 Mining tenements through and near the Chichester Range

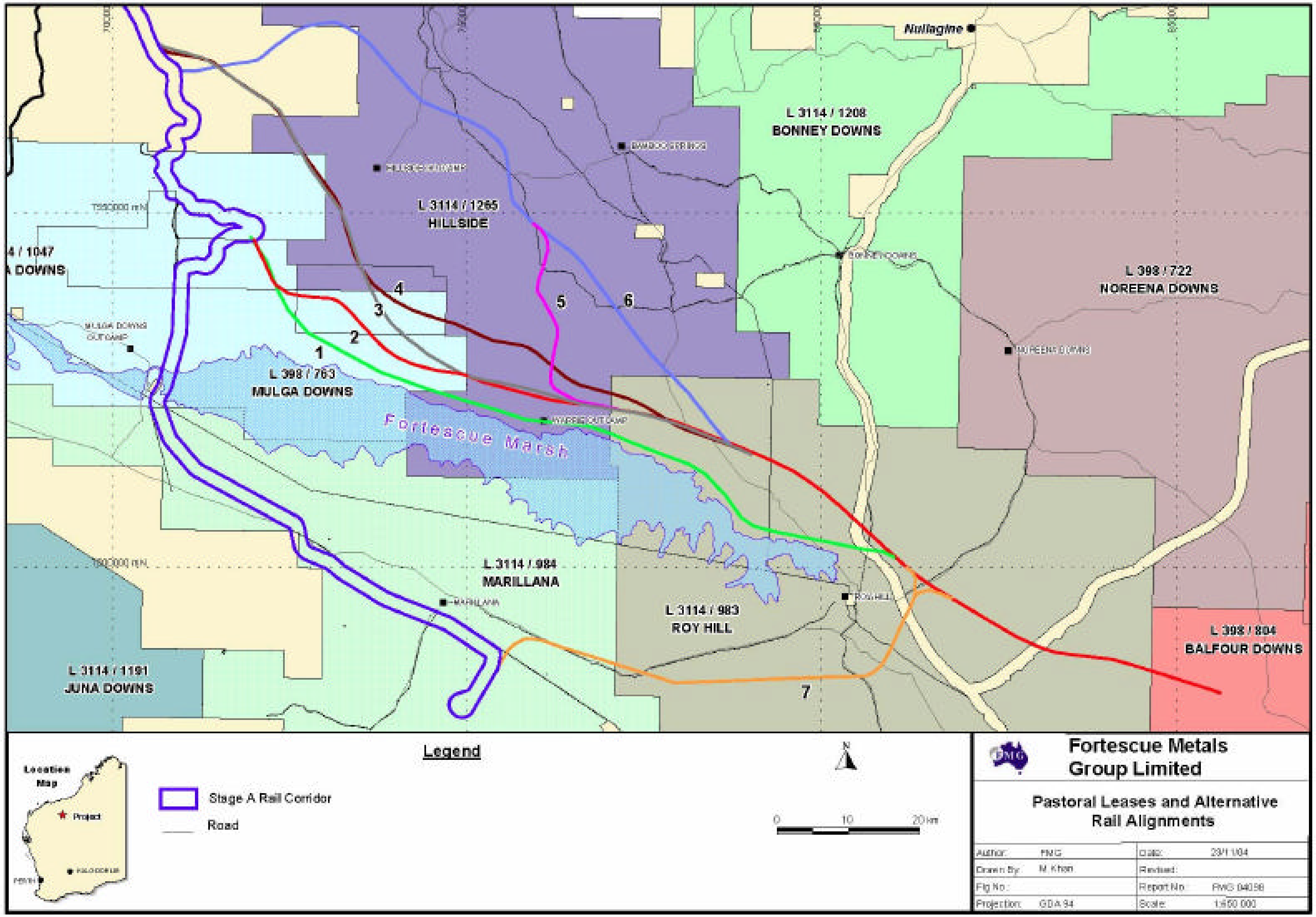

Figure 3 Alternative rail routes superimposed on pastoral leases

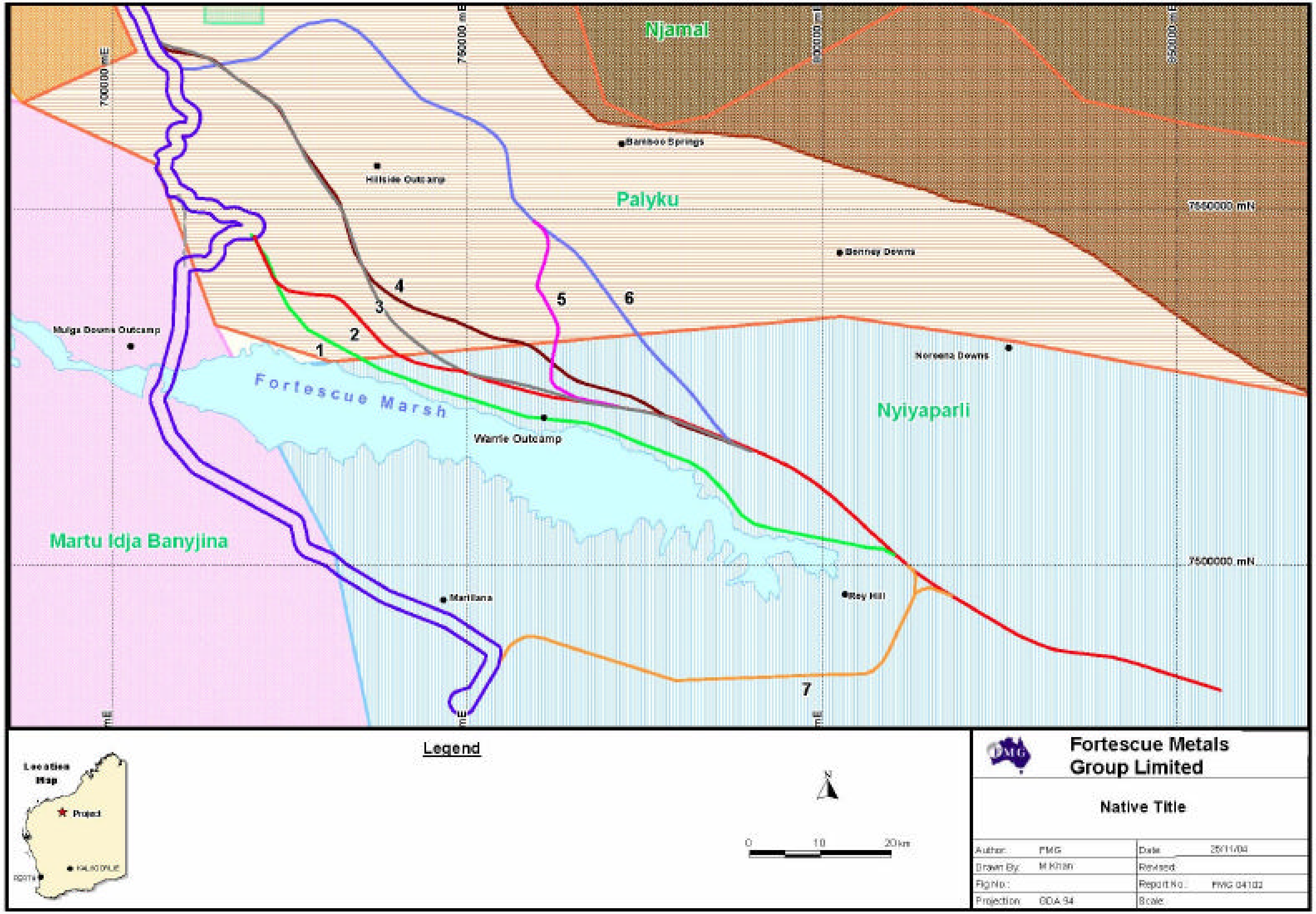

Figure 4 Alternative rail routes superimposed on native title areas

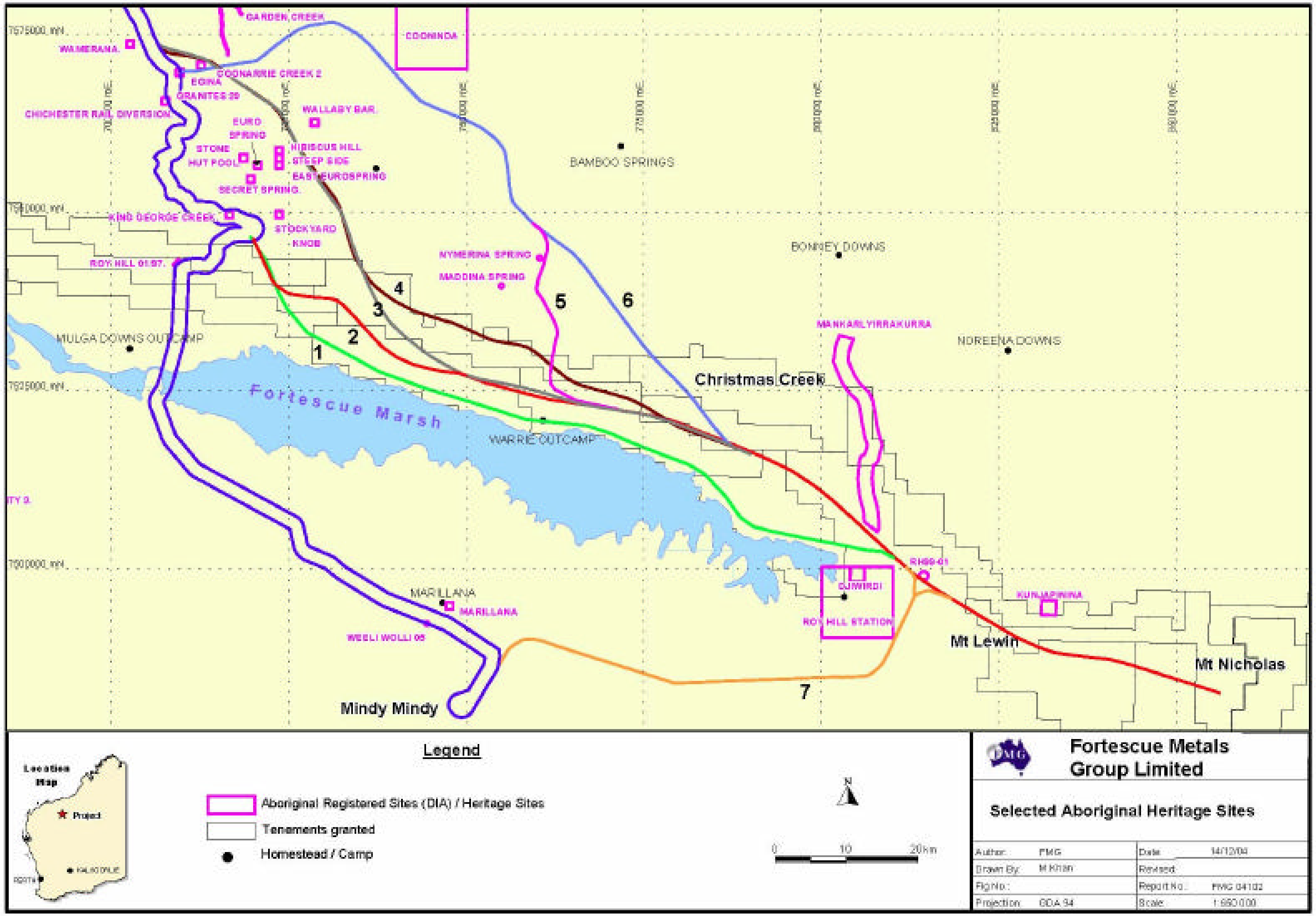

Figure 5 Alternative rail routes superimposed on DIA sites

