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MACRAES GOLD PROJECT
CORONATION NORTH WASTE ROCK STACK
DESIGN REPORT

Prepared for: 29 April 2016

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1.0 INTRODUCTION

Oceana Gold (New Zealand) Limited (OceanaGold) operates a gold mine at Macraes Flat, East Otago, known as the Macraes Gold Project (MGP). The location of the MGP is shown in Figure 1. Gold extraction from the current mining operation involves mining of open pits and underground (Frasers Underground). Associated with the MGP are waste rock stacks (WRS) for disposal of pit overburden material and tailings storage facilities for disposal of tailings.

The MGP was extended in 2015 with the commencement of the Coronation Project, comprising the Coronation Pit, Coronation WRS and haul road to the current MGP mining operation. The Coronation Project is located on the ridgeline to the north of Deepdell Creek and Horse Flat Road, as shown in Figure 2.

OceanaGold propose an extension to the existing Coronation Project, referred to as the Coronation North Project. The extension comprises:

- A western extension of Coronation Pit to increase the potential ore from about 5Mt to 8.5Mt.
- Development of the new Coronation North Pit to the north of the currently consented Coronation WRS. The new pit is estimated to contain about 9Mt of ore.
- Development of the new Coronation North WRS (CNWRS) to the east and north east of the current Coronation Project including approximately 270Mt of waste rock and covering an area of about 230Ha. The new WRS is capable of containing all the waste rock excavated from the eastern extension to Coronation Pit and Coronation North Pit.
- The existing haul road to the MGP will be extended northwards across the currently consented Coronation WRS and then between the proposed Coronation North Pit and WRS.

This report summarises the design of CNWRS.

All plans grids, references and geological orientations referred to in this report are to mine north, which is approximately 45 degrees anti-clockwise from true north.

2.0 RESOURCE CONSENTS

Consents held for the existing Coronation WRS are listed in Table 2.1 below, and copies are included in the Coronation Waste Rock Stack Operations and Management Plan (Ref.1). It is anticipated that similar consent conditions will apply to the proposed CNWRS and the design has been carried out on this basis.

Table 2.1: Consent Conditions for Existing Coronation WRS

Consent	Description
Land Use Consent - 201.2013.360 and LUC-2013-225	Land Use Consent for Coronation gold mining operations
Water Permit - RM12.378.01	To permanently divert water around the Coronation Waste Rock Stack and into unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek the for the purpose of preventing surface water ingress and managing stormwater runoff
Discharge Permit - RM12.378.02	To discharge silt and sediment to water for the purpose of constructing the Coronation Waste Rock Stack
Discharge Permit - RM12.378.03	To discharge waste rock and contaminants from waste rock to land, or into land in circumstances which may result in contaminants entering water, for the purpose of constructing the Coronation Waste Rock Stack
Discharge Permit - RM12.378.04	To discharge contaminants to water from the base and toe of the Coronation Waste Rock Stack for the purpose of waste rock disposal
Discharge Permit - RM12.378.05	To discharge water and contaminants from silt ponds to unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of operating silt ponds associated with the Coronation Pit and the Coronation Waste Rock Stack and for the purpose of disposing of water from the dewatering of Coronation Pit
Land Use Consent - RM12.378.06	To disturb, deposit onto or into and reclaim the bed of the unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of constructing the Coronation Waste Rock Stack
Water Permit - RM12.378.07	To take groundwater for the purpose of dewatering Coronation Pit and use for the purpose of dust suppression
Discharge Permit - RM12.378.08	To discharge waste rock to land in Coronation Pit for the purpose of disposing of waste rock

Water Permit - RM12.378.09	To permanently divert water around Coronation Pit and into unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek for the purpose of preventing surface water ingress and managing surface water runoff
Water Permit - RM12.378.10	To take surface water for the purpose of dewatering Coronation Pit and use for the purpose of dust suppression
Water Permit - RM12.378.11	To take groundwater for the purpose of creating the Coronation Pit Lake
Water Permit - RM12.378.12	To take surface water for the purpose of creating the Coronation Pit Lake
Discharge Permit - RM12.378.13	To discharge water containing contaminants from the Coronation Pit Lake to unnamed tributaries of Maori Hen Creek, Trimbells Gully and the Mare Burn for the purpose of operation of the Coronation Pit Lake
Water Permit - RM12.378.14	To dam water in Coronation Pit for the purpose of creating the Coronation Pit Lake
Discharge Permit - RM12.378 .15	To discharge contaminants from mining operations and post mining rehabilitation to air for the purpose of undertaking mining operations

Condition 5 of resource consent RM12.378.03 and condition 11.2 land use consent 201.2013.360 and LUC-2013-225 requires the consent holder to engage a suitably qualified geotechnical engineer to design the waste rock stack and submit a Construction Issue Design Report prior to the construction of the new rock stack.

- *Condition 5, Discharge Permit RM12.378.03;*
  The consent holder shall engage a suitably qualified geotechnical engineer to design the waste rock stack. A Construction Issue Design Report shall be prepared for the waste rock stack and this report provided to the Consent Authority prior to the construction of the new rock stack. The long term stability and performance of the waste rock stack following mine closure shall be specifically covered by the design report. Placement of material in the waste rock stack shall be in accordance with the waste rock stack Construction Issue Design Report.

- *Condition 11.2, Land Use Consent 201.2013.360 and LUC-2013-225*
  The consent holder shall engage a suitably qualified geotechnical engineer to design the waste rock stack. A construction report shall be prepared for the waste rock stack and this report provided to the Councils prior to the commencement of construction of the waste rock stack. The report shall include details of site formation, design construction, appearance, and testing for stability of the waste rock stack, and shall include evaluation of the long-term stability and performance of the waste rock stack.

Condition 3 of resource consent RM12.378.06 relates to the requirement to construct underdrains in the watercourses that underlie the waste rock stack.

- *Condition 3.*
  Underdrains shall be constructed in the natural channels that form the unnamed tributaries of Maori Hen Creek, Trimbells Gully, Mare Burn and Camp Creek beneath the footprint of the Coronation Waste Rock Stack by placement of large rocks covered by appropriately graded material to provide sufficient filtering to prevent blockage of the drains by finer materials.

Condition 11.1 of land use consent 201.2013.360 and LUC-2013-225 relates to the seismic requirements for the waste rock stack and is addressed within this report.

- *Condition 11.1*
  The Coronation Waste Rock Stack shall be designed for operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (MDE) with a recurrence interval of 2,500 years and otherwise shall otherwise be designed in accordance with sound engineering practice.

3.0 DESCRIPTION OF WASTE ROCK STACK

The Coronation Project is located on the ridge line between Sister Peaks and Highlay Hill, north of Horse Flat Road, as shown in Figures 2 and 3. .

The footprint area of the CNWRS is about 230ha. It has the capacity to store 130Mm^3 of waste rock which equates to 270Mt (with an assumed average density of rock fill of 2.1t/m^3).

The batter slopes of the CNWRS have been designed to blend as naturally as possible with the natural landscape. The maximum height of the waste rock within the CNWRS is about 130m and the outer shoulders have an overall slope of about 1(v):3(h). The CNWRS is shown in Figure 3 with the underlying topography.

4.0 TOPOGRAPHY AND SURFACE DRAINAGE

The topography in the Macraes area is dominated by a gently undulating remnant schist peneplain. Regional drainage patterns are dominated by east and north striking fault orientations and strike ridges of the east dipping foliation, with streams often extended along faults, joint sets, or more erodible lithological units.

The CNWRS is located north of the catchment divide between the Shag Catchment to the south and the Taieri Catchment to the north (i.e. within the Taieri catchment as shown in Figure 2). The ground falls to the north and north east with overland flow to Maori Hen Creek and Trimbells Gully via a series of tributary creeks as shown in Figures 2 and 3. The ground slopes typically vary between about 1(v):8(h) to 1(v):40(h), except in the creeks where the slopes are locally steeper.

5.0 GEOLOGY AND GEOTECHNICAL INVESTIGATION

5.1. Regional Geology

The basement rock in Central and East Otago comprises Otago schist. The Otago schist is primarily composed of psammitic and pelitic grey schist derived from metamorphism of Mesozoic age sandstone and mudstone. In the area of Macraes Flat, the rocks have been metamorphosed to green schist metamorphic facies, giving a strongly foliated fabric of dark grey micaceous and light grey quartz-rich laminations.

From previous geotechnical investigations for the MGP it is apparent that the prominent geological structure includes a well developed schistosity with two dominant fault sets. West of the Footwall Fault, that defines the Footwall of the Hyde – Macraes Shear Zone (HMSZ), the schistosity is folded and has a varying trend over the project area revealing a series of anticlines and synclines. Foliation dips either to the northwest, north, west or south west. East of the Footwall Fault (Hangingwall) the schistosity has more of an easterly trend. At Coronation the Footwall Fault position is inferred as a subtle feature on the landscape. Unlike Frasers and Round Hill to the south, where gold mineralisation extends vertically for 100m to 120m below the Hangingwall Shear to the Footwall Fault, at Coronation the gold mineralisation is restricted to a 10m thick Hangingwall Shear that is underlain by 90 to 100m of unmineralised foliated schist. The CNWRS is located to the east of the proposed Coronation North Pit and overlies the northern inferred extension of both the Footwall Fault and the Hangingwall Shear.

The major set of faults has an eastern trend. They exhibit Miocene (recent tectonic) deformations and are related to formation of the Alpine Fault. This deformation has faulted and folded the surface within Central and East Otago to produce the present-day basin and range topography.

The second set of faults has a northern trend, and the most significant of these is the Hyde-Macraes Shear Zone.

The Hyde–Macraes Shear Zone (HMSZ) comprises a mineralised shear zone which has been mapped for at least 25km by OGL geologists. The HMSZ represents the principal gold bearing ore body exploited by OceanaGold and generally strikes north and dips at about 15° to the east. Tectonic displacement associated with the HMSZ is inferred to be in the order of hundreds of metres, with this movement initiating some 120 to 150 million years ago. The ore-schist zone of the HMSZ consists of predominantly pelite and semipelite, but includes blocks of psammite, typically well foliated and containing mineralised quartz veins.

5.2. Geotechnical Investigation

Geotechnical investigation for the CNWRS comprised field mapping of the site. Reference has also been made to the borehole investigation and mapping carried out for the adjacent Coronation North Pit (Ref.2).

5.2.1. Fieldwork

The fieldwork was carried out 2nd and 3rd of February 2016 and comprised a walkover survey and mapping by a Senior Engineering Geologist. The results of the field mapping are shown in Figure 4.

5.2.2. Soils

The prevalent rock outcrops and head scarps of shallow slips observed on the sides of gullies, show that there is only a thin layer of soil overlying the bedrock.

5.2.3. Schist

The schist observed on site comprises well foliated, highly to moderately jointed semi-psammitic schist.

The foliation is well developed and a recent walk over survey showed the foliation generally dipping between 9° and 20° to the north east on the eastern side of the CNWRS (Figure 4). On the western and northern extents of the CNWRS, the dip of the foliation varies between 4° and 24° towards the north and northeast.

The schist is moderately jointed with joints generally steeply dipping between 60° and 80° to the south and south west or north to northeast (Figure 4).

The above observations are generally consistent with those from the investigation for Coronation North Pit (Ref.2).

No strength testing has been undertaken on schist in the CNWRS area. Elsewhere on the Macraes Gold Project the typical unconfined compressive strength of unweathered schist is between about 20MPa and 40MPa, normal to foliation. Schist typically has a lower unconfined compressive strength along the direction of foliation. This is reflective of the layered nature of the rock and the presence of weak, mica-rich laminations. It is anticipated that the strength of the schist underlying the proposed CNWRS will be consistent with that found elsewhere in the Macraes Gold Project area.

5.2.4. Inferred Areas of Instability

No areas of significant historical or incipient instability were observed on site. Where the creeks dissect the underlying schist bedrock beneath the CNWRS the steepness of the slopes generally vary depending on the local dip of the foliation and discontinuities. Typically the side slopes to the creeks are steeper where the foliation is dipping into the slope (i.e. governed by block failures) and gentler sloping where the foliation is dipping out of the slope (i.e. governed by block sliding on the foliations and the slopes are typically parallel to the dip).

