REPORT

Baw Baw Shire Council EMO Review

Geotechnical Considerations

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18105651-001-R-RevB

16 August 2018

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Executive Summary

Parts of Baw Baw Shire Council (BBSC) are susceptible to landslide and erosion. Risk associated with these processes are managed by BBSC via the Erosion Management Overlay (EMO). This report provides a discussion on the suitably of the EMO as it is currently defined and administered and provides recommendations and considerations for improving the EMO.

The EMO extent and its management in BBSC is different from that of other Victorian councils in several key aspects:

- The extent of the EMO is broad, and whilst areas susceptible to landslide are covered by the EMO, it covers a greater extent than it needs to if it were to more accurately cover just areas susceptible to landslide.
- Applications submitted in areas subject to the EMO do not require a mandatory assessment by a suitably qualified geotechnical specialist. However, BBSC at its discretion may request the applicant to provide a geotechnical assessment. The decision made by BBSC in this respect appears to be based on experience and engineering judgement. No detailed shire wide study has been undertaken to delineate areas susceptible to landslide or to zone landslide susceptibility.

There is an opportunity to refine the EMO extent. One option for doing this is to use criteria developed by the West Gippsland Catchment Management Authority (WGCMA) in 2008. Whilst this would be a low cost option, there are limitations with this method because the criteria used by the WGCMA do not cover all of BBSC and were developed for a purpose other than informing planning controls.

Refining the EMO extent using current day methods would likely require the acquisition of airborne LiDAR data. This data is used to develop a digital terrain model which is then used by geomorphologists and engineering geologists to identify areas susceptible to landslide. The EMO extent would then be refined to include areas that have or could be impacted by landslide. Re-mapping the extent of the EMO using aerial LiDAR data would be expected to substantially reduce the extent of the EMO compared to what it is currently.

In addition to landslide, BBSC is subject to erosion, we recommend that erosion be managed separately to landslide hazards either through a separate EMO schedule, other planning controls (for example the Environmental Significance Overlay) or through the building and construction process, for example through construction management plans.

Further to refining the EMO extent, the schedule could be refined to mandate that the applicant obtain an assessment of landslide risks and hazards associated with the proposed development by a suitably qualified geotechnical specialist. Tools can then be developed to assist statutory planners to assess applications triggered by the EMO. These methods have operational precedent in other local government areas of Victoria and would remove the requirement for BBSC to internally assess landslide risks associated with a proposed development.

The costs of refining the EMO is likely to be relatively high, in the order of $150k to $250k if LiDAR data needs to be acquired. The benefits of reducing the extent of the EMO and simplifying the application requirements and decision process may need to be weighed against the cost of remapping and refining the EMO. Presently, there are not a significant number of development applications within areas subject to the EMO. However, we understand there may be future development pressures in EMO areas.

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1.0 INTRODUCTION

For many years, parts of Baw Baw Shire Council (BBSC) have been recognised as being susceptible to erosion, landslip and slope degradation processes, with detailed studies of landslide and erosion having been undertaken from the 1970's onwards. The BBSC Erosion Management Overlay (EMO) and schedule was introduced in 2006, with the objective of implementing the State Planning Policy Framework and the Local Planning Policy Framework to protect areas prone to erosion, landslip[1] and other land degradation processes by minimising land disturbance and inappropriate development in susceptible areas.

On behalf of BBSC, the Department of Environment, Land, Water and Planning (DELWP) has engaged Mesh Planning (Mesh) to assist in refining the Baw Baw Planning Scheme. As part of this work, Mesh are required to review the existing EMO provisions and to provide recommendations for future amendments to the spatial extent of the EMO, the schedule to the EMO and the administration of the EMO. Golder Associates Pty. Ltd. (Golder) has been engaged by Mesh to provide geotechnical input to their review, specifically related to the hazards arising from landslide, erosion and slope degradation processes in BBSC and whether those hazards are adequately managed by the existing EMO provisions. The scope of work for this engagement was set out in our proposal of 16 July 2018 (ref: 18105651-001-L-Rev0) and was authorised by Mesh via email on 18 July 2018. This report sets out the results of our study, provides a discussion on the adequacy of the current BBSC EMO and sets out opportunities for improvements as they relate to geotechnical aspects.

2.0 AIMS OF STUDY

The aims of the study are as follows:

- To review work undertaken by others to assess the susceptibility of land within BBSC to erosion, landslide and slope degradation processes.
- To review to the spatial extent of the BBSC EMO, comment on its adequacy and identify opportunities to improve the spatial extent of the EMO and the way it is administered.
- To relay experience related to the administration of EMOs in other local government areas and to provide input to the potential redrafting of the BBSC EMO schedule.

3.0 BACKGROUND

The current extent of the BBSC EMO appears to be based primarily on an assessment of slope angle and identification of cleared areas that are known to be prone to landslide. Figure 1 presents the extent of the BBSC EMO.

[1] Note that in this report the terms 'landslip' and 'landslide' are used interchangeably.

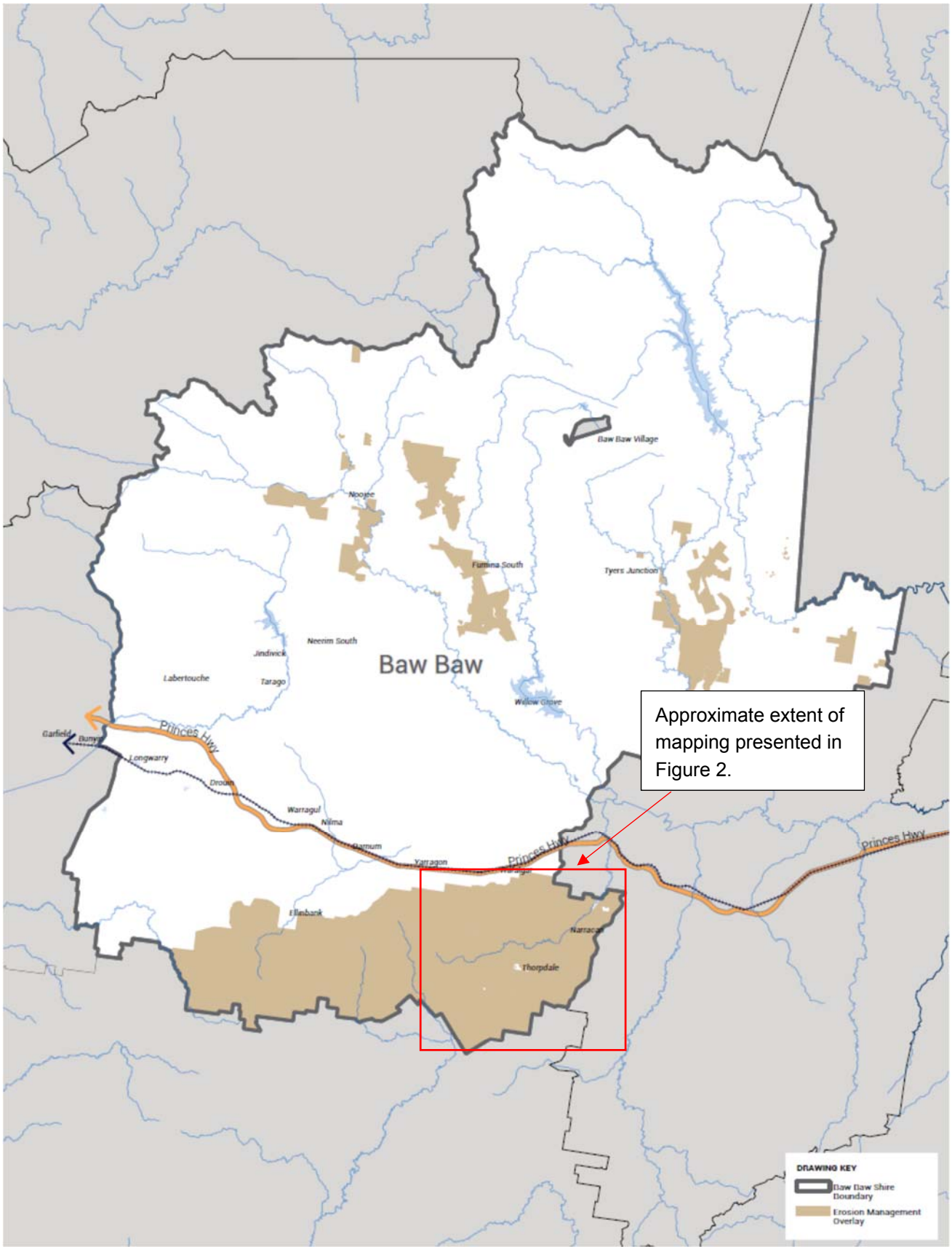

Figure 1: Extent of BBSC EMO indicated by brown shading (image sourced from LandChecker.com.au)

With reference to Figure 1, the large EMO area to the immediate south of Trafalgar appears to have been delineated on the basis of a history of landslide in this area. Brumley (1979) presents a map showing landslides mapped at that time near Thorpdale, as shown in Figure 2. The current spatial extent of the EMO does not appear to consider the detail of specific landslides. Rather, it covers the entire area with steep slopes, parts of which are known to be affected by landslides.

The schedule to the BBSC EMO (VC37 dated 19 January 2006) requires a planning permit application in relation to building and works within the EMO where the slope angle is more than 20% over a distance of 50 m either side of the proposed works. The current EMO appears to generally cover areas that align with this criterion. Notwithstanding this, the existing EMO does not appear to be underpinned by methodology that we would consider best practice in mapping landslide susceptibility. Furthermore, the EMO appears to be 'snapped' to property boundaries rather than its extent being strictly based on criteria related to slope attributes and landslide susceptibility, which would not typically be related to property boundaries.