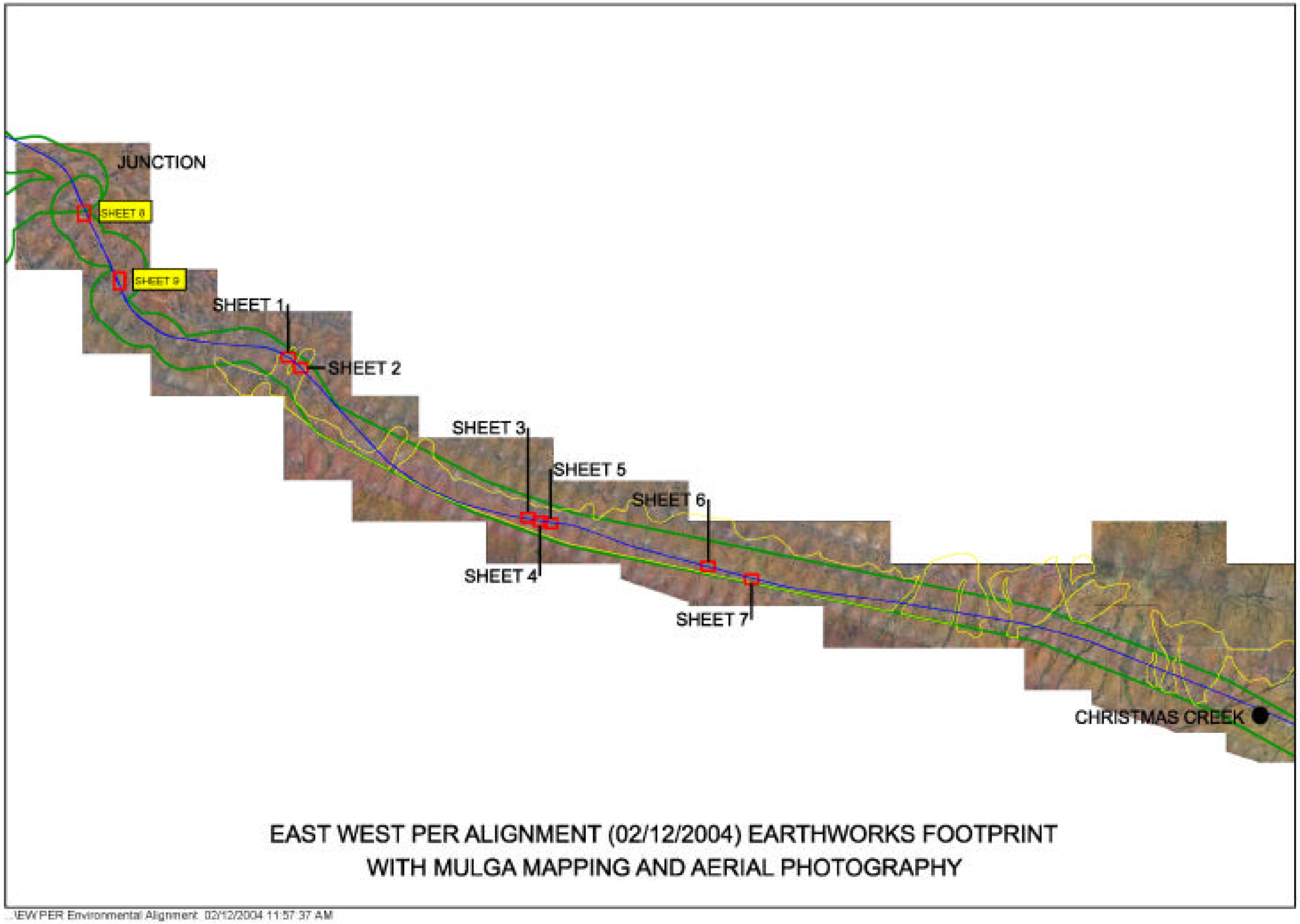

Figure 6 Photomosaic showing locations of enlargements to be studied in more detail

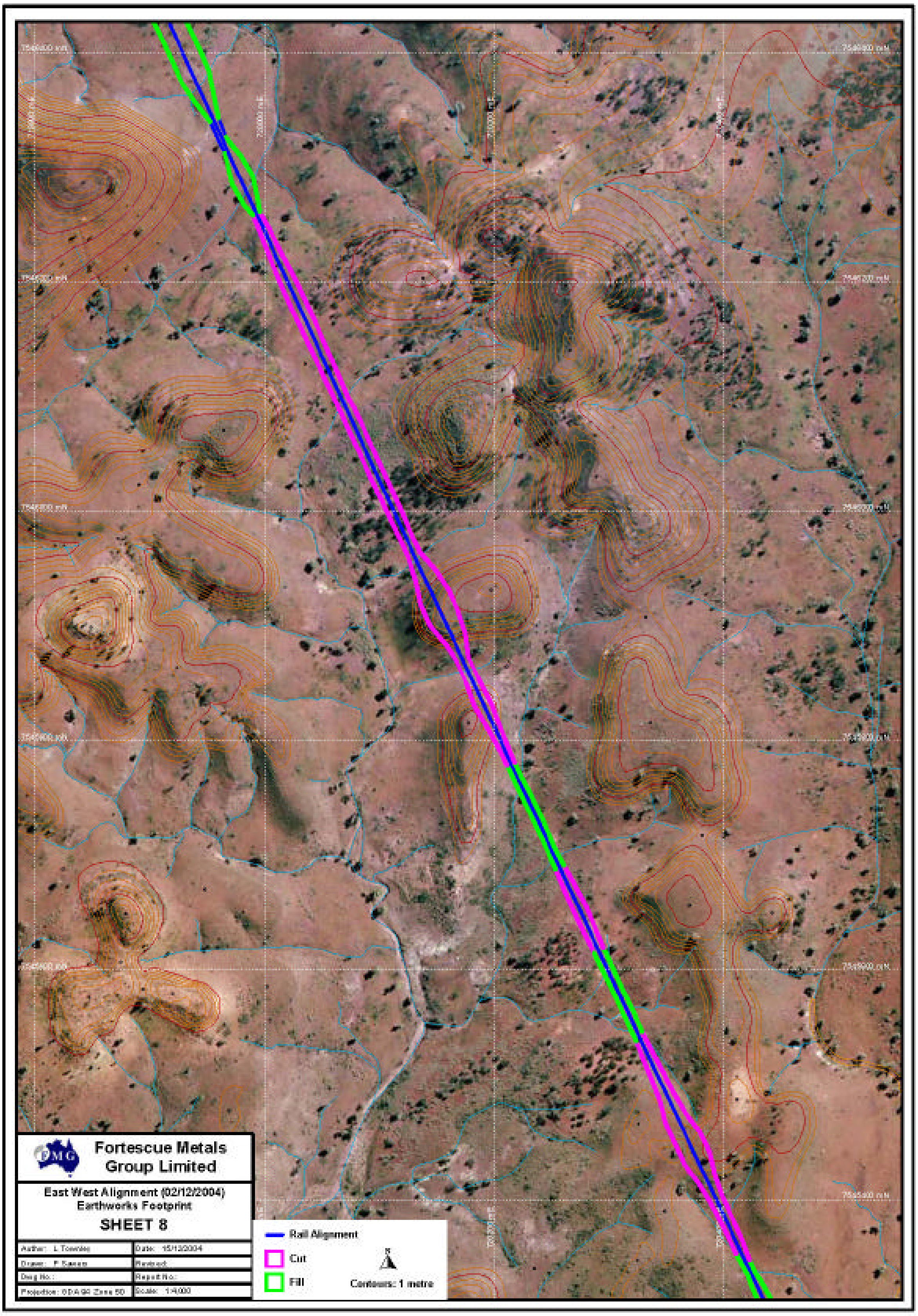

Figure 7 Footprint of rail formation in Chichester Range (Sheet 8 in Figure 6)

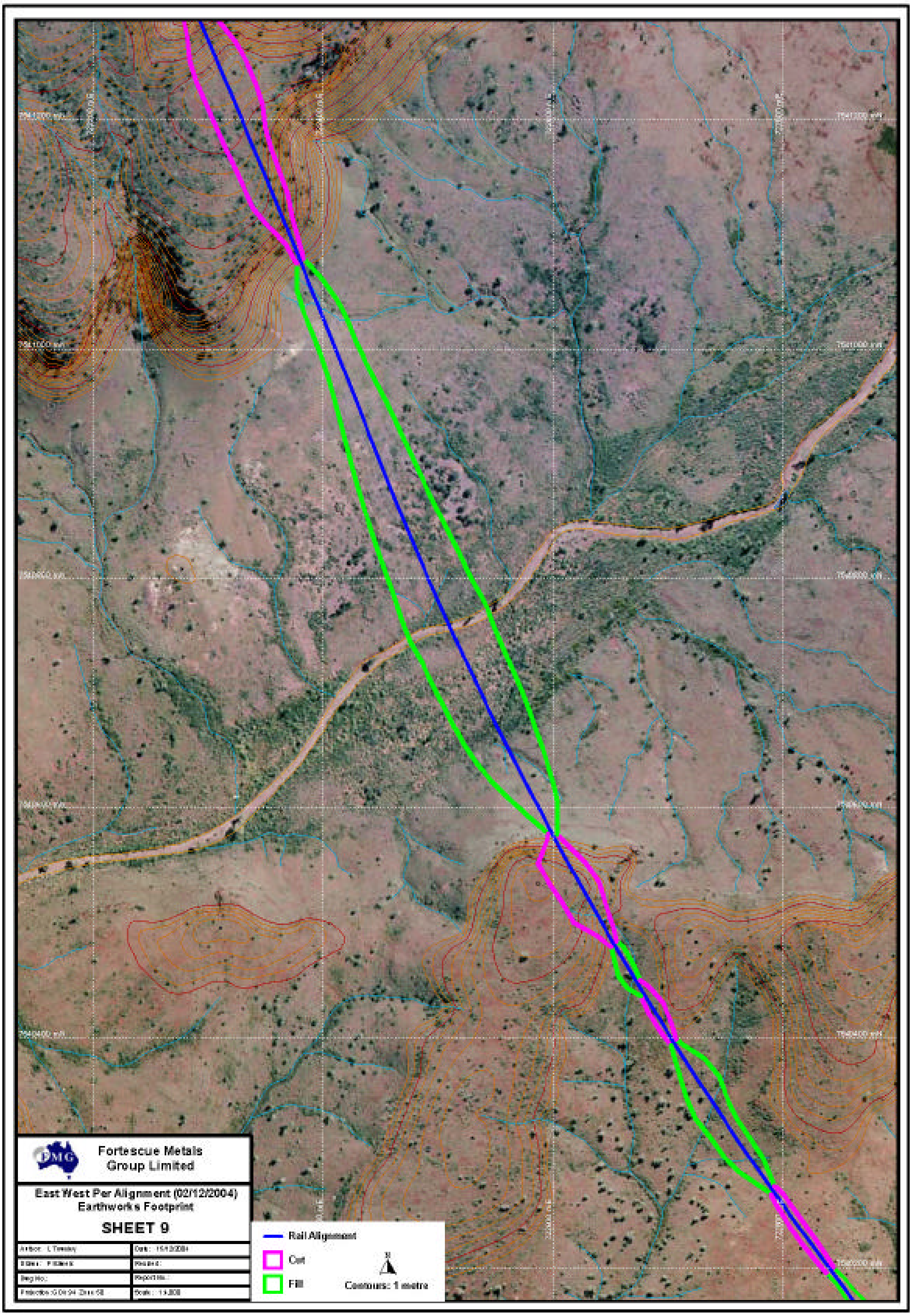

Figure 8 Footprint of rail formation in Chichester Range (Sheet 9 in Figure 6)

