



APPENDIX D ARDG RESPONSE TO DPE WATER

Hills of Gold Wind Farm (SSD-9679) Amended Report – ARDG Response to DPE Water Request for Additional Information

Below is a response to the request for further information from DPE Water in relation to potential for the Verden Road Quarry Project to intersect a groundwater aquifer.

1. Existing Environment

1.1 Landform and Topography

The FCNSW Permit Area that covers the Verden Road Quarry Project (the Project Area) is centred on two prominent hills located at the western edge of a large (490 hectare) Tertiary volcanic plateau (**Figure 1**). Older underlying basement rocks of the New England Orogen have been exposed by weathering and erosion in the western part of the Project Area. Both hills are superimposed on a broadly east-west oriented narrow plateau that defines the boundary between the Folly Creek catchment (to the north) and Quackanacka Gully catchment (to the south). Drainage depressions across the Project Area are ephemeral and typically shallow and poorly defined.

Figures 2 – 3 show the location and cross sections of the proposed Western and Eastern Extraction Operation Areas within the broader landscape context, being located on an elevated plateau close to its maximum elevation. The smaller of the two hills is covered by the proposed Western Operations Area and includes an existing Forestry Corporation of NSW (FCNSW) quarry operation that extracts columnar-jointed olivine basalt from the core of a Tertiary-age volcanic vent / plug. The hill has a prominent conical shape that reflects its volcanic origin and is effectively superimposed on the surrounding terrain. The hill covers an area of approximately 6 ha and has elevations ranging from 1,162m AHD at its crest to 1,108m at the base of its eastern flank adjacent to the saddle between the two hills (**Figure 4**). Slopes gradients range from 18° to 34°.

The more prominent of the two hills is located to the east and is covered by the proposed Eastern Operations Area. Based on fieldwork undertaken by ARDG in 2022 (drone survey, surface mapping, rock sampling, lab testing), this hill is also interpreted as the remnants of a Tertiary-age volcanic vent / plug and covers an area of approximately 6 ha. Elevations range from 1,220m AHD at its crest to 1,166m on the north-western flank of the hill, where a break in slope appears to define a geological discontinuity (**Figure 4**). Slope gradients range from 15° to 24°.

1.2 Drainage

The Project Area is located within the Peel River catchment and drains via overland sheet flow (when soils are saturated) to ephemeral drainage depressions on the southern side of the site, which drain to Quackanacka Gully (**Figure 1**), which in turn drains to Burrows Creek and eventually the Peel River, approximately 3 km downstream from Nundle (4.8 km to the west of the Project area). The Peel River flows via Chaffey Dam and Tamworth to the Namoi River, with the confluence being located approximately 8 km downstream of Keepit Dam.

1.3 Geology

Regional mapping by the Geological Survey of NSW (NSW Seamless Geology Database Zone 56) suggests that the surface geology of the eastern half of the Project Area corresponds with an area mapped as Tertiary-age Liverpool Range Volcanics. The basaltic volcanics correspond with higher topographic elevations across the Project Area. In contrast, the geology of the western half of the Project Area is mapped as sandstone, conglomerate and mudstone of the underlying Permian-age Andersons Flat Beds (Manning Group).

Fieldwork undertaken by ARDG in 2022 has resulted in a further refinement of the understanding of the geological environment of the area. The two prominent hills within the Project Area that are associated with the proposed Western and Eastern Operations Areas are characterised by extensive outcrops of columnar-jointed olivine basalt (**Figures 5 – 7**). The basalt outcrops represent the core of high-level volcanic intrusions (plugs) that were emplaced into a volcanic vent environment within the older Andersons Flat Beds. Weathering and erosion have since partially exposed the vent environment.

Quarrying operations by FCNSW adjacent to the eastern edge of the basalt plug in the Western Operations Area have exposed a flanking zone of poorly sorted, boulder to cobble size fragmental basaltic breccias at elevations lower than the adjacent exposed basalt (**Figure 8**). These volcanoclastic breccias exhibit crudely developed bedding features that dip at 30 – 40° in an easterly direction. These rocks represent a talus apron that formed on the Tertiary land surface immediately adjacent to the volcanic vent, within which the basalt was emplaced.

FCNSW operations on the western flank of the hill covered by the proposed Western Operations Area have also exposed highly weathered (clay-altered) basaltic tuffs that contain occasional clasts of pebble-sized basaltic material. The tuffs are likely to have been sourced from the adjacent volcanic vent.

