

5 Constraint analysis

This chapter presents the constraint and opportunity analysis for the I I social, environmental and technical factors that were assessed as part of the Plan. It includes the maps for each analysis and a combined constraint map.

5.1 Introduction

As part of the planning for the Bells Line of Road corridor a constraint and opportunity analysis was prepared to assess existing conditions within the Bells Line of Road corridor that may influence the location and nature of future road development. It is a high level of analysis, undertaken at a level of detail appropriate for strategic corridor planning.

The constraint analysis involved mapping social, environmental and technical information about potential opportunities and constraints within the corridor and is an important tool for preparing the Plan and for detailed corridor planning. The extent of mapping covers about five kilometres either side of the Bells Line of Road and extends to include the Sydney motorway network.

The constraint analysis was based on key findings from previous studies, as well as more recent information gathered during the preparation of the Plan, including the outcomes of the community involvement process, where the community was specifically asked to identify constraints that may affect future road development.

Topic areas

The analysis looked at the following I I social, environmental and technical factors:

- > Land use
- > Geotechnical
- > Ecology
- > Landscape character
- > Visual character
- > Aboriginal heritage
- > Non-Aboriginal heritage
- > Water quality
- > Flooding
- > Noise
- > Air quality

How the constraints were mapped and classified

To identify the importance of each potential constraint, classifications of high, medium and low were assigned to each area. These classifications reflect the significant local issues within the corridor. Generally speaking, for an individual area or environmental factor:

- > A high constraint suggests that road development would be undesirable in terms of that environmental factor and would need a strong justification, careful design and environmental management measures to be implemented.
- > A moderate constraint suggests that the road development would have potential impacts that require consideration in terms of design and appropriate environmental management.
- > A low constraint suggests that the road development would have a lower impact and there is greater certainty around the possible design solutions and measures to minimise impacts.

The constraint analysis for the I I factors is presented below.

Limitations and assumptions

The constraint analysis uses the following limitations and assumptions:

- > The maps show existing conditions within the corridor at a broad scale.
- > The analysis is based on available data, with limited field investigation.
- > The analysis covers a large corridor and a vast amount of spatial data. The broad level of the spatial data limits the details available at a local level.

Specific limitations within topic areas are discussed in the relevant sections below. It should be noted that any specific programs or projects arising from the plan would be subject to environmental impact assessment and planning approval processes, where detailed investigations would be carried out, as appropriate.

5.2 Land use

The Bells Line of Road corridor contains many important and varied land uses. These existing land uses and identified growth areas will be a key influence on future road development within the corridor.

5.2.1 Mapping methodology

The land use constraint analysis considered the impact that future road development may have on current and future land uses. Key land uses within the corridor were assigned a constraint classification, as summarised below.

High constraint

- > Residential
- > Open space – environmental protection (including national parks and World Heritage areas).



Small lot agricultural land use

- > Open space – recreation
- > Military
- > Mining

Moderate constraint

- > Future proposed urban development (including the North West Growth Centre).
- > Commercial land.
- > Small rural lots (less than 10 hectares within a rural land use class).
- > Active fruit growing.
- > Special use and community facilities.
- > Floodplain agriculture.

Low constraint

- > Industrial land
- > Infrastructure (including existing road reserves, easements and the Castlereagh Corridor).

- > State forest
- > Large rural lots (greater than 10 hectares).

5.2.2 Community input

Community comments and feedback relating to land use highlighted:

- > The importance of the village settlement pattern adjacent to the Bells Line of Road.
- > The amenity and value of villages, including Kurrajong Hills and the residential areas around Bowen Mountain and Grose Vale.
- > The potential impacts on traffic congestion due to land use changes.
- > The potential impacts of a bypass or motorway on local businesses (eg The Apple Bar, Tutti-Frutti, and The Turpentine Tree), and tourist attractions (eg Mount Tomah Botanic Gardens, orchards and slot canyons).
- > Concerns about the length of the planning process. This could create uncertainty for prospective buyers of properties, who could be hesitant to purchase properties due to concern about the potential for future road widening.



Fruit growing in the Bilpin area

5.2.3 Mapping results

Land use constraints are shown in **Figure 5.1**.

High constraint areas

- > The largest concentration of high constraint is associated with the central section, with smaller, more isolated areas of high constraint in the eastern and western areas.
- > The largest continuous area of high constraint is associated with the Blue Mountains and Wollemi national parks. More dispersed areas of high constraint in the eastern and western sections reflect residential centres including Richmond,

North Richmond, Windsor, Quakers Hills and Lithgow. High constraint in these areas can also be attributed to open space (nature reserves, including Shanes Park and recreational facilities), mining (quarries in the east and mainly coal operations in the west) and Department of Defence land.

Moderate constraint areas

- > In the central areas and to the west of Richmond, the moderate constraint reflects the village settlement pattern of smaller rural lots (particularly around Mount Tomah, Mount Wilson and Bilpin) and the presence of fruit growing.

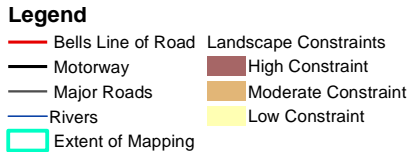
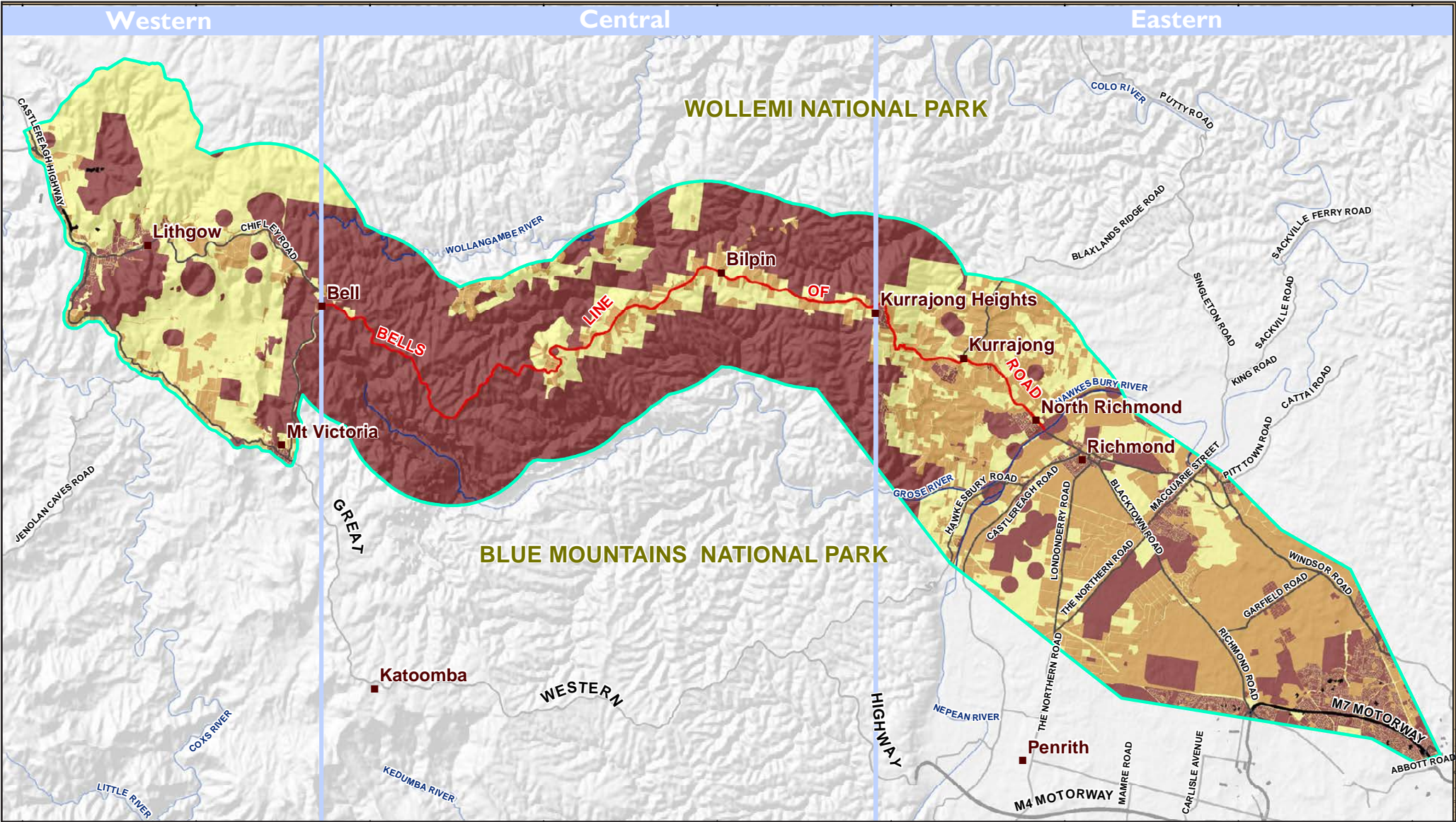


Figure 5.1
Land use constraints

- > In the eastern section, the moderate constraint highlights the North West Growth Centre and special use/community facilities such as the University of Western Sydney campus and TAFE NSW Western Sydney campus. Moderate constraint also reflects the occurrence of specialised agriculture associated with the Hawkesbury River flood plain, fruit growing and small lot settlements.
- > In the western section, moderate constraint is associated with the Newnes State Forest and the small lot village settlements of Clarence and Little Hartley.

Low constraint areas

- > Low constraint areas along the corridor reflect the presence of large rural lots.
- > Low constraint in the eastern section reflects areas of infrastructure, including the Castlereagh Corridor.

5.2.4 Future investigations

The land use analysis represents a snapshot of current and known future land uses. Any future planning or implementation of upgrade(s) will need to consider any planned changes to land use likely to occur, including any additional mining operations. As such, the land use constraint map will need to be updated, and will need to include detailed site-specific land use investigations.

Additionally, native title (including land subject to native title claims) and Aboriginal-owned land will need to be considered for any future planning.

5.3 Geotechnical

The Bells Line of Road corridor is geologically and geotechnically diverse, with mountainous areas associated with the Blue Mountains National Park contrasting with the Cumberland floodplain and Hartley Valley. The geotechnical constraint analysis considered geological and geotechnical conditions that would influence road constructability, and geotechnical hazard during the operational phase of road development.