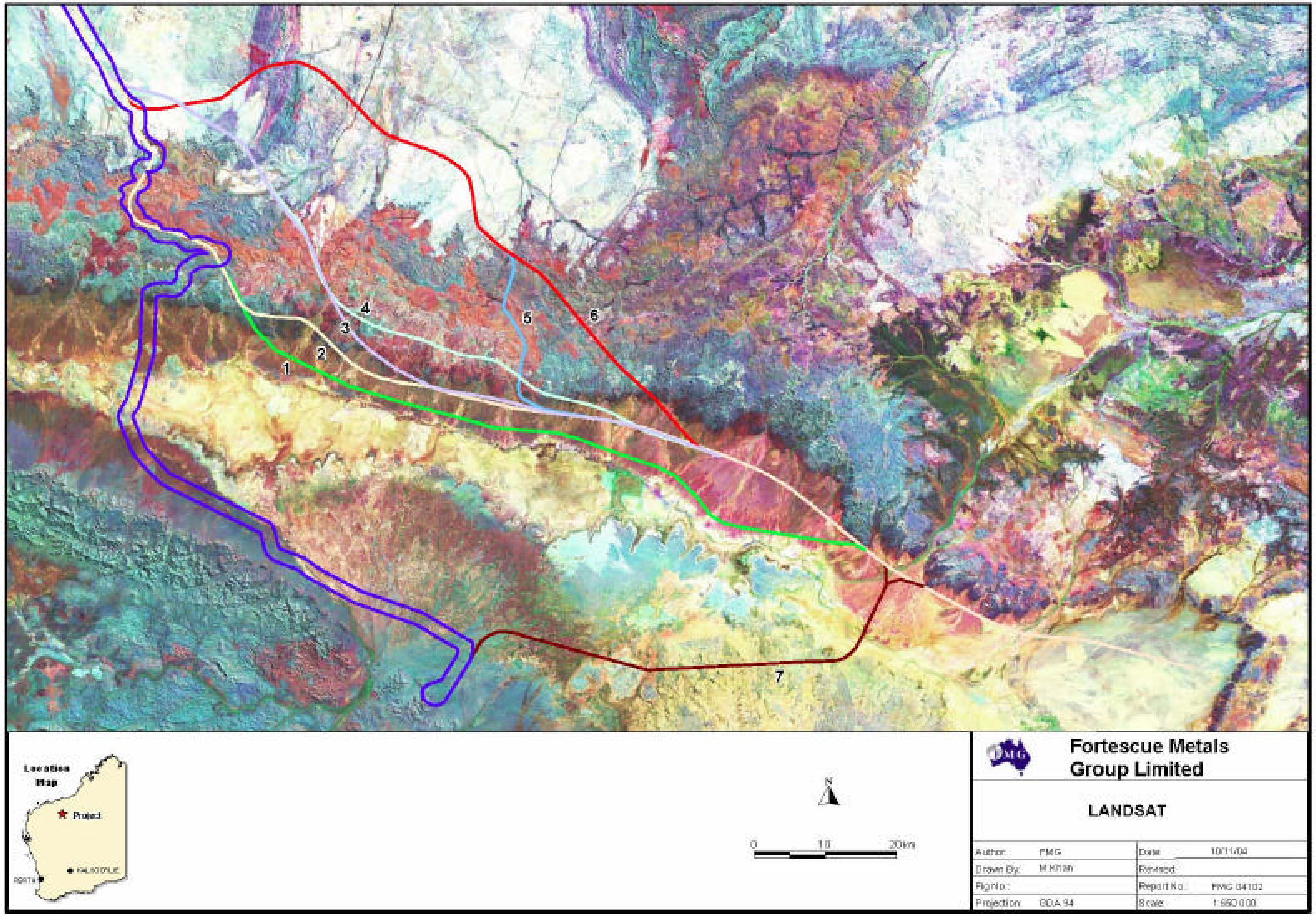

Figure 9 Alternative rail routes superimposed on LANDSAT image

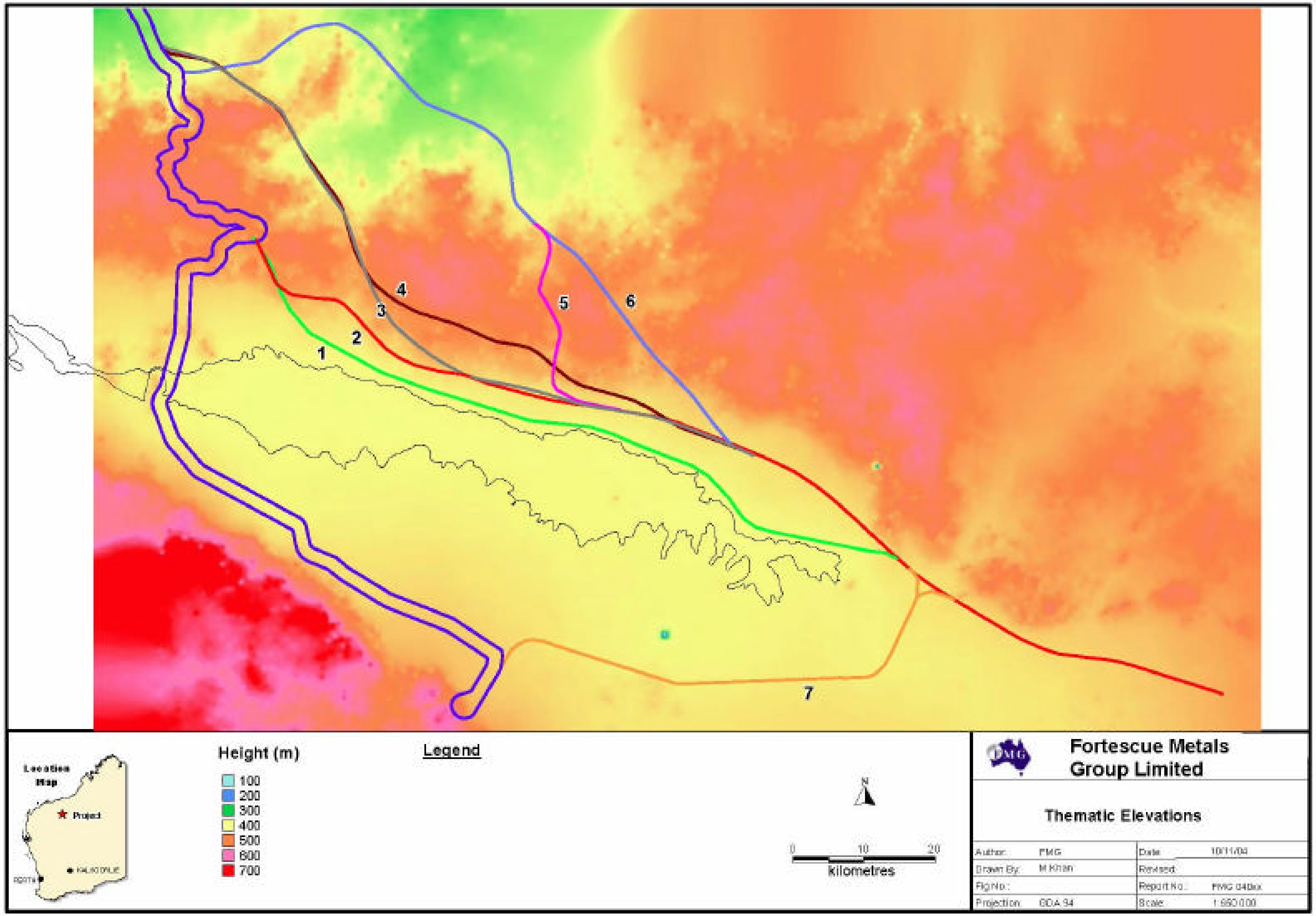

Figure 10 Alternative rail routes superimposed on thematic spot heights (topography)