Due to their propensity to weather, sedimentary rocks of the Andersons Flat Beds are poorly exposed across the site.

1.4 Soils

Soil development within areas mapped as Tertiary volcanics varies from shallow skeletal soils in areas of significant columnar jointed basalt outcrop, to heavy clay loams in areas of deeper weathering associated with basaltic breccias and tuffs. Soils associated with the older sedimentary rocks have been highly disturbed and modified as a result of long term FCNSW plantation activities.

2. Groundwater

While deeper drilling is yet to be undertaken (which may or may not confirm the existence and/or precise depth of any groundwater aquifer within the Project Area), examination of the topography of the landscape indicates that if a groundwater aquifer exists, it must occur at some depth below the proposed depth extent of extraction for both the proposed Western and Eastern Operations Areas. Further, given the incised topographic character of the landform surrounding the Project Area, any groundwater gradient is likely to mimic the broader topography and therefore should dip in a westerly direction beneath the east-west trending ridgeline on which each hill is superimposed.

Given that the two broadly circular hills covered by the proposed Western and Eastern Operations Areas are relatively small in area (*i.e.* each approximately 6 ha) and are effectively ‘superimposed’ on the surrounding landscape, the local groundwater aquifer in the vicinity of each hill cannot occur at an elevation higher than the highest elevation point where each hill ‘intersects the surrounding landscape’.

In the case of the proposed Western Operations Area, the highest elevation of the point where the hill ‘intersects the broader surrounding landscape’ is located at the saddle on Verden Road, at the front entrance (east) of the existing quarry (refer **Figure 4** and **Figure 9**). The elevation of the saddle is between 1106 and

1107 mAHD, and logically if a groundwater aquifer exists, it must occur below that depth. The proposed maximum depth of extraction in the Western Operations Area is 1108 mAHD.

In the case of the proposed Eastern Operations Area, the highest elevation of the point where that hill 'intersects the surrounding landscape' is located at the saddle on Blackberry Road (north-eastern side of hill). The elevation of the saddle is between 1172 and 1173 mAHD, and logically if a groundwater aquifer exists, it must occur below that depth. The proposed maximum depth of extraction in the Eastern Operations Area is 1174m AHD (refer **Figure 4** and **Figure 10**).

FCNSW quarrying activities at the existing quarry pit (proposed Western Operations Area) strongly support the above assessment / interpretation based on the following:

- Prior to commencing quarrying operations, FCNSW undertook a drilling program comprising 20 percussion holes within the basalt resource, each to approximately 20 m depth. Drilling across the site extended to depths of between 1140 – 1088 mAHD (*i.e.* up to 20 m below the current floor level and proposed maximum depth of quarrying of 1108 mAHD), with eight (8) of the holes drilled below this level. No groundwater was recorded in any of the drill holes.
- FCNSW has operated the existing Verden Road Quarry since early 2020 and has extracted the eastern flank of the hill from the peak down to the level of the current processing area (*i.e.* maximum extraction level proposed by ARDG of 1108 mAHD) (refer **Figure 4** and **Figure 9**). FCNSW has advised ARDG that quarrying to date has not encountered any groundwater seepage from the faces of the extraction area or intersected any groundwater in the existing quarry operation. The absence of any groundwater is particularly relevant in the context of an extremely wetter than usual 'La Nina' climatic environment over the last three years.
- No seepage points are evident on either hill above or below the proposed elevation of maximum extraction depth at each site.
- Examination of the Eastern Operations Area also supports the aforementioned assessment / interpretation, with no seepage points observed around the flank of the hill above the proposed maximum depth of extraction. Further, FCNSW has cut an access track around the eastern side of this hill (refer **Figure 4**) which extends below the proposed maximum extraction level, with no seepage or groundwater encountered.

3. Potential Interaction with Groundwater

In the case of the proposed Western Operations Area, it is proposed to extract to a level no deeper than the existing level (1108 mAHD) of the FCNSW processing area (refer **Figure 4** and **Figure 9**). Extraction depth in the Eastern Operations Area is proposed to a similar relative level (refer **Figure 4** and **Figure 10**).

Relative to the surrounding landscape, both sites represent small volcanic plugs that sit above the surrounding underlying Permian-age Andersons Flat Beds. As such, it would not be expected to encounter a groundwater aquifer in these relatively small, elevated volcanic environments.