Steep terrain in Blue Mountains National Park

5.3.1 Mapping methodology

The geotechnical constraint analysis considered the following aspects:

- > Slope – slope is an indicator of geotechnical hazard. Higher areas of slope generally contribute to a higher level of hazard.
- > Slope curvature – slope curvature is an indicator of the change in slope. Cliff areas and drainage lines have a high curvature value as they represent difficult areas for road construction.
- > Geology – different geological types have characteristics that influence both constructability and geotechnical hazard.
- > Faults and neotectonics – fault lines present particular geotechnical hazards.
- > Rivers – river crossings present particular constructability issues due to the geotechnical characteristics of riverbeds and banks.
- > Mines – mines often create areas of instability and subsidence.
- > Geomorphology – different geomorphological features exhibit different characteristics in terms of stability and, therefore, geotechnical hazard.
- > Acid sulphate soils – these exhibit particular characteristics (apart from their environmental risks) that influence constructability, primarily in relation to their potential to corrode construction materials.

Each geotechnical aspect was classified as either a high, moderate, low or null constraint based on its influence on any future road upgrade. The final geotechnical constraints map is a composite of all the input constraint maps. Constraint classifications for each of the above aspects are summarised in **Table 5.1**.

Table 5.1 Geotechnical constraint classifications

	Low constraint	Moderate constraint	High constraint
Slope	Slopes less than 5	Slopes between 5–15	Slopes greater than 15
Slope curvature	–	–	Cliffs Drainage lines
Geology	Sandstone	Volcanics Quaternary alluvium and colluvium	Shale
Faults and neotectonics	Greater than 25 m from the Kurrajong Fault	–	Less than 25 m from the Kurrajong Fault
Rivers	Greater than 200 m from rivers	–	Less than 200 m from rivers
Mines	–	Less than 1 km from coal mines Less than 500 m open (gravel) mines	Known boundaries of mines
Geomorphology	Tunnel locations	Drainage Areas of potential palaeochannels	Historic landslide features Cliffs Rocky outcrops
Acid sulphate soils (ASS)	Areas mapped with a probability of encountering ASS between 6–70%	–	Areas mapped with a probability of greater than 70% of encountering ASS

5.3.2 Community input

There were limited community concerns raised regarding geotechnical constraints. Specific concerns were raised about the preservation of slot canyons, which are considered to be irreplaceable heritage and recreational resources. The most popular canyons for visitors are very close to the road, and are less than a metre wide. Recreational canyons will need to be considered in future corridor development activities.

5.3.3 Mapping results

Geotechnical constraints are shown in **Figure 5.2**.

High constraint areas

- > High geotechnical constraint is associated with the more mountainous areas of the central and western sections, reflecting high slope as well as less stable geological units.

Moderate constraint areas

- > Moderate constraint is associated with the flatter areas of the Cumberland Plain (eastern section) and Hartley Valley (western section), as well as isolated areas along the ridgeline (central section).

Low constraint areas

- > Low constraint is generally restricted to small areas in the west, around the Newnes Plateau and small, isolated areas dispersed throughout the central section of the corridor.

5.3.4 Future investigations

Planning for future road development in the corridor will require more detailed geotechnical assessment, looking specifically at route options and involving more detailed site reconnaissance. Specific geotechnical testing will also be required. Recreational canyons will need to be considered in any route development work and assessment.

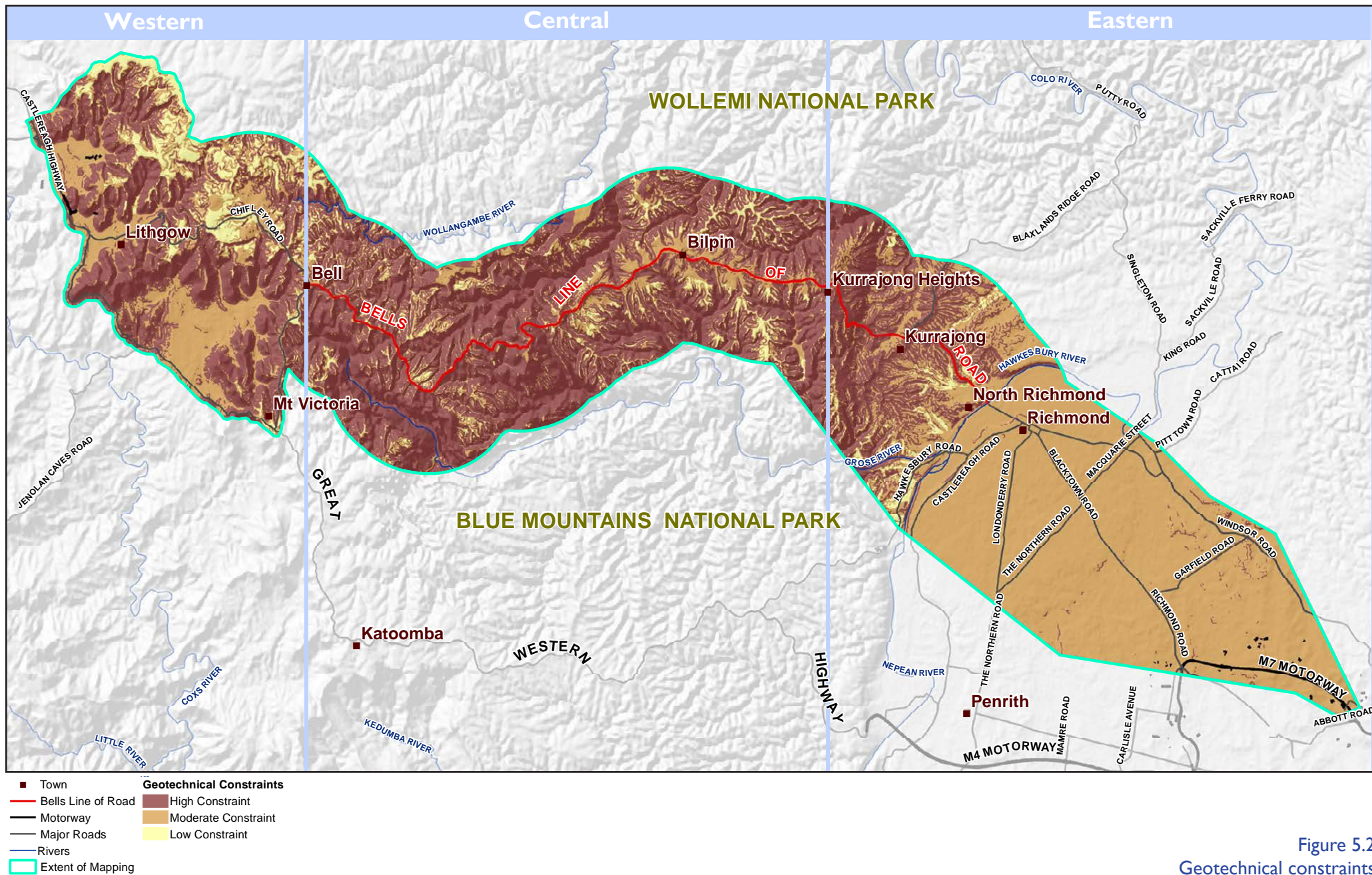


Figure 5.2
Geotechnical constraints

5.4 Ecology

The Bells Line of Road corridor contains areas of exceptionally high ecological values. The ecology of the area is critical to the decision-making process for any future road upgrade.



Melaleuca/Eucalypt vegetation community

Between Kurrajong Heights and Bell, the Bells Line of Road passes through the Greater Blue Mountains World Heritage Area with Wollemi National Park to the north and Blue Mountains National Park to the south. This central section features dense native vegetation with associated fauna.

In the eastern section, the surrounding area has been heavily cleared. However there are still large and significant remnant patches of native vegetation associated with various Endangered Ecological Communities on the

Cumberland Plain and the escarpment near Kurrajong.

The western section features dense native vegetation, particularly along the Darling Causeway and Chifley Road.

5.4.1 Mapping methodology

The ecology constraint analysis was based on three aspects:

- > Native vegetation.
- > Endangered ecological communities.
- > Riparian vegetation and aquatic habitats.

The following constraint classifications were used to develop the ecology constraints map:

High constraint

- > Endangered ecological communities, un-fragmented native vegetation and riparian zone vegetation, and significant aquatic habitats.

Moderate constraint

- > Fragmented native vegetation that is not an endangered ecological community.

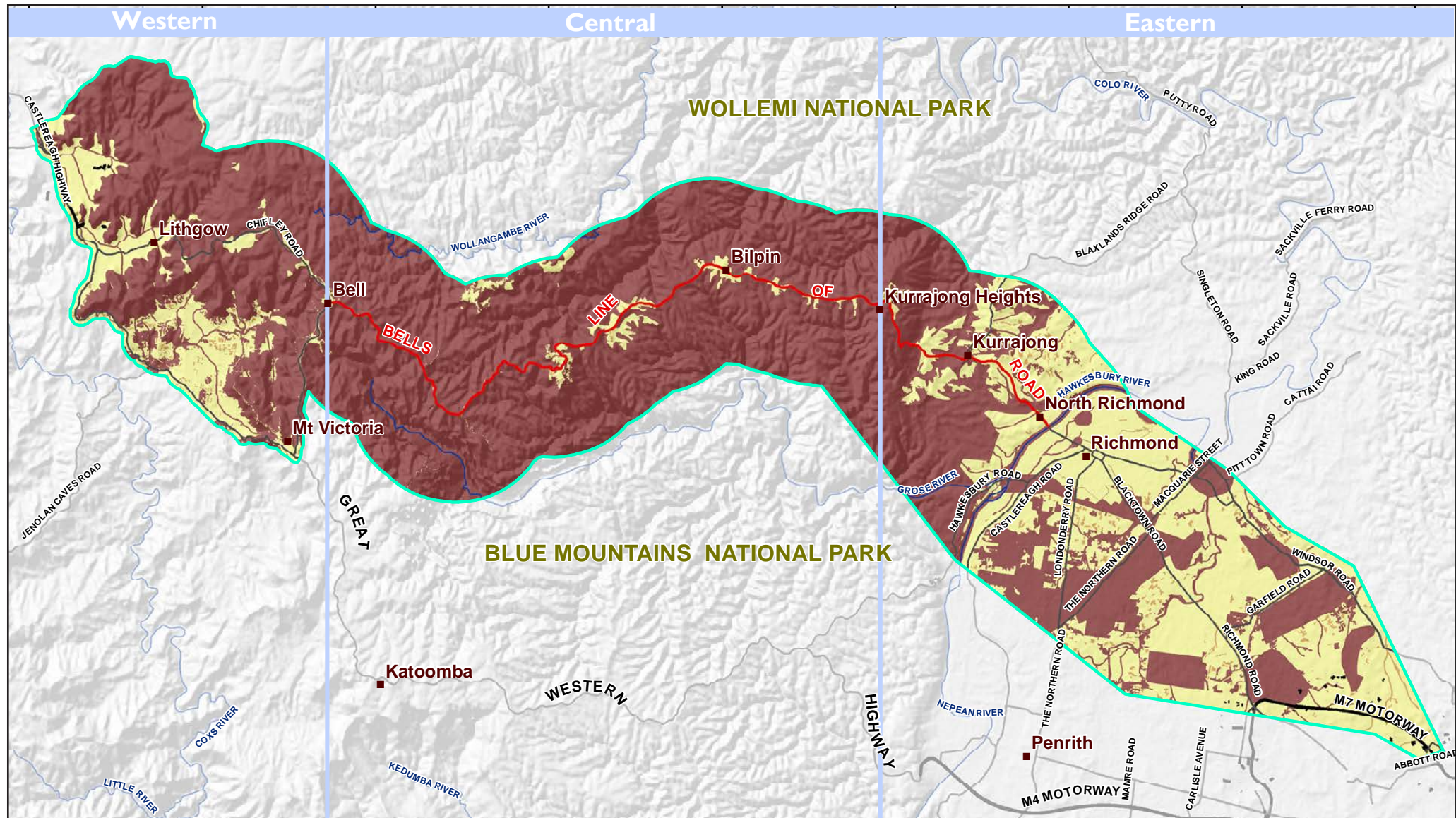
Low constraint

- > Areas not containing native vegetation.