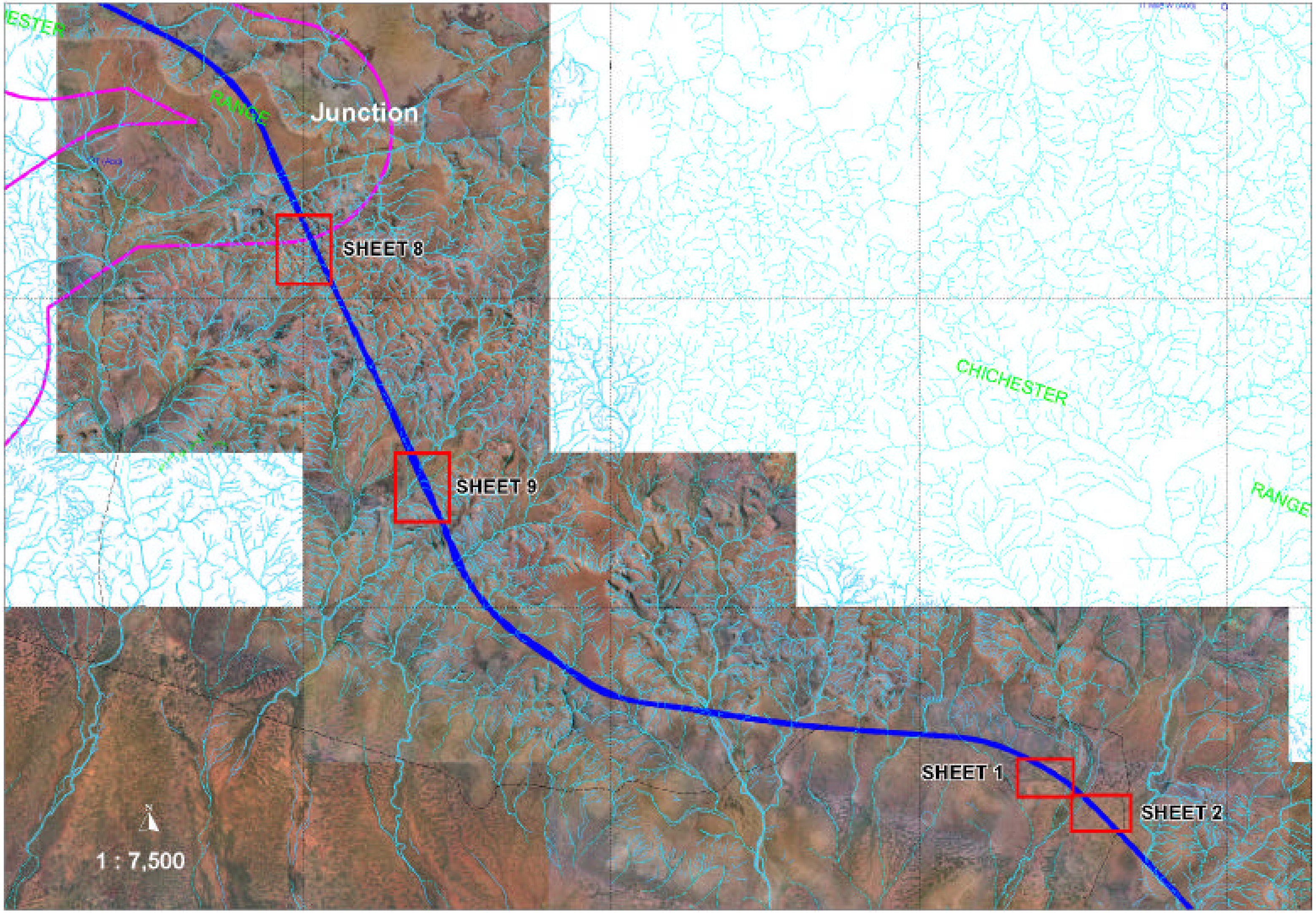

Figure 11 Structure of stream network in Chichester Range

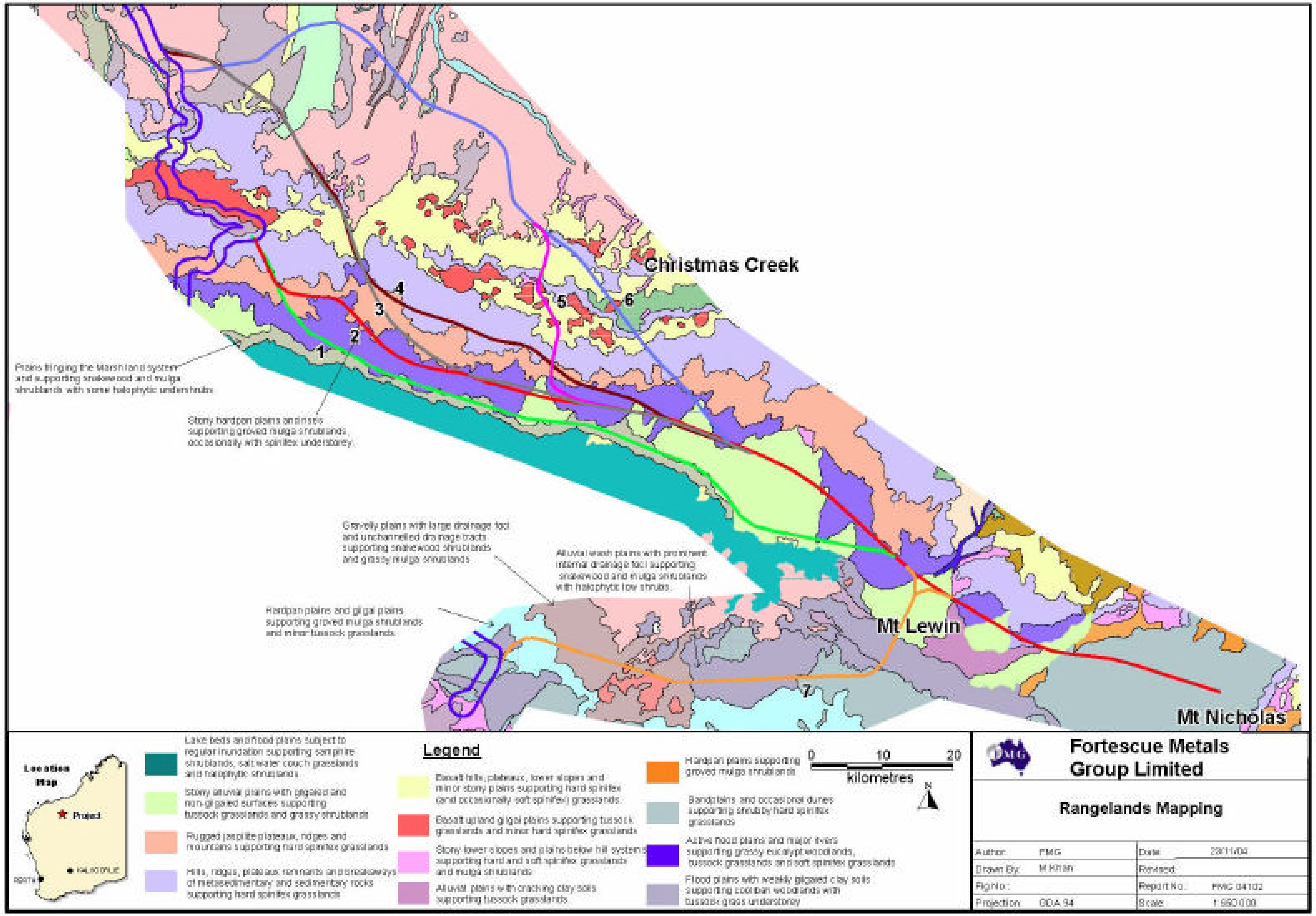

Figure 12 Alternative rail routes superimposed on rangelands mapping

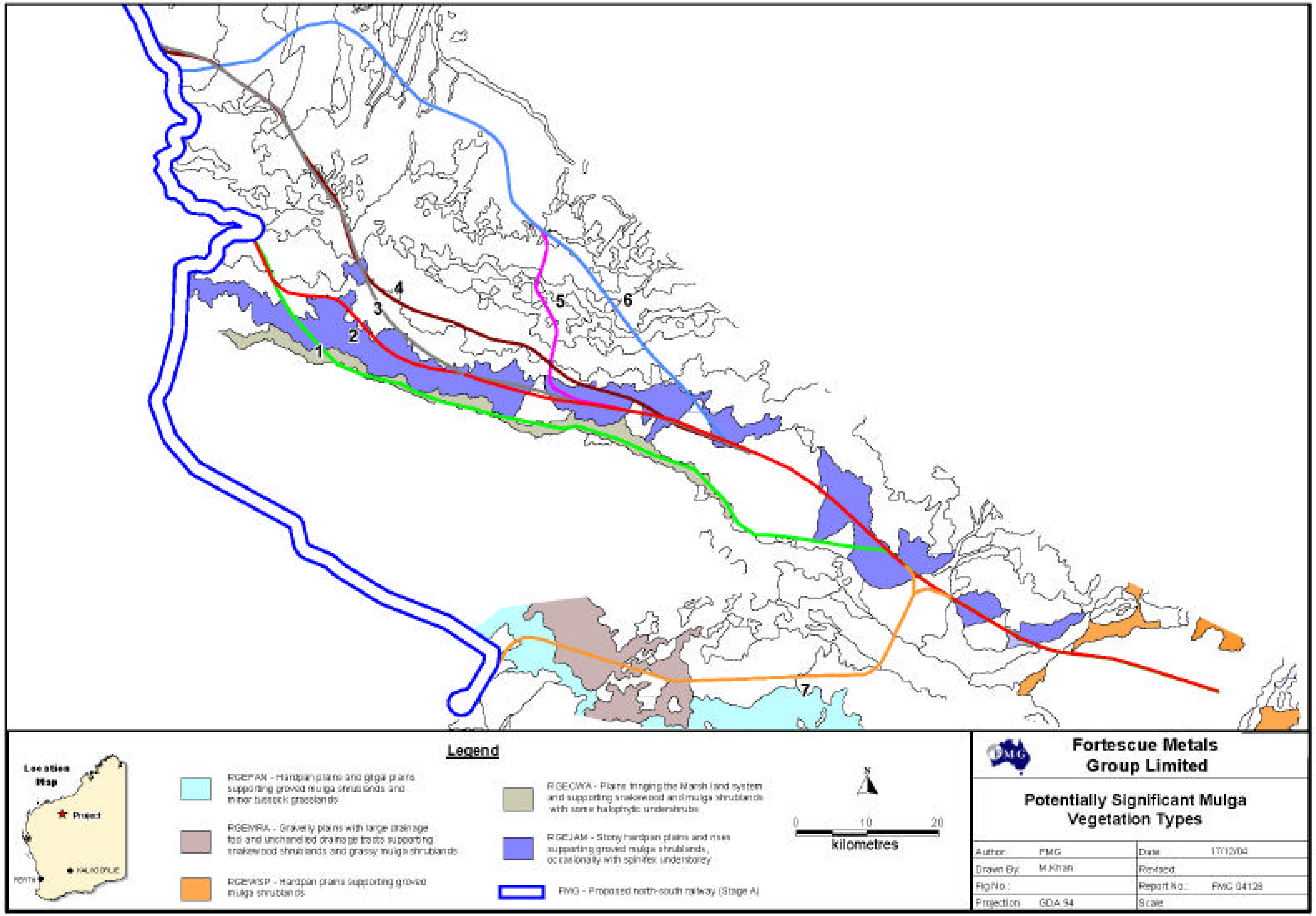

Figure 13 Alternative rail routes superimposed on mulga vegetation types

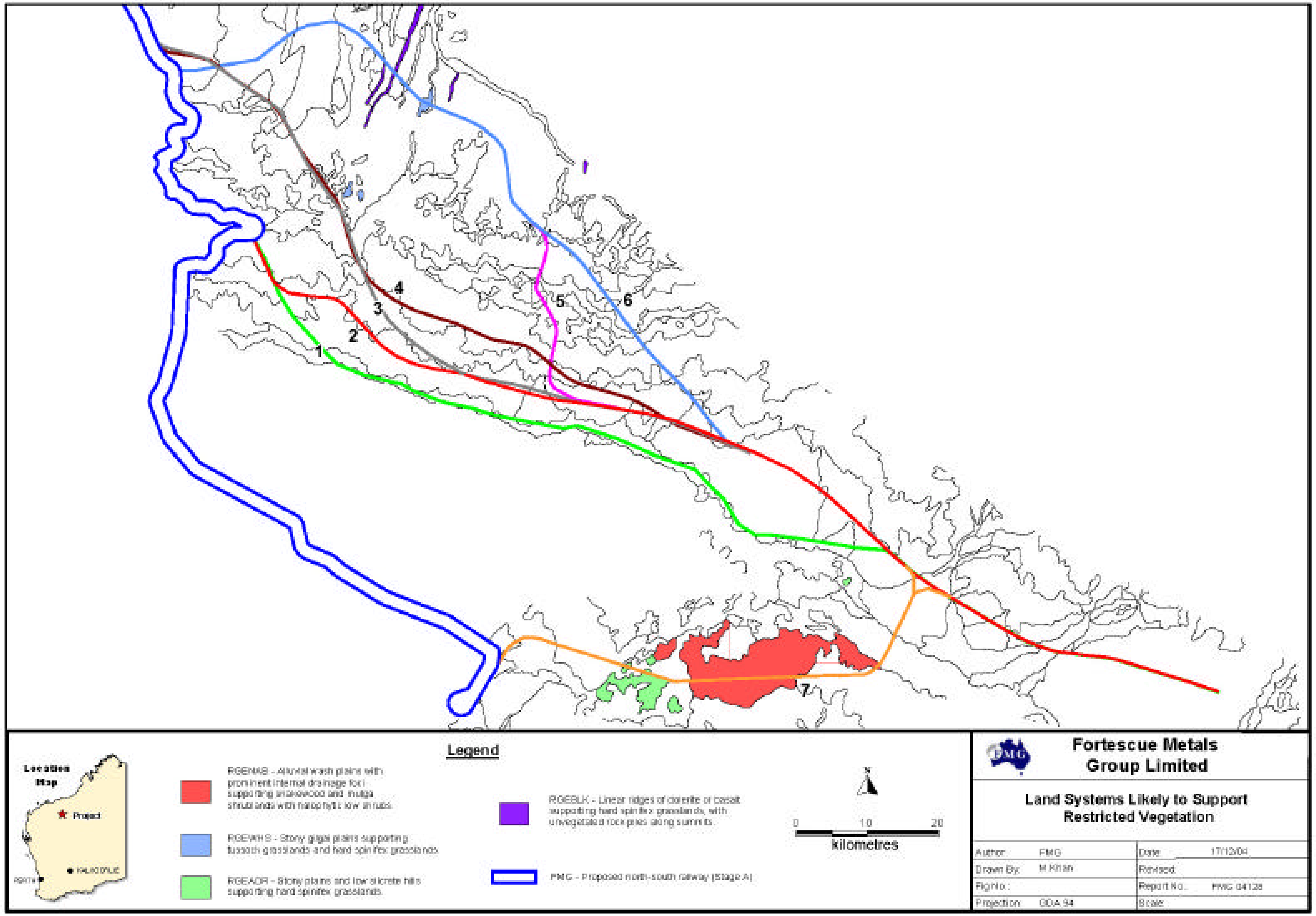

Figure 14 Alternative rail routes superimposed on land systems likely to support restricted vegetation