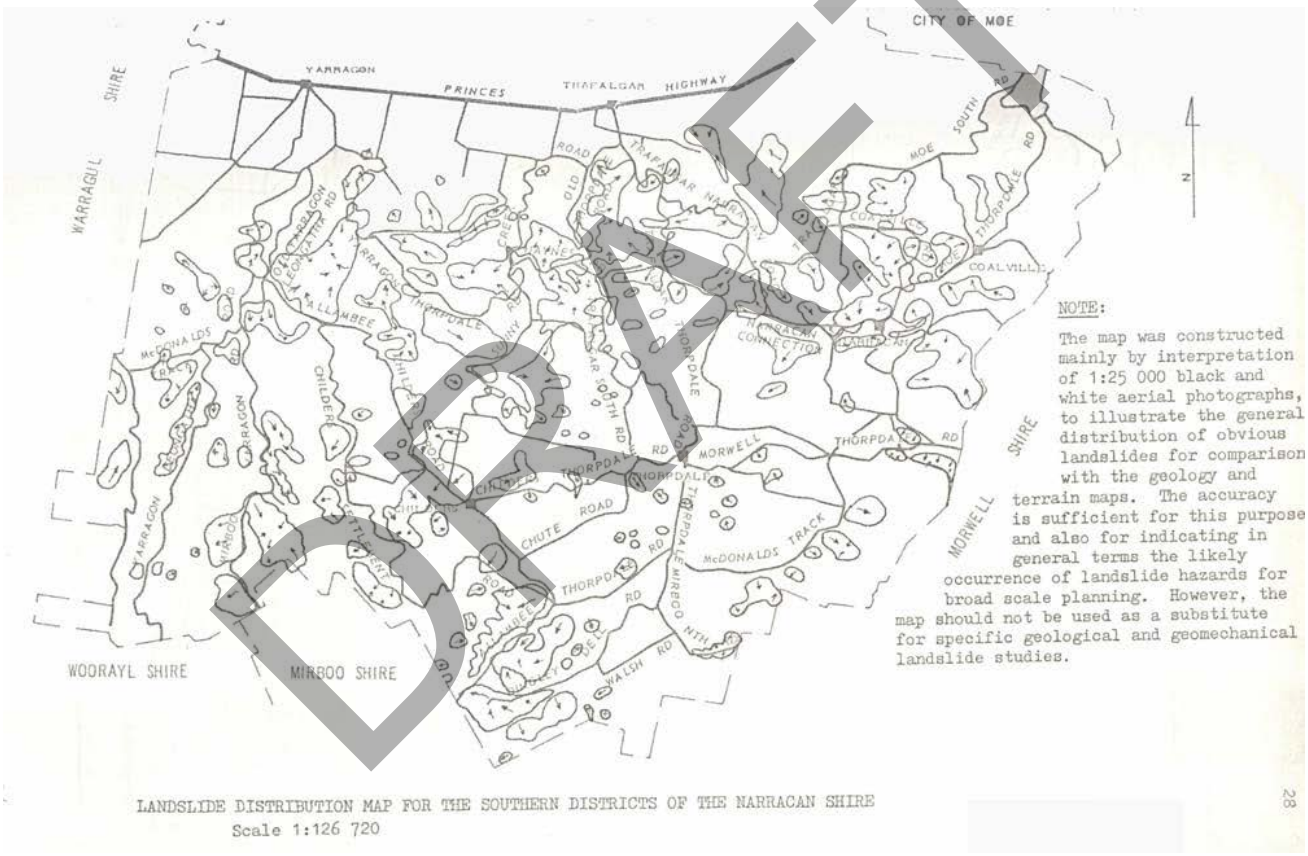

Figure 2: Landslides mapped around Thorpdale, Brumley (1979). Approximate map extent shown in Plate 1.

In 2008, subsequent to the implementation of the BBSC EMO, the West Gippsland Catchment Management Authority (WGCMA) produced a soil erosion management plan (WGCMA 2008). The plan covers part, but not all of the BBSC and includes an assessment of land susceptibility to four key erosion and slope degradation processes:

- Rill and sheet erosion.
- Gully and tunnel erosion.
- Landslide.

- Wind erosion.

The maps produced by the WGCMA cover only the eastern part of BBSC. Notwithstanding this, parts of BBSC are assessed as having a high to very high susceptibility to each form of these erosion processes, with the exception of wind erosion. Figure 3 is an extract from the WGCMA 2008 report showing the susceptibility maps arising from this study.

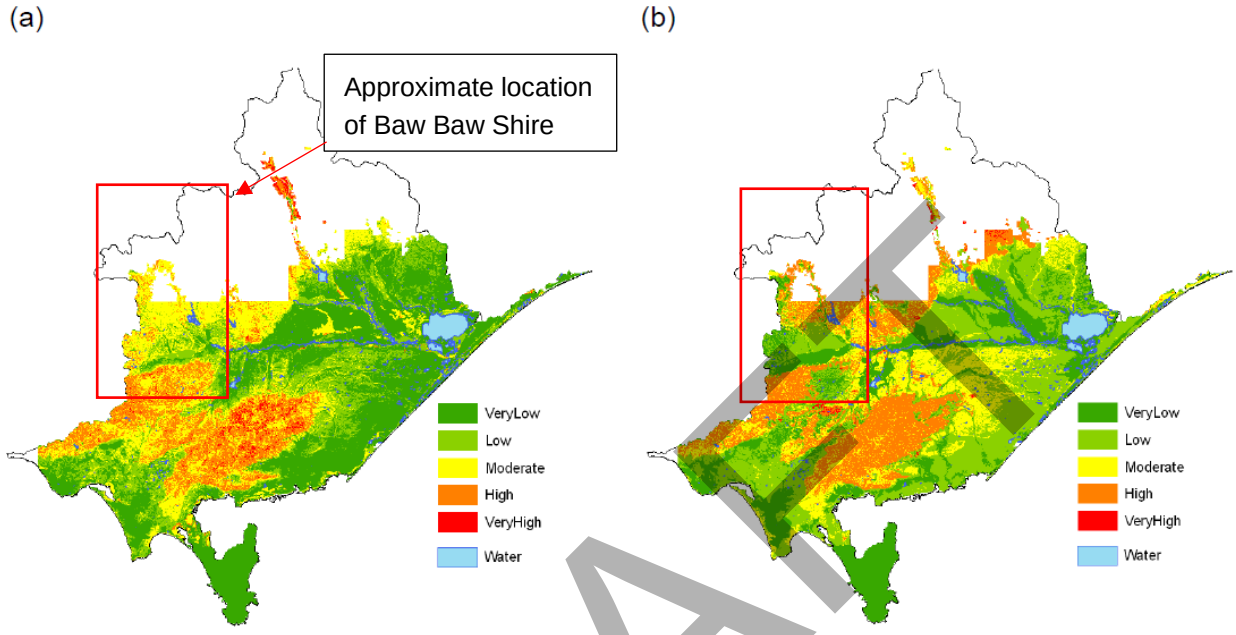

Figure 9: (a) Susceptibility of management to sheet or rill erosion, and (b) susceptibility to gully or tunnel erosion

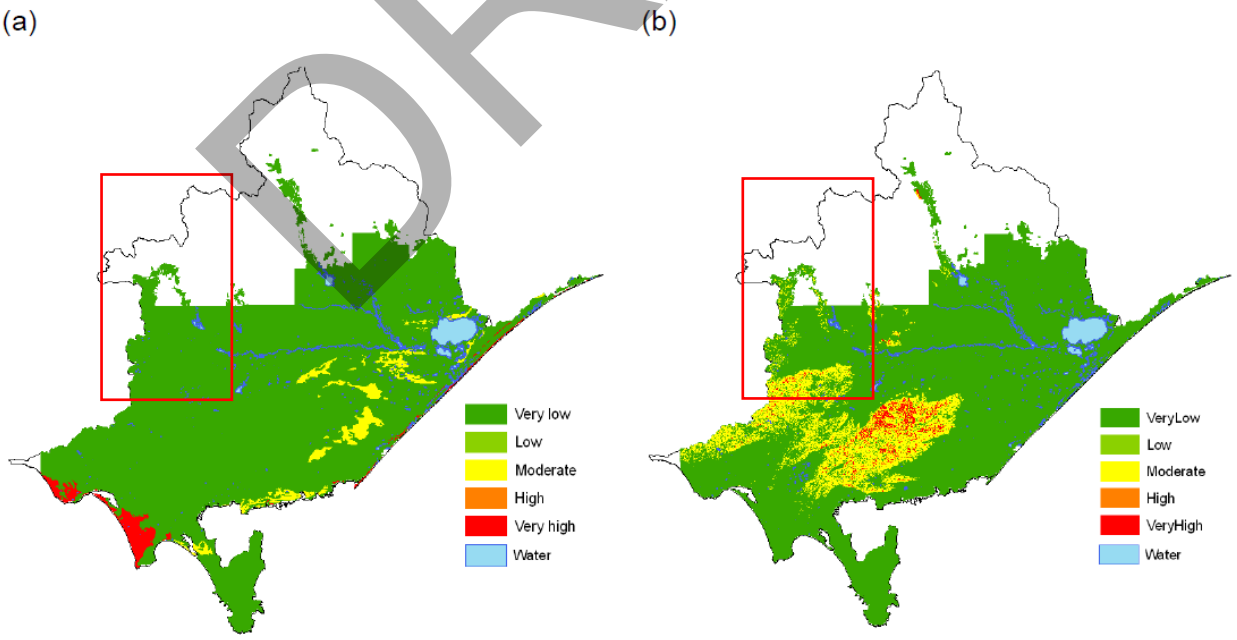

Figure 10: (a) Susceptibility of management units to wind erosion, and (b) susceptibility to slumping

Figure 3: Extract from WGCMA 2008 showing areas susceptible to erosion and slope degradation processes.

Appendix 4 of WGCMA 2008 sets out the criteria that were adopted to identify areas susceptible to each of these processes, with criteria based primarily on geology, soil type, and slope angle. The criteria adopted appear to be based on published and general criteria, rather than criteria developed specifically for the region. However, in general, the study presented in WGCMA 2008 appears to present a more comprehensive assessment of erosion susceptibility than that on which the BBSC EMO appears to be based.

This report draws comparison between the existing spatial extent of the EMO and the susceptibility mapping provided in the WGCMA 2008 report and provides a discussion on the merits of updating the EMO based on the criteria set out in WGCMA 2008.

4.0 LITERATURE REVIEW

Existing information relevant to the identification and management of landslide and erosion hazards in BBSC was sourced and reviewed to assess current and past practices in this area. Information contained in the various background documents along with potential limitations are discussed.

4.1 BBSC EMO and schedule

The schedule to the BBSC EMO sets out circumstances where a permit is required for development in areas affected by the EMO. In general, a permit is required where:

- Buildings or works are to be undertaken in areas with a slope angle higher than 20% (1 in 5) where the slope angle is measured across a distance of 50 m either side of the area of the proposed works.
- Where buildings have a plan area of greater than 100 m^2.
- Where earthworks are required.
- Where vegetation is to be removed.

An application for development within the EMO must be accompanied by:

- Plans showing the existing site conditions and proposed earthworks.
- The means proposed to stabilise disturbed areas.

Various decision guidelines are listed. The following appear to be the key guidelines that relate to landslide and require an assessment by the responsible authority as to whether:

- The proposed development will be affected by erosion or landslide.
- The proposed development will cause or contribute to erosion or landslide.