5.4.2 Community input

Numerous comments were received from the community about the ecology, flora and fauna of the corridor. There was substantial concern about the potential impacts on vegetation and threatened and endangered species if future road development were to occur. The following areas, species and communities were specifically mentioned:

- > Western Sydney dry rainforest.
- > The flora and fauna of Botanist's Way (a tourist drive that includes Bells Line of Road).
- > Blue Mountains National Park.
- > Hanging swamps on sandstone.
- > Giant dragonfly habitat.
- > Little Wheeny Creek – platypus, echidna, wallabies.
- > Bellbird habitat.
- > Small pockets of ecological communities on Bellbird Hill.
- > Large trees, including *Eucalyptus deanei*, near Bilpin.
- > Extensive corridor linkages between fauna populations in the Grose Wilderness and Wollemi National Park.



Legend

- | | |
|----------------------|-------------------------------|
| — Bells Line of Road | Ecological Constraints |
| — Motorway | ■ High Constraint |
| — Major Roads | ■ Moderate Constraint |
| — Rivers | ■ Low Constraint |
| □ Extent of Mapping | |

Figure 5.3
Ecological constraints

- > The Air Services Australia site, which the Castlereagh Road corridor passes through. This contains critically endangered vegetation communities, notably about 250 hectares of Cumberland Plain shale woodlands and Shale-Gravel transition forest and 111 hectares of Cooks River Castlereagh ironbark forest, mostly in good condition and free of weeds. This site also contains habitat for a considerable number of bird species that are now rare and declining in the Sydney area.
- > Endangered ecological communities within the road reserve of the Bells Line of Road corridor.

In addition, many people who provided comments were concerned about the impacts of an upgraded road on the environment of the Blue Mountains and Wollemi national parks. These concerns related to:

- > Negative impacts on tourism, cultural heritage, endangered shale forest communities and upland swamps.
- > Possible loss of National Park land.
- > Permanent damage to the Greater Blue Mountains World Heritage Area, two wilderness areas and the Wollemi and Blue Mountains national parks, including impacts on the Wollangambe and Grose rivers.

5.4.3 Mapping results

Ecological constraints are shown in **Figure 5.3**.

High constraint areas

- > There are extensive areas of high ecological constraint within the Bells Line of Road corridor. This reflects the native vegetation communities associated with the Blue Mountains and Wollemi national parks (including endangered ecological communities, especially on the Cumberland Plain), riparian ecology, and state forests in the central and western areas.

Moderate constraint areas

- > Areas of moderate constraint reflect areas of fragmented vegetation communities. These are isolated in small concentrations, particularly south of Richmond on the Cumberland Plain and within the Hartley Valley.

Low constraint areas

- > Areas of lower constraint are generally seen in areas where vegetation has been disturbed by urban development (eastern section) and rural development (central and western sections).

5.4.4 Future investigations

Any future road planning and design will require detailed ecological studies. More targeted mapping and species identification will be required in relation to:

- > Extent and condition of vegetation, particularly endangered ecological communities.
- > Presence and location of threatened and other significant flora species.
- > Actual and potential presence of threatened and other significant fauna species.
- > Presence of endangered ecological communities, as listed under NSW and/or Commonwealth legislation.
- > Extent of wildlife movement corridors.
- > Types and location of quality habitat.
- > Condition and extent of aquatic habitats and species.

5.5 Landscape character

Landscape character is the aggregate of built, natural and cultural aspects that make up an area and provide its unique sense of place.

The Bells Line of Road corridor offers areas of visual richness and a diverse range of experiences. These qualities are a function of climate, topography characterised by major changes in elevation and dramatic landforms, cultural and heritage items, and the close proximity of unique vegetation. The corridor includes the Wollemi and Blue Mountains national parks and the Hawkesbury River.

At both ends of the corridor are established towns with embodied European heritage, the Macquarie towns of Richmond and Windsor at the outer extent of Sydney's metropolitan footprint in the east and Lithgow in the west.

5.5.1 Mapping methodology

The landscape constraint analysis was based on the following characteristics of the landscape alongside the corridor:

- > Geology
- > Topography
- > Culture
- > Economy
- > Transport environment
- > Land use
- > Pedestrian/cycle amenity
- > Vegetation
- > Hydrology
- > Views
- > Built form

The corridor was divided into two broad categories (urban and wilderness) which were then broken into further discrete landscape characters.

Landscape character types

Along the length of the route there are two broad landscape categories:

- > Urban/rural/settled landscapes clearly modified for human use or habitation.
- > Wilderness landscapes, mostly undisturbed bushland or forest.

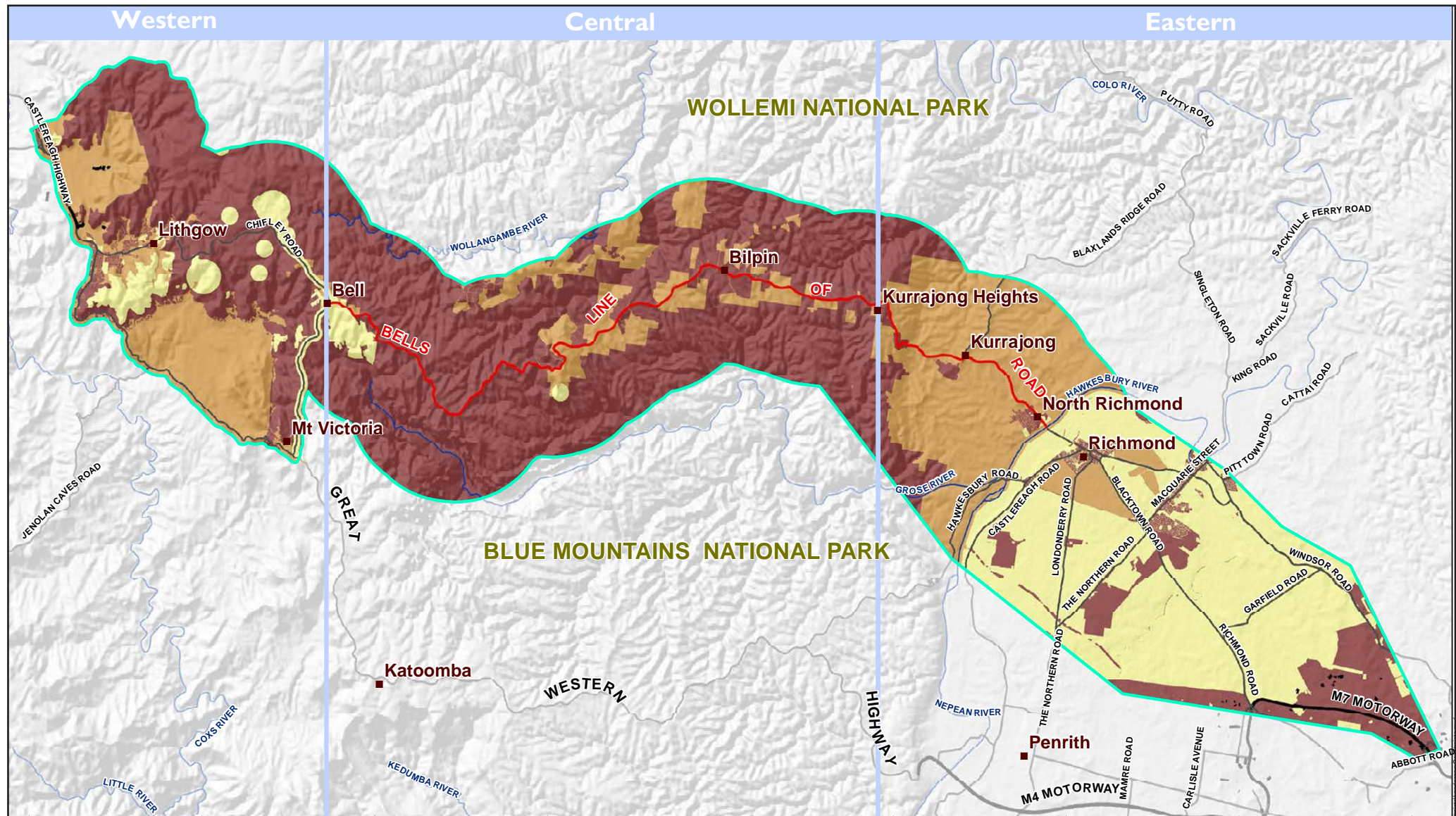
At a more detailed level, the corridor contains 17 discrete landscape character types. Each was assigned a constraint level (high, moderate, low) based on its sensitivity to any road upgrades. The character types and constraint level classifications are summarised in **Table 5.2**.