No areas of inferred significant historic shallow slumping/instability were observed within the area of the proposed CNWRS. Very localised shallow slumping/instability is evident along some of the creeks considered to be associated with erosion and undercutting at the toe of the slopes during heavy rainfall and flow within the creeks that cross the CNWRS.

Soil creep was also inferred on some of the steeper slopes. Where localised soil creep was evident, the soil mantle is reasonably thin and can be cleared as part of the foundation stripping.

6.0 DESIGN

6.1. Design Life

The estimated duration of the operation and rehabilitation of the CNWRS is about 5 years (2016 – 2021) and will remain in place forever.

6.2. Stability

6.2.1. General

Engineering Geology Ltd (EGL) has carried out both static and seismic stability analyses of the CNWRS. The analyses do not include the stability of potential shear failures into the existing Coronation Pit and the proposed Coronation North Pit. This has been covered by Pells Sullivan Meynink in their design for the pits (Ref.2). Their analyses conclude that the CNWRS is a sufficient distance from the Coronation North Pit (about 190m) and extension to the Coronation Pit (about 80m) to not represent a significant stability risk.

The stability of the CNWRS has been analysed using the same design approach and parameters as that used for the existing consented Coronation WRS (Ref.3).

Analyses of long-term static stability of the shoulders of the waste rock stack and stability when subjected to design earthquake loads have been undertaken. Limit equilibrium analyses of the slope have been undertaken using the SLOPE/W program, Geostudio 2012 (Ref.4). The Spencer solution method (Ref.5) has been used for the analyses of circular potential failure surfaces. This is considered to be a rigorous limit equilibrium approach. The Janbu simplified method (Ref.6) has been used for the analyses of potential block failure surfaces.

Limit equilibrium analyses have been undertaken to calculate the Factor of Safety (FoS) for static loading conditions and to also determine the yield coefficient (k_y) under seismic loading conditions.

The possibility of failure through foundation soils has been considered. The seismic stability of the CNWRS complies with Condition 11.1 of DCC and WDC Consents (No. 201.2013.360 and LUC-2013-225) for the existing Coronation WRS (Ref.3). This condition requires that "*the waste rock stacks shall be designed for operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (MDE) with a recurrence interval of 2,500 years and otherwise shall be designed in accordance with sound engineering practice*".

Stability analyses have been undertaken for three cross sections through the CNWRS considered to be the most critical in terms of loading, topography and rock foliation/discontinuities. The location of the cross-sections is shown in Figure 4 and the cross section shown in Figure 5.

6.2.2. Waste Rock Characteristics

The waste rock is anticipated to consist of a mixture of psammitic and pelitic schist. It is to be excavated from the existing Coronation Pit and the proposed Coronation North Pit. The schist rock varies from completely to slightly weathered, depending on the relative depth of excavation.

Physical characteristics of the excavated rockfill were assessed during the design phase for the tailings embankments and were based on tests conducted on samples of rockfill, schist and other various rock types used for similar projects.

The waste rock to be placed in the stack will be end-tipped, so it is assumed to be non-structural fill. The waste rock segregates when end-tipped, such that each lift (approximately 10-20m high) varies from coarse rock at the bottom to silty sandy rockfill at the top. Consequently the WRS consists of layers of rockfill of varying permeability. Generally the rockfill could be expected to be free-draining, except at the top of each lift where a thin low permeability layer is created by the trafficking of the dump trucks.

The following shear strength function has been adopted for waste rock which is consistent with that previously used for WRS at MGP and the existing Coronation WRS (Ref.3):

Shear strength (τ) $= 1.29\ \sigma'^{\,0.91}$ (kPa), where σ' is the effective overburden pressure.

The design unit weight used is 21.5kN/m^3.

6.2.3. Foundation Material Characteristics

The *in situ* rock beneath the proposed CNWRS is similar to that beneath the existing Coronation WRS (Ref.3), so the same foundation shear strength parameters have been adopted for design. They are summarised below:

Intact rock

Effective cohesion	=	50 kPa
Effective friction	=	40 degrees

The above shear strength parameters are based on shearing through relatively intact rock at about right angles to the foliation dip. As discussed in Section 5.2.3, the measured foliation dips between about 9° and 24° to the north east on the eastern side of the CNWRS, with a calculated average dip of about 20°. A second set of shear strength parameters has therefore been adopted for the rock where failure could potentially occur along the rock foliation and any minor faults/shear zones dipping to the north east. The shear strength parameters are the same as those adopted in similar circumstances for the stability analysis of the existing Coronation WRS (Ref.3) and given below.

Shear along foliations and minor faults/shear zones

Effective cohesion	=	47 kPa
Effective friction	=	23 degrees

6.2.4. Ground Water Conditions

The stability analyses assume that the natural ground is saturated and the CNWRS is fully drained. The CNWRS is comprised of rockfill and the gullies beneath the CNWRS are infilled with coarse rockfill to ensure good drainage. Some localised perched groundwater may occur on the thin low permeability trafficked layers within the CNWRS (refer Section 6.2.2), but due to the 10 to 20m vertical spacing between these layers is unlikely to significantly affect the overall stability of the CNWRS.

6.2.5. Static Stability

The results of the static stability analyses are presented in Appendix A and summarised in Table 6.1 below. Static stability has been undertaken for two potential failure conditions using circular failure surfaces:

1. Potential failure surface within the CNWRS
2. Potential failure surface passing through both the CNWRS and foundation

Table 6.1. Summary of Static Slope Stability Analyses

Section	Potential Failure Surface	FoS	Fig. No.
A-A’	Critical Failure Surface within CNWRS	2.6	A1
	Failure Surface through the CNWRS and Foundation	2.8	A2
B-B’	Critical Failure Surface within CNWRS	2.5	A3
	Failure Surface through CNWRS and Foundation	2.1	A4
C-C’	Critical Failure Surface of CNWRS	2.4	A5
	Failure Surface through CNWRS and Foundation	2.5	A6

(1). Section B-B’ was analysed with a foliation dip of 20° within the foundation beneath the WRS

The stability analyses including failure through the insitu rock are based on the average measured dip of the foliation (i.e. 20 degrees). A sensitivity analysis has been carried out to check the stability for varying foliation dip. The analyses were undertaken using Section B-B' which has the lowest FoS in Table 6.1. This shows that if the foliation dips at 10° over the whole shear surface through the insitu rock then the FoS reduces from 2.1 to 1.8 (refer Figure A4a). Sensitivity analyses have also been carried out using Section B-B' assuming planar failure surfaces. In this case the calculated FoS for a foliation dip of 20° and 10° is 2.0 and 2.1 respectively, similar to that determined above assuming a circular failure surface (refer Figures 4b and 4c).

On the basis of the above analyses the performance of the CNWRS under static loading is satisfactory, as all the calculated FoS are above 1.5, the minimum value considered acceptable for static stability.

6.2.6. Seismic Stability

Seismic stability analyses of the CNWRS has been undertaken for the following two levels of earthquake shaking;

- Operating Basis Earthquake (OBE) - 150 year return period
- Maximum Design Earthquake (MDE) – 2,500 year return period.

A single section representing the most critical cross section around the external perimeter of the CNWRS (Section B-B') was used for checking the seismic stability.

Peak horizontal ground accelerations attributable to the OBE and MDE were obtained from acceleration response spectra generated by the Institute of Geological and Nuclear Science to assess the seismic hazard for design of the tailings storage embankments at the MGP (Ref.7). The spectra were generated from a model which combines earthquakes associated with the three closest faults to the MGP (Billy's Ridge, Taieri Ridge, and Hyde faults).

The levels of peak ground acceleration used for analysis of the seismic stability of the CNWRS are:

- OBE (150 yr) = 0.13 g
- MDE (2,500 yr) = 0.65 g

The ground motion amplification (ratio of crest acceleration to PGA) relationship given by Harder et al. (Ref.8) has been used to determine the peak motion at the crest of the CNWRS. This method is based on actual measurements of ground motions recorded at the crests of embankments relative to those recorded near the base. Crest accelerations of the CNWRS predicted by this method are 0.43g and 0.91g for the OBE and MDE levels of ground motion respectively. Accelerations will vary throughout the CNWRS and this needs to be accounted for in the stability analyses. The estimated average lateral accelerations for both OBE and MDE levels of earthquake shaking applied to each potential failure surface are given in Table 6.2.

The same rockfill strength as used for static stability ($\tau = 1.29\,\sigma'^{\,0.91}$ kPa) has been adopted for assessing seismic stability, as no strength softening of the waste rock is anticipated during earthquake shaking.

Stability has been assessed for potential failure surfaces located at H, 2/3H and 1/3H below the top of the CNWRS, where H is the full height of the CNWRS. Where yielding is predicted, permanent deformations are estimated using the Makdisi and Seed method (Ref.9). This method allows for the dynamic response of the potential failure sliding mass to be considered. Engineering judgement was used to develop lower and upper estimates using the Makdisi and Seed method, as they do not present results in a probabilistic framework.

The results of the seismic stability analysis are presented in Appendix A and summarised in Table 6.2 on the following page.

Under the OBE loadings, some minor permanent seismic deformations of up to 1cm are estimated (Refer to Table 6.2 and Figures A7 to A9 (Section A-A'), A13 to A15 (Section B-B') and A19-A21 (Section C-C')). The very minor yielding is highly unlikely to have any significant impact on the performance of the CNWRS.

Under the MDE loading some minor permanent seismic deformations of up to a maximum of 22cm are estimated (Refer to Table 6.2 and Figures A10 to A12 (Section A-A'), A16 to A18 (Section B-B') and A22-A24 (Section C-C')). The estimated deformations are minor and are unlikely to have any significant affect on the long term performance of the CNWRS.

Table 6.2. Summary of Seismic Slope Stability

Section	Loading Condition	Failure Surface Location	k_h(1) (g)	k_y(2) (g)	FoS	Estimated Permanent Deformation(3) (cm)	Figure No.
A-A’	OBE	1/3H	0.43	-	1.0	-	A7
	OBE	2/3H	0.28	-	1.3	-	A8
	OBE	H	0.13	-	1.7	-	A9
	MDE	1/3H	0.91	0.43	-	3-18	A10
	MDE	2/3H	0.78	0.40	-	2-10	A11
	MDE	H	0.65	0.38	-	1-3	A12
B-B’	OBE	1/3H	0.43	0.39	-	0-1	A13
	OBE	2/3H	0.28	-	1.3	-	A14
	OBE	H	0.13	-	1.7	-	A15
	MDE	1/3H	0.91	0.39	-	4-22	A16
	MDE	2/3H	0.78	0.40	-	2-10	A17
	MDE	H	0.65	0.32	-	1-7	A18
C-C’	OBE	1/3H	0.43	0.41	-	0-1	A19
	OBE	2/3H	0.28	-	1.2	-	A20
	OBE	H	0.13	-	1.6	-	A21
	MDE	1/3H	0.91	0.41	-	3-20	A22
	MDE	2/3H	0.78	0.37	-	2-12	A23
	MDE	H	0.65	0.37	-	1-3	A24

(1). k_h = average acceleration within the potential failure mass for various return period earthquakes
(2). k_y = yield acceleration within the potential failure mass for a FoS = 1.0, determine using pseudostatic limit equilibrium stability analyses
(3). Simplified permanent deformation estimated using Makdisi and Seed (1978)
(4). Section B-B’ was analysed with a dipping foliation of 20° within the foundation of the WRS for the Full Height Failure Surface

6.3. Surface Drainage

A perimeter drain will be constructed around the toe of the CNWRS to collect stormwater runoff and divert it into the silt ponds as shown in Figure 6. Runoff flows are expected to be quite small because a high proportion of rainfall is expected to infiltrate the rock fill. This is consistent with what has been observed on site for the existing WRS.

Perimeter drains are to be constructed largely by excavating into the natural ground. Some short sections may be located in fill. Drains will be sized to have sufficient capacity to carry the peak runoff from the 10 minute, 5 percent AEP (20 year storm) whilst retaining 0.3m freeboard.

Temporary clean water diversion drains and diversion culvert will be constructed at the early stages of the CNWRS to reduce the catchments contributing to the silt ponds. The concept is shown in Figure 6.

6.4. Subsurface Drainage

Existing ephemeral gullies beneath the CNWRS footprint are to be filled with coarse free draining waste rock material either through high tiphead segregation or direct placement. This will enable subsurface drainage of gullies which are filled downstream by waste rock. Subsurface drainage will ultimately report to the Taieri River to the north.

