

Appendix A.5.3.2

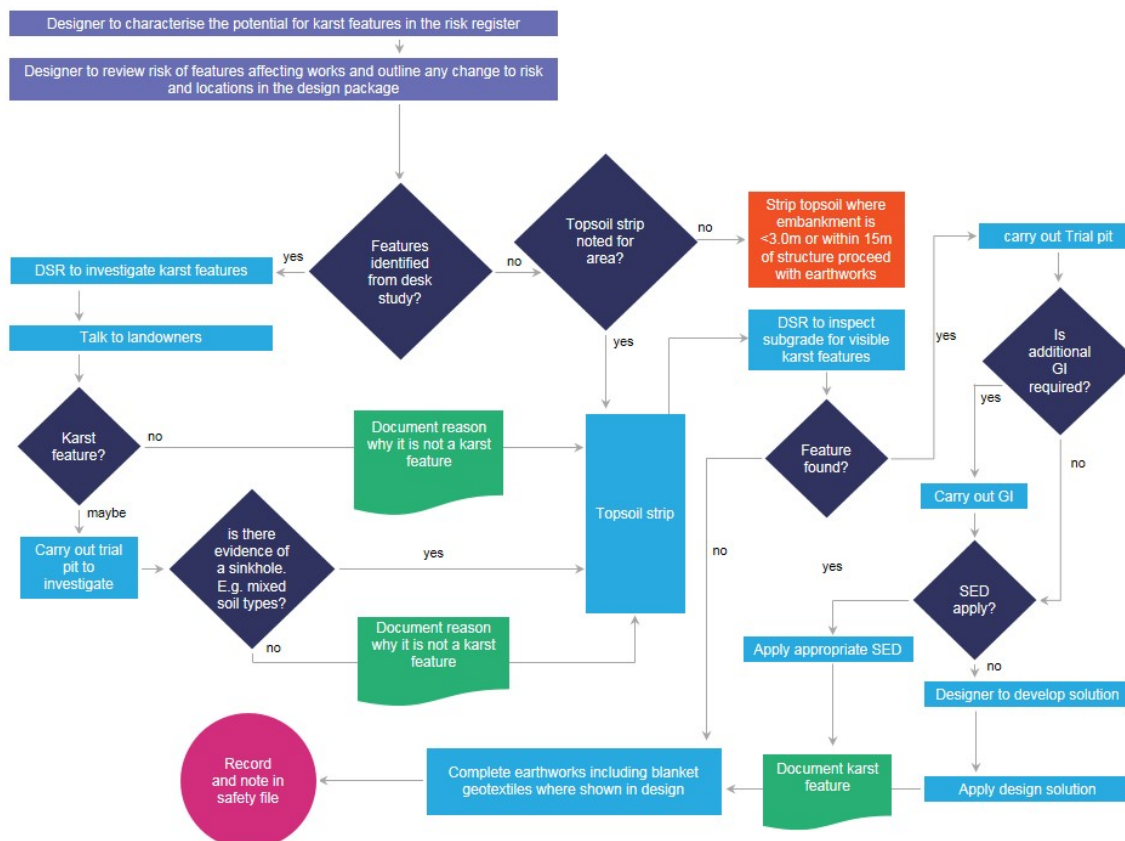
Karst Protocol

1 General

The eastern section of the proposed road development is underlain by Limestone where there is some risk of karst subsidence (i.e. rock or superficial soils collapsing leaving a surface depression or voided, weak ground). The unpredictable nature of karst subsidence should be recognised in the course of the construction works. Where karst features are encountered or suspected, care shall be taken to avoid disturbing them and they shall be brought to the attention of the Geotechnical Designer as soon as possible. These features represent a hazard to construction operations and may represent a hazard to the performance of the proposed road development. They also represent potential point inputs where runoff from the site could enter the aquifer impacting on groundwater and downstream surface water receptors. Based on desk studies and the available ground investigation data, it is anticipated that karst features will be encountered along the proposed road development. All known karst features are presented in the Chapter 9 Soils and Geology of the EIA Report and are discussed in terms of flow paths and groundwater bodies in the Chapter 10 Hydrogeology of the EIA Report. A protocol for the karst inspection is shown on Figure 1.

A hydrogeologist and geotechnical expert will be appointed, as per the Schedule of Commitments, for the construction phase by the contractor.

Figure 1: Flowchart for the karst inspection protocol¹



¹ **Terminology:** SED – Standard Earthwork Detail; GI – Ground Investigation. Where SEDs are indicated, these refer to details/drawings which shall be developed at the detailed design stage of the proposed road development.