Based on the logic and observations outlined in **Section 2**, the shallow extent of proposed quarry extraction within the Project Area is not expected to intersect any groundwater aquifer, which if present, must be located at a depth below the level of proposed extraction in the proposed Western and Eastern Operations Areas (refer **Figure 4** and **Figures 9 – 10**).

With respect to the impact of resource extraction on recharge of any underlying groundwater aquifer that may be present, the very small size of each of the two hills, their steep slopes and geological character,

prevents them from being able to hold any significant groundwater and therefore contribute in a significant way to aquifer recharge.

4. Conclusion

Given that proposed extraction activities within the confined extraction footprints will not extend to depth below the base of each hill, which as discussed is superimposed on the surrounding landscape, proposed extraction activities are predicted to not intersect any groundwater aquifer in these areas. As discussed previously, historical FCNSW quarrying operations have not intersected any groundwater to date.

Consequently, impacts on groundwater are therefore considered unlikely during construction and extraction operations and no groundwater interactions or adverse impacts are predicted as a result of the Project.

Notwithstanding, a drilling program will be undertaken prior to construction to define the extent and geotechnical properties of the rock to depth. In the unlikely event that any water is encountered during the drilling program (that is not incidental pore / rock fracture water), standing water levels (if present) would be recorded and further investigated to ensure that there is no interaction between quarry operations and this water. Any information collected would be collated and advice provided to DPE Water.