6.5. Silt Control

Runoff from the CNWRS during construction will be directed to silt ponds located in the gullies immediately downstream as shown in Figure 6 and discussed in the erosion and sediment control report (Ref.10). Temporary silt ponds will also be constructed upstream of the toe silt ponds in the early stages of development of the CNWRS. The CNWRS will be constructed with the working surface sloping down away from the outside shoulder. The runoff will then infiltrate the rockfill and percolate through the coarse fill subsurface drainage system before discharging as seepage downstream of the CNWRS. Experience to date indicates that not much silt is generated during waste rock stack construction due to a combination of the material used and the progressive nature of stripping and rehabilitation as the waste rock stack is constructed. Most of the runoff infiltrates the rockfill and the silt is removed before the seepage emerges from the toe of the rock stack.

6.6. Rehabilitation

The final contoured surface of the CNWRS is to be rehabilitated by spreading 0.3m of weathered rock plus 0.2m of topsoil, excavated from the foundations, and then grassed. Once the grass is established any runoff from the CNWRS will be of good quality.

7.0 CONSTRUCTION AND QUALITY CONTROL

Construction of the CNWRS will be undertaken by OceanaGold, or in part by contractors under the direct supervision of OceanaGold employees. OceanaGold is responsible for setting out the works, ensuring that the rock stack is constructed to the design profile, that foundation stripping and preparation is properly carried out, subsurface drainage material is suitably placed, surface drainage is properly constructed and maintained, and that rehabilitation (i.e. topsoiling and grassing) is to high standards. The proposed construction methods and rehabilitation strategies are similar to those employed on the existing tailing storage facilities and waste rock stacks, and these have been successful during the 25 years of operation at the MGP.

It is anticipate that similar consent conditions to those for the existing Coronation WRS will apply to the CNWRS, such as the specific requirements affecting construction as summarised below:

Conditions 12 and 13 of RM12.378.01 and Conditions 7 and 8 RM12.378.06 refer to the requirement for cleaning of construction plant to avoid spreading didymo and the need to minimise work in waterways.

Condition 12a of RM12.378.06 requires if there is discovery of koiwi tangata (human skeletal remains) or Maori artefact material that the Consent Holder shall without delay:

i. Notify the Consent Authority, Tangata whenua and New Zealand Historical Society, in the case of skeletal remains, the New Zealand Police and
ii. Stop work within the immediate vicinity
iii. Any koiwi tangata discovered shall be handled and removed by tribal elders responsible for the tikanga (custom) appropriate to its removal or preservation

Condition 12b of RM12.378.06 requires if there is discovery of any features or archaeological features that pre-dates 1900, or heritage material, or disturbs a previously unidentified archaeological or history site that the Permit Holder shall without delay:

i. Stop work within the immediate vicinity
ii. Advise the New Zealand Historical Places Trust, and in the case of Maori features or materials, the Tangata whenua, and if required, shall make an application for an Archaeological Authority pursuant to the Historic Places Act 1993
iii. Arrange for a suitably qualified archaeologist to undertake a survey of the site.

8.0 CONCLUSIONS

The CNWRS is designed in accordance with accepted engineering practices. Existing WRS have been designed to similar standards and their performance to date has been satisfactory. Construction procedures, including supervision and quality control practices for the CNWRS will meet accepted engineering standards.

All final slopes of the CNWRS have been designed for a static factor of safety against instability exceeding 1.5 for the expected water levels.

The WRS has been designed for an operating basis earthquake (OBE) with a recurrence interval of 150 years and maximum design earthquake (MDE) with a recurrence interval of

2,500 years. Minimal deformation is expected as a result of the OBE and satisfactory performance has been calculated in terms of settlement and slope deformation under the MDE event.

Based on the results of the static and seismic stability analyses conducted it is concluded that the CNWRS is sufficiently stable to remain suitable for the intended long term use of pastoral farming post rehabilitation and mine closure.

OceanaGold will ensure short and long term stability of the CNWRS, associated works, and surrounds at all times during the operational life of the structure. This will be achieved through construction, rehabilitation and ongoing monitoring in accordance with the controlling documents:

Coronation Waste Rock Stack Design Report (i.e. this report);
Coronation Sediment Control Plan (Ref 10);
Coronation Water Quality Management Plan (Ref.11)

ENGINEERING GEOLOGY LTD

Report prepared by

C Sweeney (Engineering Geologist)

C Wu (Geotechnical Engineer)

Reviewed by:

J Yeats (CPEng)

REFERENCES

1. Oceana Gold (New Zealand) Limited (2014) 'Coronation Waste Rock Stack Operations and Management Plan, June 2014'.

2. Pells Sullivan Meynink (2016) 'Impact of the Coronation and Coronation North Waste Rock Stacks on Open Pits' letter Ref PSM71-204L, dated 12 April 2016.

3. Engineering Geology Ltd (2014) 'Macraes Gold Project, Coronation Waste Rock Stack, Design Report'.

4. GEO-SLOPE International Ltd (2012) 'Stability Modelling with SLOPE/W: An Engineering Methodology', GEO-SLOPE International Ltd.

5. Spencer, E. (1967) 'A Method of Analyses of the Stability of Embankments Assuming Parallel Inter-Slice Forces', Geotechnique, Vol. 17, No. 1, pp 11-26.

6. Janbu, N. (1954) Applications of Composite Slip Surfaces for Stability Analysis. In Proceedings of the European Conference on the Stability of Earth Slopes, Stockholm, Vol. 3, pp. 39-43.

7. Litchfield N, McVerry G H, Smith W, Berryman K R and Stirling M (2005) 'Seismic Hazard Study for Tailings Embankments at Macraes Gold Project' GNS Client Report 2005/135.

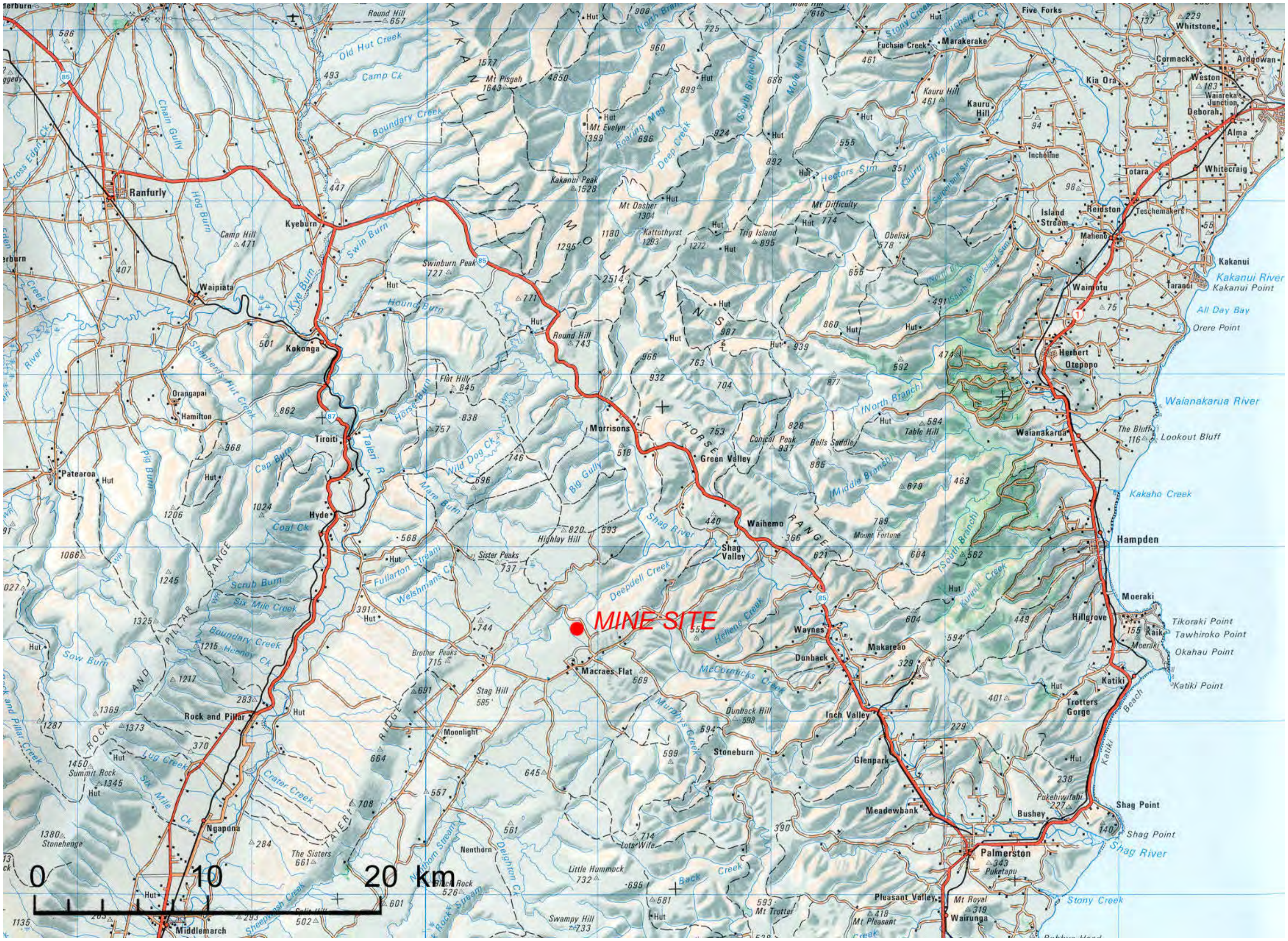
8. Harder, L.F., Bray, J.D., Volpe, R.L. and Rodda, K.V. (1998) 'performance of Earth Dams during the Loma Prieta Earthquake' US Geological Survey Professional Paper 1552-D, pp D3-D26.

9. Makdisi, F.I. and Seed, H.B. (1978) 'Simplified Procedure For Estimating Dam and Embankment Earthquake-Induced Deformations', Journal of the Geotechnical Engineering Division, ASCE GT7, pp 849-867.

10. Engineering Geology Ltd (2016) 'Oceana Gold (New Zealand) Ltd, Macraes Gold Project, Coronation North Project, Erosion and Sediment Control'

11. Ocean Gold (New Zealand) Limited (2014) 'Coronation Water Quality Management Plan 2014'.

FIGURES
1 TO 6



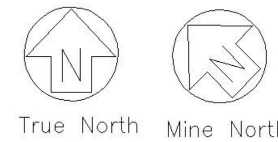


Figure 1

Source: NZMS Sheet 15 Waitaki.