Comments on document

Based on our review of the schedule to the BBSC EMO, we provide the following comments:

- The types of development that trigger an EMO are relatively broad. This could be refined by, for example, nominating the size (e.g. area and depth of cut or fill) of earthworks that trigger an application and by including development that has the potential to contribute to erosion and landslip by changing surface or subsurface drainage conditions.
- The schedule to the EMO does not specifically list application requirements. Notably, there is no requirement within the schedule for a site specific assessment of landslide or erosion risk by a suitably qualified geotechnical professional, either engaged by the applicant or the responsible authority.
- There is no requirement to assess the specific risk to a proposed development from landslide or erosion, nor criteria against which the risk can be compared. As discussed subsequently, we understand that BBSC uses its discretion as to whether to request the applicant to provide a geotechnical assessment.
- The decision guidelines appear to require some form of assessment of landslide or erosion risk by the responsible authority. Whilst the responsible authority may request a site specific assessment to inform their assessment, there appear to be no mandatory requirements for a site specific assessment to be provided.
- There is no requirement for a geotechnical declaration or similar. This has been adopted by other local government areas with landslide susceptibility (Yarra Ranges, Frankston, Colac Otway and Moreland) and requires a suitably qualified professional geotechnical practitioner to assess the risks to the proposed development from landslide and to sign a form stating that they have assessed (or otherwise) the risks to life and property associated with the proposed development to be tolerable. This form (the geotechnical declaration) is submitted as part of the planning application.

4.2 WGCMA Soil Erosion Management Plan (WGCMA 2008)

The WGCMA document sets out a scientific study which describes erosion and landslide issues within the West Gippsland catchment area (WGCA), part of which overlaps with BBSC. Susceptibility and risk maps are presented in this document along with recommendations to manage the risks associated with these processes.

Erosion and Landslide Processes

The following erosion and landslide processes are identified in the study and susceptibility maps are presented for each process (Figure 2). We have not commented on wind erosion processes described in WGCMA 2008 because the report indicates BBSC to have very low susceptibility to this form of erosion.

Rill/sheet erosion – defined as soil detachment under the action of rainfall and surface water runoff. This form of erosion typically acts over large areas. Areas with loose topsoil on slopes are particularly susceptible to this form of erosion. The susceptibility of areas to this form of erosion are defined in terms of:

1) Soil type, with more dispersive sandy and silty soils more susceptible.
2) Soil thickness, with thicker soils typically less susceptible.
3) Slope angle.

Various criteria or 'rules' are defined for these attributes to zone the susceptibility of the WGCA to this form of erosion. Five categories defined as Very Low to Very High have been derived. The basis for the criteria provided appear to be general, based on published literature rather than a site specific study, however it is reported that some ground truthing was undertaken to check the outcome of the desktop based assessment.

Gully/tunnel erosion – defined as erosion which occurs when soil is removed by running water, with erosion consequently concentrated along drainage lines. Gully erosion is similar to tunnel erosion, the difference being that in tunnel erosion, the near surface soils can remain intact whilst erosion occurs underneath. The tunnels may then collapse to form gullies. The criteria used to assess susceptibility to gully or tunnel erosion is based on:

- Slope angle, where areas with higher slope angles are more susceptible.
- Soil type and grain size with more dispersive soils such as silt more susceptible.
- Depth to rock where greater depth to rock is more susceptible.
- The geological origin of the soils.

Landslides – defined as the movement downslope of materials where the main driver is gravity, rather than water as is the case with erosion. In the WGCA, landslides are typically triggered by intense or prolonged rainfall and exacerbated by vegetation clearance. A criteria is presented to assess the susceptibility of other areas to landslide, which is based on the underlying geology and slope angles. The criteria presented appear to be experience based rather than based on a statistical analysis of landslides that have previously occurred within the study area. The criteria selected indicate:

- A higher landslide susceptibility where sites are underlain by soils derived from basalt compared to soils derived from sedimentary rock.
- A higher landslide susceptibility on steeper slopes.

Management measures are presented in the report, including management measures that can be implemented by local government. A summary of relevant management practical measures, or what are termed 'on ground' works in the WGCMA 2008 report is presented below:

- Revegetation of areas prone to erosion and landslide.
- Protection of existing remnant vegetation.
- Stock exclusion fencing to restrict stock damage to areas prone to erosion and landslide.
- Fencing intended to ensure that land use practices are consistent with the erosion or land use susceptibility, for example classifying land and controlling the time of year on which pastures are grazed or land cultivated based on the susceptibility to erosion at the time of year.
- Designing and implementing earthworks to prevent surface water concentration and uncontrolled runoff.

Comments on Document

Based on our review of relevant information in WGCMA 2008, we provide the following comments:

- Three types of erosion (excluding wind erosion) are described and BBSC is noted as having some susceptibility to all three. The current BBSC EMO appears to align roughly with the areas identified in WGCMA 2008 as being susceptible to landslide.
- There is a reasonable basis to the criteria used to identify areas susceptible to erosion. However, we note that the methods and technologies used to undertake studies such as this have improved since WGCMA 2008 was prepared. For example, remote sensing data such as LiDAR allows very high resolution digital elevation models to be developed from which areas subject to erosion or landslide processes can be accurately identified and delineated.
- The criteria used to assess susceptibility to landslide and erosion are somewhat generic and there may be scope to improve the resolution of the assessment of susceptible areas by developing site specific criteria.
- The management measures recommended are well established methods and appear reasonable. However, other management measures at a scale appropriate to development applications under the EMO such as limiting the depth of cut or fill earthworks and requiring engineer design of retaining walls could also be considered.

4.3 Brumley (1979)

We understand the Brumley (1979) report to be the most comprehensive assessment of landslides in BBSC undertaken to date. However, we note that the study covers only part of BBSC, the area around Thorpdale in the former Shire of Narracan. The study was undertaken by the Geological Survey of Victoria at the request of the Shire of Narracan in response to landslide damage which was frequently affecting roads and farms and because of a trend towards subdivision in landslide prone areas. The study discusses landslide only, with erosion not addressed in detail.

The following summarises key aspects of the Brumley (1979) report:

- Vegetation clearance in the area for farmland was undertaken in the 1920's which is likely to have increased the susceptibility of the area to landslide.
- There is a strong correlation between rainfall and landslide occurrence, and rainfall is inferred to be the main landslide trigger. Notwithstanding this, there is also a possibility for landslide to be triggered by earthquake.
- It is common for landslides to be associated with earthworks, such as road batters and farm dams.
- The typical landslide type observed is a slump with associated earthflow, generally with some structural control due to bedding planes. In the 1970's several of these landslides were occurring annually, with a greater number occurring during years with higher rainfall.
- The landslides are generally slow moving, with the rate of advance of earthflows around 1 m per minute.
- Three classifications of landslides are made:
    1) active or 'contemporary' landslides;
    2) dormant landslides on which movement has not been observed, however on which movement could occur under adverse conditions; and,

3) ‘fossil’ landslides which are likely thousands of years old and on which movement is not expected to occur. Some of the fossil landslides are very large, in some cases over 1 km across and are inferred to have occurred in the Pleistocene (more than 10,000 years ago) under different prevailing climate than today. In some cases, new active landslides have formed on larger fossil landslides.

- The landslides within the study area occur in residual soils formed from the weathering of the underlying Cretaceous and Tertiary age rocks. The soils derived from the Cretaceous age rocks are typically fine silty sands or clayey silts which extend to depths of around 4 m to 6 m. The soils derived from the Tertiary age rocks are typically high plasticity clays which extend to a depth of greater than 1 m below ground surface.
- The principal cause of landslide is described as intense rainfall and associated groundwater level fluctuations, with influences on landslide susceptibility including slope angle, geology, soil type, vegetation clearance, drainage and earthworks.
- Remedial measures are recommended including the removal of unstable landslide material, improvements to surface drainage, revegetation and slope support such as retaining walls.

Comments on Document

- The Brumley (1979) report presents a comprehensive inventory of landslides identified at the time within the study area and thoroughly identifies and discusses the contributing factors.
- The mitigation measures suggested appear reasonable.
- Although a landslide inventory has been developed, the inventory has not been used to further identify areas that could be susceptible to landslide.
- The study does not cover all of the BBSC as it is currently defined, nor does it assess landslide susceptibility on all of the geological materials known to be present within BBSC. For example, the landslide susceptibility of the Devonian age rocks in the north of BBSC is not discussed.
- The study does not address erosion, only landslide is addressed.

5.0 SITE VISIT AND COUNCIL DISCUSSIONS

5.1 BBSC Discussions

At a meeting held with representatives from BBSC (statutory planning, strategic planning and engineering) the Department of Environment, Land, Water and Planning (DELWP) and WGCMA, the administration of the current EMO was discussed. The following summarises the key points arising from the discussions held at the meeting:

- BBSC receives only a small number of applications each year in EMO areas, with the majority being applications for dwellings or out buildings.
- In rare cases, BBSC engineering may request the applicant to provide a geotechnical report which addresses landslide hazards. There is experience that where reports are requested, the reports provided are sometimes of poor quality.

- The decision on whether to request a geotechnical report is not mandated or made based on formal guidelines. This decision is made based on the experience and judgement of the BBSC Engineer. This system is reported to have been working successfully.
- Applications are referred to DELWP as the referral authority. There is reportedly little value in the current process, and we understand that DELWP generally does not engage a geotechnical specialist to assess the referral.
- There have not been substantial landslide hazards within BBSC insofar as they affect development. There are new estates currently being developed in BBSC which involve reasonably extensive earthworks. Some erosion has been observed to be associated with the earthworks. This erosion is generally not managed using the EMO. However, there would usually be a requirement for the applicant to submit a construction management plan which addresses erosion management during construction.

Some discussion was held with respect to whether the EMO should be modified from its current form. Options for modifying the EMO were put forward and discussed, including:

- Making no change to the current mapping extent and administration. It was suggested by BBSC that there are not a sufficient number of applications affected by the EMO to warrant substantial modification. The counter to this view was that, although there may not be much development in EMO areas currently, there may be future development pressures in EMO areas. Notably, one of the reasons for the Brumley 1979 study was the pressure for development within EMO areas. Another view was put forward noting that there may be areas with a sufficiently high risk from landslide to warrant revision to the EMO.
- Adopting the WGCMA 2008 susceptibility mapping as the basis for the EMO was discussed. WGCMA urged caution against this approach, noting that the 2008 mapping was produced for a different purpose than what it would be used for as a planning control and it may not be directly transferable.
- Remapping the extent of the EMO was discussed. It was noted that this would likely require the acquisition of airborne LiDAR data, which would incur significant cost. Notwithstanding this, the LiDAR information would have uses beyond what is needed only for developing the EMO. It was discussed that there might be a ‘trade-off’ between spending money to remap the extent of the EMO using current best practice versus the benefits obtained by reducing the number of properties subject to the EMO and the resulting reduction in developments triggering a planning application under the EMO.
- A discussion was held on the merits of developing two EMO schedules, one that addresses landslide hazards and a second that addresses erosion hazards. The planning controls for each would be different with erosion controls generally along the lines of ensuring good construction practices to prevent surface water runoff and erosion from earthworks. The schedule addressing landslide issues would require a suitably qualified geotechnical practitioner to assess risks to life and property associated with the proposed development.