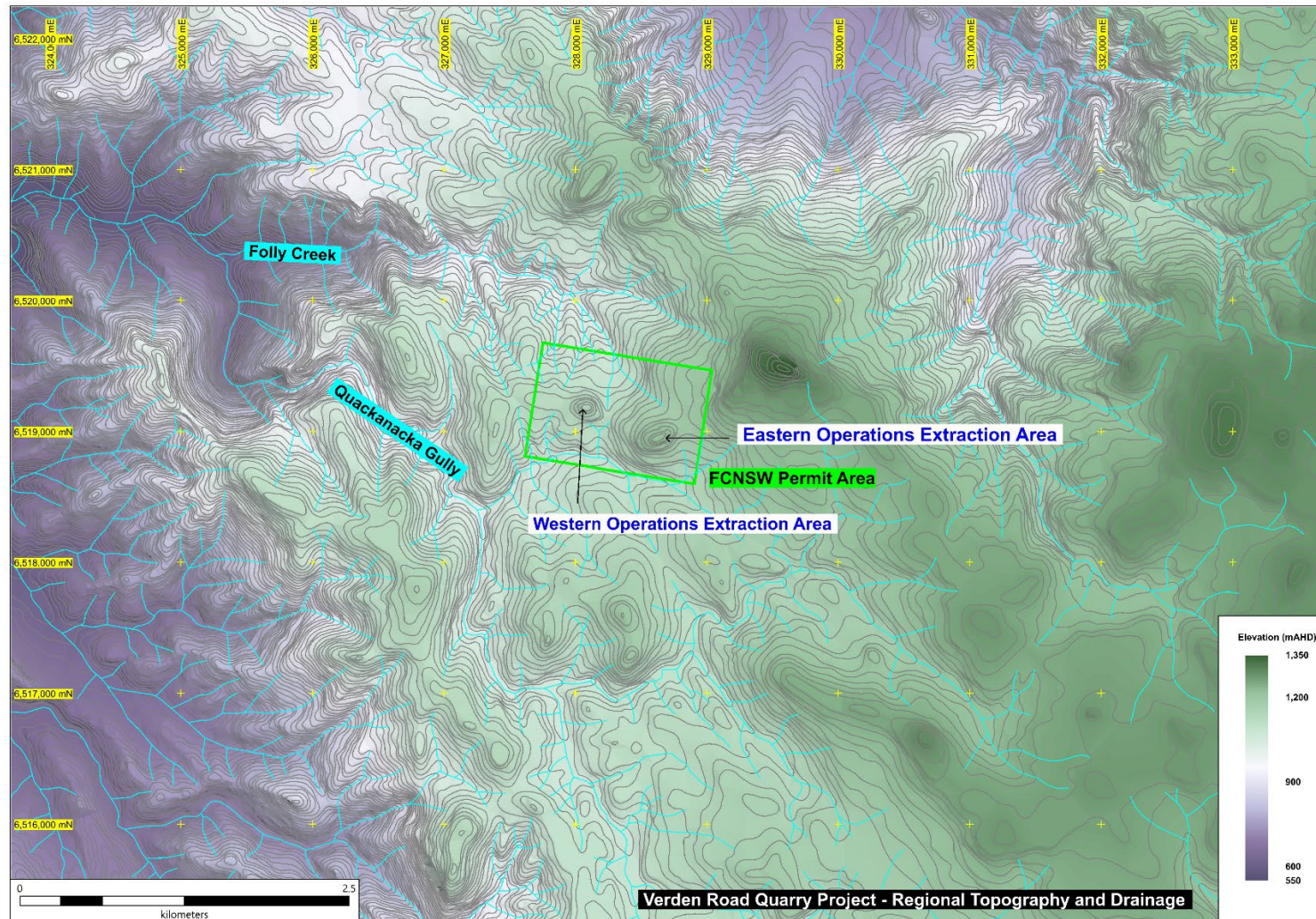


Figure 1 – Verden Road Quarry Project Area and Regional Topography and Drainage showing the location of proposed Western and Eastern Operations Extraction Areas

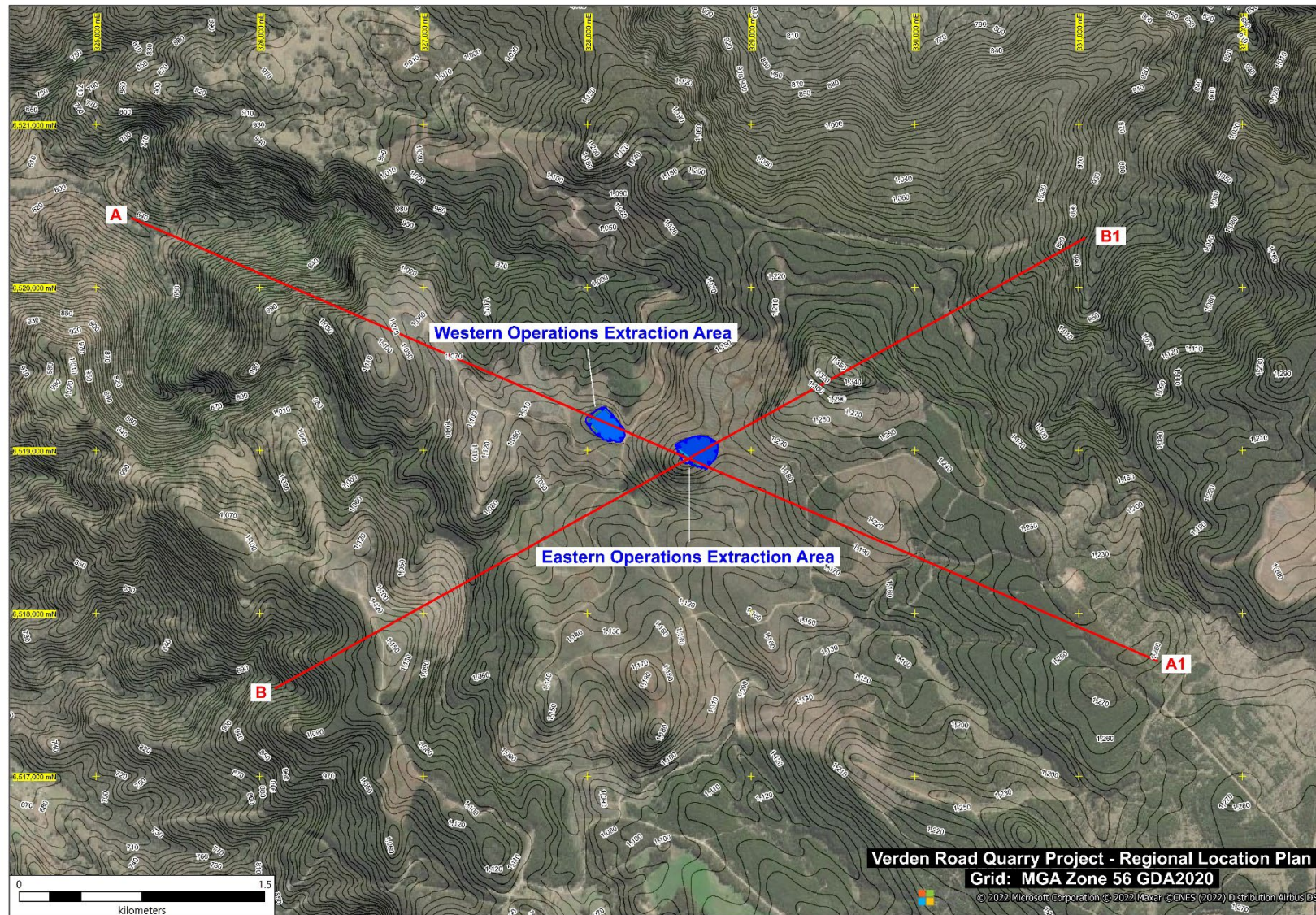


Figure 2 – Western and Eastern Operations Extraction Areas regional overview and cross sections orientation