Engineering Geology Ltd
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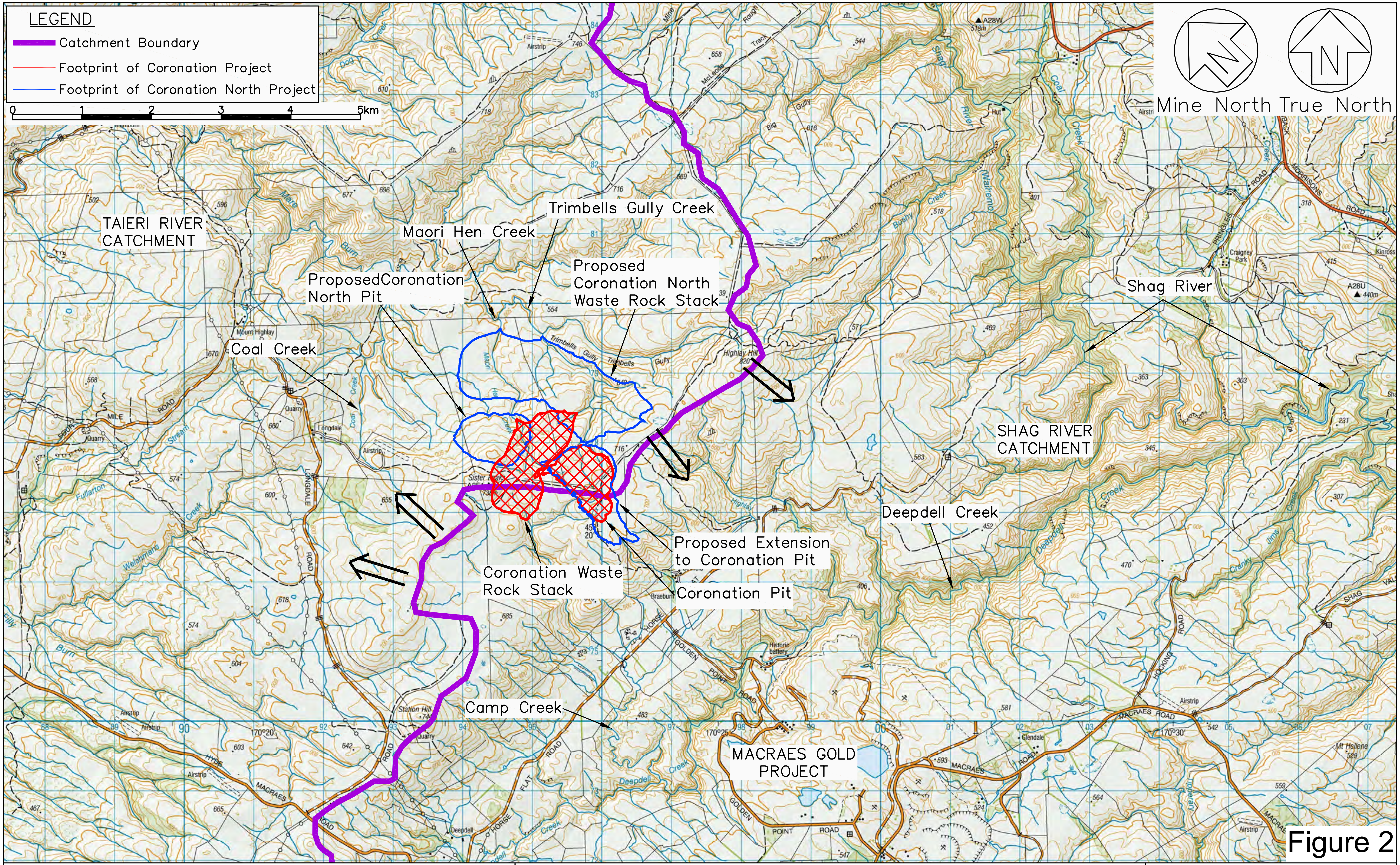
OCEANA GOLD (NEW ZEALAND) LTD
Macraes Gold Project
Locality Plan

Ref. No.: 1410
Date: 26 June 2002
Drawn: SP
File: local.grf



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OCEANA GOLD (New Zealand) LTD, MACRAES GOLD PROJECT
Coronation North Project
Site Plan

Drawing No.	7703-Fig 2
Date:	April 2016
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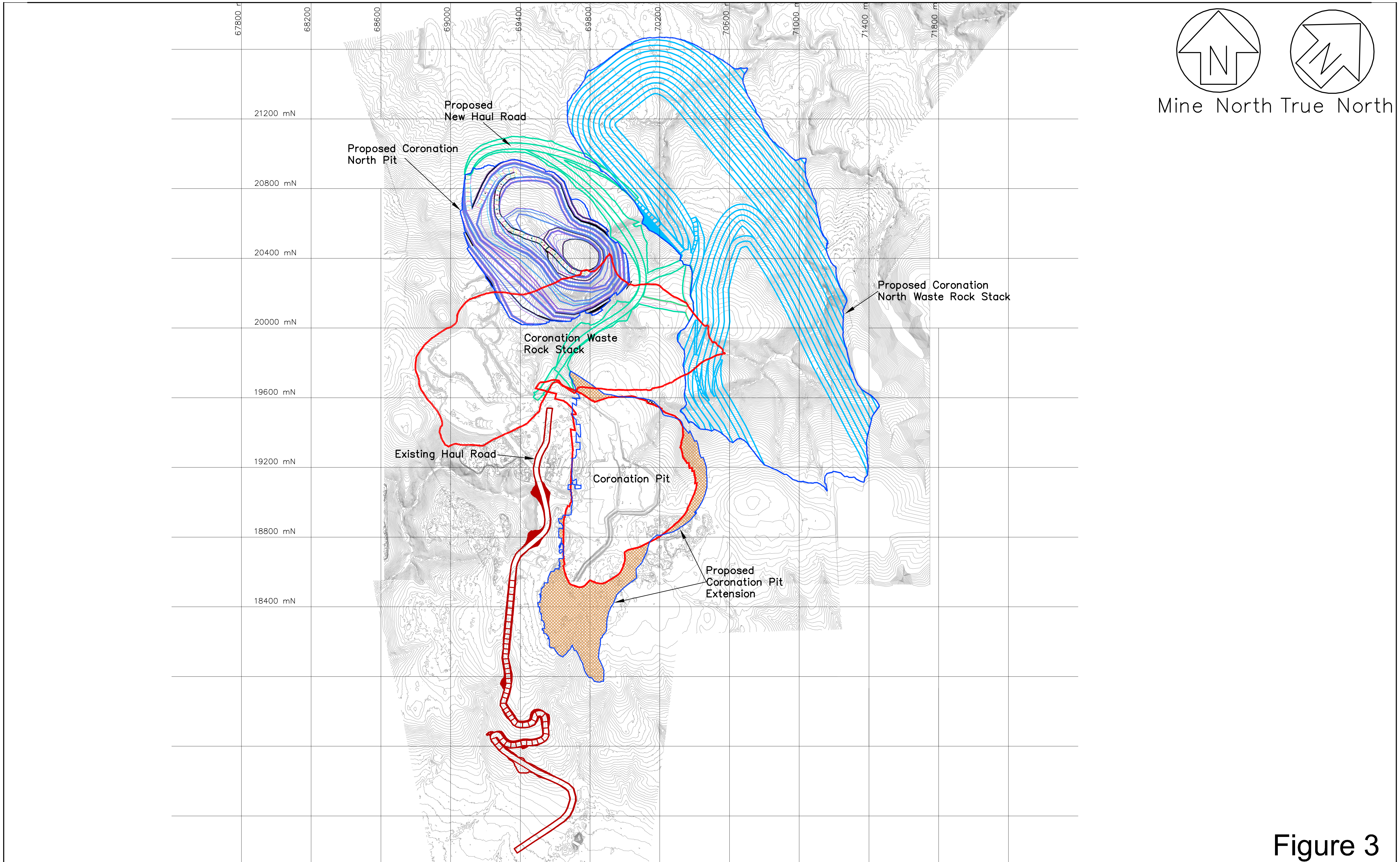

Figure 3

ENGINEERING GEOLOGY LTD
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OCEANA GOLD (NEW ZEALAND) LTD, MACRAES GOLD PROJECT

Coronation North Project

Coronation North Waste Rock Stack and Pit

Drawing No. 7703–Fig 3
Date: 4 March 2016
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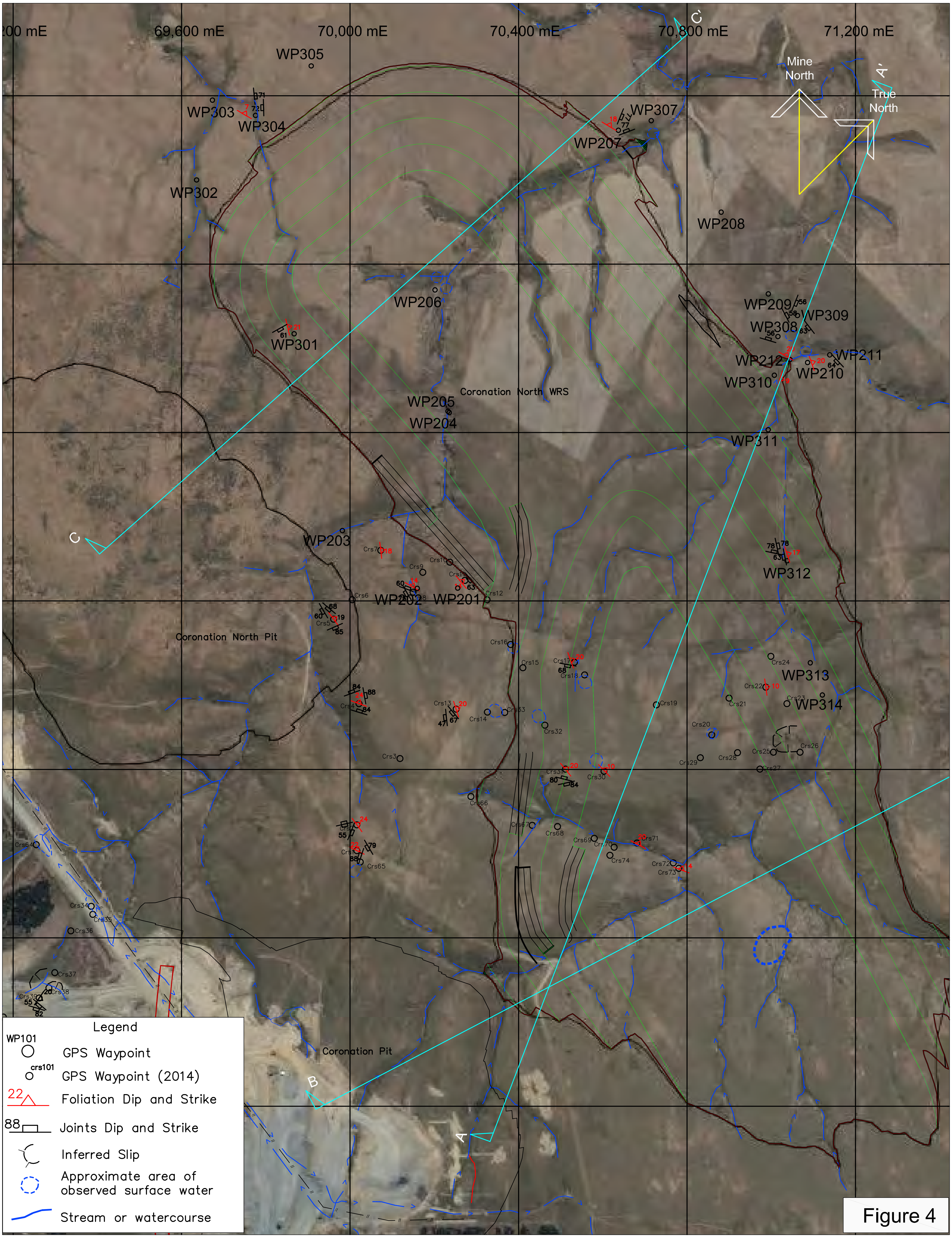

Figure 4

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Ph (09)486-2546, Fax (09)486-2556

OCEANA GOLD(NZ) LTD,MACRAES GOLD PROJECT
Coronation North Waste Rock Stack
GEOLOGICAL FIELD MAPPING

PROJECT:	Coronation North WRS
AREA:	Coronation North WRS Macraes
CONSULTANT DRAWING No.	7703-Fig 4

JOB NUMBER:	ORIGINAL SCALE:	SIZE:	REV
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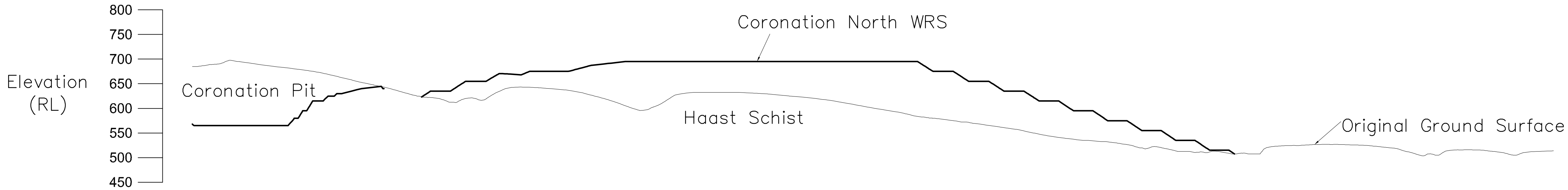
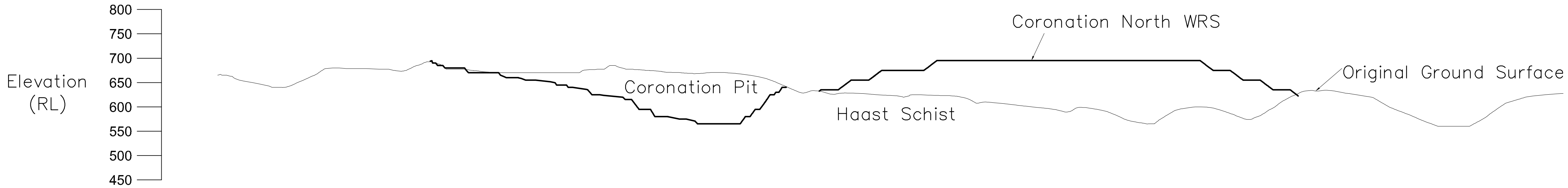
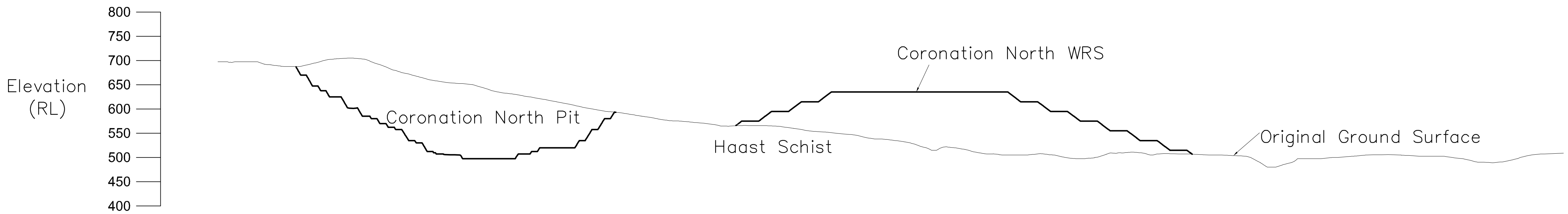


Section A-A'



Section B-B'



Section C-C'

Figure 5

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OCEANA GOLD(NZ) LTD,MACRAES GOLD PROJECT
Coronation North Waste Rock Stack
Cross Sections

No.	BY	DATE	REVISION	CHECKED	APPROV.