The meeting provided useful input into the discussion and recommendations set out in this report and informed the issues which are subsequently discussed.

5.2 Site Visit

A site visit was undertaken to observe areas subject to the EMO within BBSC. The following areas currently affected by the EMO were visited:

- Areas around Noojee, Neerim North and Icy Creek.

- Areas around Rawson and Erica.
- The eastern Strzeleckis between Poowong East and Childers.
- The area around Thorpdale.

The assessment made was visual only and included only areas that could be observed from public roads along the route indicated in Figure 4. Not all areas were observed, and the observations should be considered cursory only. The locations visited are indicated in Figure 4. Observation and discussion from the areas visited is presented below.

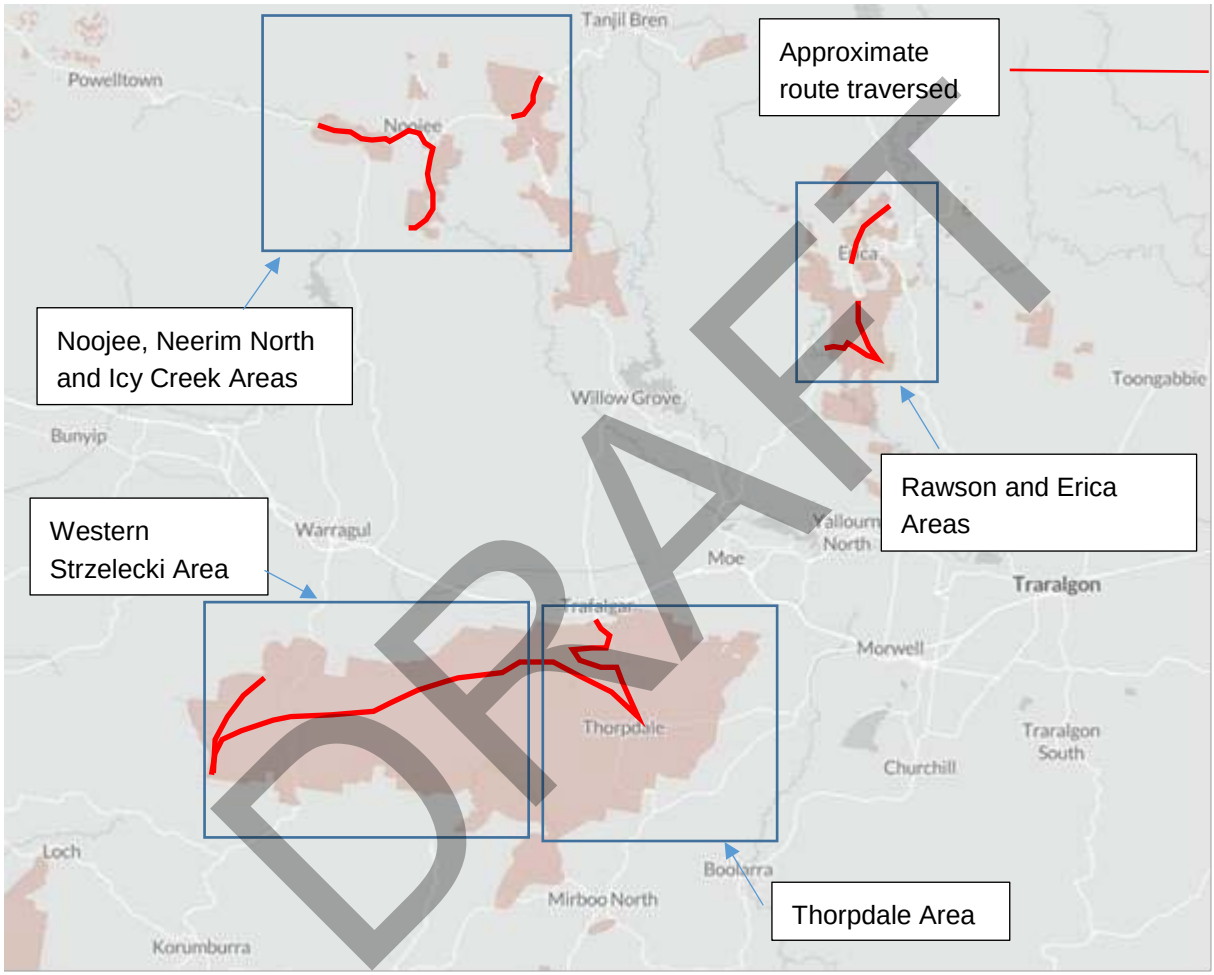

Figure 4: Approximate areas visited during the field visit.

Noojee, Neerim North and Icy Creek Areas

Based on the Geological Survey of Victoria 1:250,000 geological map of Warburton (which covers part of the Baw Baw Shire), this area is underlain by Devonian age siltstone and sandstone which has been metamorphosed to hornfels due to its proximity to a granite intrusion. Some of the hills have a capping of Tertiary age Older Volcanics.

Visual observation of the areas subject to the EMO, indicates slopes are relatively steep, with slopes greater than 20% common in this area. Slopes are relatively uniform and for the most part no evidence for recent or active landsliding was observed.

Figure 5 provides an example of the uniform slopes observed in this area.

Figure 5: Example of uniform slopes at Piedmont (west of Noojee) in an area subject to the current EMO.

One feature that could be a landslide was observed just off the Old Fumina Road between Neerim North and Fumina, as indicated in Figure 6. Otherwise there was no significant erosion or landslide activity observed in this part of the EMO and no development or assets were observed from the traversed route that appeared to be at risk from landslide or erosion.

Figure 6: Possible Landslide just off Old Fumina Road between Neerim North and Fumina.

Rawson and Erica Areas

Based on the 1:250,000 geological map of Warburton the Rawson and Erica areas are underlain by Devonian age siltstone and sandstone with a remnant capping of Tertiary age Older Volcanics. Slopes in this area were observed to be relatively uniform. Areas underlain by the Older Volcanics exhibited some evidence for relict or fossil landsliding in the form of undulating and irregular slopes. However, no evidence for recent or active landsliding was observed. Figure 7 presents an example of undulating slopes in Older Volcanics near Erica.

Figure 7: Example of undulating slopes in Older Volcanics near Erica.

West Strzeleckis – Poowong East to Childers

The 1:250,000 geological mapsheet of Warragul indicates that the west Strzelecki Ranges between Poowong East and Childers are underlain by Cretaceous age Sandstone and Siltstone. This material is gently folded and faulted and has prominent bedding planes. Slopes in this material are relatively steep, typically more than 20% on the flanks of narrow ridges. Many landslides were observed in this material some of which appeared to be relatively recent and probably active. Based on the site visit, landslides in this material are relatively common.

Figure 8: Examples of Landslides within the Strzelecki Group between Poowong East and Childers.

The landslides observed typically occur on steep slopes, generally 20% or more. They are relatively shallow and appear to have some structural control, that is, sliding occurs on discontinuities within the rock mass such as bedding planes. Based on observations of the geomorphology, the landslides appear to have relatively rapid movement, developing into earthflows at their toe.

Some evidence for gully erosion was also observed, however the incidence of gully erosion was observed to be minor relative to that of landslides. An example of gully erosion on the Strzelecki Group is presented in Figure 9.

Figure 9: Examples of gully erosion within the Strzelecki Group between Poowong East and Childers.

The area visited is predominantly rural and no landslides were observed to have affected houses. Previous landslides appear to have affected roads which has necessitated repairs such as those on the road between Ferndale and Strzelecki. The gabion wall structures built to repair the road appear to be in relatively good condition as indicated in Figure 10.

Figure 10: Examples of landslides repair on the road between Ferndale and Strzelecki.

Thorpdale Area

Based on the 1:250,000 scale geological mapsheet of Warragul, the Thorpdale area is predominantly underlain by Tertiary age, deeply weathered Older Volcanics. This area was the subject of the Brumley 1979 study which identified relatively frequent landsliding throughout the area (Figure 2). The landslides in the Thorpdale area are within the residual soils of the Older Volcanics and are typically large block slides which develop into earthflows. Brumley 1979 presents a schematic diagram, adapted from Varnes 1958 which illustrates the mode of landslide within the Older Volcanics of the Thorpdale area. This schematic diagram is reproduced in Figure 11.

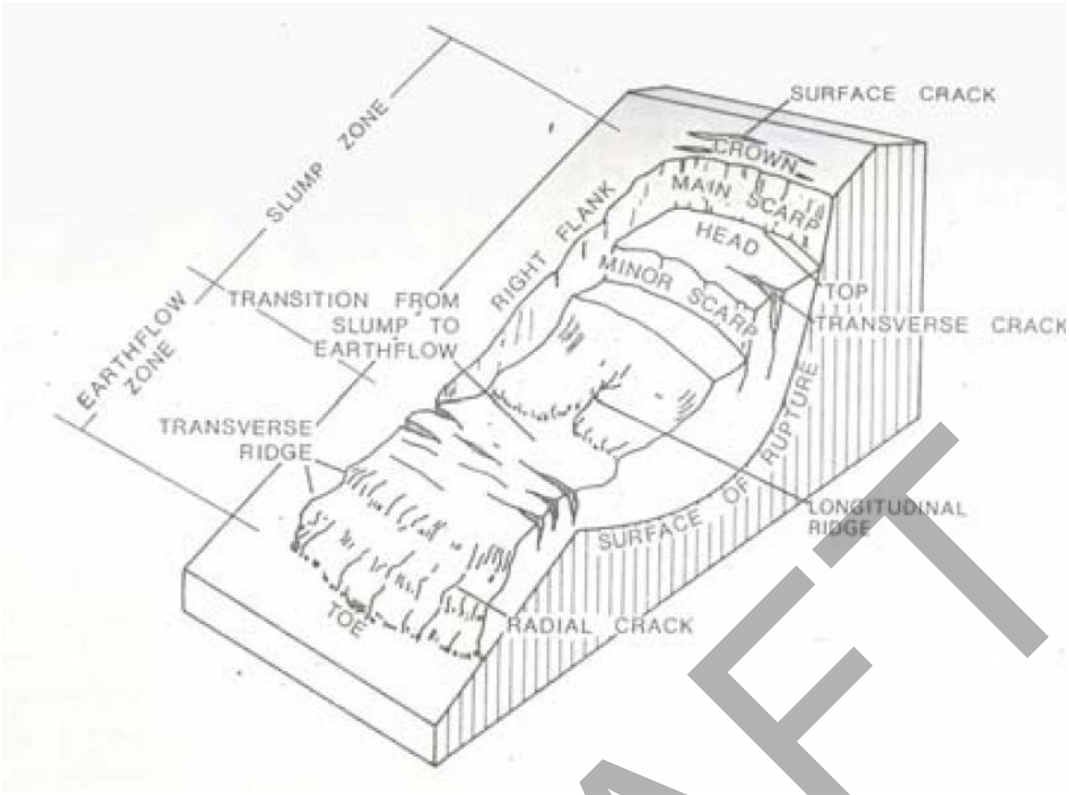

Figure 11: Schematic diagram illustrating landslide mechanism in Older Volcanics in the Thorpdale area. Varnes 1958, reproduced by Brumley 1979.

