

9. Concepts for remedial engineering works

The conceptual remedial options presented have been prepared primarily for discussion and assessment and final detailed options will depend on the direction chosen by DSE. Should DSE select a protection strategy then an assessment regarding the amount of cliff top land to be kept and how much land is willing to be given over to the solution will be required. The following three remedial engineering works options have been considered to date:

- Option 1: Anchored bored pile wall at pinch point and cliff battered back
- Option 2: Anchored bored pile wall at pinch point and rockfill toe buttress
- Option 3: Soil nailing and shotcrete facing

The options presented herein are concepts only and are provided for consideration by DSE and possibly other stakeholders. Any evaluation and assessment of these options should be in accordance with DSE's (and other stakeholder's) own policies on risk acceptance and overall risk management strategies.

Final detailed design work and documentation would be required to complete any remedial solution once a particular option has been selected. All options involve realignment of the stairs to the beach.

9.1 Option 1: Anchored bored pile wall and excavated batter

Concept sketches for the anchored bored pile and excavated batter option are provided in Appendix AA. The plan view indicates the extent of remedial works which are likely to be required for this option:

- Anchored bored pile wall to provide a near vertical retention system for the pinch point at the entrance to Clifton Court,
- Excavation of the already failed landslip at the end of Wade Street to safe batter slopes, and
- Additional excavations to safe batter slopes for the cliffs adjacent to Anderson Point where imminent failure of the cliff is likely

The main advantage of this option is that the existing access conditions to Clifton Court from Wade Street are likely to be maintained.

Anchored Bored Pile Wall

We have preliminarily assessed that in order to maintain the existing access conditions to Clifton Court the following engineering elements are likely to be required:

- Wall approximately 15 m long as assessed along the top of the cliff
- Approximately 17, 900 mm diameter bored piles required
- Approximately 16, 20 m long anchors required

Excavated batters

PB has assessed locally that 35 degree slopes appear to be reasonably stable batter angles in the upper Portland cliff sections comprising extremely to highly weathered basalt. Batter excavations, to provide an engineered slope at and in the vicinity of the Wade Street

landslip, are therefore proposed to be 1V:2H (i.e. approximately 30 degrees). All engineered slopes would include placement of geofabric material followed by hydroseeding.

The plan view in Appendix AA indicates that the proposed excavation works are likely to extend approximately 70m as estimated along the top of the cliffs. In addition, approximately 30m of land would be lost behind the top of the existing Wade Street cliff face if this option was adopted. As a result, the car park as it exists at the end of Wade Street would most likely be lost.

We also understand that funding has been approved to relocate the cable tram tracks to near the existing water tower. The proposed excavations as part of this option therefore are not likely to interfere with the proposed re-alignment of the tram tracks.

9.2 Option 2: Anchored bored pile wall and rockfill buttress

Concept sketches for the anchored bored pile and rockfill toe buttress option are provided in Appendix AB. The plan view indicates the extent of remedial works which are likely to be required for this option:

- Anchored bored pile wall to provide a near vertical retention system at the entrance to Clifton Court (see Option 1 earlier),
- Minor excavations in the Newer Volcanics and Maretimo Clays in order to prepare the cliff faces (failed and unfailed) for rockfill placement, and
- Placement of the rockfill toe buttress

If adopted, the preliminary assessment of Option 2 suggests that the existing carpark at the end of Wade Street would most likely be unaffected.

Anchored Bored Pile Wall

Option 1 provides a summary of the key aspects in relation to the proposed anchored bored pile wall remedial option.

Excavations

Minor excavations in the Newer Volcanics and Maretimo Clays would most likely be required to prepare the slope for placement of the rockfill toe buttress. In particular:

- Excavations in the Newer Volcanics would be required to provide key-in between the rockfill and the failed/unfailed exposed cliff face
- Excavations in the Maretimo Clays would be required to expose the top of limestone, thereby, allowing placement of rockfill on a solid foundation.

Rockfill Toe Buttress

The rockfill toe buttress as it is proposed would provide additional stabilisation to approximately the upper two thirds of the cliffs which have failed in the project study area. The proposed rockfill batter slope would most likely be finished to a grade of approximately 1V:1.5H.

In addition, the toe buttress should employ a durable rock source preferably of igneous origin. Argillaceous rocks which are subject to breakdown to finer components should not be selected.

In addition, the size and shape of rock would need to be assessed during detailed design.

9.3 Option 3: Soil nailing and shotcrete facing

Concept sketches for the soil nailing and shotcrete facing option are provided In Appendix AC. The plan view indicates that the extent of remedial works required includes not only the already failed landslip at the end of Wade Street but also treatment to the cliffs threatened by imminent failure near Anderson Point.

If adopted, this option is expected to encroach on the Wade Street car park to a limited extent.

Wade Street landslip section

- In order to retain the existing headscarp a soil nail wall option could be adopted over a distance of approximately 35 m, as assessed along the top of the cliff. The exposed cliff face for soil nailing would be approximately 20 m long, requiring approximately 8 rows of nails.
- At the location of the Wade Street landslip the preferred construction methodology would be to drill the first four rows of soil nails from above (i.e. street level) with a longreach excavator and remote controlled drill mast. The benefit of this approach would be to add some stability back into the failed slope
- Once the top four rows of soil nails have been secured and providing an excavator can create a stable platform the remaining four rows could be drilled from near the base of the vertical cliff face. These four rows would then be drilled using a top-down approach and any loose material would be scaled from the cliff face prior to commencing drilling works.

Unfailed northern cliff section near Anderson Point

- In order to treat the adjacent unfailed cliff section initial excavations are recommended. As assessed from the top of the cliffs, the excavations would need to extend for approximately 40 m. An exposed cliff face approximately 32 m long would later require soil nailing with approximately 12 rows of nails required.
- The excavation and soil nailing methodology would need to be assessed with a specialist geotechnical contractor during detailed design to assess the effects of any interaction with treatments that would also be required for the failed Wade Street cliff face. It is likely, however, that a staged top-down construction methodology would be required.

Additional information

A summary of additional key aspects for the soil nail wall option as based on our preliminary assessment are included below:

- Top-down construction method is likely to be required to stabilise vertical cliff face/s
- Soil nails are likely to be spaced at approximately 2.5 m centres and 8 m long
- Installation of strip drains along the exposed cliff face would be required
- Installation of high tensile mesh and shotcrete facing will most likely be required for localised stability between nails with a standard geogrid beneath to encourage natural vegetation
- A footing for the mesh and shotcrete facing would be required