PROJECT: Coronation WRS
AREA: Coronation WRS Macraes
CONSULTANT DRAWING No. 7703-Fig5

JOB NUMBER:	ORIGINAL SCALE:	SIZE:	REV
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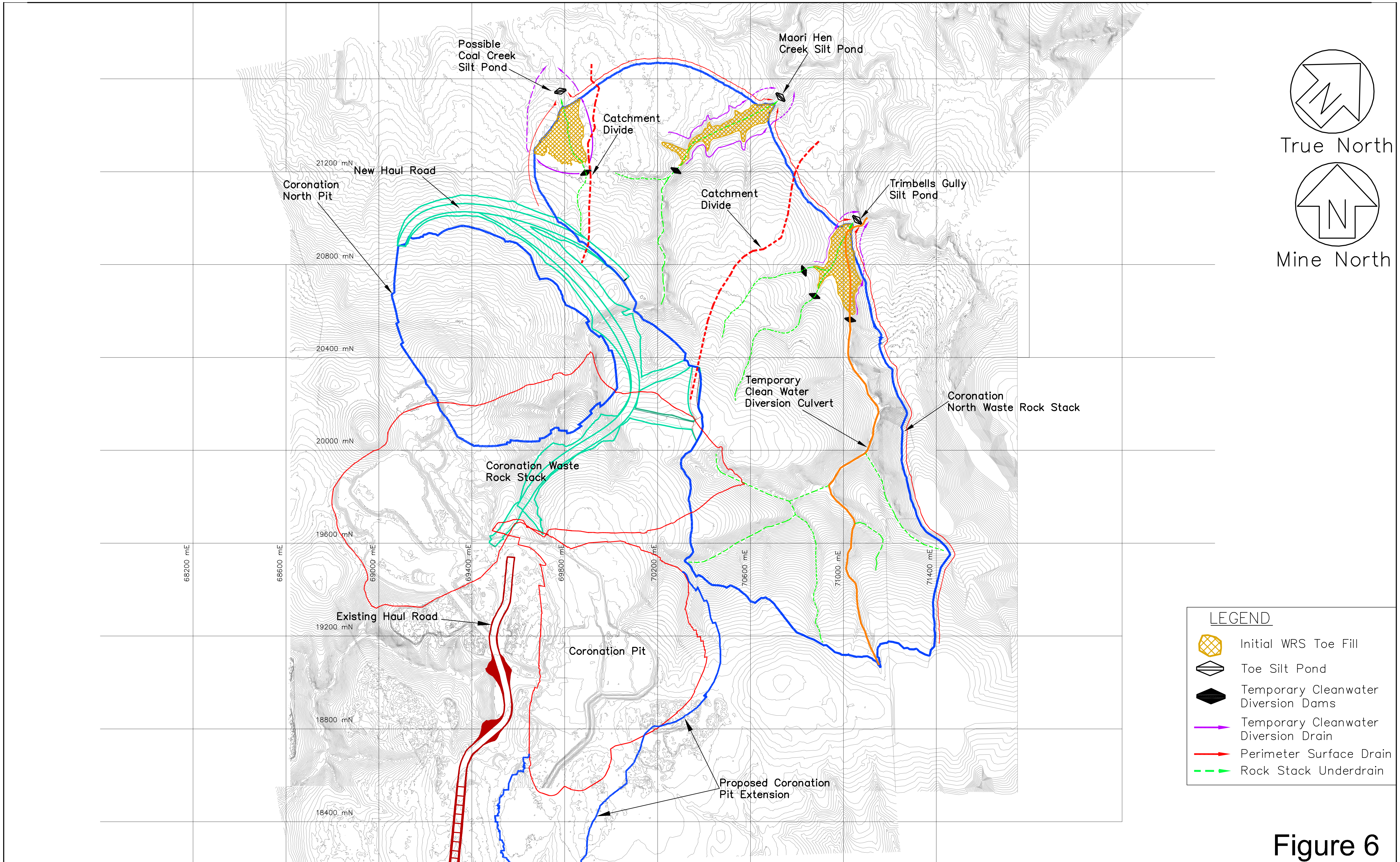

Figure 6

ENGINEERING GEOLOGY LTD
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OCEANA GOLD (NEW ZEALAND) LTD, MACRAES GOLD PROJECT
Coronation North Project
Coronation North Waste Rock Stack and Pit
Erosion and Sediment Control Features

Drawing No. 7703-Fig 6
Date: 4 March 2016
Drawn: DLM/BL/JS
Scale: 1:15000 (@A3)
Filename: 7703-Fig6.dwg

APPENDIX A

STABILITY ANALYSES

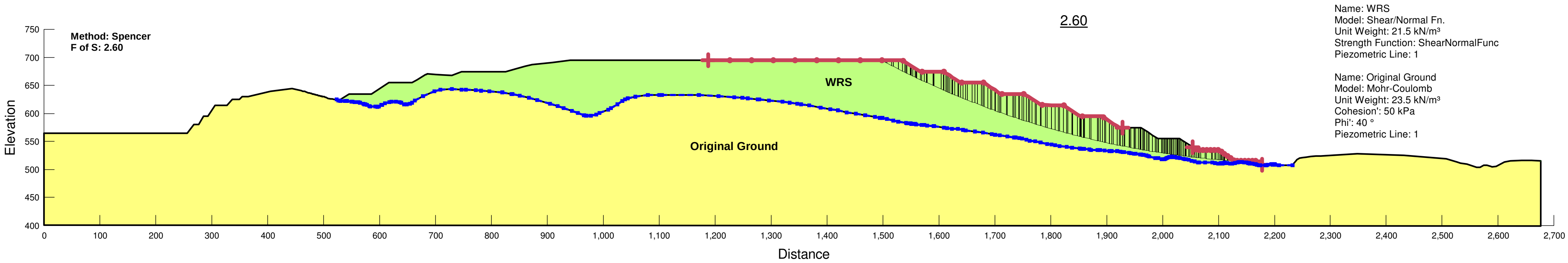


Figure A1

Coronation North WRS
Section A-A'
Static Stability - Critical Failure Surface of the WRS

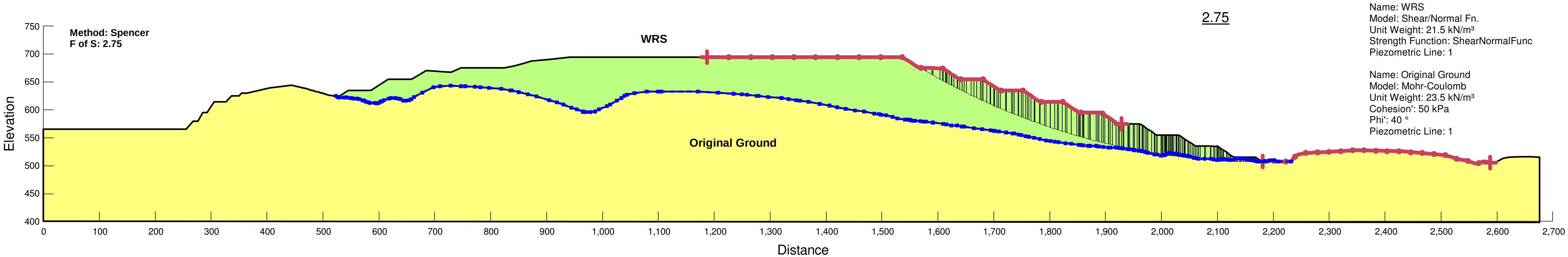
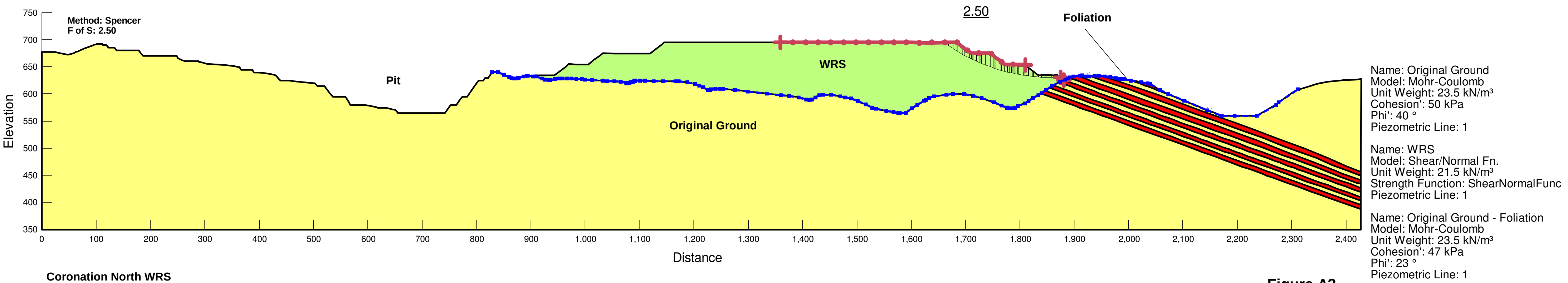


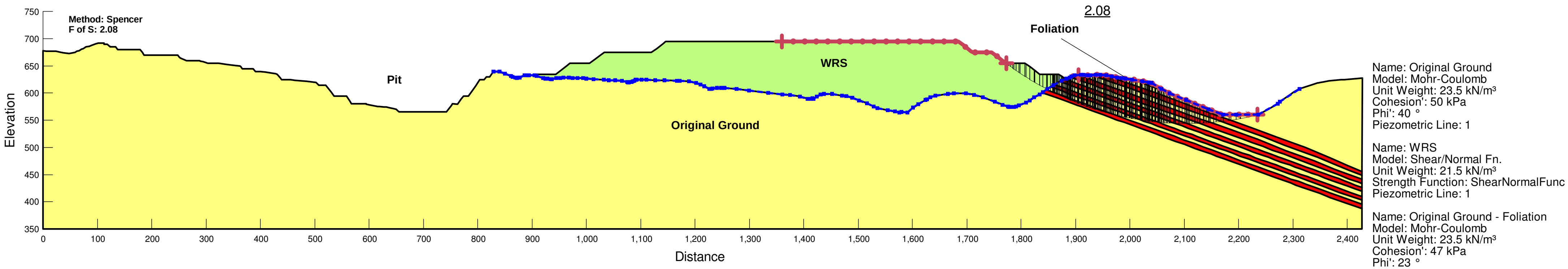
Figure A2

Coronation North WRS
Section A-A'
Static Stability - Critical Failure Surface penerates through the Foundation



Coronation North WRS
Section B-B'
Static Stability - Critical Failure Surface of the WRS