Rural landscape with wilderness landscape in the background

Table 5.2 **Landscape character types**

Character type	Constraint level	Description
Established suburban	High	Larger areas of residential land (plus schools, shops, etc), mainly in north-western Sydney, Kurrajong and Lithgow.
Mountain village	High	Urban centres in the central section that form a service base with schools, post offices, accommodation, general stores, etc.
High street civic	High	Established centres that serve a civic function (eg local council chambers, police stations, courthouses, commercial and retail).
Forest ridgeline	High	Areas where Bells Line of Road is on a ridgeline with forest immediately adjacent to the corridor, with very few built elements.
Mountain pass	High	Areas along the road corridor associated with sharp changes in elevation and winding routes that provide a constantly changing visual experience.
Forest flood plain	High	Flood plain areas with remnant or regrowth forest and agricultural land. The suitability of much of the surrounding land for agriculture means that large areas of this character type are rare.
Forest mountain/national park	High	Areas in the central section with native vegetation, either untouched or regrowth forest. Spatial quality is enclosed.
River/riparian	Moderate	Areas where a watercourse (eg Hawkesbury River) is large enough to have a visual presence as well as offering recreational opportunities such as water-skiing or parkland on its banks.
Mountain rural	Moderate	Rural properties above the escarpment mainly in the central section, and, to a lesser extent, in the western section.
Rural escarpment	Moderate	The area above the Hawkesbury River beyond North Richmond, characterised by a repeating pattern of agricultural land, residential areas, small shopping centres and remnant vegetation.
Rural valley	Moderate	The area between Great Western Highway and the base of the ridges. Contains Newnes Plateau, Darling Causeway and Chifley Road, and comprises rural residential land and small village centres.
Institutional	Moderate	Department of Defence land, universities, TAFEs and other institutional land.
New growth area residential	Low	Future land release areas within the North West Growth Centre.
Rural flood plain	Low	Rural areas in the South Creek–Hawkesbury River flood plain area. Includes agriculture and related businesses such as agricultural and landscape supplies, as well as some concentrated recreational areas.
Combined road/rail corridor	Low	Where road and rail corridors run parallel and within visual proximity of each other.
Commercial/retail	Low	Areas with commercial and retail activity, generally located in areas of higher residential density.
Industrial	Low	Industrial land, including mining. Use tends to be concentrated on the floodplain and around Lithgow.



Legend

- | | |
|----------------------|-------------------------------|
| — Bells Line of Road | Ecological Constraints |
| — Motorway | ■ High Constraint |
| — Major Roads | ■ Moderate Constraint |
| — Rivers | ■ Low Constraint |
| □ Extent of Mapping | |

Figure 5.4
Landscape character constraints



Rural activity in the Kurrajong area

5.5.2 Community input

Many community members living in the Bells Line of Road corridor expressed concerns about:

- > Potentially losing the unique character of the area if major road upgrades were to occur. The rural lifestyle, the agricultural land and country atmosphere were viewed as contributors to the tourist economy, and were highly valued lifestyle factors.
- > The potential for communities to be physically divided should a major road upgrade be built.

5.5.3 Mapping results

Landscape character constraints are shown in **Figure 5.4**.

High constraint areas

- > Areas in close proximity to the unique vegetation of the Wollemi and Blue Mountains national parks and the Hawkesbury River.
- > Areas in the central section, mainly due to the sensitivity of the 'forest mountain' character zone and regular occurrence of mountain villages.
- > The established towns with embodied European heritage – the Macquarie towns of Richmond and Windsor in the east and Lithgow in the west – at both ends of the corridor.

Moderate constraint areas

- > The majority of the rural areas west of the Hawkesbury River.

Low constraint areas

- > Areas of low constraint occur where the built environment will change in the future in the North West Growth Centre.

5.5.4 Future investigations

When planning for future road upgrades, detailed urban design investigations will be required. An urban design framework for the corridor should be developed to incorporate the following objectives:

- > Urban structure: Maintain and enhance the urban structure of settlements that occur along the corridor.
- > Existing communities: Maintain and enhance the integrity of Blue Mountains and Cumberland Plain communities that contribute to the unique character of the corridor.
- > Cultural elements: Maintain and enhance those cultural elements within the corridor that contribute to the unique character of Bells Line of Road.
- > Natural features: Maintain and enhance the existing natural features within the corridor that contribute to its unique visual and landscape character.
- > Landscape value: Maintain and enhance the World Heritage and Blue Mountains National Park landscape that contributes to the unique visual and landscape character along the corridor.
- > Views: Maintain and enhance short and long distance views, within the corridor and from surrounding major vantage points, that contribute to the unique visual character of the Bells Line of Road corridor.
- > Planning: Use the urban, landscape and visual assessment process to assist the selection and planning of the corridor.

5.6 Visual character

Constraints associated with visual character differ from landscape character in that they relate to the change to the landscape that would be visually perceivable as a result of new road development, rather than potential impacts on the broader urban and rural fabric.

The Bells Line of Road corridor contains dramatic visual landscape associated with the national parks, changes in elevation and a range of visually sensitive land uses.

5.6.1 Mapping methodology

The visual constraint analysis evaluated the likely visual sensitivity of any upgrade(s) of Bells Line of Road. The analysis considered three main inputs representative of the visual character of the corridor – land use, native vegetation and slope. These inputs were considered separately in the visual analysis and combined in an overall visual character constraint map.

Land use

Land use was used as an indicator for the location of viewers and to help assess land use sensitivity to possible future road upgrade(s). A higher constraint was given to areas with a higher number of viewers, where views are of a longer duration, and/or where the quality of views is particularly important, including the dramatic visual landscape of the Blue Mountains and Wollemi national parks.

High constraint

- > Small rural lots (less than 10 hectares), rural, active fruit growing, flood plain agriculture and open space/environmental protection areas.

Moderate constraint

- > Areas with commercial, special use/community, open space/recreation and residential land uses.

Low constraint

- > Areas with industrial, military, infrastructure and forestry land uses.

Native vegetation

The clearing of native vegetation will generally result in changes to the landscape, such as scarring and/or changes to vistas.

High constraint

- > Areas of native vegetation, particularly more densely forested areas.

Low constraint

- > Areas with no native vegetation.

Slope

Slope has a correlation with earthworks volumes. Generally, the steeper the terrain, the greater the level of cut and fill required during construction, and the greater the potential change in the landscape.

High constraint

- > Areas with a slope of greater than 15 per cent.

Medium constraint

- > Areas with a slope of 5–15 per cent.

Low constraint

- > Areas with a slope of 0–5 per cent.



Section of Bells Line of Road indicating the visual effect of a road through forest

5.6.2 Community input

Community input highlighted the importance of the scenic environment to the community. Specific comments related to views to and from Bells Line of Road, including views to orchards, the passage of road through a forested landscape and the importance of views to the cliffs and Grose Valley between Mount Tomah and Bell.

In addition, there were concerns about potential impacts of road upgrades on the scenic values of, and views from, the Grose and Wollemi wilderness areas within the Blue Mountains National Park and the highly scenic Gardens of Stone.

5.6.3 Mapping results

Visual character constraints are shown in **Figure 5.5**.

High constraint areas

- > The visually dramatic bushland landscape within the national parks has great visual importance. Areas of high constraint are found predominantly in the central and western sections associated with the occurrence of native vegetation and high slopes of the Blue Mountains and Wollemi national parks.

Moderate constraint areas

- > Areas of moderate constraint in the eastern section reflect the flatter, relatively less vegetated areas.
- > Areas of moderate constraint in the western section are generally due to the presence of native vegetation.

Low constraint areas

- > Areas of low constraint are largely to the east of the Hawkesbury River and reflect less visually sensitive land uses (eg rural settlement) and relatively flatter, cleared areas.

5.6.4 Future investigations

Visual character will change over time, depending on changes in adjoining land use and vegetation growth. Therefore, this analysis and mapping should be reviewed and updated as part of future investigations. A detailed visual impact assessment will need to be undertaken in relation to planning for any future road development in the corridor.

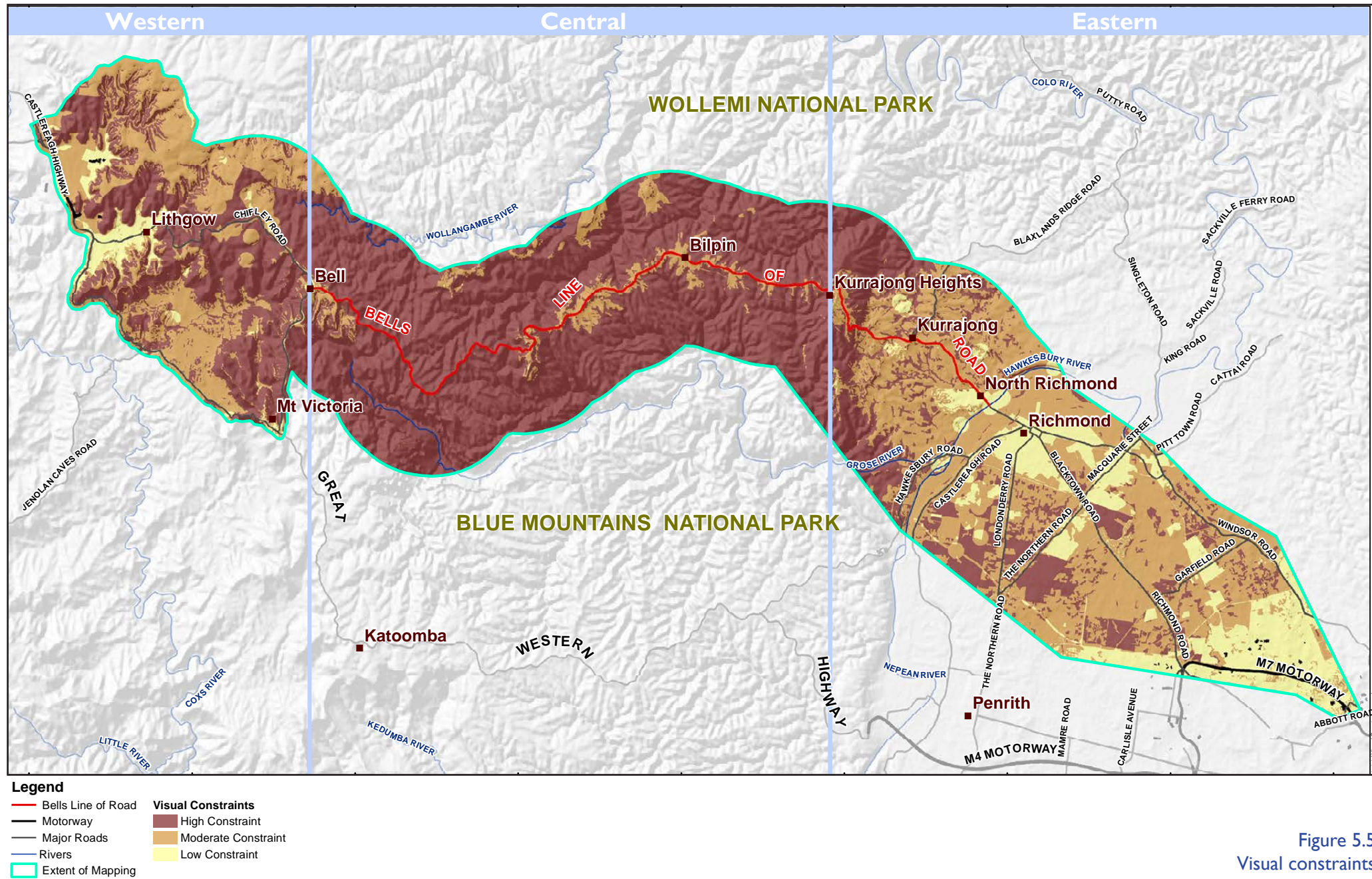


Figure 5.5
Visual constraints

5.7 Aboriginal heritage

There is a rich heritage of Aboriginal occupation in the Bells Line of Road corridor. The widely varying topography and environment, however, resulted in different patterns of use by Aboriginal people.