Several examples of landslides with similar morphology to that illustrated in Figure 11 were observed during the site visit. At least two landslides were observed which have led to earthflows impacting the Thorpdale - Trafalgar Road. Past remedial works have been installed comprising post and lagging retaining walls at the toe of the landslides. These retaining walls appear to have aged and exhibited some dilapidation as shown in Figure 12.

Figure 12: Examples of retaining walls supporting earthflows on the Thorpdale-Trafalgar Road.

Landslides were observed to encroach upon residential development on the outskirts of Trafalgar as indicated in Figure 13. Based on this observation, it is feasible that future development within the Trafalgar area could be susceptible to landslides. Furthermore, if development were to extend further south, it would encroach upon areas that have been previously affected by landslides.

Figure 13: Residential development near foot of landslides at Trafalgar, Thorpdale-Trafalgar Road.

6.0 SUMMARY OF CURRENT EMO IMPLEMENTATION AND ADMINISTRATION

Based on the outcomes of our desktop information review and Council discussions, the following provides a high level summary of our understanding of what we consider to be the basis of the BBSC EMO, the risk to life and property in BBSC from landslide and erosion and the means by which these risks are managed using the EMO.

Landslides and erosion have been occurring in the BBSC area since before European settlement and relatively large portions of BBSC are susceptible to these processes. The prevalence and frequency of landslides and erosion is likely to have been exacerbated by land clearance undertaken in the 1920's. Erosion processes, including rill/sheet and gully/tunnel erosion present a significant risk to agriculture and may present a risk to property and the environment, although they are unlikely to present a risk to life. Given their slow rate of movement, landslides are predominantly expected to present a risk to property. However, landslides could also present a risk to life if they impact upon roads or habitable buildings.

The basis of the current BBSC EMO appears to be landslide rather than erosion, although there are parts of BBSC which are susceptible to erosion. The criteria on which the EMO is based appear to be slope angle and past landslide occurrence. Notwithstanding this, the 'resolution' of the EMO is relatively low. There do not currently appear to be significant development pressures in areas subject to landslide. However, there is potential for future development to encroach upon areas susceptible to landslides.

The current schedule to the BBSC EMO does not specifically require or mandate an assessment of a proposed development application by a suitably qualified professional geotechnical practitioner with experience in landslides and slope stability. Based on the meeting with BBSC, a decision on whether to request a geotechnical report for a particular application is made by BBSC's engineers based on their experience and judgement. Such requests are made of applicants on a relatively infrequent basis.

There does not appear to be a means of identifying if a proposed development is on land that has previously been affected by landslides or if the proposed development could contribute to future landslides. There is no mapping of landslides and statutory planners do not have any tools available to assess whether a proposed development could be affected by landslide.

For most applications within the EMO area, there is no involvement by an independent third party in assessing or reviewing the landslide risk associated with a proposed development. There also appears to be no clearly-defined acceptance criteria for landslide risk, i.e. the maximum level of risk to life or property that BBSC can accept.

7.0 EMO ADMINISTRATION IN OTHER LOCAL GOVERNMENT AREAS

This section provides commentary based on our experience of the administration of landslide hazards in other local government areas (LGAs) of Victoria within which there are areas susceptible to landslide. Note that all of the examples provided below pertain to landslide, rather than landslide and erosion. Despite the name, the EMO is typically used in Victoria to manage development risks associated with landslide more so than erosion. Notably in some other states, landslide and erosion are managed through separate planning controls.

Yarra Ranges Council (YRC)

YRC which borders BBSC was one of the earliest LGAs to implement planning controls for landslide. A series of landslides occurred in the 1980's in the Yarra Ranges causing the loss of several houses, temporary closure of a primary school and significant damage to infrastructure. A landslide susceptibility zoning was introduced in 1991 within the Shire of Lilydale then developed into the YRC EMO in 2001 covering the then amalgamated Shires of Lillydale, Sherbrooke and Upper Yarra.

The YRC EMO is specific about the information to be submitted in support of a planning application. A geotechnical specialist is required to visit the site and to assess landslide hazards: both hazards that could affect the proposed development and hazards that could be caused by the proposed development. The geotechnical specialist is engaged by the applicant.

There is a two level process in place:

- If the geotechnical specialist does not identify any significant landslide hazards on the site, they prepare a report setting out their observations and with a conclusion stating that no significant hazards were identified. This report is termed a '*geotechnical assessment*'. Approximately 80% of the applications assessed in the YRC EMO fall into this category. The geotechnical assessment would typically form part of a site classification report (soil report) that would usually be required for building purposes.
- If significant landslide hazards are identified, then a '*landslide risk assessment'* must be prepared in accordance with the methods set out in the Australian Geomechanics Society Landslide Risk Management Guidelines (2007). This is a national document which represents best practice for landslide risk management in Australia. The outcomes of the risk assessment are compared to acceptance criteria set out in the schedule to the EMO and used to inform the decision on the application.
- In both cases, the geotechnical specialist is required to sign a document (the geotechnical declaration), to confirm they have viewed the development plans, have visited and assessed the site and that in their professional opinion the development can be undertaken to an acceptable or tolerable level of risk. They must also confirm their qualifications by demonstrating chartership with a relevant professional body.

Geotechnical assessment reports are reviewed by statutory planners. A geotechnical consultant is engaged to assist statutory planners in assessing these reports. This includes:

- Assisting with setting up a decision process map to provide guidance on what the geotechnical assessment report should include.
- Providing training to statutory planners on landslide hazards in Yarra Ranges and on how to assess geotechnical assessment reports.
- Preparing maps which subdivide the EMO into different levels of susceptibility based on the history of landslide and potential for landslide. These maps are not publicly available, but intended as tools to

assist the planners, who otherwise have no training in landslides or geology, to assess whether the conclusions of the geotechnical assessment are consistent with expectations.

Landslide risk assessment reports are sent for independent peer review by a geotechnical consultant engaged by YRC. Additionally, geotechnical assessment reports may be sent for peer review if the planner identifies potential issues and is uncertain as to whether the report meets the requirements of the EMO.

YRC has also developed a landslide inventory which is an online GIS layer showing all known landslides within Yarra Ranges along with information about the landslide. This information is intended for and made available to geotechnical specialists operating in Yarra Ranges and assists them in assessing landslide risk to proposed developments.

Frankston City Council (FCC)

FCC has three separate EMO schedules, EMO1, EMO2 and EMO3. There is no specific reason for this other than historical reasons as three EMO areas were added via amendments several years apart. The FCC EMO area is informed by interpretation of LiDAR information and ground truthing which allowed an accurate delineation of landslides and landslide features. There are active landslides within the extent of the FCC EMO which have historically resulted in damage and destruction of dwellings.

The FCC EMO schedule is similar to the YRC EMO and is administered in a similar way with a geotechnical consultant engaged by FCC to provide training for statutory planners and to peer review development applications on sites where the risk to life and property from landslide is higher.

Colac Otway Shire (COS)

COS has similar geological conditions to those of the BBSC and similar landslide hazards, although greater development pressures given growth in areas near the Great Ocean Road. There have been significant consequences in COS from landslides, in particular related to landslide impacts which have caused closure of the Great Ocean Road. Vegetation clearance (e.g. for logging or farming) has had an impact on landslide susceptibility in COS and in recent years the potential for bushfire to increase susceptibility to landslide has been a focus for COS due to the impact of the December 2015 bushfire that destroyed vegetation, buildings and (predominantly timber) retaining walls within the Wye River and Separation Creek townships. Landslide hazards in and around these townships have been a key consideration for planning of the bushfire recovery and geotechnical practitioners are required to consider the impact of the bushfire on landslide risk when submitting reports for new planning applications in these townships.

The administration adopted by COS is similar to that of YRC with a two level assessment and peer review system in place. They have had some issues related to the competence of geotechnical specialists operating in the area and in some cases arranged multiple independent peer reviews before taking a decision not to accept reports from particular geotechnical specialists.

COS was the first council in Victoria to publish an online landslide inventory, an initiative which has since been subsequently adopted by YRC.

Moreland City Council (MCC)

MCC has different landslide hazards than the aforementioned councils. The terrain in Moreland is generally stable, unless inappropriate hillside development causes instability. There were instances where inappropriate development caused excavations to collapse which presented a risk to life and led to a decision to implement an EMO. Given the type of landslide hazards in Moreland, the administration of the EMO is slightly different to that of the aforementioned LGA's. The schedule requires the involvement of a geotechnical specialist at the planning stage. The role of the geotechnical specialist is to assess whether the proposed development could introduce slope stability hazards and where appropriate to recommend measures for mitigating those hazards.

The role of the statutory planners is to ensure that the measures recommended in the geotechnical report are implemented and to ensure that the endorsed plans show the required measures. A geotechnical declaration must be provided by the geotechnical specialist to verify that the development plans show their recommended measures. No third party peer review is usually required and it is usually feasible for development to proceed provided the application has been assessed by a suitably qualified geotechnical engineer and the appropriate landslide mitigation measures are in place. This is not the case in the aforementioned Councils in which there are some circumstances where development is not practically feasible. BBSC is expected to fall into the latter category, with development in some areas of the Strzeleckis not practically feasible.

8.0 OPPORTUNITIES TO IMPROVE THE BBSC EMO

This section sets out opportunities for improving the BBSC EMO and schedule. This has been framed as a series of key questions or decisions that may need to be made to progress updates or amendments to the EMO, with the advice provided intended to inform future decisions.

8.1 Does BBSC need an EMO?

Section 13.03-2 of the Victorian Planning Provisions addresses erosion and landslip. This section is reproduced below.