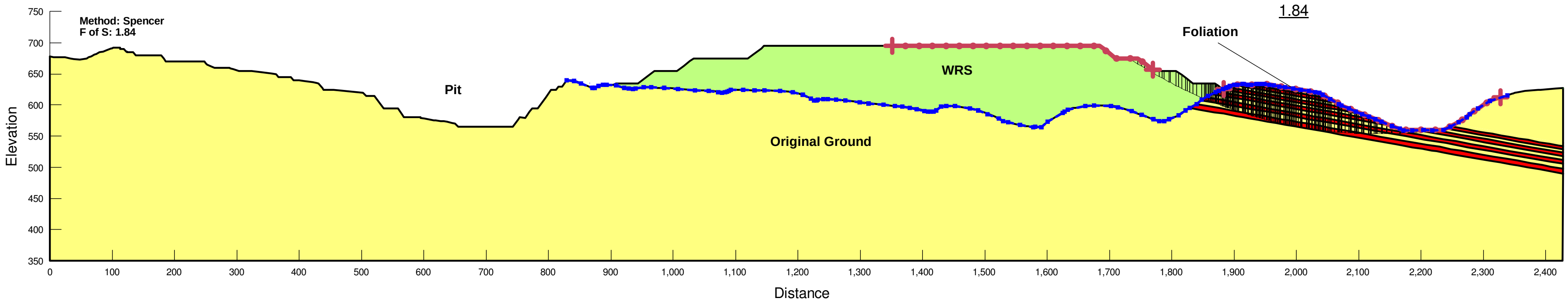
Figure A3



Coronation North WRS
Section B-B'
Static Stability - Critical Failure Surface penetrates through the Foundation

Foliation Dip Angle =20deg, Circular Failure Surface

Figure A4



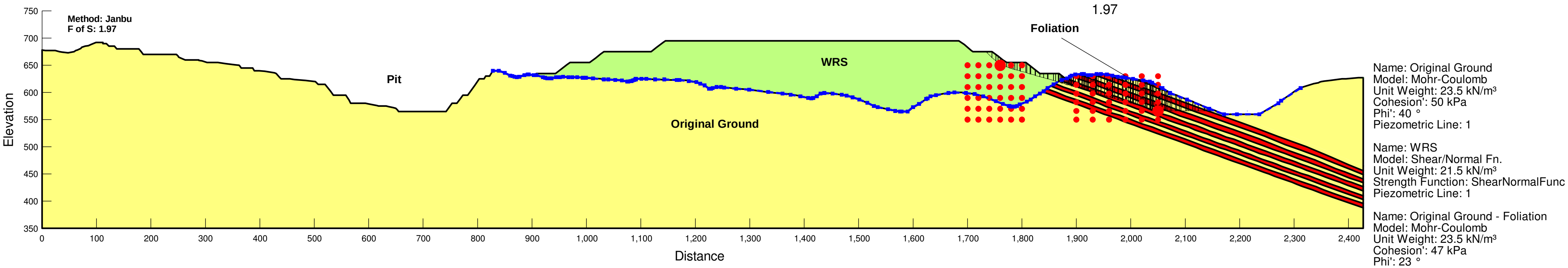
Name: Original Ground
Model: Mohr-Coulomb
Unit Weight: 23.5 kN/m³
Cohesion': 50 kPa
Phi': 40 °
Piezometric Line: 1

Name: WRS
Model: Shear/Normal Fn.
Unit Weight: 21.5 kN/m³
Strength Function: ShearNormalFunc
Piezometric Line: 1

Name: Original Ground - Foliation
Model: Mohr-Coulomb
Unit Weight: 23.5 kN/m³
Cohesion': 47 kPa
Phi': 23 °
Piezometric Line: 1

Figure A4a

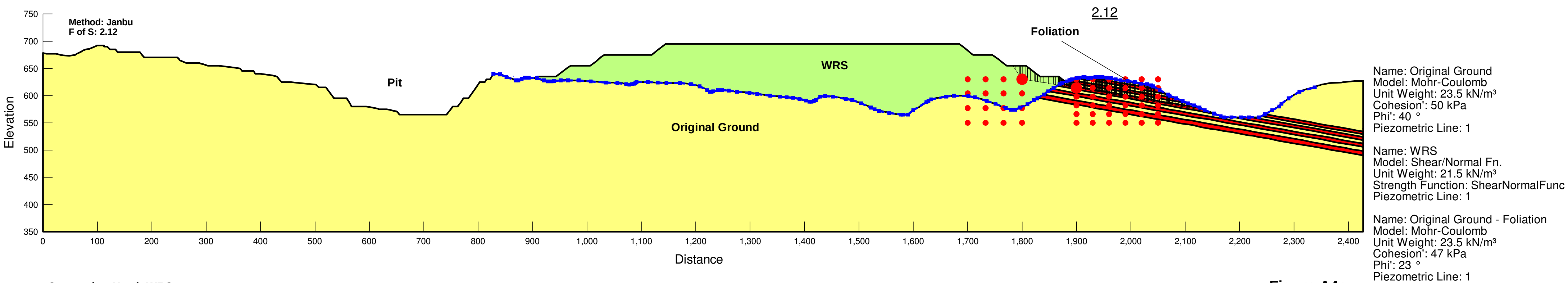
Coronation North WRS
Section B-B'
Static Stability - Critical Failure Surface penetrates through the Foundation
Foliation Dip Angle =10deg, Circular Failure Surface



Coronation North WRS
Section B-B'
Static Stability - Critical Failure Surface penetrates through the Foundation

Foliation Dip Angle =20deg, Planar Failure Surface

Figure A4b



Coronation North WRS
Section B-B'
Static Stability - Critical Failure Surface penetrates through the Foundation

Foliation Dip Angle =10deg, Planar Failure Surface

Figure A4c

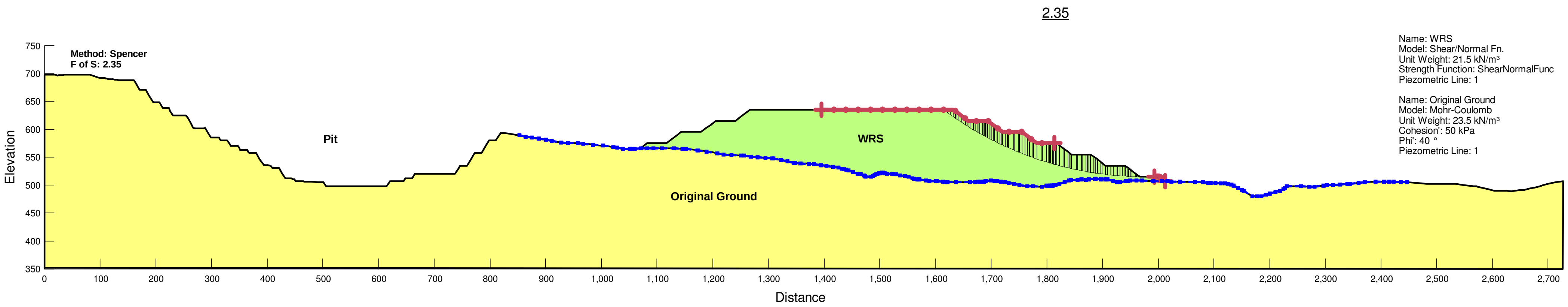


Figure A5

Coronation North WRS
Section C-C'
Static Stability - Critical Failure Surface of the WRS

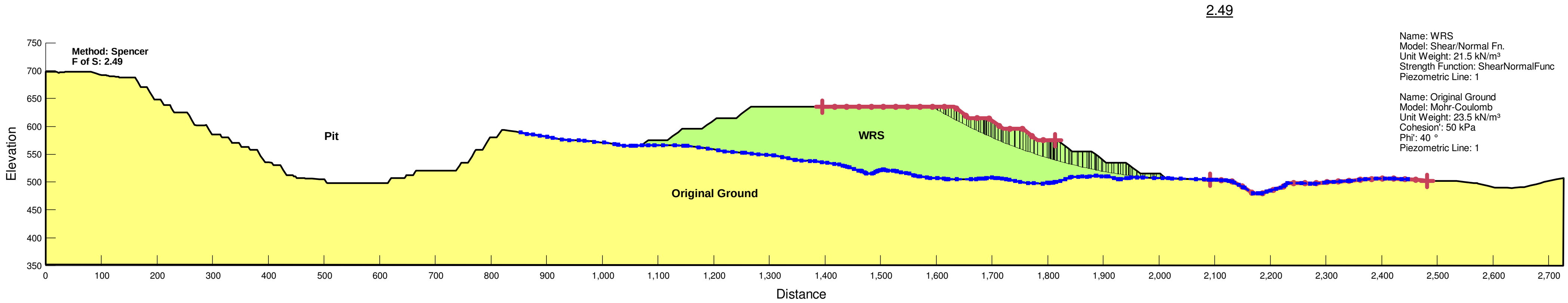


Figure A6

Coronation North WRS
Section C-C'
Static Stability - Critical Failure Surface penetrates through the Foundation

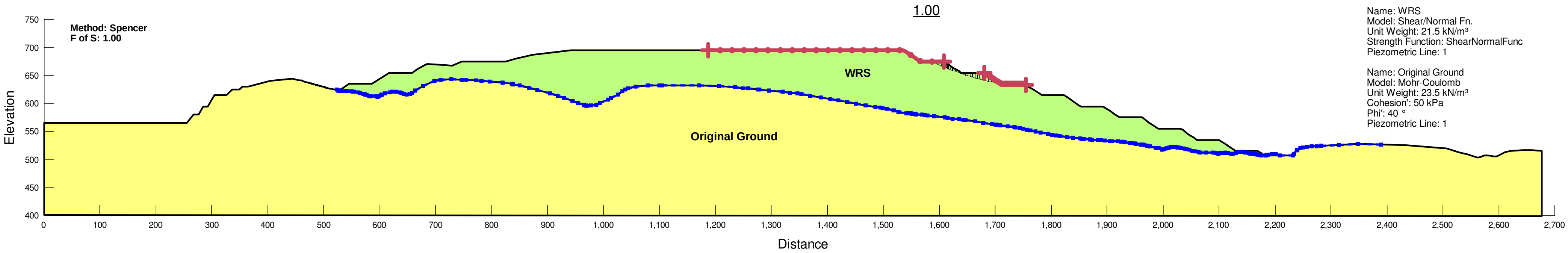


Figure A7

Coronation North WRS
Section A-A'
Seismic OBE - Failure Surface located 1/3H below Crest
Horiz Seismic Coef.: 0.43

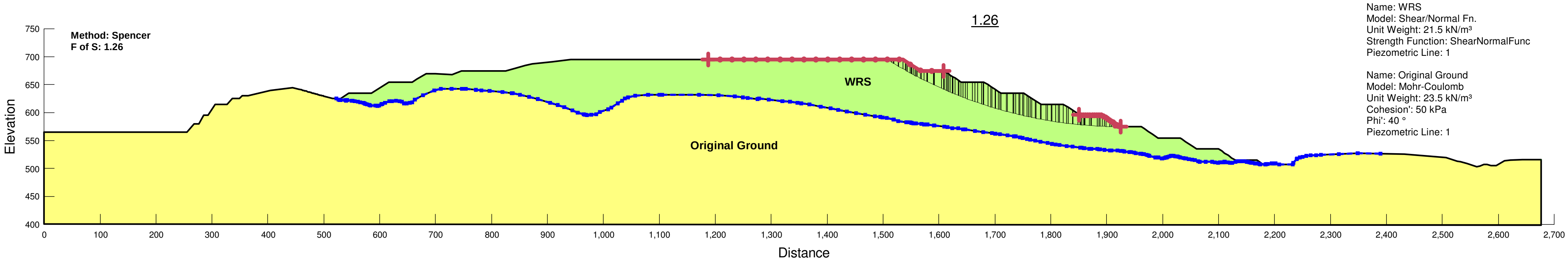


Figure A8

Coronation North WRS
Section A-A'
Seismic OBE - Failure Surface located 2/3H below Crest
Horiz Seismic Coef.: 0.28