Aboriginal heritage is understood to varying degrees across the Bells Line of Road corridor. The eastern section has been well studied over the last 20 years. However, there is an absence of baseline information for the central and western sections, which means that these areas are relatively poorly understood archaeologically.

5.7.1 Mapping methodology

The Aboriginal heritage constraint analysis aimed to show areas of the corridor more likely to have had Aboriginal occupation. These are considered to have a higher sensitivity to upgrade(s) of Bells Line of Road, and therefore were rated with a higher constraint.

Due to the different land uses and differences in topography between the east and west of the Hawkesbury River, two different occupation models were developed:

- > East of the Hawkesbury River on the Cumberland Plain, the corridor is characterised by flatter, more disturbed flood plain. Vegetation is more fragmented than to the west of the river, reflecting the influence of rural and residential land uses. The eastern occupation model for the Cumberland Plain considers the following factors and the interaction between them: native vegetation, creeks and waterways, and disturbance. Aboriginal occupation and the preservation of any artifacts is considered more likely along waterways and within areas of undisturbed native vegetation.

- > West of the Hawkesbury River, the corridor is characterised by the steeper, heavily vegetated land of the Blue Mountains. The western occupation model for the Blue Mountains considers the following factors: native vegetation, geology (ie the presence of Hawkesbury Sandstone), creeks and waterways, and slope. Similar to the eastern model this model considers that Aboriginal occupation and the preservation of any artifacts is more likely along waterways and within areas of undisturbed native vegetation. Additional factors of slope and geology have been included in the western model to take into account accessibility and transversibility of steep terrain and that certain geologic layers have a greater likelihood of formation of rock shelters and surfaces suitable for engraving.

High, moderate and low constraints for each of the above factors have been identified. Inputs into the two occupation models are listed below:

Cumberland Plain (east of Hawkesbury River)

High constraint:

- > Native vegetation within 100 metres of a creek or waterway.

Moderate constraint:

- > Native vegetation greater than 100 metres from a creek or waterway.

Low constraint

- > Land without native vegetation – that is, cleared land.

Blue Mountains (west of Hawkesbury River)

Native vegetation

High constraint:

- > Areas of native vegetation.

Low constraint:

- > Un-vegetated areas – that is, cleared land.

Geology**High constraint:**

- > Hawkesbury Sandstone, which has a greater likelihood of formation of rock shelters and surfaces suitable for engraving.

Low constraint:

- > Geology that is not Hawkesbury Sandstone.

Waterways**High constraint:**

- > Land within 100 metres of creek or waterway.

Low constraint:

- > Land greater than 100 metres from creek or waterway.

Slope**High constraint:**

- > Land where slope is less than 20 per cent.

Low constraint:

- > Land where slope is greater than 20 per cent.

5.7.2 Community input

Aboriginal cultural heritage and its preservation was of interest to the wider community. A number of specific areas were suggested as having potentially significant cultural heritage value and recommended for investigation during planning for the corridor. Specific input and concerns relating to Aboriginal cultural heritage and its need for preservation included:

- > Bells Line of Road – considered to be used as an ancient footpath by Aboriginal people.
- > Dharug and Wiradjuri associations – from North Richmond to Bell.
- > Aboriginal land claims – particularly east of the Hawkesbury River.

5.7.3 Mapping results

Aboriginal heritage constraints are shown in **Figure 5.6**.

High constraint areas

- > High constraint is restricted to small, concentrated areas, particularly in the central region, associated with the occurrence of Hawkesbury Sandstone and accessible areas along drainage lines. High constraint is strongly influenced by the occurrence of creeks and vegetation, especially within the eastern section.
- > In the more mountainous areas to the west of the Hawkesbury River, where slope has a greater influence, dispersed areas of high constraint occur due to the occurrence of waterways, Hawkesbury Sandstone and lower slope.

Moderate constraint areas

- > Concentrated areas of moderate constraint are dispersed throughout the eastern, central and western sections of the corridor. These correspond with drainage lines and creeks, especially west of the Hawkesbury River, as well as vegetated areas, slope and geology.

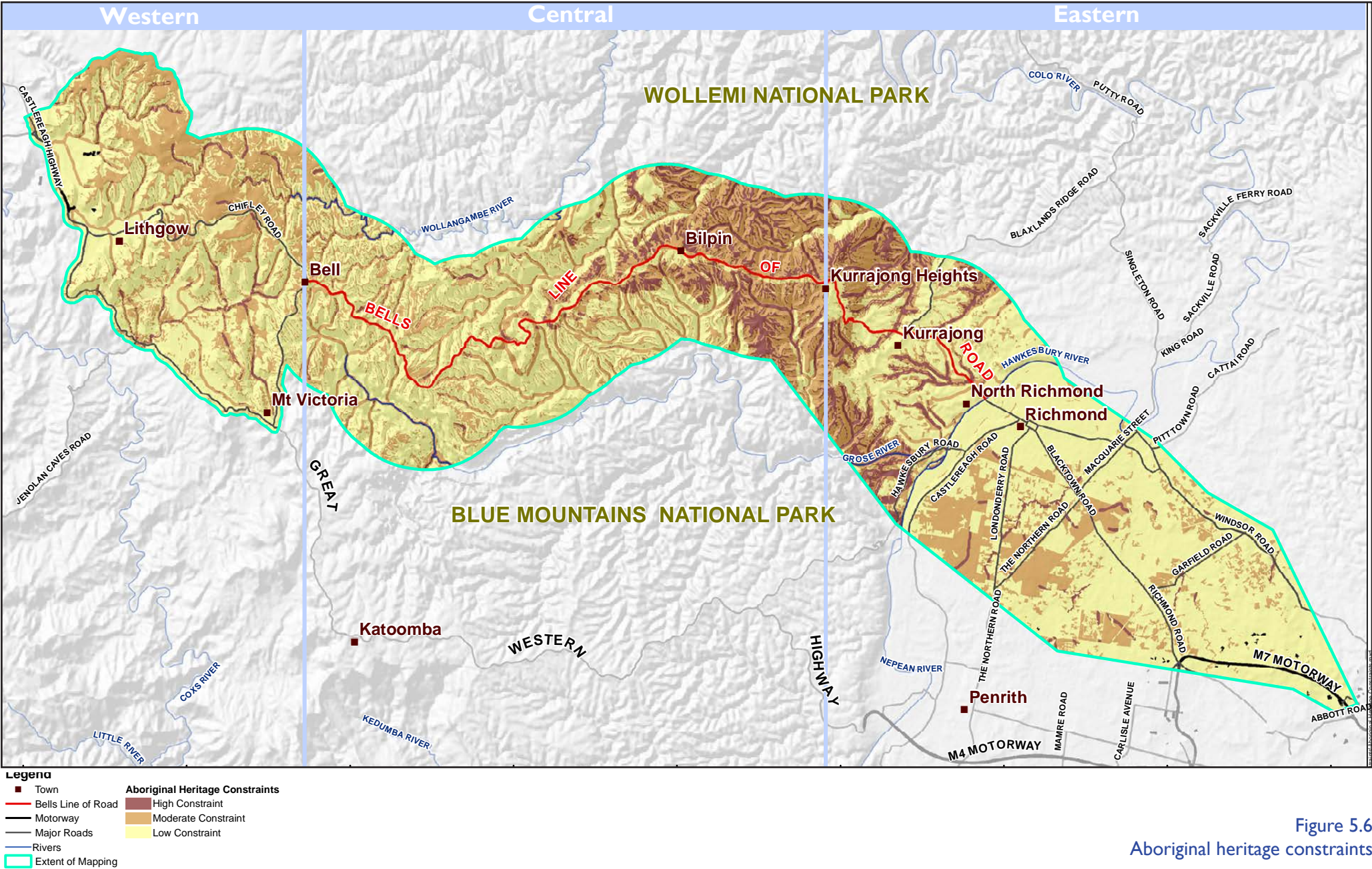


Figure 5.6
Aboriginal heritage constraints

Low constraint areas

- > Low constraint is dispersed throughout the corridor. East of the Hawkesbury River, low constraint corresponds with land disturbed by rural and residential land uses. Within the Blue Mountains (west of the Hawkesbury River) low constraint areas correspond to particularly high-slope areas, reflecting less accessible areas.

5.7.4 Future investigations

The limited information available on Aboriginal cultural heritage sites, together with the importance of this area indicates a need for a detailed, site-specific assessment of Aboriginal heritage as part of any future investigations. This would include targeted surveys and consultation with the Aboriginal community.

5.8 Non-Aboriginal heritage

The Bells Line of Road corridor and townships of the area have a rich cultural heritage, associated with exploration and settlement within the mountains. Non-Aboriginal heritage sites include sites of State, regional and local significance. The Greater Blue Mountains World Heritage Area, which is listed on the World Heritage and National Heritage registers, is also included in the constraints mapping.

5.8.1 Mapping methodology

The constraint classifications for the non-Aboriginal heritage analysis are based on a search of currently listed sites within the corridor. Constraint classifications are:

High constraint

- > Any listed site of State, regional and local significance, and any listed site on the World Heritage List or National Heritage List and identified historic trails.

Moderate constraint

- > Not considered.

Low constraint

- > No listed sites.