SECTION 13.03-2 EROSION AND LANDSLIP

Objective

To protect areas prone to erosion, landslip or other land degradation processes.

Strategies

Identify areas subject to erosion or instability in planning schemes and when considering the use and development of land.

Prevent inappropriate development in unstable areas or areas prone to erosion.

Promote vegetation retention, planting and rehabilitation in areas prone to erosion and land instability.

Policy Guidelines

Planning must consider as relevant:

- *Any relevant regional catchment strategy.*
- *Any special area plan prepared under the Catchment and Land Protection Act, 1994.*

With reference to the above, BBSC has areas that are unstable due to landslides and areas which are prone to erosion including rill/sheet erosion and gully/tunnel erosion. There has been past development in these areas and there is potential for future development in these areas. In some cases, development in areas affected by landslide has been inappropriate, for example road construction and associated earthworks as described in Brumley (1979). Furthermore, it is possible that future development could:

- be adversely affected by landslide or erosion, or;
- could exacerbate or trigger landslide or erosion.

On this basis, we consider it appropriate that BBSC has an EMO and note that this would be consistent with the Victorian Planning Provisions, Section 13.03-2.

8.2 Is the current extent of the EMO suitable?

The criteria used to define the extent of the current EMO are unclear. It appears that the extent of the current EMO is based on slope angle and general experience of landslides within an area. No shire wide landslide inventory or detailed study of landslide susceptibility appears to have been undertaken. We expect that the area affected by the EMO could be significantly refined by adopting clearly defined criteria. This would improve the 'resolution' of the EMO and is likely to reduce the area affected by the EMO. As an example, Figure 14 compares the YRC EMO in the Warburton area with the BBSC EMO in the Noojee area. The extent of the YRC EMO is based on a detailed assessment and well defined criteria based on slope angle and underlying geology. The different resolution is apparent.

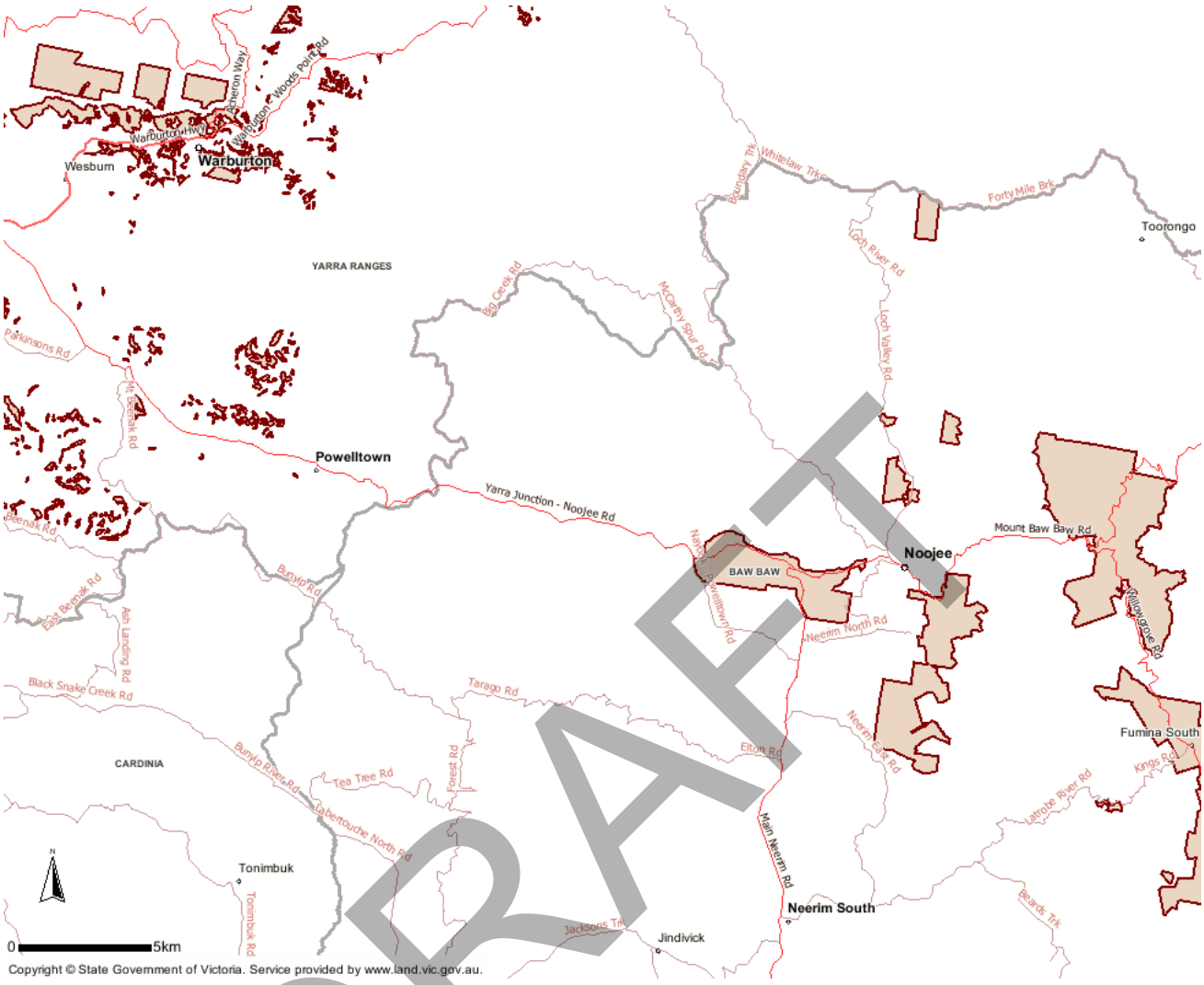

Figure 14: Comparison between YRC (left of figure) and BBSC EMO (right of figure) in the Warburton, Powelltown and Noojee Area.

In our opinion there is opportunity to refine the BBSC EMO. Doing so would likely reduce the extent of area affected by the EMO. In our experience, it is better in urban areas for the EMO to have as high a resolution as can be achieved with modern methods of geological and geomorphological assessment. For example, MCC initially proposed an EMO with a broad and generic extent based on limited geological study. With further, more detailed studies, more than 100 properties were removed from the initially proposed EMO, which had significant long term benefits to MCC and the community. In Frankston, high quality LiDAR data allowed the boundaries of areas susceptible to landslide to be defined to an accuracy of around 1 m. At this accuracy, there are many properties which are only partly affected by the EMO, which further serves to reduce the number of developments which trigger a requirement for a permit under the EMO and informs planning the location of building envelopes on the site.

Developing a new EMO in line with modern techniques would require the production of a high resolution digital terrain model. Airborne LiDAR information would need to be acquired in order to produce the terrain model. An example of a hillshade filter on a digital terrain model from FCC is presented in Figure 15. This would incur significant cost, likely $100k to $150k. Consequently there would be a trade off between the costs required to refine the EMO against savings arising from reducing the EMO extent and the number of planning applications triggered under the EMO.

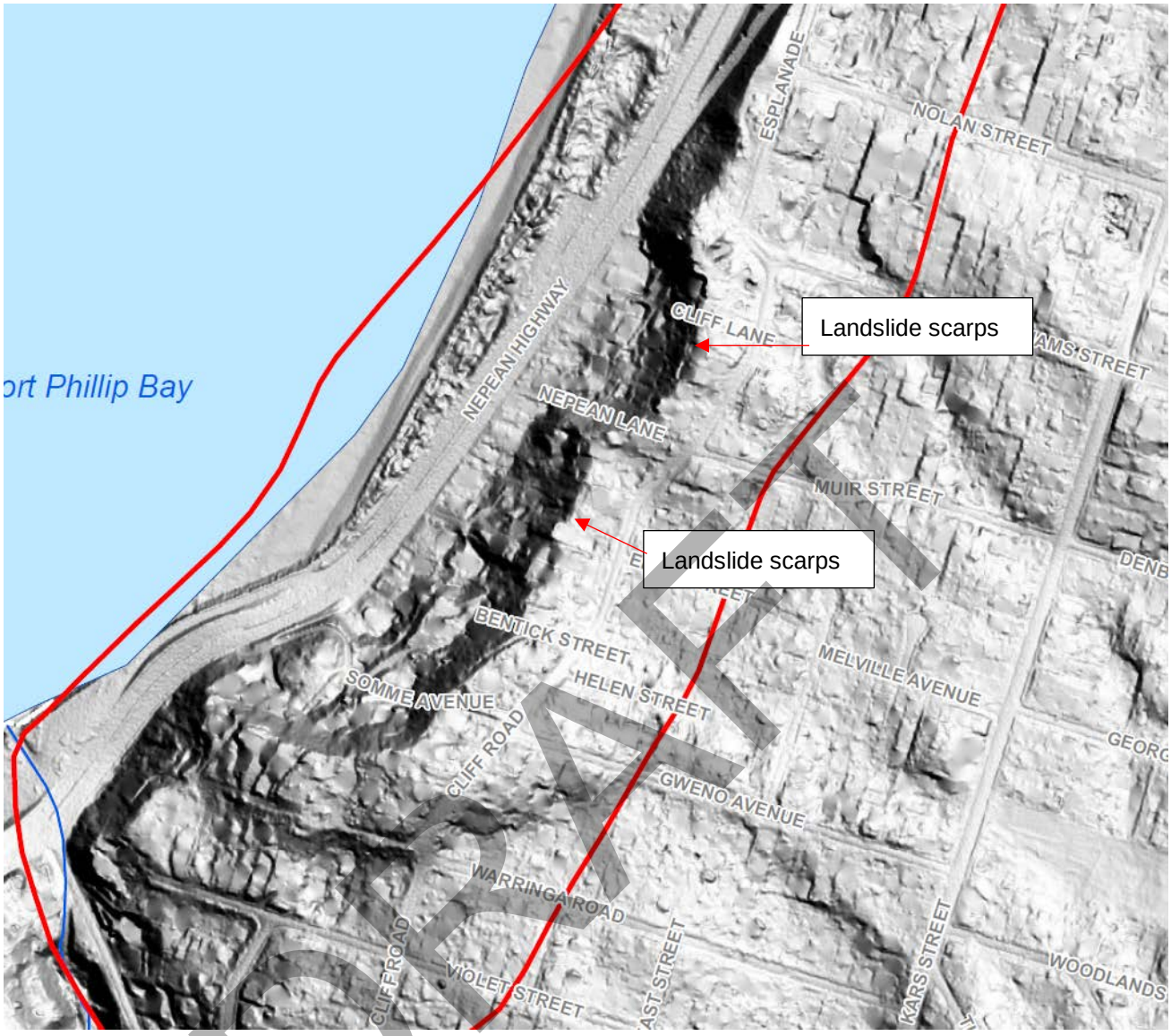

Figure 15: Example of hillshade filter on digital terrain model used to develop the EMO for FCC.