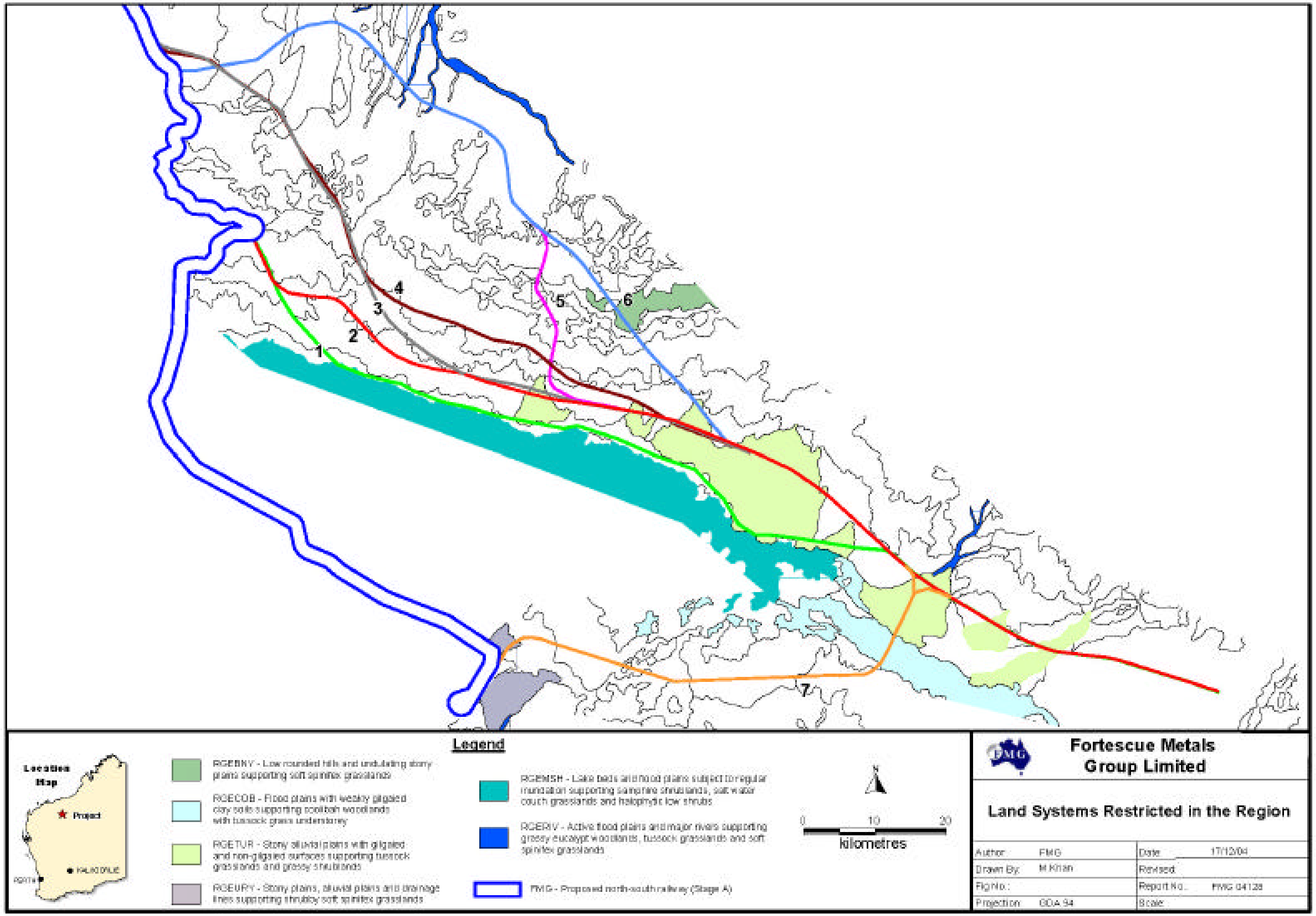

Figure 15 Alternative rail routes superimposed on land systems restricted in the region

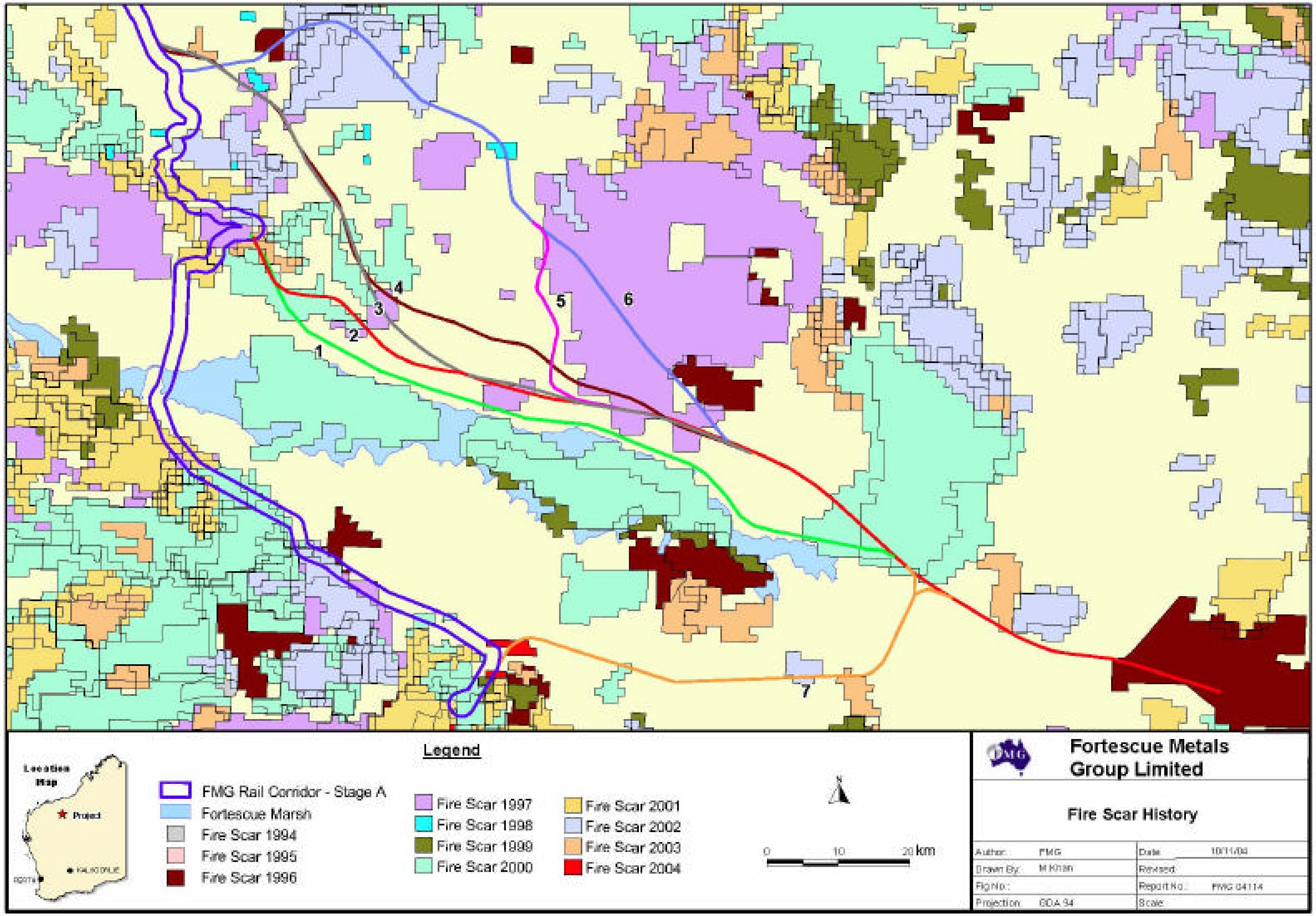

Figure 16 Alternative rail routes superimposed on fire mapping

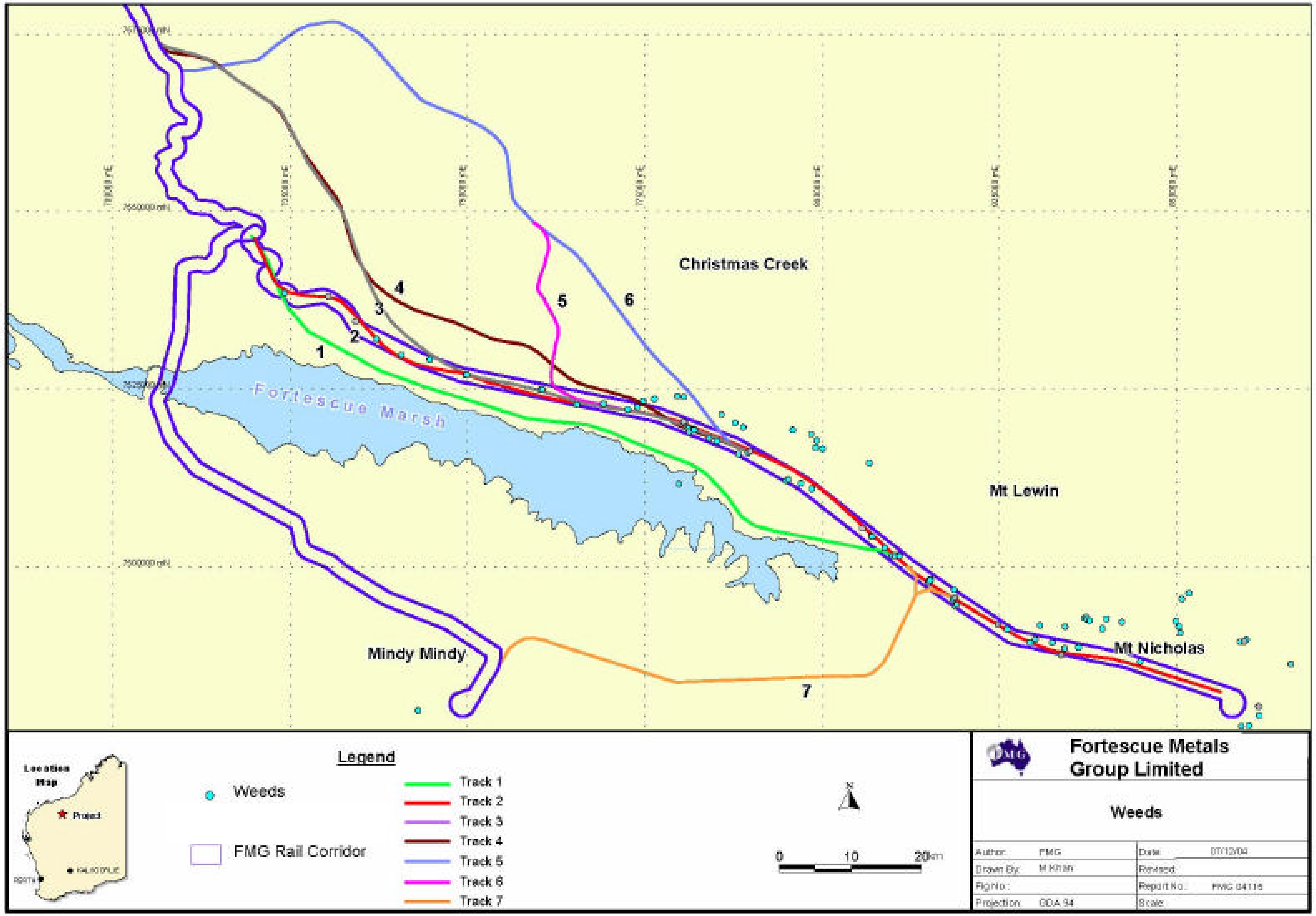

Figure 17 Alternative rail routes superimposed on mapping of weeds along Route 2 rail corridor and near mine sites