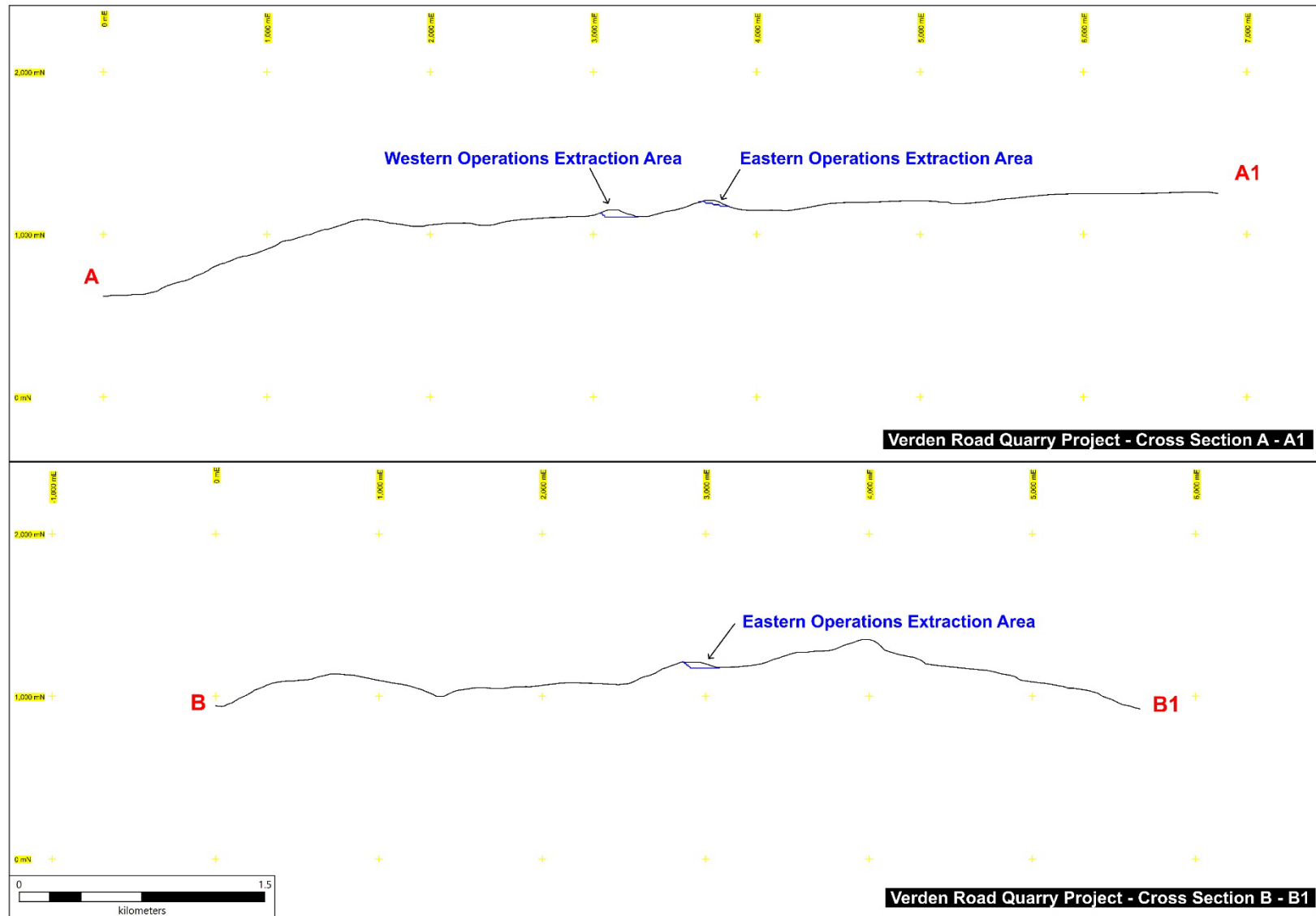


Figure 3 – Western and Eastern Operations Extraction Areas regional cross sections