8.3 Should the BBSC EMO consider landslide hazards, erosion or both?

Under the Victorian Planning Provisions, planning must consider any relevant regional catchment strategy. For BBSC, the WGCMA 2008 report is a relevant document. That report identifies areas susceptible to landslide and two types of erosion: rill/sheet erosion and gully/tunnel erosion. The criteria used to assess susceptibility to erosion are set out in WGCMA 2008 and these criteria could be applied to all of BBSC to identify land susceptible to erosion.

The current extent of the EMO appears to mainly consider landslide. There is an opportunity to expand the EMO to cover areas susceptible to erosion in addition to landslide. To inform an assessment of the value of this addition, we offer the following comments:

- Landslide generally presents a greater risk to life and structures than erosion. Erosion mainly presents a risk to agriculture and the environment in terms of soil run off and stream siltation and aggradation.

- At the scale of the built environment, for example dwellings and roads, erosion is generally more manageable than landslide. Erosion at local scale can generally be managed with drainage improvements, vegetation and other erosion protection measures. Landslides of the type and size known to occur in BBSC cannot be managed as readily.
- Based on the susceptibility maps presented in WGCMA 2008 and assuming that areas assessed as having a medium to very high susceptibility to erosion were to be added to the EMO, the extent of the BBSC EMO would be significantly greater than it is currently.
- We are aware of several EMO's in Victoria that are based predominantly on landslide rather than erosion susceptibility. Vegetation removal is a key trigger for erosion. Risks associated with vegetation removal are addressed in other overlays such as the Environmental Significance Overlay (ESO). Erosion is most likely to affect farming areas, and impacts from farming are addressed in the provisions for the farming zone (FZ).
- Earthworks, such as those undertaken for new residential estates may be subject to erosion. However, control of erosion due to construction is generally a requirement associated with all earthworks and would typically be managed through a construction management plan or work method statement rather than planning controls.
- It may be difficult to address both landslide and erosion hazards under one EMO schedule. Separate schedules outlining different application requirements could be considered for landslide and erosion, if there was considered to be a desire to have an overlay that specifically addresses erosion. For example whilst the schedule for landslides requires the applicant to obtain a geotechnical assessment, the schedule for erosion might require the applicant to develop and implement a construction management plan. WGCMA 2008 provides useful guidance for erosion management and could form the basis of a guideline for best practice erosion management within Baw Baw. To further manage erosion, BBSC could consider implementing a requirement for construction management plans to include sections outlining how erosion will be managed through the course of development construction.

Whilst there are a number of inputs to the decision on whether to include erosion susceptible areas in the EMO, on balance, from a geotechnical perspective it is our view that the BBSC EMO should be based on areas susceptible to landslide only rather than landslide and erosion. Issues associated with erosion of disturbed ground such as earthworks for residential estates can be managed through construction practices rather than planning controls.

8.4 How should the extent of the EMO be assessed?

We offer four methods that could be used to define the extent of the EMO. These are discussed below along with the advantages and disadvantages of each method.

1. Retain Current EMO extent

The current EMO could be retained. Table 1 sets out some advantages and disadvantages of this approach.

Table 1: Advantages and disadvantages of retaining the current EMO extent

Advantages	Disadvantages
No cost to undertake further studies to define areas susceptible to landslide.	Area susceptible to landslide very general and may cover more area than is necessary.
No requirement for a planning scheme amendment with the associated time and cost implications.	The current EMO extent may omit some areas susceptible to landslide and erosion.
Although it covers more area than could be necessary, most areas susceptible to landslide are expected to be covered by the current EMO extent.	The criteria used to define the EMO extent does not accord to what would be considered current best practice.
	BBSC retains responsibility for judging whether a development could be subject to significant landslide risk and whether to request the applicant has the geotechnical risk assessed.

2. Redefine the EMO extent based on the criteria provided in the WGCMA 2008 report

WGCMA 2008 provides criteria for assessing erosion and landslide susceptibility. For landside, the criteria for assessing susceptibility are reproduced in Table 2.

Table 2: Susceptibility to landslide as defined in the WGCMA 2008 report

Soil Type	Slope Class	Susceptibility Rating
Basalt Soils	Slopes up to 10% slump-earth flows occasionally occur	Low
	Slopes between 10% and 40% slump earth-flows occur often	Moderate
	Slopes greater than 40% slump-earth flows are common	High
Strzelecki Soils	Slopes up to 20% slump-earth flows occasionally occur.	Low
	Slopes between 20% and 40% slump-earthflows are common	Moderate
	Slopes greater than 40% slump-earth flows occur often	High
All Other Soils		Low

Table 3 sets out some advantages and disadvantages associated with adopting the criteria set out in Table 2, assuming areas with moderate and high landslide susceptibility are included in the EMO and that landslide criteria only are used to define the EMO rather than landslide and erosion criteria.

Table 3: Advantages and disadvantages of redefining the EMO extent based on WGCMA 2008

Advantages	Disadvantages
Relatively low cost to redefine EMO extent.	Requires a planning scheme amendment with associated time and cost implications.
Consistent with the WGCMA approach and in line with the Victorian Planning Provisions which require consideration of the regional catchment management authority approach.	Does not cover some parts of the BBSC area which are currently within the EMO. For example, the north of the BBSC area (Noojee, Walhalla, Baw Baw) is underlain by Devonian age rocks for which there is no criteria provided in WGCMA 2008, despite parts of these areas currently being subject to the EMO and likely to have landslide susceptibility.
The requirement to obtain a geotechnical assessment is mandated, removing the responsibility for this decision from BBSC.	EMO definition is not fully consistent with current best practice.
	Criteria are very approximate and not based on a detailed study. This may result in the unwarranted inclusion in the EMO of some areas and omission of others.
	WGCMA has advised caution against adopting the criteria set out in WGCMA 2008 without undertaking further studies to assess their applicability for the BBSC EMO.

Rather than directly adopt the WGCMA 2008 criteria, there may be an opportunity to review and refine them rather than proceeding with a full review as described subsequently. For example, adding additional criteria to cover other geological units. However, we note that there would remain inherent uncertainty with this approach because the criteria would not be based on a detailed study.

3. Redefine the EMO extent based on current best practice

The criteria set out in the WGCMA 2008 report to define landslide susceptibility are very approximate and based on two criteria: soil type or geology and slope angle. The Australian Geomechanics Society Guidelines for Landslide Risk Management (2007) sets out a method for assessing landslide susceptibility. The following provides an overview of what we would consider to be current best practice for assessing landslide susceptibility.

1. *Develop a landslide inventory*

A landslide inventory would be established for all of the BBSC. This involves the creation of a GIS based database in which the spatial extent of all known landslides are recorded. In addition to recording the spatial extent of known landslides, as many attributes about the landslide as are known are also recorded. For example, geological information, time of occurrence, type of trigger, damage arising, etc. In addition to informing the extent of the EMO, the landslide inventory would also be used as a tool for planners and geotechnical specialists to assess planning applications submitted in areas affected by landslides.

The identification of landslides would be undertaken using the following techniques:

- LiDAR information covering the entire BBSC area would be obtained and used to produce a digital terrain model then processed to highlight geomorphological features indicative of past landslide. If not currently available, it may be necessary to commission an airborne LiDAR survey. Interpretation of the LiDAR information would be done by a geomorphologist or engineering geologist with a specialisation in landslide identification. There may be advantages in obtaining LiDAR information over a broad area extending beyond Baw Baw Shire. This information has many applications in addition to geomorphological assessment. For example, it can be used for hydrological analysis including flood assessment, bushfire assessment and management and as a basis for infrastructure design. We note that Tasmania has undertaken LiDAR surveys which cover most of the populated area of the state for the above purposes.
- A search of historical records would be undertaken to obtain information about past landslides in the BBSC. The Brumley (1979) report would inform this review along with Council and state records.
- Field mapping would be undertaken to 'ground truth' the indications gained from the digital terrain model and search of historical records. Further information about the landslides would be gained in this way.
- If warranted, detailed investigation such as drilling could be undertaken of some landslides. However, in our experience this would not usually be necessary as part of a study to define the EMO extent.

2. *Identify areas susceptible to landslide.*

Generally, areas that have directly been affected by landslides would be included in an EMO. An assessment of each landslide would be undertaken to assess the area that could be adversely affected if the landslide were to remobilise, including areas upslope that could be affected by regression and areas downslope that could be affected by debris runout. These areas would also be considered susceptible to landslide and included in the EMO.

The attributes of landslides identified would be analysed to assess the contributing factors to landslide. Most EMO's in Victoria and the WGCMA 2008 criteria consider slope angle and geology or soil type as the only two attributes defining landslide susceptibility. However, a detailed study can also consider attributes such as slope aspect (in Victoria, prevailing rainfall or geological structure can make one side of a hill more susceptible to landslide than the other), catchment area upslope of the susceptible area and proximity to water courses and groundwater conditions.

Based on an analysis of existing landslides, criteria are established to define the susceptibility of other slopes to landslide. These areas would also be included in an EMO. For example, a study of existing landslides might identify that slopes underlain by Older Volcanics which are steeper than 15% are susceptible to landslides. In a similar way to what has been done by other LGAs, areas that *have* been affected by landslide and areas that *could* be affected by landslides can be separately delineated and this information used as a tool by planners to assess planning applications in areas susceptible to landslide.

3. *Develop EMO schedule*

The EMO schedule can then be developed based on the study of areas susceptible to landslide. Application requirements and landslide management techniques are recommended based on the type of landslides expected to occur and the risk they are likely to present to life and property. It is important that the planning

application requirements for areas at risk from landslide are consistent with the level of risk the landslides present to life and property. The EMO schedule should set out the acceptance criteria for landslide risk.

Table 4 sets out advantages and disadvantages of undertaking new studies to redefine the extent of the EMO.

Table 4: Advantages and disadvantages of redefining EMO extent on current best practice

Advantages	Disadvantages
EMO extent conforms with best practice and is as accurate as can be reasonably defined using current technologies and practice.	Significant cost outlay – could be in the order of $150k to $200k or more given the likely requirement to acquire airborne LiDAR data.
Likely to reduce the overall area affected by the EMO in BBSC with associated administrative implications.	Requirement for a planning scheme amendment and associated time and cost implications.
Consistent with EMOs in other LGAs.	A possibility that some areas not currently within the EMO will be recommended for inclusion, with associated administrative implications.
The requirement to obtain a geotechnical assessment is mandated, removing the responsibility for this decision from BBSC.	
Simple to use tools are produced in the process which assist statutory planners in assessing planning applications subject to the EMO.	
May pick up areas not currently in the EMO which should be, thereby reducing risk to BBSC.	