5.8.2 Community input

The community expressed a preference to preserve non-Aboriginal heritage items during any future plans for the road corridor. A number of specific areas were suggested as having heritage value and recommended for investigation during planning for the corridor. The community identified the presence of a number of heritage items and associations, including:

- > The presence of colonial architecture and convict relics along and near the existing route.
- > The use of Bells Line of Road as a major stock route and a walkway to the western goldfields, and its connections to scientific and botanical explorations.
- > The road at North Richmond, Kurrajong Heights and Mount Tomah and its connections with early explorations from 1793 to 1823.
- > Associations with explorers Matthew Everingham, George Caley and Archibald Bell Jr, after whom Bells Line of Road was named.
- > History associated with 19th century botanist and natural historian Louisa Atkinson, who at one time resided in Kurrajong Heights, where she gathered and painted flora and fauna.

5.8.3 Mapping results

Non-Aboriginal heritage constraints are shown in **Figure 5.7**.

High constraint areas

- > The largest concentration of high constraint is located in the central section, and is attributed to the Greater Blue Mountains World Heritage Area.
- > Items of high constraint (heritage listed sites) are dispersed throughout the study area, associated with individual sites within townships and suburbs.
- > The more substantial clusters of individual sites are found around the larger and older centres of occupation – Kellyville, Rouse Hill, Riverstone, Agnes Banks, Castlereagh, Kurrajong, Kurrajong Heights, Hartley, Lithgow and, particularly, Richmond and Windsor. Sites are also located at Mount Victoria and Mount Wilson.

Low constraint areas

- > Generally, non-Aboriginal heritage is a low constraint across the eastern and western areas of the corridor.

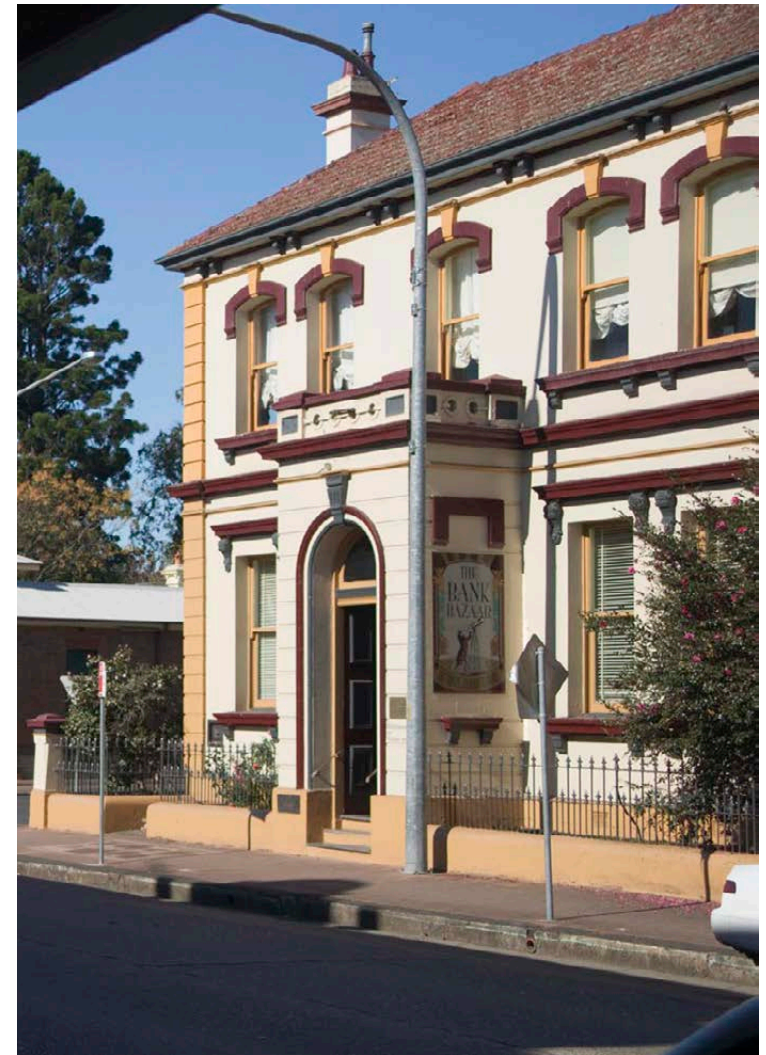
5.8.4 Future investigations

The constraint mapping provides a general overview and does not include all listed sites, due to some listings lacking specific location data. There are also likely to be a large number of unlisted sites with heritage significance occurring within the corridor. Future detailed investigations would need to identify these.

Any future upgrade to Bells Line of Road will also require consideration of sites that are currently nominated for listing on the statutory registers. Such items/sites include the Blacktown Native Institution and the Colebee/Nurragingy Land Grant nominations on the State Heritage Register and the Hartley Valley, which is currently nominated for listing on the National Heritage List.

Additionally, future planning will also need to consider the heritage listed walking trails (there are more than 300 trails) of the Blue Mountains World Heritage Area.

Fieldwork will need to be undertaken as part of future planning. It is expected that the number of potential heritage items and archaeological sites will increase after detailed historical analysis and a site survey are undertaken. More detailed investigations will need to consider both direct and indirect impacts on heritage items, and consider design measures to minimise any impacts.



Heritage building in Richmond

5.9 Water quality

Bells Line of Road lies within the Hawkesbury–Nepean River Catchment, one of the most important rivers in the greater Sydney area. The Hawkesbury–Nepean River system provides drinking water for Sydney, the Blue Mountains and the Illawarra, and water for agriculture and coal-mining operations. It also supports commercial and recreational fishing. In addition, the corridor includes the ‘wild river’ catchments of the Grose and Colo rivers (as defined by the *National Parks and Wildlife Act 1974*). Wild river declaration provides a high level of protection and conservation to some of the least disturbed watercourses in NSW. Water quality protection is particularly important in these areas.

5.9.1 Mapping methodology

The water quality constraint analysis focused on mapping watercourses and sensitive catchments with the potential to be affected by road upgrade(s). Sensitive catchments were identified as drinking water catchments and the ‘wild river’ catchments of the Grose and Colo rivers.

Buffers were established around the watercourses to quantify areas of constraint. For the purposes of identifying the importance of potential water quality impacts and the risks to any upgrade(s), the following classifications were used.

High constraint

- > Less than 50 metres from a watercourse.

Moderate constraint

- > Within 50–100 metres of a watercourse.
- > Within a wild rivers catchment, for the Grose or Colo rivers.
- > Within a drinking water catchment.

Low constraint

- > Greater than 100 metres from a watercourse and outside a wild rivers or drinking water catchment.

5.9.2 Community input

The community raised specific concerns about potential impacts on river systems and drinking water catchments. Specific comments included concerns about:

- > Impacts on the Wollangambe and Grose rivers.
- > A possible Lithgow bypass (potentially associated with an upgrade of the Bells Line of Road corridor). It was commented that this could impact on Lithgow’s drinking water supply.
- > The need to protect dams in the keyline dam system, directly west of North Richmond. These dams will need to be considered in planning any upgrade(s) to the Bells Line of Road.

5.9.3 Mapping results

Water quality constraints are shown in **Figure 5.8**.

High constraint areas

- > High constraint areas include watercourses, such as the Hawkesbury River and water courses feeding this and the Grose and Colo rivers. These high constraint areas correspond directly to watercourses, where the potential impacts on water quality are considered the highest.



Moderate constraint areas

- > The large proportion of moderate constraint areas in the central and western sections reflects the occurrence of drinking water and the catchments of the Grose and Colo rivers (which are classified as wild rivers). The moderate constraints do not relate directly to watercourses but rather the catchments which feed them.

Low constraint areas

- > Low constraint areas dominate the eastern section of the corridor, as there are no specific catchments in this area.

5.9.4 Future investigations

Any planning for future upgrade(s) must consider potential impacts on both the wild river and drinking water catchments, which are protected by State legislation and planning policies. Similarly, development within a drinking water catchment must demonstrate neutral or beneficial effects on water quality.

Any road development in the corridor will require a site-specific soil and water management plan to address construction phase water quality and may require water quality monitoring to be undertaken.

Water quality will also be an important component of the design of any future road development due to the need to avoid road contaminants entering sensitive waterways as a result of road operation. Planning and design will need to consider spill containment and the quality of day-to-day road runoff.



Hawkesbury River near Richmond



Rural land use on the Hawkesbury River flood plain

5.10 Flooding

Major waterways within the study area include the Hawkesbury, Grose and Colo rivers and their tributaries.

Historically, flooding associated with the Hawkesbury River has been a concern, with flood immune access and flood evacuation routes an important consideration.

5.10.1 Mapping methodology

The flooding constraint analysis focused on the Cumberland Plain and flooding associated with the Hawkesbury River. Flooding was not considered a key constraint in the more mountainous areas. The constraints classifications were based on the 1 in 100 year flood event of the Hawkesbury River. The following constraints classifications were used:

High constraint

- > No high constraint was applied as flooding issues can to some extent be addressed in road design.

Moderate constraint

- > Within the 1 in 100 year flood level for the Hawkesbury River.

Low constraint

- > Outside the 1 in 100 year flood level for the Hawkesbury River.

5.10.2 Community input

Community comments about flooding were in relation to the provision of a flood-free access from Bells Line of Road across the Hawkesbury flood plain.

5.10.3 Mapping results

Flooding constraints are shown in **Figure 5.9**.

High constraint areas

- > There are no areas of high constraint.

Moderate constraint areas

- > Areas of moderate constraint are restricted to the Cumberland Plain.

Low constraint areas

- > Flooding is a low constraint along most of the corridor.

5.10.4 Future investigations

Hydrological modelling will be required in the planning phase of any future road development in the corridor. The provision of flood immunity will also need to be considered.

Consideration of other modelled flood levels other than the 1 in 100 year event will also be important in future planning and design, including the probable maximum flood event, as well as smaller (higher recurrence interval) events.