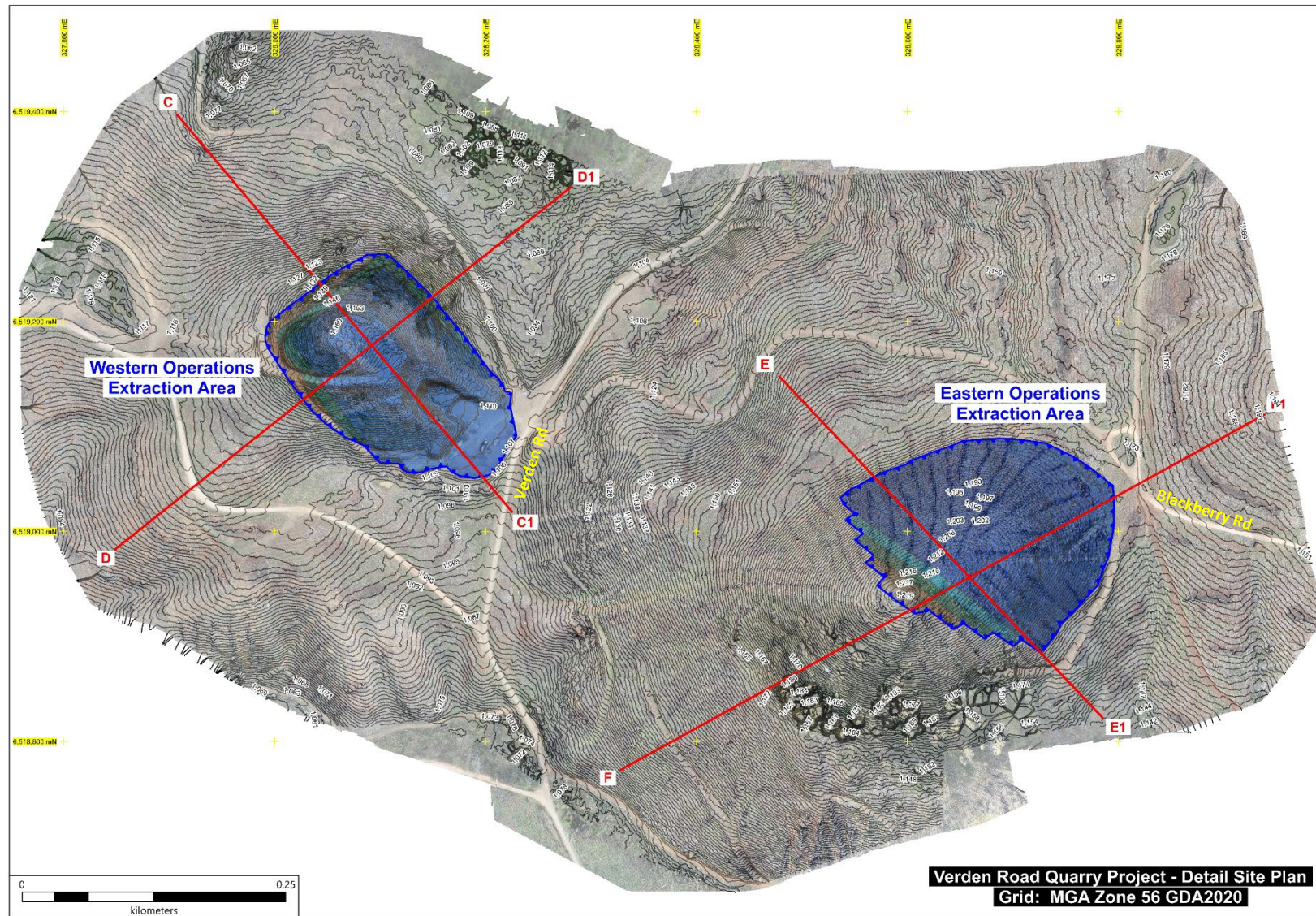


Figure 4 – Western and Eastern Operations Extraction Areas local topography overview and cross sections orientation



Figure 5 – Oblique aerial view looking north of existing FCNSW quarry operation within proposed Western Operations Area. Note extensive outcrop exposure of columnar-jointed basalt within centre of hill. (GR:327,945 mE 6,519,060 mN – looking N)