4. Redefine the EMO extent based on existing topographical information

The same method as set out above to redefine the EMO could be undertaken using currently available topographic information rather than airborne LiDAR data. The currently available topographic information is likely derived from photogrammetry and is not as accurate a LiDAR derived data. We would estimate that landslides mapped using current topographical information would have an error margin of around ±20 m whereas with LiDAR the margin of error could be as low as ±1 m. The age of the current topographic data could also be a limitation with respect to identifying recent landslides. Table 5 sets out what we consider to be the advantages and disadvantages of redefining the EMO extent using existing topographical information.

Table 5: Advantages and disadvantages of redefining EMO extent using existing topographical information

Advantages	Disadvantages
Likely to reduce the overall area affected by the EMO in BBSC with associated administrative implications.	Some cost outlay – could be in the order of $50k to $100k.
Consistent with EMOs in other LGAs.	Requirement for a planning scheme amendment and associated time and cost implications.
The requirement to obtain a geotechnical assessment is mandated, removing the responsibility for this decision from BBSC.	A possibility that some areas not currently within the EMO will be recommended for inclusion with associated administrative implications.
Simple to use tools are produced in the process which assist statutory planners in assessing planning applications subject to the EMO.	The overlay would be superseded once better quality topographical (LiDAR) information becomes available. This could feasibly be within a few years.
May pick up areas not currently in the EMO which should be, thereby reducing risk to BBSC.	

8.5 What should be covered in an EMO schedule?

In Victoria, the principles behind EMO schedules can be broadly categorised into two types:

- Areas where landslides are unlikely to occur unless they are triggered by inappropriate development (e.g. MCC).
- Areas where landslides could occur irrespective of development (e.g. YRC, FCC, COS).

BBSC is within the latter category and so precedents from YRC, FCC and COS are relevant. Their EMOs have been developed through several amendments over a number of years based on practical experience of their use. The following key elements from these schedules could be considered in a revised schedule for BBSC.

- The site of a proposed development must be assessed by a geotechnical specialist at planning stage. The geotechnical specialist must provide a report and declaration stating whether there are landslide hazards on the site that could affect, or could be affected by the proposed development. The schedule should set out the minimum requirements for geotechnical assessment reports prepared in support of planning applications.

- There is a two tier geotechnical assessment process whereby sites on which no significant landslide hazards have been assessed require a simpler geotechnical assessment, usually done as part of a site classification report. Sites with significant hazards or where landslides are known to have previously occurred require a more detailed landslide risk assessment. It is more cost effective for the applicant to only undertake the geotechnical assessment if this is all that is needed, and not unnecessarily spend on a landslide risk assessment if the risks on the site do not warrant it.
- There is provision for the responsible authority to procure peer review, in particular for high risk sites.
- There are clearly defined criteria setting out the basis of the EMO which can be tested as part of specific planning applications, including acceptance criteria for landslide risks to life and property.
- The schedule defines the minimum qualifications required by a geotechnical practitioner to assess landslide hazard and make recommendations for the management of landslide risks.

In our opinion, the current BBSC EMO could be significantly improved by incorporating an assessment of landslide prone sites by a suitably qualified geotechnical practitioner at planning stage.

8.6 What types of development should trigger a planning application in the EMO?

Broadly speaking, development within the BBSC EMO could fall into two categories:

1) development that could be at risk from existing landslide hazards, and

2) development that could change the likelihood, (and therefore risk) of a landslide occurring.

The former refers to development within areas that could be adversely affected by landslide irrespective of how the development modifies the environment. An example might be a dwelling constructed immediately downslope of a landslide which has the potential to move and impact the dwelling. The latter refers to development that changes the ground attributes that contribute to landslide, for example modifying the slope angle through earthworks or changing the soil moisture through the construction of dams and drainage measures.

As a general guide, a permit requirement would be triggered under the EMO where:

- The development involves earthworks with cut or fill higher than 1 m. This is based on the consequence of collapse and draws precedent from Work Safe Victoria guidelines which address the safety of unsupported excavations.
- The development has the potential to cause the concentration of water in the soil, for example disposal of stormwater from an impermeable roof, dams, tanks, swimming pools and effluent disposal fields.
- The development has the potential to significantly change soil moisture conditions, for example removal of large trees or vegetation clearance over a large area.
- There are significant consequences if the development is impacted by landslide, for example habitable buildings and dwellings, large outbuildings, critical services and infrastructure.

The YRC EMO schedule was amended in 2016 to increase the number of development types that were exempt from submitting a planning application under the EMO. This amendment was driven by experience over 15 years of EMO implementation and may form a useful precedent for BBSC. Developments unlikely to change the existing landslide hazards or water in the soil such as small extensions and carports and small

outbuildings without earthworks, were made exempt. Provision is also included for YRC to waive the requirement for a geotechnical assessment at their discretion, with the decision on whether to implement this waiver made in consultation with a geotechnical consultant.

8.7 Can landslide and erosion hazards be addressed in the building rather than planning stage of a development application?

If landslide hazards are assessed only at building stage, it must be assumed that it is feasible to undertake any type of development on landslide susceptible areas, perhaps with landslide mitigation measures. This is not the case in BBSC. Some landslides are of sufficient size and type that development, for example residential development may not be practically feasible. This must be assessed at planning rather than building stage. Based on our experience of EMO administration in other LGAs landslide hazards are generally managed through the planning and building approval stages as follows:

Planning Stage

- Geotechnical specialists are involved to assess whether there are landslide hazards that could affect the proposed development.
- The risk to the development from landslide is assessed by a professional, suitably qualified geotechnical specialist. In some cases the assessment may indicate that the development is not be feasible because the risks from landslide are too high and cannot be effectively mitigated.
- A two stage approach is applied whereby a geotechnical assessment is undertaken which seeks to identify if there are any significant landslide hazards on the site. This would usually be done as part of a site classification report which would be required for building purposes. If no significant landslide hazards are observed on the site, no further assessment is required. If hazards are identified, a landslide risk assessment would then need to be undertaken.
- Where appropriate, the geotechnical specialist advises on landslide risk mitigation measures. These might typically include retaining walls, drainage controls and minimal earthworks.

At this stage, the applicant is made aware of whether the development is feasible and will have some indication of the cost of landslide mitigation measures if these are required. The applicant can make an informed decision as to whether to move ahead to building stage, modify or abandon the development given the possible cost implications of managing landslide risk. We are familiar with a number of cases where sites have been left in a condition with unsafe earthworks because the applicant was made aware of the costs of landslide mitigation too late in the process, after planning approval had been provided.

Assessing landslide risks at the planning stage also provides the regulatory authority (e.g. BBSC) the ability to identify developments that irrespective of mitigation measures would be at unacceptable risk from landslide before planning approval is granted.

Building Stage

Through the building stage, the engineering aspects of the landslide mitigation measures are assessed, for example the engineering design of retaining walls is reviewed and assessed against codes and standards to ensure they will provide the landslide risk mitigation they have been designed to provide.

Erosion Hazards

In BBSC, it is very unlikely that risks associated with erosion would result in a development being infeasible, which is in contrast to landslide hazards. Furthermore, erosion hazards can generally be managed through good construction and hillside development practices, again different to landslide hazards. In our opinion, there is scope to manage erosion hazards through the building stage. This would generally be done by requiring a construction management plan to be produced which addresses erosion and runoff management. We also note that earthworks in virtually all areas underlain by soil would typically be susceptible to erosion and would require some form of erosion management.

Based on the findings of this study there does not appear to justification for addressing erosion management through an overlay within Baw Baw Shire, as most erosion risks can be managed through CMPs, farm management plans, and the like. Insofar as development is concerned, landslide hazards are expected to present the most significant risks.

9.0 SUMMARY AND CONCLUSIONS

This report presents a high level discussion of landslide hazards and their management in BBSC. The following summarises our advice based on our assessment of landslide hazards and their management in BBSC.

- Parts of BBSC are susceptible to landslide, erosion and slope degradation processes. The type of landslides that have previously occurred in BBSC present a risk to life and property. Planning controls intended to manage landslide risk are therefore recommended.
- The current extent of the BBSC EMO does not appear to have a rigorous basis or a basis consistent with current best practice and guidelines. There is opportunity to revise the EMO extent. Doing so is expected to reduce its overall extent. However, there may also be some areas which would be included in a revised EMO that are currently excluded. There are various levels of rigour that can be applied to define the EMO extent. With modern techniques, including use of LiDAR data, the identification of areas susceptible to landslide can be undertaken to a high level of accuracy. The cost of refining the EMO in this way may need to be assessed relative to the benefits of reducing the extent of the EMO.
- It is suggested that from a geotechnical perspective the EMO extent be based on susceptibility to landslide rather than landslide and erosion, with erosion induced by earthworks and land clearance managed through construction management plans, building controls and other planning overlays such as the ESO.
- The process set out in the current schedule to the EMO does not require assessment of an application by a geotechnical specialist unless specially requested by BBSC. There is an opportunity to introduce this as a mandatory requirement in some areas, thereby removing the decision currently made by BBSC as to whether a particular development has sufficient landslide risk associated with it to warrant the applicant obtaining a geotechnical or landslide risk assessment. Doing so is expected to help BBSC to manage its risk associated with landslide impact to people and property.
- There is an opportunity to refine the types of development that trigger a planning application under the EMO to ensure an application requirement is triggered for development that could cause a landslide risk or be at risk from landslide.

- In line with other LGAs in Victoria, there is an opportunity to develop tools (e.g. a landslide inventory) to assist geotechnical specialists to assess landslide risk and to assist statutory planners to assess applications in areas subject to the EMO.
- Tools can also be developed to simplify the assessment that needs to be undertaken by statutory planners in relation to development applications in areas subject to the EMO.

10.0 IMPORTANT INFORMATION RELATING TO THIS REPORT

Your attention is drawn to the document “Important Information Relating to This Report” (LEG04, RL2), which is presented in Appendix A. The statements presented in this document are intended to advise you of what your realistic expectations of this report should be. The document is not intended to reduce the level of responsibility accepted by Golder, but rather to ensure that all parties who may rely on this report are aware of the responsibilities each assumes in so doing.

11.0 REFERENCES

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Signature Page

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https://golderassociates-my.sharepoint.com/personal/dpaul_golder_com/documents/baw baw emo/18105651-001-r-revb.docx

APPENDIX A

Important information relating to this report (LEG04, RL2)

GOLDER

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