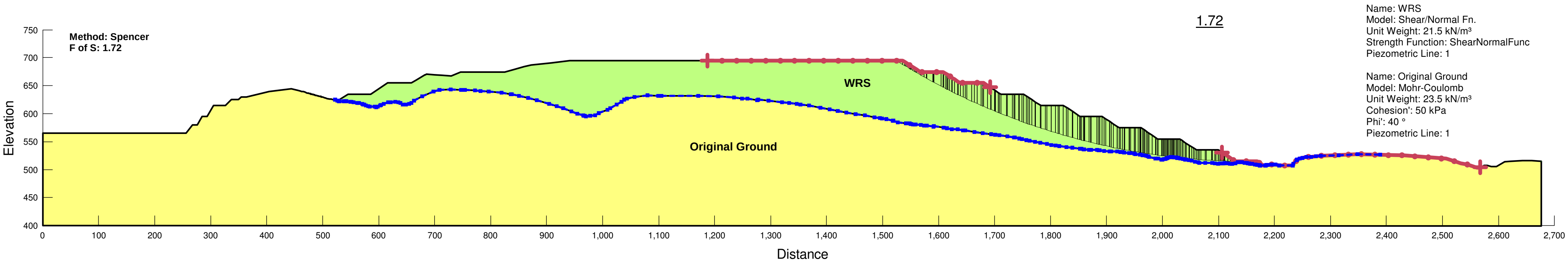


Figure A9

Coronation North WRS
Section A-A'
Seismic OBE - Full Depth Failure Surface
Horiz Seismic Coef.: 0.13

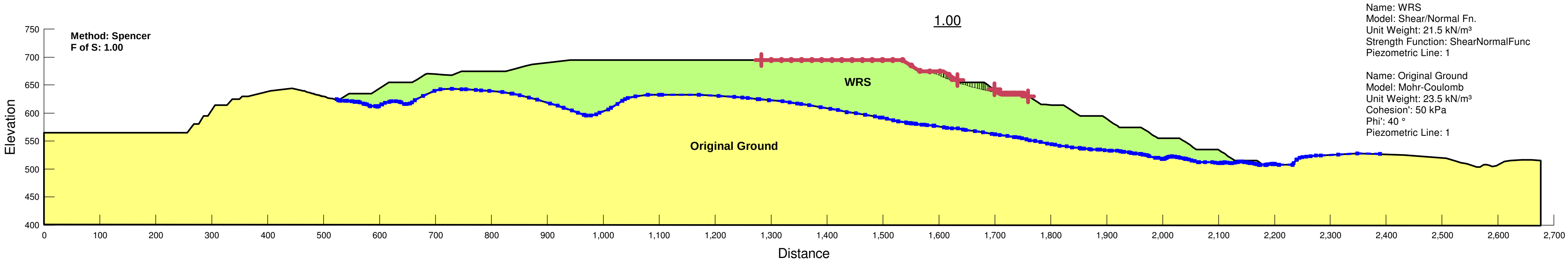


Figure A10

Coronation North WRS
Section A-A'
Seismic MDE - Failure Surface located 1/3H below Crest (Yield Acceleration)
Horiz Seismic Coef.: 0.43

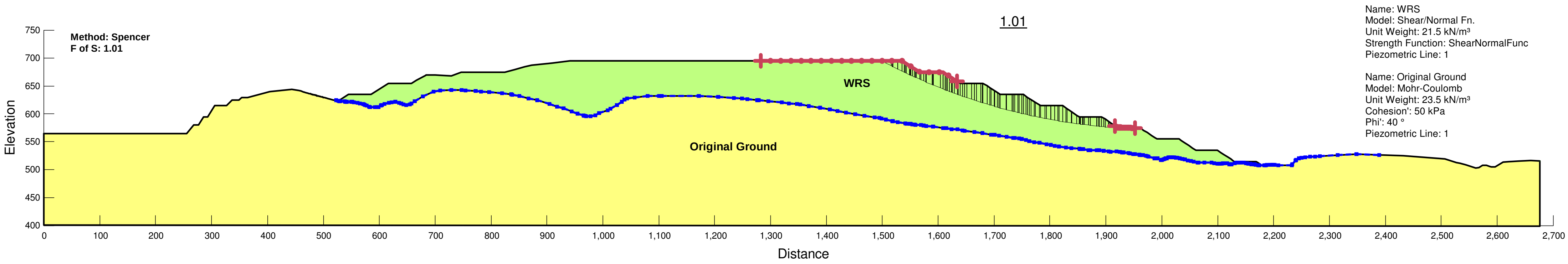
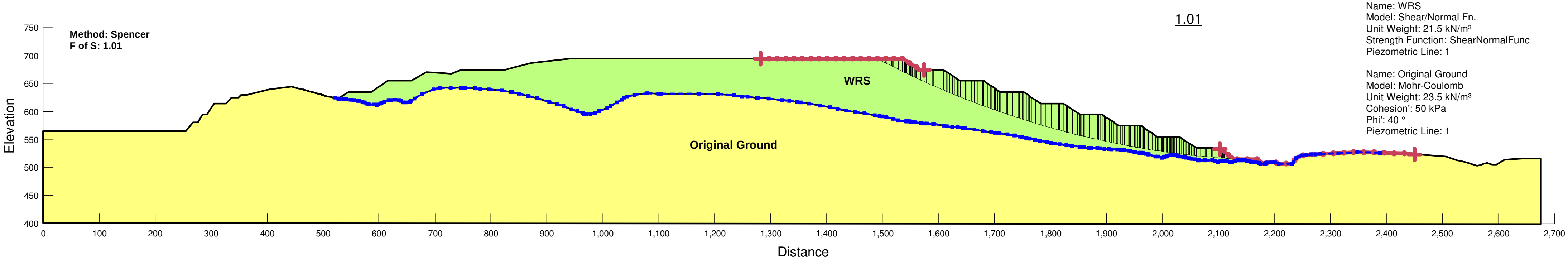


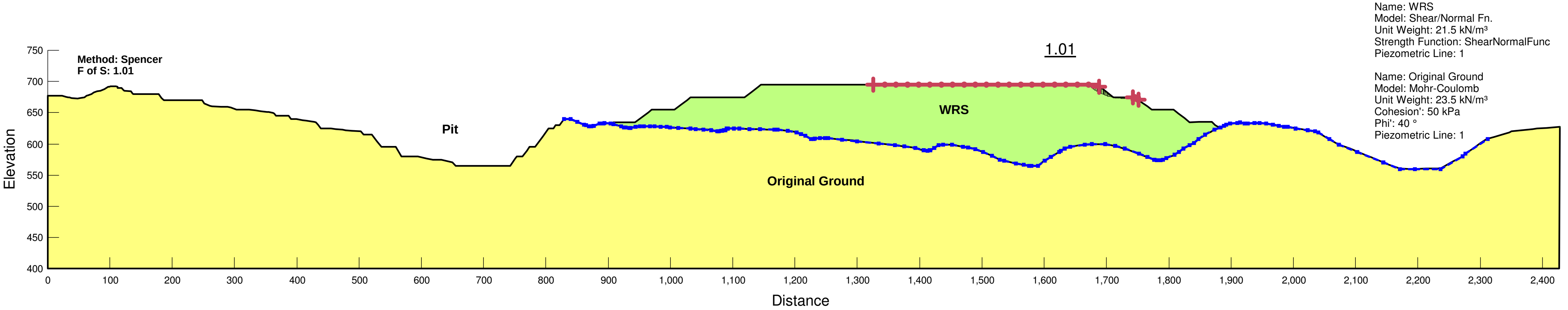
Figure A11

Coronation North WRS
Section A-A'
Seismic MDE - Failure Surface located 2/3H below Crest (Yield Acceleration)
Horiz Seismic Coef.: 0.40



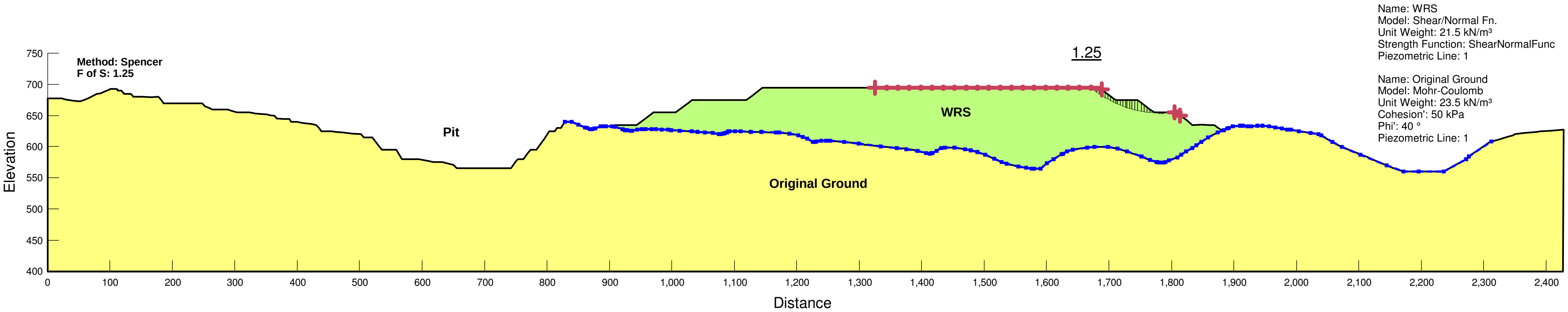
Coronation North WRS
Section A-A'
Seismic MDE - Full Depth Failure Surface (Yield Acceleration)
Horiz Seismic Coef.: 0.38

Figure A12



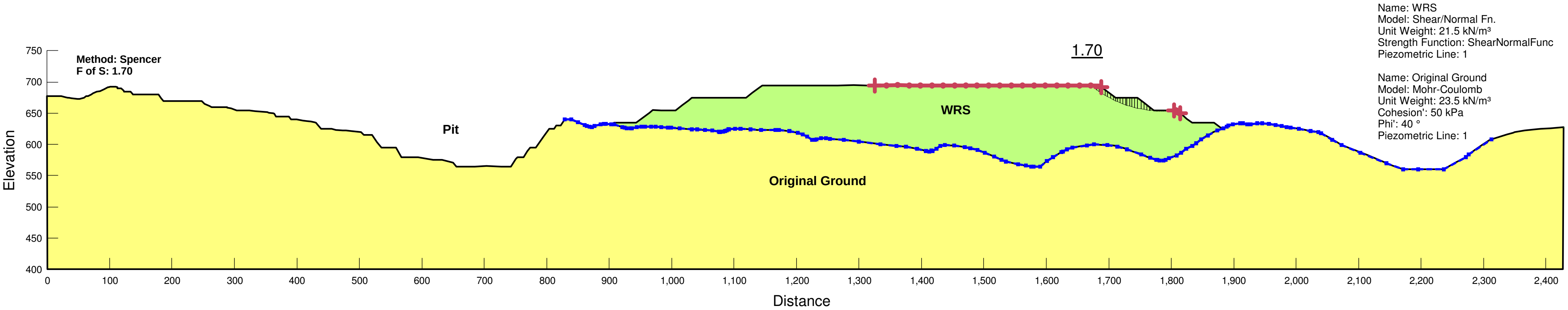
Coronation North WRS
Section B-B'
Seismic OBE - Failure Surface located 1/3H below Crest (Yield Acceleration)
Horz Seismic Coef.: 0.39

Figure A13



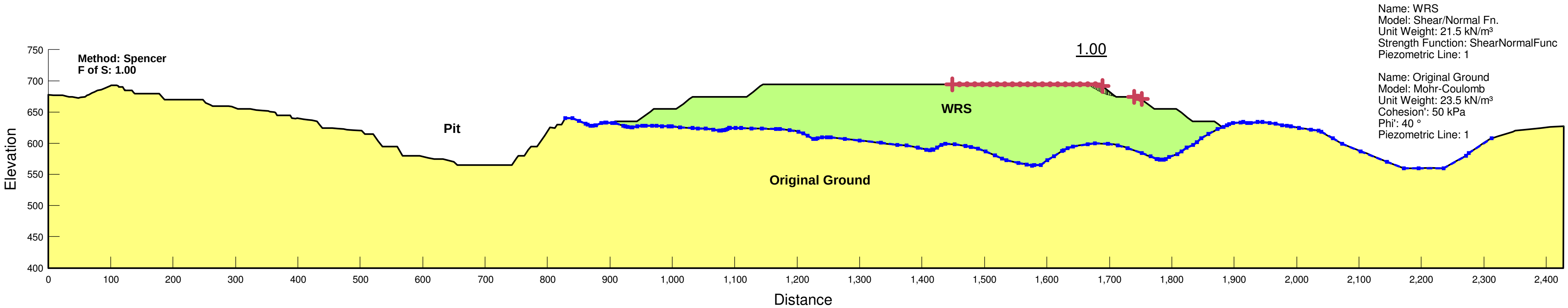
Coronation North WRS
Section B-B'
Seismic OBE - Failure Surface located 2/3H below Crest
Horz Seismic Coef.: 0.28