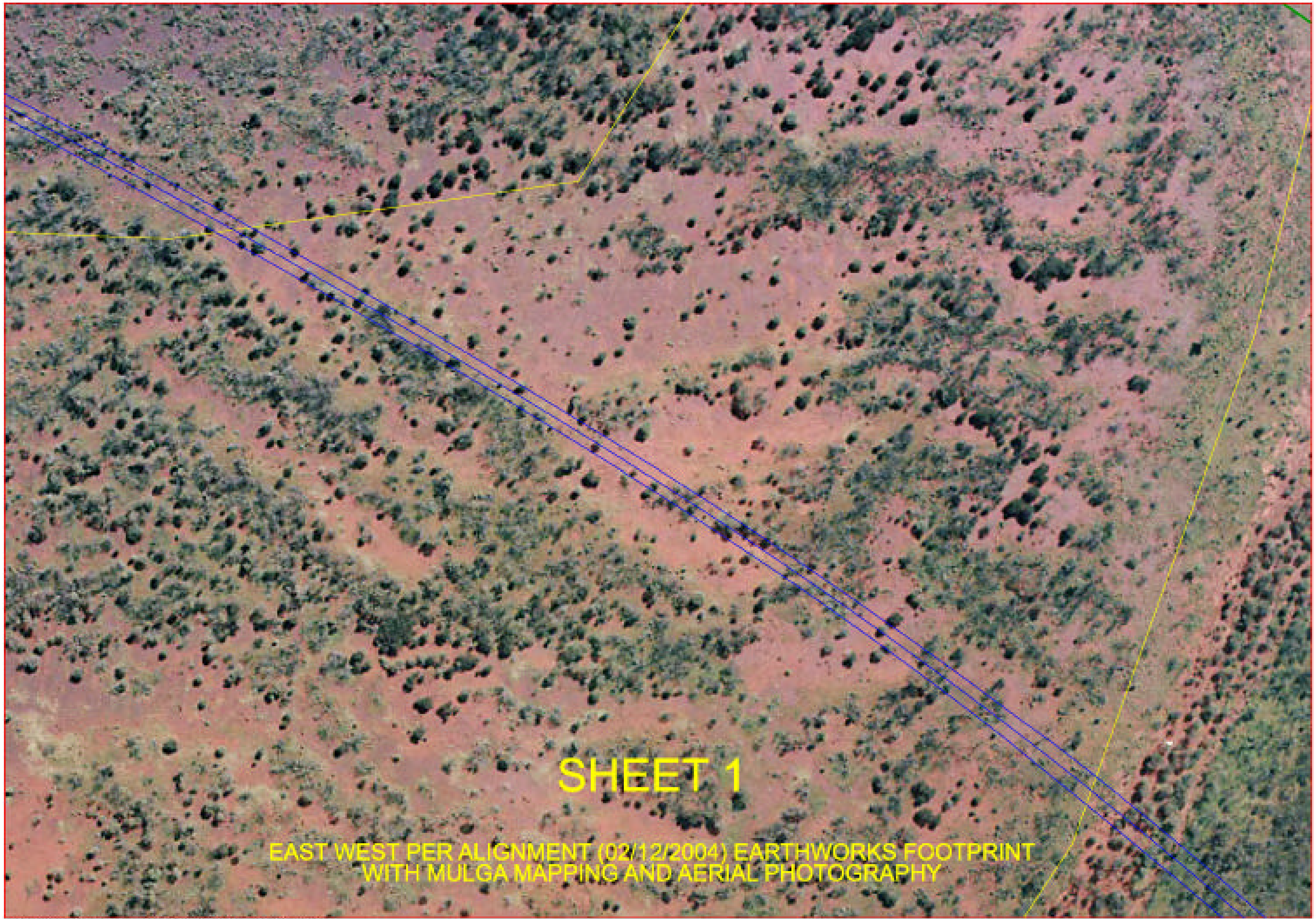

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Figure 18 Route 2 superimposed on aerial photography (see Figure 6 for location)

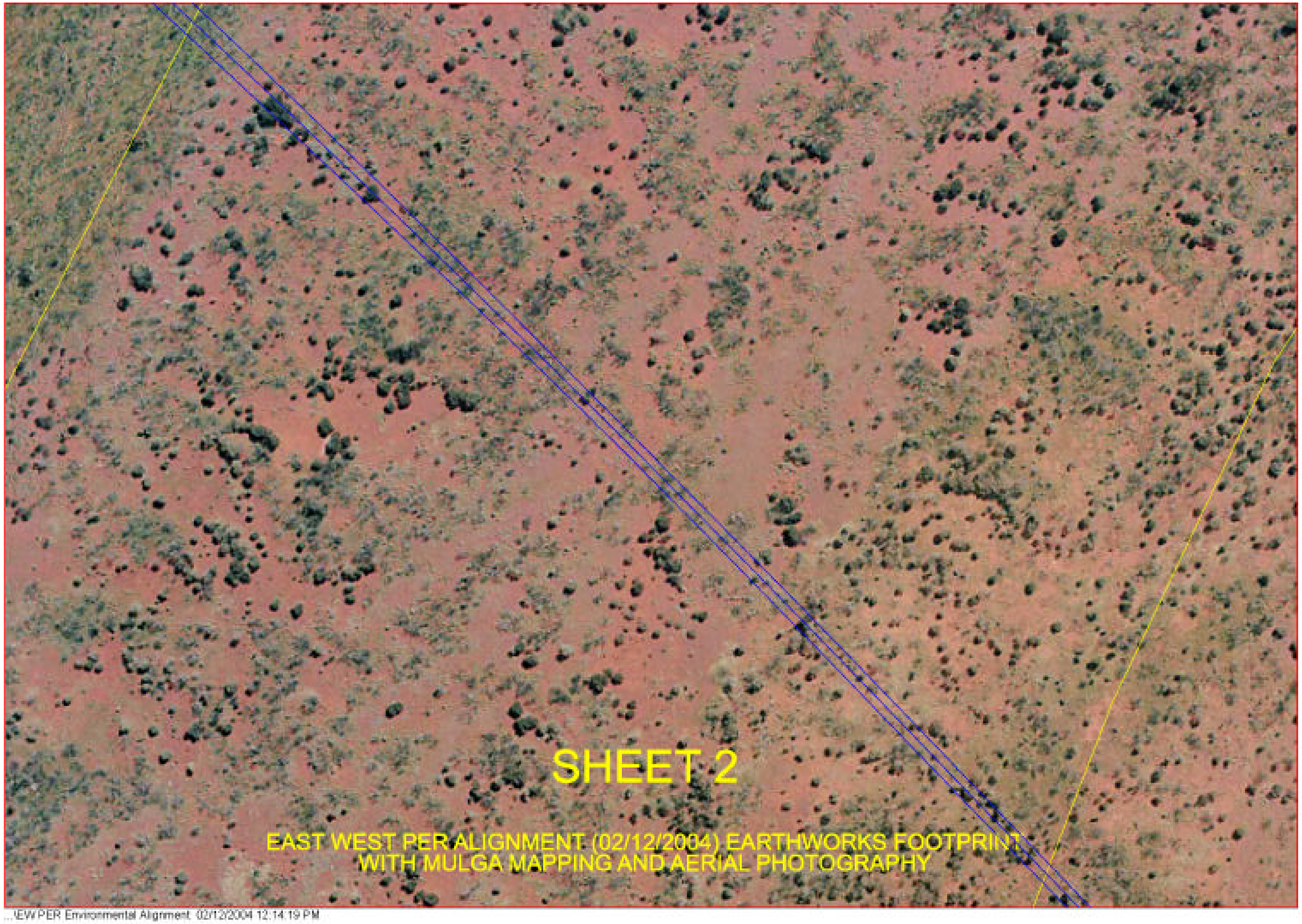

Figure 19 Route 2 superimposed on aerial photography (see Figure 6 for location)

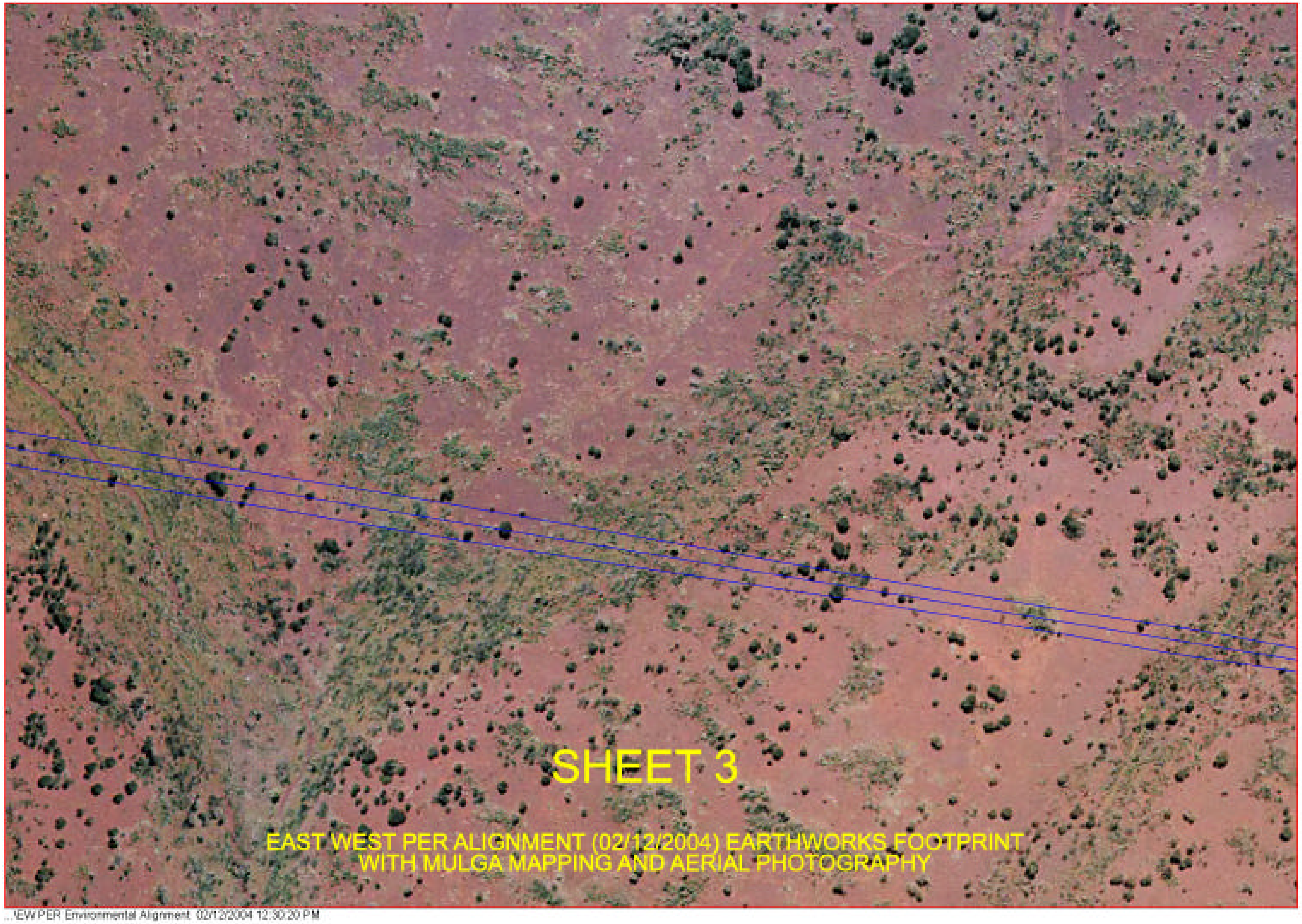

Figure 20 Route 2 superimposed on aerial photography (see Figure 6 for location)