Figure 6 – Outcrop exposure on crest of proposed Western Operations Area, looking east towards hill covered by proposed Eastern Operations Area. Note existing FCNSW quarry processing area in mid-ground. (GR:328,114 mE 6,519,152 mN – looking E)



Figure 7 – Outcrop exposure of columnar jointed olivine basalt below crest of hill within proposed Western Operations area (GR:328086m E 6519148m N – looking NW)



Figure 8 – Outcrop exposure of crudely bedded basaltic breccia on the eastern side of the hill within Western Operations area (GR:328181m E 6519127m N – looking N)

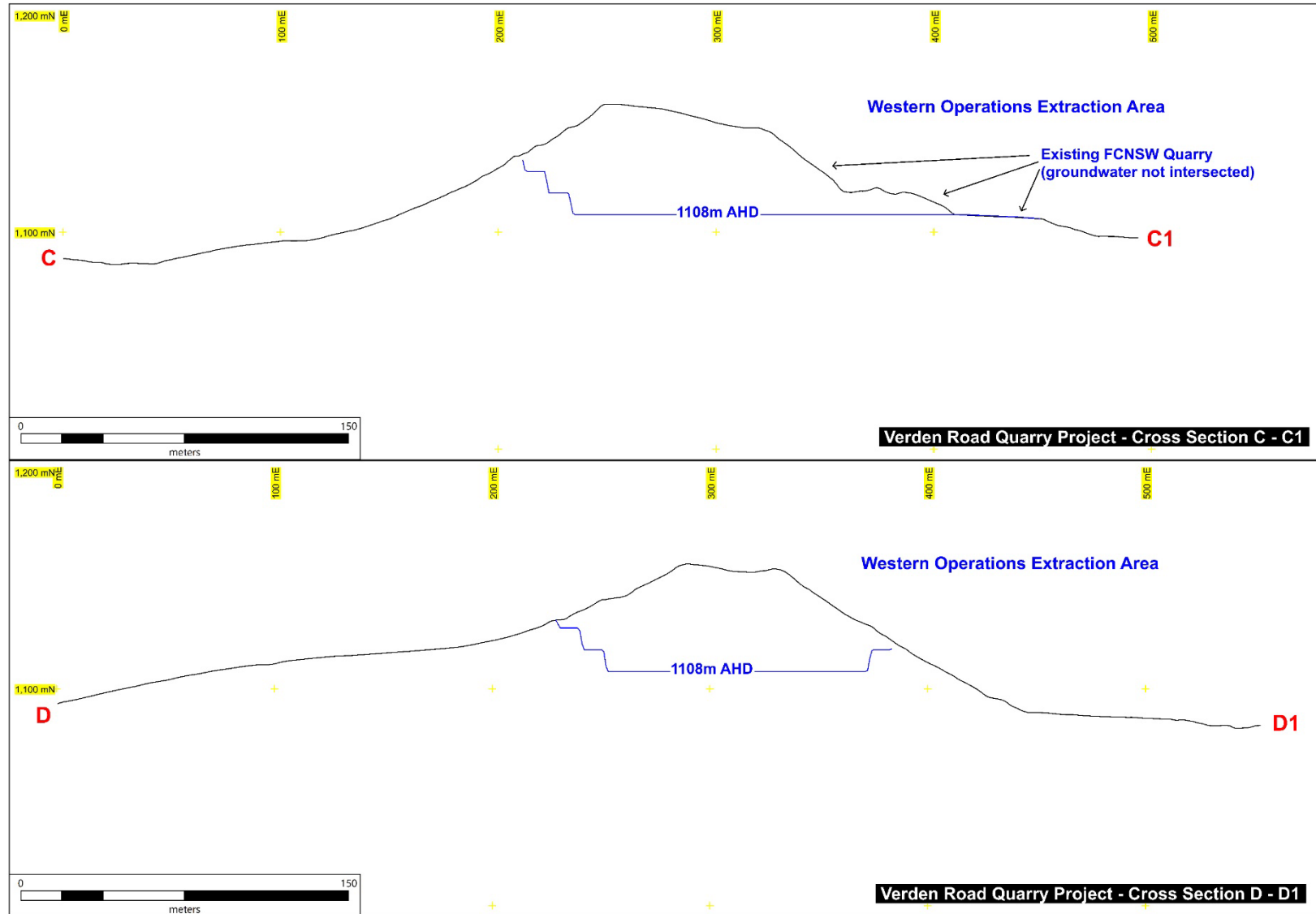


Figure 9 – Western Operations Extraction Area cross-sectional view (refer Figure 4 for cross-section reference). Proposed extraction depth shown is above the basal level of the hill / basalt. Note the existing extraction operation profile shown in Section C – C1