2 Formation inspection

In all cases the formation level is to be checked by the Designer for any local soft / weak or loose areas. The Designer is to be notified if any soft / weak or loose areas are identified.

Due to karst risks the following investigations shall be carried out:

- Formations for embankments or cuttings to be proof rolled and observed for signs of weakness
- Formations for structure foundations to be proof rolled as above. The excavation shall be extended to rock head in areas where possible

Prior to detailed design, or early in the detailed design stage, all karst features identified within the proposed development boundary shall be investigated in accordance with **Figure 1**. The results shall be documented for each feature. Where karstic features are encountered they shall be investigated by determining their surface extent and by excavating a trial pit. The Designer shall consider if additional ground investigation, geological or hydrogeological assessment is required. The Designer shall direct the Contractor on which Standard Earthwork Detail (SED) shall be employed (if applicable). Where the feature is more extensive than shown on the SEDs, the Designer shall design the remediation measures.

Each karstic feature and the remediation measures shall be documented and included in the Safety File for the operational phase of the proposed road development.

Weaknesses identified shall be investigated by probing or further rolling as appropriate to be agreed between the Designer and the Contractor. The Designer shall request additional ground investigation such as geophysics, rotary boreholes or other intrusive methods to be agreed on site.

Where karst features are identified, the details as shown on the SEDs shall be used as instructed by the Designer. The minimum design sinkhole diameter will be based on the size of the original void.

3 Remedial works to karst features beneath earthworks

All loose, soft, weak or voided soil material encountered within the karst feature shall be removed to a minimum depth as determined in the detailed design. The slopes of the excavation shall be battered to ensure stability during the works. The extent of the excavation shall be into suitable strata as agreed with the Designer. The extent of the base of the excavation shall be in accordance with the SEDs.

The base of the excavation shall be assessed to demonstrate that it is safe to support construction plant, and where this assessment reveals loose / weak ground then a base of Boulders Cobbles / Chunk Rock / Cement Slurry shall be tipped into the subsidence sinkhole as per the SEDs to form a competent, safe foundation. The remainder of the excavation shall be backfilled as per the SED with successive layers from the base upwards of coarse sand and gravel, coarse sand, fine sand and general fill to formation level. Use of cement slurry or grout will require approval from a qualified hydrogeologist to ensure that the slurry will not impact on groundwater pathways, groundwater quality or downstream surface water receptors.

A high strength geotextile shall be placed over the backfilled subsidence sinkhole. The general layout of high strength geotextiles shall be provided in the SEDs. The geotextile reinforcement shall have a 120 year design life. The detailed layout of the geotextile at each location to span the void sizes identified and confirmed on site, shall be decided by the Designer.

When a karst feature is encountered during excavation, it will be examined by the hydrogeologist who will provide guidance regarding the requirement for the feature to be sealed to prevent runoff draining into the remediated karst feature. In many situations the construction of the carriageway will provide the seal preventing runoff from entering the feature but in others geotextile liner or a cement seal shall be used as a preventative measure to stop subsidence occurring for re-activation. If karst is encountered during excavations for structures such as bridge piers or tunnel excavations then these features shall be dealt with using the karst plan and may also require sealing to prevent cement grout from entering the aquifer and impacting on groundwater flow paths but also groundwater quality. In the case of excavation any geotextiles used shall provide a good seal on the backfilled karst feature and prevent cement grout entering the aquifer.

Inspections of formations in rock shall include for identification of open joints and fissures that may be related to karst features.

Any exposed joints (fracture which shows little to no displacement normal to their surface) or fissures (long narrow opening or crack) less than 50mm width shall be inspected by probing or by other means as agreed with the Designer. Where it is identified that the fissure is not extensive and does not widen below formation level the fissure shall be bridged over by providing a layer of high strength geotextile reinforcement. The extent of geotextile reinforcement on either side of fissure shall not be less than 3m.

If the fissure is shown to widen below ground or in cases where the joints or fissures are greater than 50mm width at formation level, excavation shall be carried out to inspect the extent of fissuring below formation level. Treatment of the area shall be carried out as agreed with the Designer. The agreed treatment is expected to comprise backfilling of the excavation and bridging over using geotextile reinforcement in line with the proposals set out on the SEDs.

4 Remedial works to karst features in cutting slopes

Inspections of cutting slopes in rock shall be carried out to identify open fissures or cavities. Treatment shall be in accordance with the SEDs, or as otherwise agreed with the Designer.

5 Remedial works to karst features below structures foundations

A bespoke karst treatments system shall be designed by the Designer for all karst features identified below structure foundations. Use of cement slurry or grout will require approval from a qualified hydrogeologist to ensure that the slurry will not impact on groundwater pathways, groundwater quality or downstream surface water receptors.