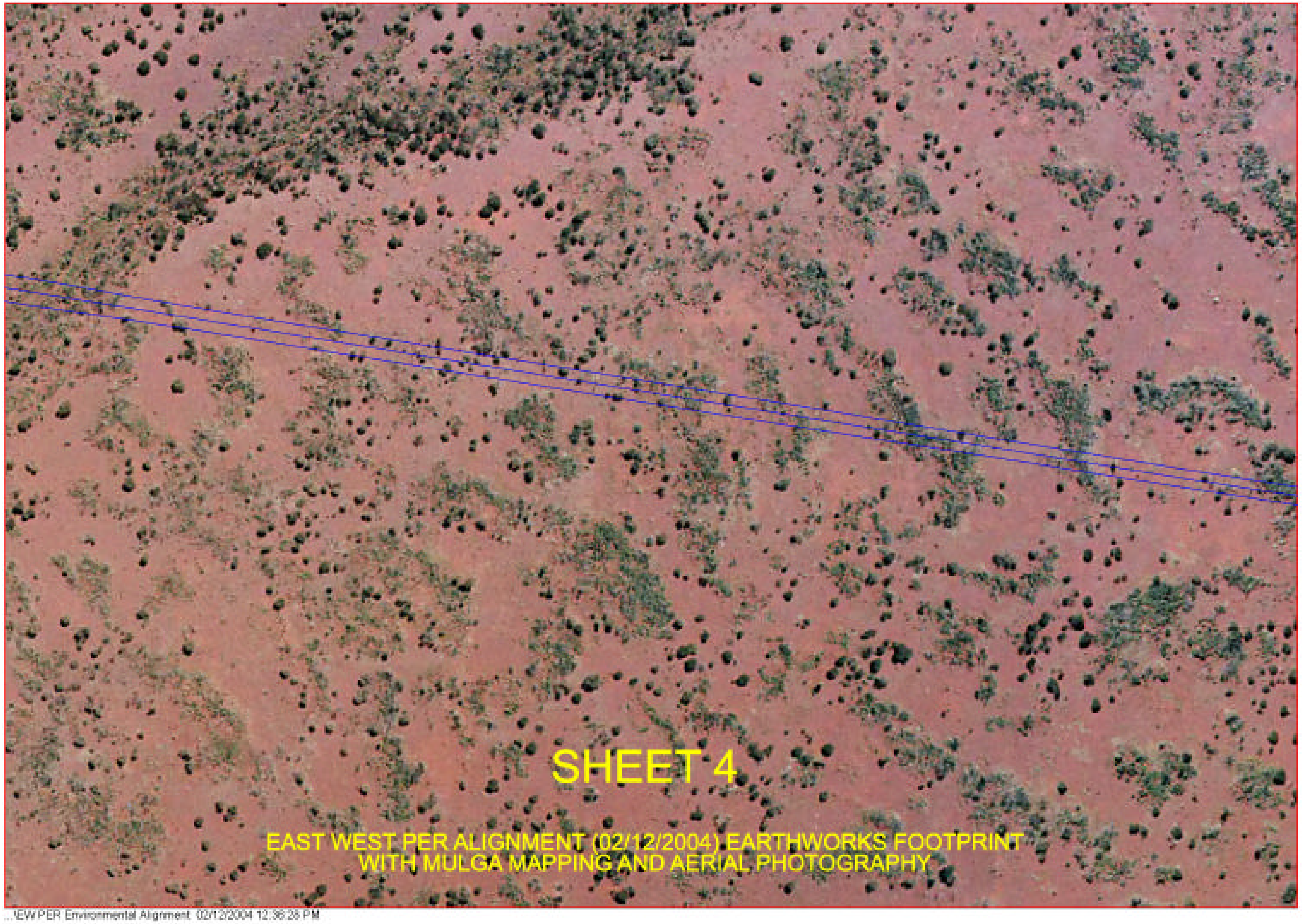

Figure 21   Route 2 superimposed on aerial photography (see Figure 6 for location)

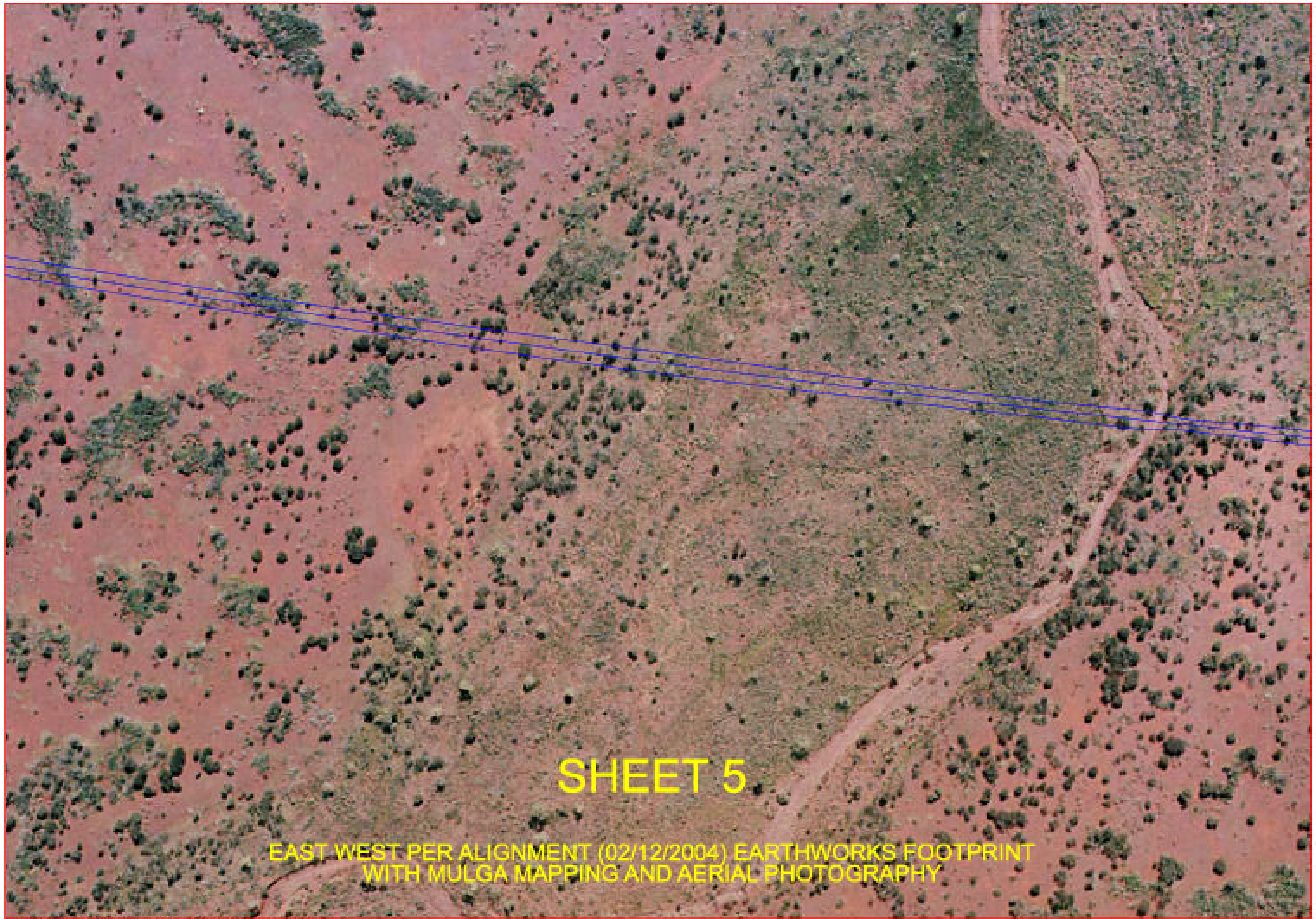

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Figure 22 Route 2 superimposed on aerial photography (see Figure 6 for location)

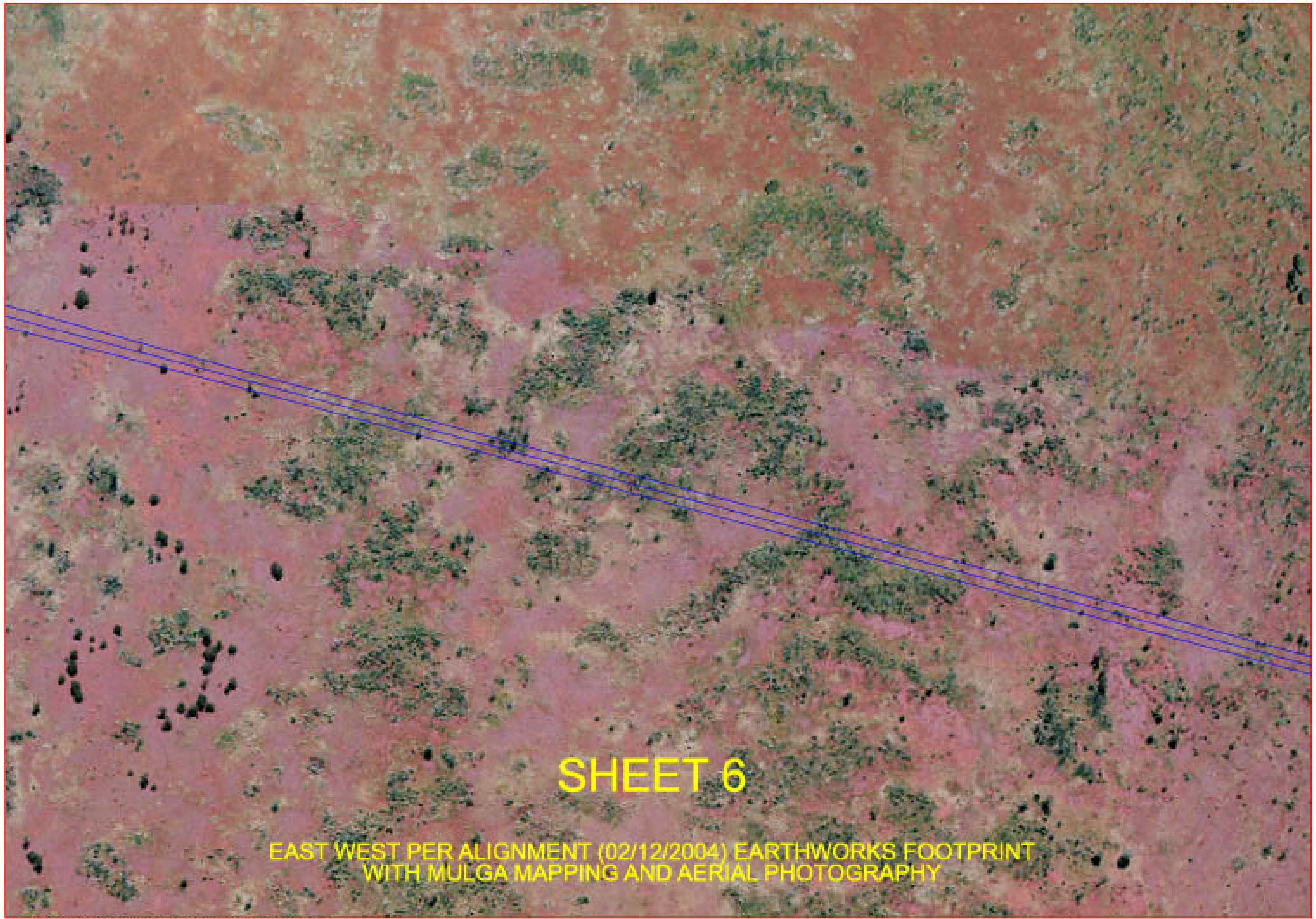

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Figure 23 Route 2 superimposed on aerial photography (see Figure 6 for location)