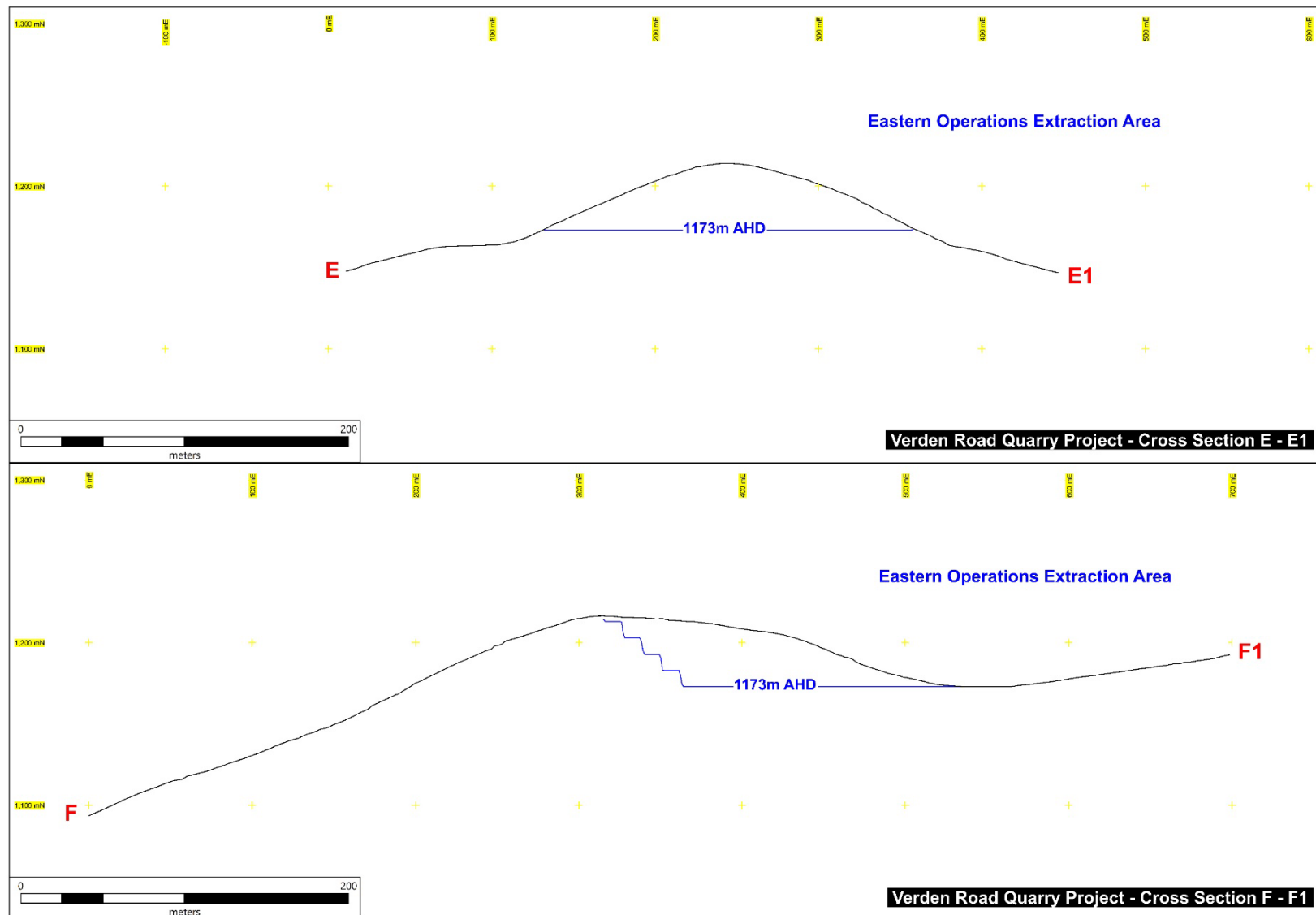


Figure 10 –Eastern Operations Extraction Areas cross-sectional view (refer Figure 4 for cross-section reference). Proposed extraction depth shown is above the basal level of the hill / basalt