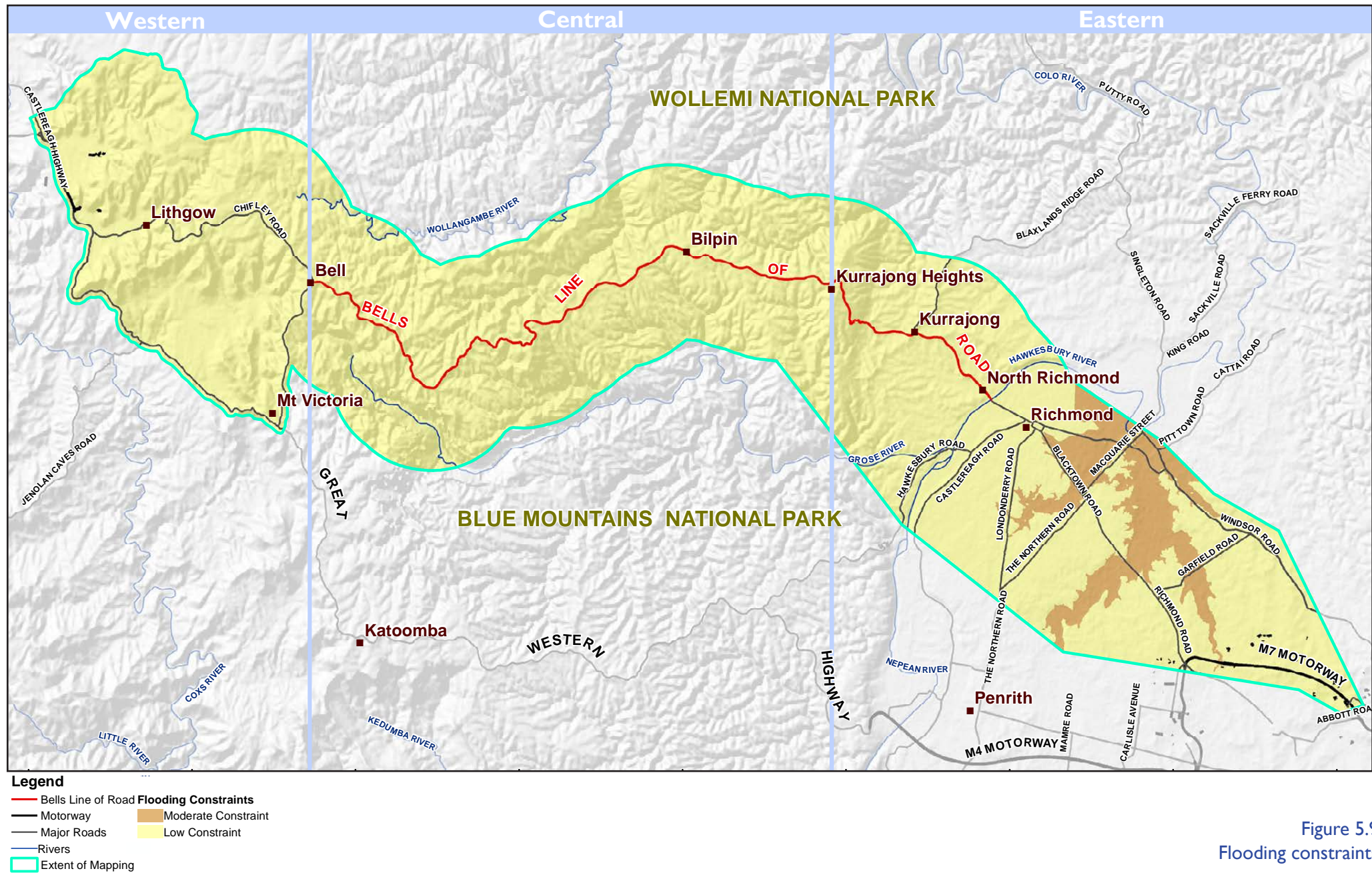


Figure 5.9
Flooding constraints



New growth areas in western Sydney will be sensitive to traffic noise

5.1.1 Noise

Noise sources in the vicinity of the Bells Line of Road corridor include motor vehicles, residential properties, farming and agricultural activities, and some commercial and industrial activities. The noise environment varies along the corridor, as do the number, type and proximity of 'noise-sensitive receivers' to potential noise sources. Noise-sensitive receivers are defined as those human activities and locations that would be likely to be impacted by an increase in noise. Within the corridor, these include residences, schools, places of worship, hospitals, aged-care facilities and other community facilities.

5.1.1.1 Mapping methodology

The noise constraint analysis focused on the location of noise-sensitive receivers. These receivers were identified through aerial photography and other mapping sources.

High constraint

- > Within 30 metres of a sensitive receiver.

Moderate constraint

- > Between 30 and 150 metres of a sensitive receiver.

Low constraint

- > Greater than 150 metres from a sensitive receiver.

5.1.1.2 Community input

Noise issues raised by the community included:

- > The importance of a quiet environment to the community, particularly in residential areas.

- > Concerns about noise created by trucks and motorbikes using Bells Line of Road. Truck noise was reported to be very loud at night, and motorbikes were reported to cause a noise nuisance on weekends.
- > Concern that an increase in traffic, especially heavy vehicles and construction vehicles, could increase noise and intrude on the bush and recreational experiences on Bells Line of Road.

5.1.1.3 Mapping results

Noise and vibration constraints are shown in **Figure 5.10**.

High and moderate constraint areas

- > High and moderate constraint areas are dispersed throughout the corridor and reflect the urban and rural settlement pattern.
- > The concentrated areas of high constraint reflect the denser areas of urban residential settlement of Richmond, Windsor, Quakers Hill and surrounding suburbs, as well as Kurrajong, Kurrajong Heights and Lithgow.

Low constraint areas

- > Noise and vibration are generally a low constraint along the majority of the corridor, due to the large areas of bushland along the corridor. The concentrations of sensitive receivers are associated with the existing road network.

5.1.1.4 Future investigations

A site-specific noise and vibration study will be needed as part of planning for any specific future upgrade. Noise modelling may be required depending on the type and location of future road development. A noise and vibration management plan may be required for future construction works and operation of the Bells Line of Road.

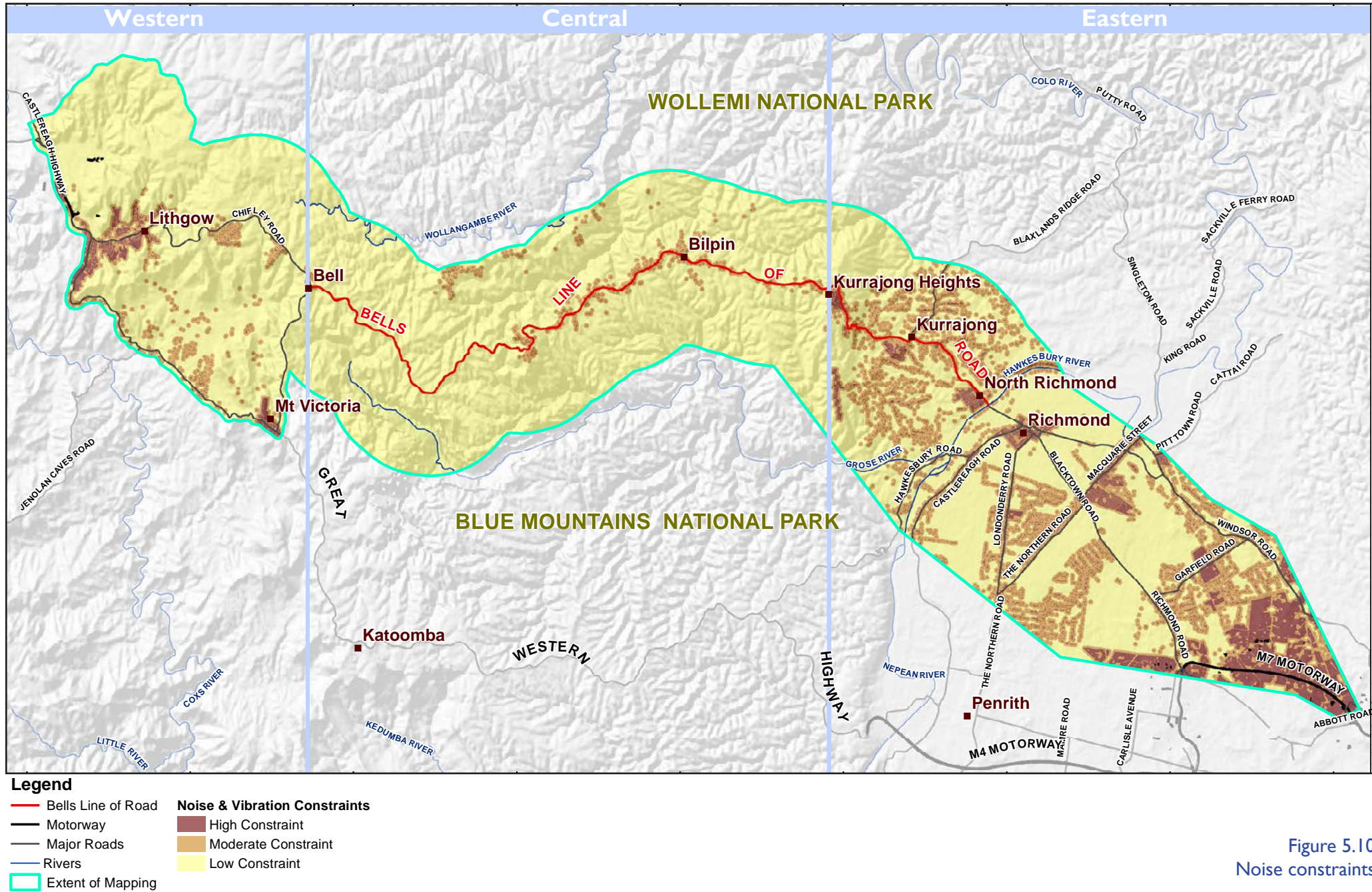


Figure 5.10
Noise constraints

5.12 Air quality

Air quality in the corridor is influenced by the Sydney Basin air shed, as well as, more locally, the level of motor vehicle emissions, domestic solid-fuel heaters, some rural and agricultural land uses, and industrial and commercial activities. The existing air quality is likely to vary along the corridor based on proximity to major roads and to other sources of air pollution, as are the number, type and proximity of sensitive receivers that could potentially be affected by any change in air quality during the construction or operation of any future road upgrade(s).

5.12.1 Mapping methodology

Sensitive receivers were identified based on existing mapping and analysis of aerial photography. From an air quality perspective, sensitive receivers are generally located close to the existing road network. Within the corridor, these include residences, schools, places of worship, hospitals, aged-care facilities and other community facilities.

The following buffer thresholds were applied for the air quality constraints map based on typical dispersion patterns of pollutants associated with major roads.

High constraint

- > Within 10 metres of sensitive receivers.

Moderate constraint

- > Between 10 to 40 metres of sensitive receivers.

Low constraint

- > Greater than 40 metres from sensitive receivers.

5.12.2 Community input

Community concerns and feedback to date relating to air quality impacts were limited. While not strictly an air quality issue, specific concerns were raised regarding increases in greenhouse gas emissions as a result of increased traffic.