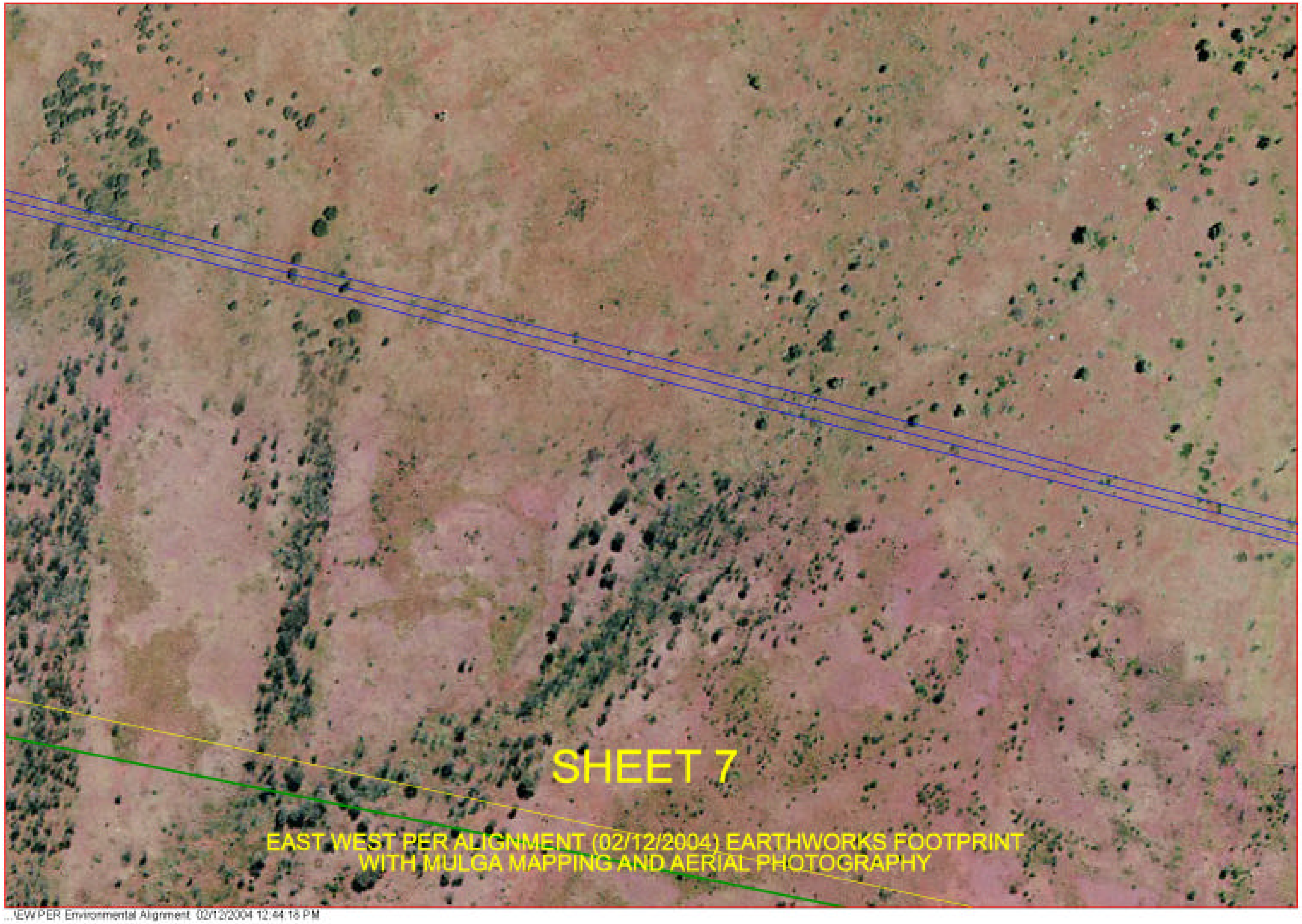

Figure 24 Route 2 superimposed on aerial photography (see Figure 6 for location)

APPENDIX

Appendix 1 – Report Prepared by Mattiske Consulting

MULGA ISSUES – Fortescue Metals Group Project Areas

In preparing this summary Mattiske Consulting Pty Ltd has relied on the following datasets and the experience of studies in the area by Dr Libby Mattiske (since 1979).

1. Authorship, Data Custodian and Data Source

Title: Pilbara Ranges Project Rangeland Survey
Date: 30-10-2002 (issued November 2004)
Custodian: Agriculture WA
Jurisdiction: Western Australia
Abstract: Land system mapping of the Pilbara Region by A.L. Payne, A.M.E. Van Vreeswyk and P. Hennig, Agriculture Western Australia, and K.A. Leighton, Department of Land Administration., Agriculture Western Australia. Publication Scale 1:250, 000. To accompany Technical Bulletin in preparation.

Pre-European Vegetation
Title: Pre-European Vegetation
Date: June 2004
Custodian: Agriculture WA
Jurisdiction: Western Australia
Source_mapping_code - Original coded notation used by J.S. Beard in the Vegetation Survey of Western Australia
Citation - A.J.M. Hopkins, G.R. Beeston, D.P. Shepherd (2001). A database on the vegetation of Western Australia. Stage 1. Technical Report Number 251 (in press).
Notes - The major sources of data in the database was the published and unpublished mapping of J.S. Beard at 1:250,000 scale; which was used as the basis for Beard (1975). Mapping of the south west corner was compiled by A.J.M. Hopkins from various sources.

2. Overview of Findings

On the basis of data extracted from Hopkins et al. (2004) and based on previous regional vegetation mapping by Beard (1975), the proportion of the Mulga communities within each subregion of the IBRA sub-regions of Western Australia are summarized in Table 1. The data illustrates marked differences between the representation of Mulga communities in the respective areas. Overall, approximately 20% of these three regions have Mulga present. The region with the most Mulga is the Fortescue, with over 60% of the region comprised of Mulga communities. The Chichester region has less than 2% of the region with Mulga communities present.

The proposed mining developments are largely associated with the Fortescue subregion; whilst the proposed railway corridors pass through the Fortescue and Chichester subregions.

Table 1: Summary of the proportion of Mulga communities in different IBRA subregions

IBRA Subregion	Vegetation Communities with Mulga	Total Area of Mulga in Region (ha)	Proportion of area with Mulga (%)
Chichester	6	125349.51	1.5
Fortescue	8	1135662.87	60.5
Hamersley	10	1828194.65	32.03
TOTAL	17	3089207.00	19.4

In delineating these proportions for Table 1 it must be recognised that the Mulga communities are very variable and Mulga is not always dominant in the respective communities. The differences in the respective Mulga communities is in part illustrated in the extracted descriptions in Table 2.

Table 2: Vegetation descriptions from Hopkins et al. (2004) and based on Beard (1975)

VEGETATION TYPE CODE	DESCRIPTION
18	Low woodland; Mulga (*Acacia aneura*)
28	Open low woodland; Mulga
29	Sparse low woodland; Mulga, discontinuous in scattered groups
39	Shrublands; Mulga scrub
165	Low woodland; Mulga and Snakewood (*Acacia eremaea*)
166	Low woodland; Mulga and *Acacia victoriae*
169	Shrublands; Mulga and *Minnieritchie* scrub
181	Shrublands; Mulga and Snakewood scrub
188	Shrublands; Mulga and *Acacia sclerosperma* scrub
199	Hummock grasslands, shrub steppe; Mulga over soft spinifex *Triodia* on rises
215	Low woodland; Mulga on dolerite
216	Low woodland; Mulga (with spinifex) on rises
222	Sparse low woodland; Mulga and *Acacia victoriae* in scattered groups
562	Mosaic: Low woodland; Mulga in valleys / Hummock grasslands, open low tree-steppe; snappy gum over *Triodia wiseana*
567	Hummock grasslands, shrub steppe; Mulga and Kanji over soft spinifex and *Triodia basedowii*
568	Hummock grasslands, shrub steppe; Mulga and Snakewood over *Triodia wiseana*
624	Hummock grasslands, shrub steppe; Mulga over soft spinifex and *Triodia basedowii*
625	Shrublands; Mulga and *Minnieritchie* sparse groups
644	Hummock grasslands, open low tree steppe; Mulga and Snakewood over soft spinifex and *Triodia basedowii*

The potential impact of the proposed facilities on these respective Mulga communities for the proposed mining areas and the proposed infrastructure areas cannot be determined at this stage as the detail of the proposed clearing areas were not provided at the time of this assessment.

3. Potential Impact of Railway Route Options on the Mulga communities

The potential areas of Mulga communities that may be influenced by the alternative railway line options are summarized in Table 3 (on the basis of the landsystem mapping of Payne et al. 2002).

Table 3: Summary of Railway Line Route Options based on Landsystem Data from Payne et al. (2002)

LANDSYSTEM DATA		
Route	**Mulga Communities affected as Total Area (ha)**	**Ranking****
1	334	7
2	306	6
3	261	4
4	205	2
5	209	3
6	146	1
7	283	5

**Ranking from lowest to highest proportion of total affected area with Mulga communities.

Table 4: Landsystem Descriptions from Payne et al. (2002)

Landsystem Mapping Code	Description
RGECWA	Plains fringing the Marsh land system and supporting Snakewood and Mulga shrublands with some halophytic undershrubs.
RGEFAN	Hardpan plains and gilgai plains supporting groved Mulga shrublands and minor tussock grasslands.
RGEJAM	Stony hardpan plains and rises supporting groved Mulga shrublands, occasionally with spinifex understorey.
RGEMRA	Gravelly plains with large drainage foci and unchannelled drainage tracts supporting Snakewood shrublands and grassy Mulga shrublands
RGENAB	Alluvial wash plains with prominent internal drainage foci supporting Snakewood and Mulga shrublands with halophytic low shrubs.
RGEWSP	Hardpan plains supporting groved Mulga shrublands

The landsystem mapping data, based on Payne et al. (2002) provides a basis for assessment. The area that will affect the least area of landsystems supporting Mulga communities is Route 6, whilst Route 4 is the second least area of Mulga communities. Based on the landsystem data, Route 1 has the highest amount of Mulga community. To place this into perspective, of the total 25 landsystems supporting Mulga communities involved, only 6 of these 25 landsystem mapping units are potentially influenced by the seven route alternatives. Of these landsystems the "Jam" landsystem is the most influenced on all routes, Table 5.

Table 5: Areas of the Landsystems (based on Payne et al. 2002) which include Mulga communities that may be influenced by the Railway line options (based on a 40 metre corridor)

Landsystem Mapping Code	Route 1	Route 2	Route 3	Route 4 (ha)	Route 5	Route 6	Route 7
RGECWA	206	0	0	0	0	0	0
RGEFAN	0	0	0	0	0	0	29
RGEJAM	119	297	253	197	200	138	123
RGEMRA	0	0	0	0	0	0	62
RGENAB	0	0	0	0	0	0	62
RGEWSP	9	9	8	8	9	8	7
Total Mulga Disturbance	334	306	261	205	209	146	283
Total Vegetation Disturbance	725	654	786	842	885	842	700