5.12.3 Mapping results

Air quality constraints are shown in **Figure 5.11**.

High and moderate constraint areas

- > Areas of high and moderate constraint reflect the settlement patterns of urban and rural residential areas.
- > More concentrated areas of high constraint in the eastern and western sections reflect the denser urban areas.

Low constraint areas

- > Air quality is a low constraint along the majority of the corridor because of the distribution of sensitive receptors and the generally small area of potential impact associated with air quality from roads in a rural environment.

5.12.4 Future investigations

A site-specific air quality study may be required for future road development. This may require modelling of air quality impacts if projected traffic volumes and the proximity of sensitive receivers warrant this.

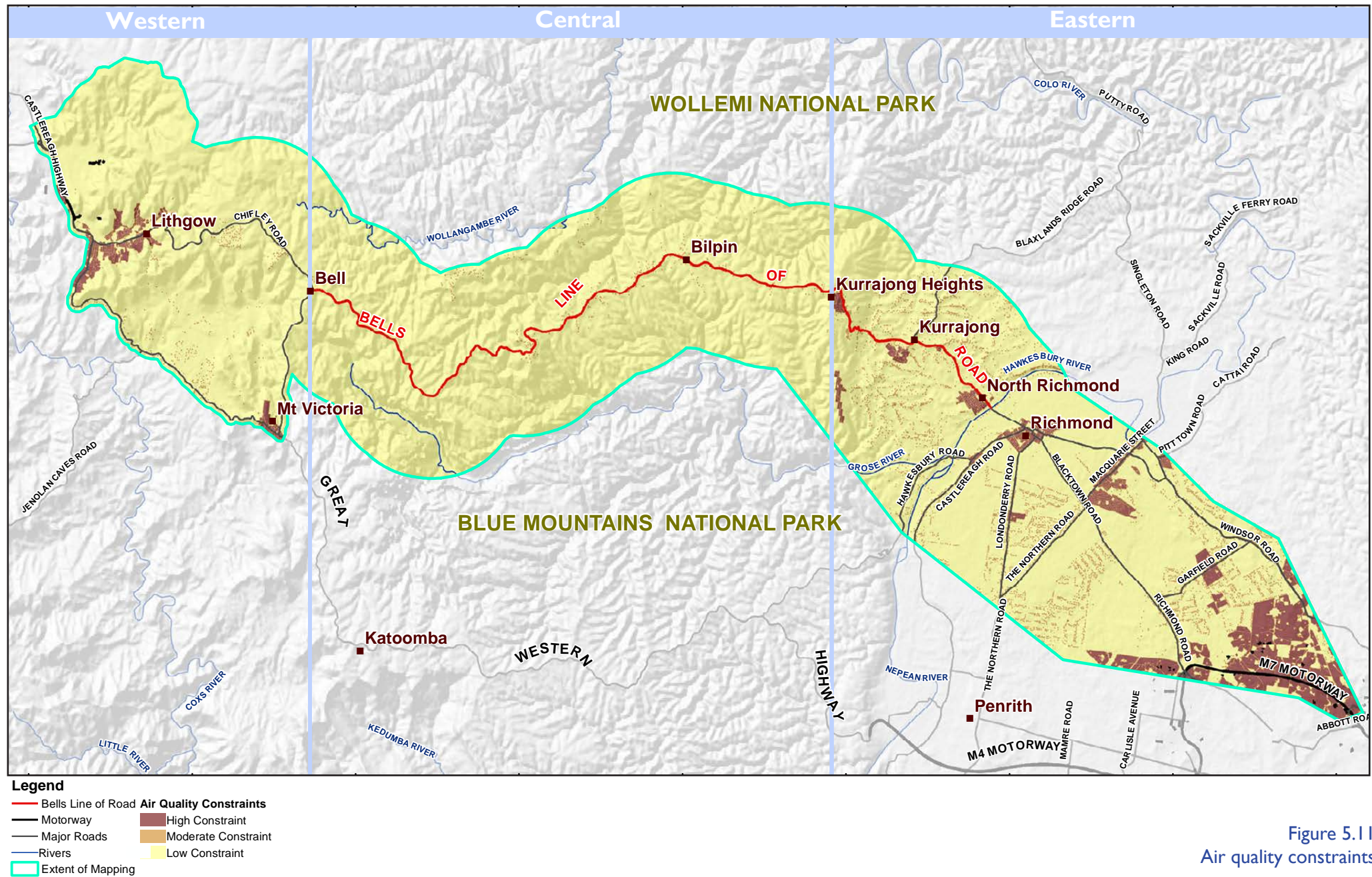


Figure 5.1 I
Air quality constraints

5.13 Overview of constraints

A combined constraints map was prepared from the 11 environmental, social and technical factors presented above. Equal weighting was given to all factors at this point of development. The combined map (**Figure 5.12**) shows areas of higher and lower constraint on a graduated scale.

Higher constraint areas

- > Areas of higher constraint in the eastern section are generally associated with urban and vegetated areas.
- > Generally, the higher constraint areas are within the central section, associated with the steeper and more vegetated land of the Greater Blue Mountains World Heritage Area (Blue Mountains and Wollemi national parks).
- > Areas of high constraint in the western section correspond to urban areas as well as specific land uses, including mining and defence land.

Moderate constraint areas

- > Areas of more moderate constraint include vegetated areas outside the World Heritage boundaries and some smaller lot rural areas and larger lot rural areas with steeper terrain.

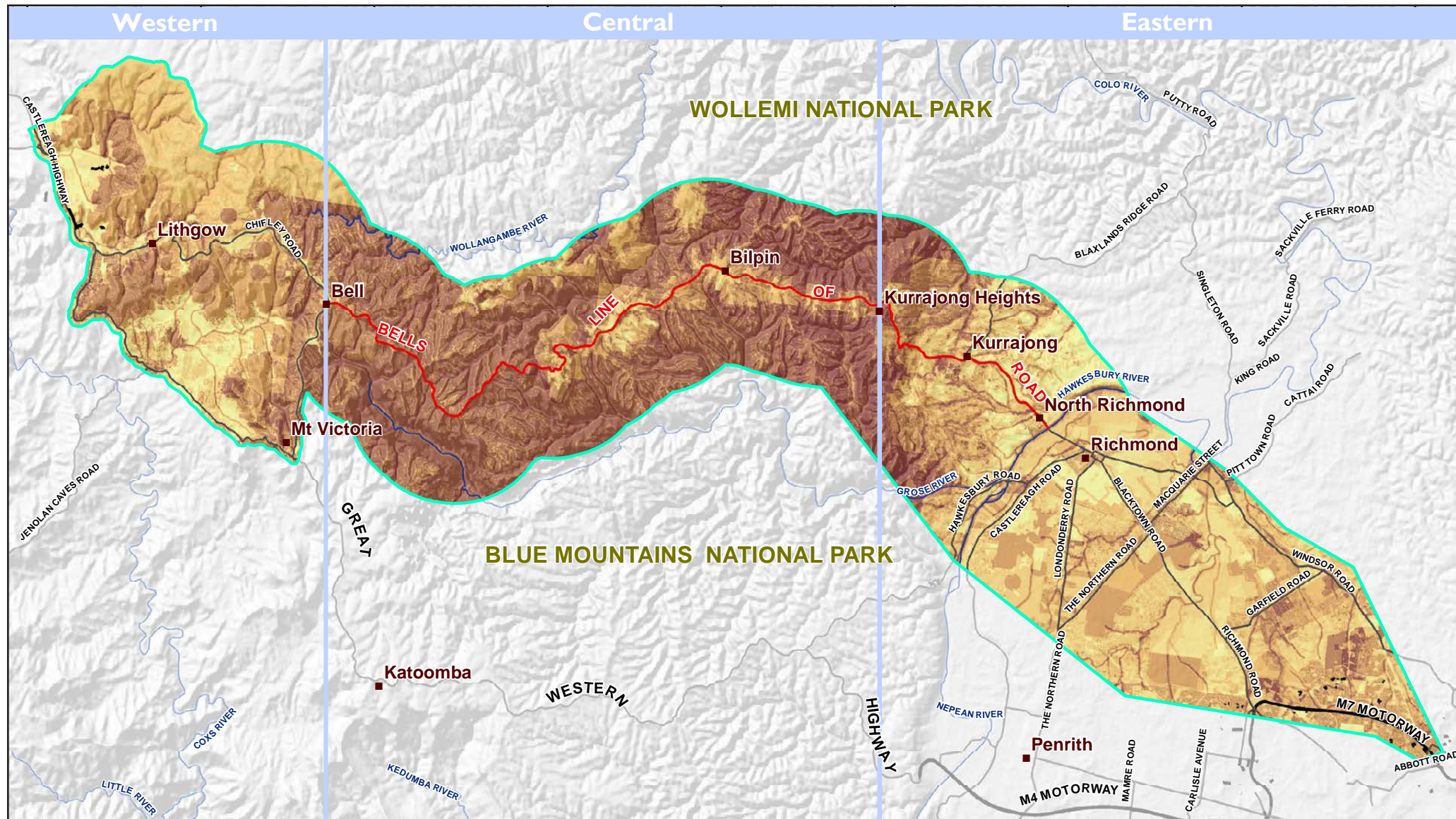
Lower constraint areas

- > Areas of lower constraint are generally associated with the rural, un-vegetated, flatter areas of the eastern and western sections.
- > Lower constraint in the central section generally corresponds with areas directly adjacent to the Bells Line of Road.

This constraint analysis suggests that any major road upgrade through the central and western parts of the Bells Line of Road corridor would be extremely challenging from an environmental, approvals and cost perspective.

This area (particularly the central section) includes the Greater Blue Mountains World Heritage area which has a wide range of ecological and cultural values. It also coincides with challenging terrain which would be likely to add greatly to the cost of construction (refer to Section 5.3 Geotechnical constraints). Any major road upgrade through this area would require an extremely strong justification in terms of community need and economic benefit to counter the potential environmental and social impacts.

There are more opportunities for new road development in the eastern section than in the central and western sections. In this section there are areas of lower environmental value and terrain that are generally more conducive to road construction. One major challenge in this area is increasing urbanisation in western Sydney, which will gradually increase the level of constraint on new road development. Early planning for any future road development in this area will maximise opportunities to integrate the road development into future urban areas, minimising its impact to those communities.



Legend

- Bells Line of Road
 - Motorway
 - Major Roads
- Composite Constraints**
- Higher constraint
 - Lower constraint

Figure 5.12
Combined constraints