Figure A14



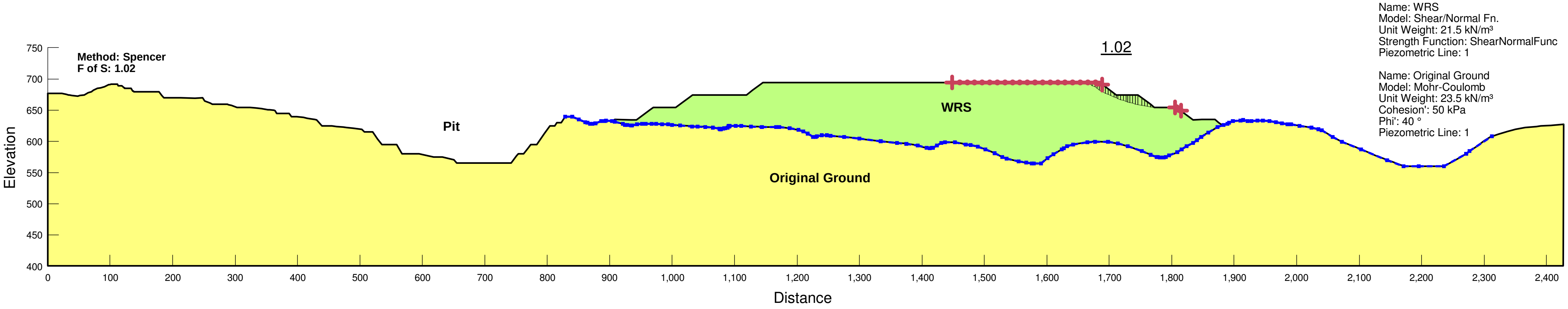
Coronation North WRS
Section B-B'
Seismic OBE - Full Depth Failure Surface
Horz Seismic Coef.: 0.13

Figure A15



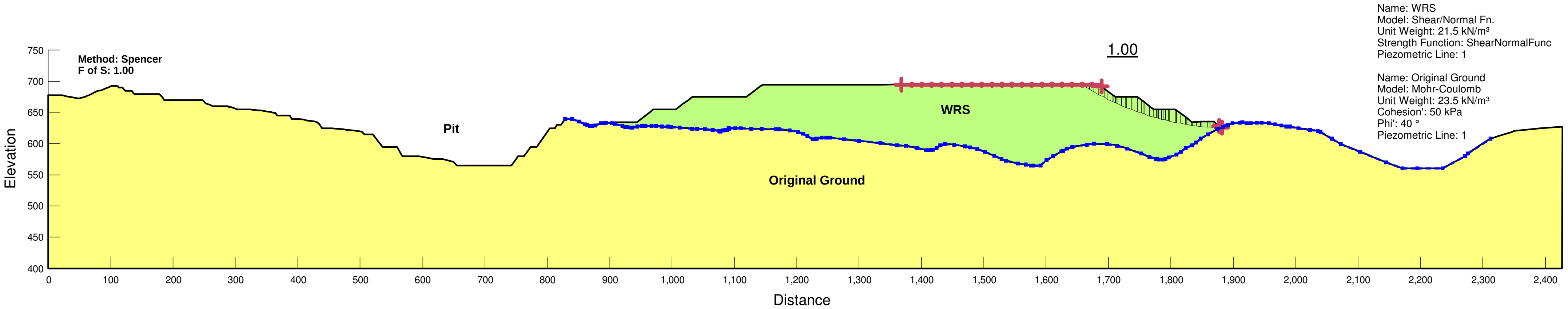
Coronation North WRS
Section B-B'
Seismic MDE - Failure Surface located 1/3H below crest (Yield Acceleration)
Horz Seismic Coef.: 0.39

Figure A16



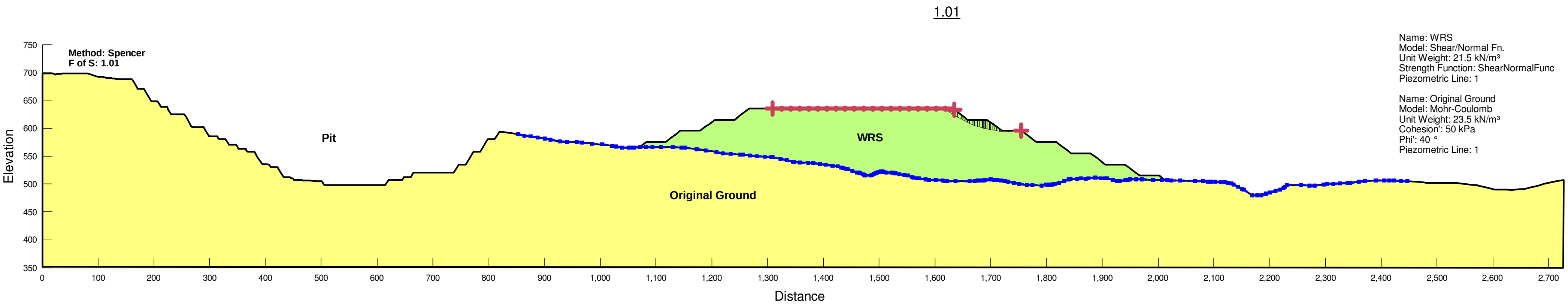
Coronation North WRS
Section B-B'
Seismic MDE - Failure Surface located 2/3H below Crest (Yield Acceleration)
Horz Seismic Coef.: 0.40

Figure A17



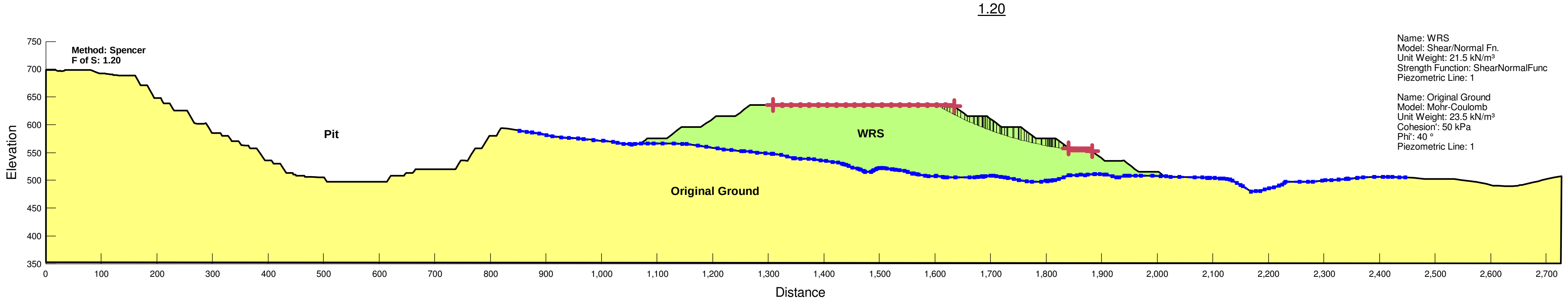
Coronation North WRS
Section B-B'
Seismic MDE - Full Depth Failure Surface (Yield Acceleration)
Horz Seismic Coef.: 0.32

Figure A18



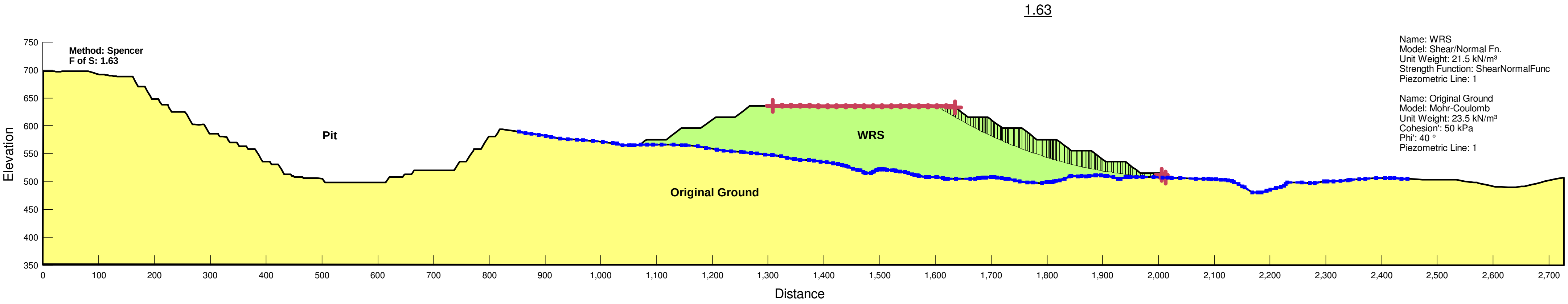
Coronation North WRS
Section C-C'
Seismic OBE - Failure Surface located 1/3H below Crest (Yield Acceleration)
Horz Seismic Coef.: 0.41

Figure A19



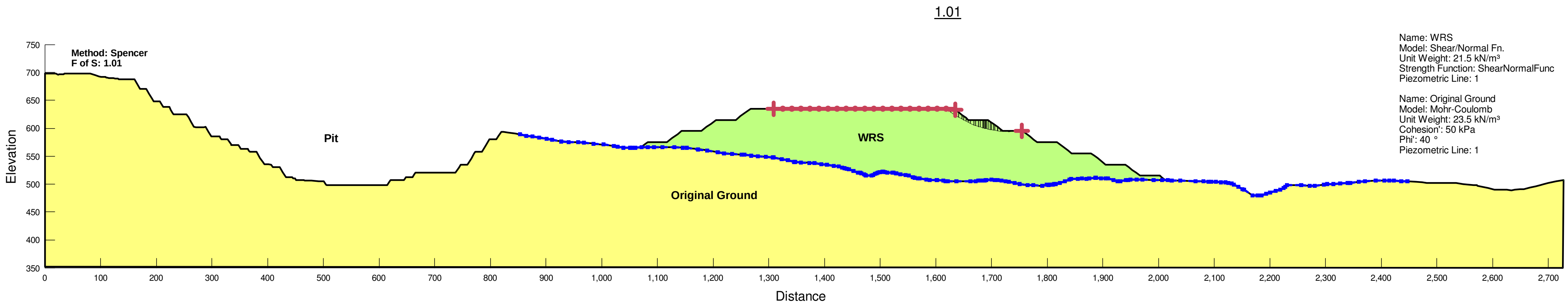
Coronation North WRS
Section C-C'
Seismic OBE - Failure Surface located 2/3H below Crest
Horz Seismic Coef.: 0.28

Figure A20



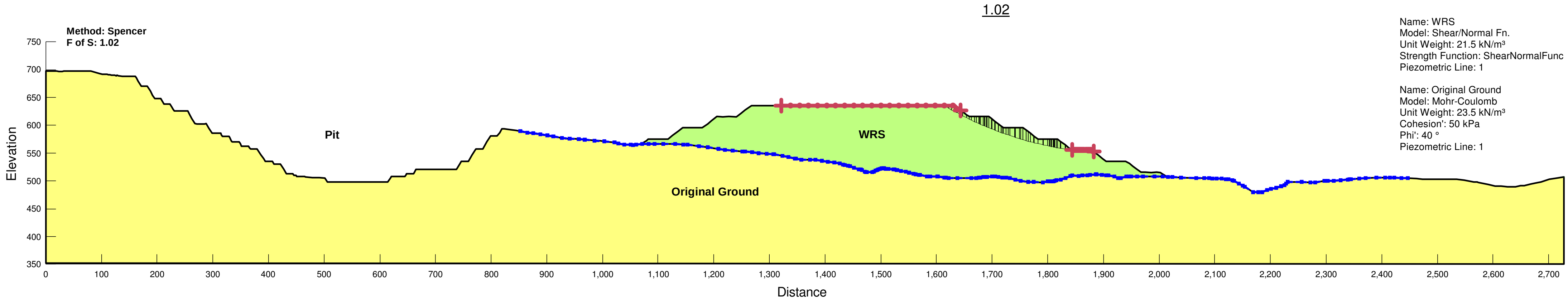
Coronation North WRS
Section C-C'
Seismic OBE - Full Depth Failure Surface
Horz Seismic Coef.: 0.13

Figure A21



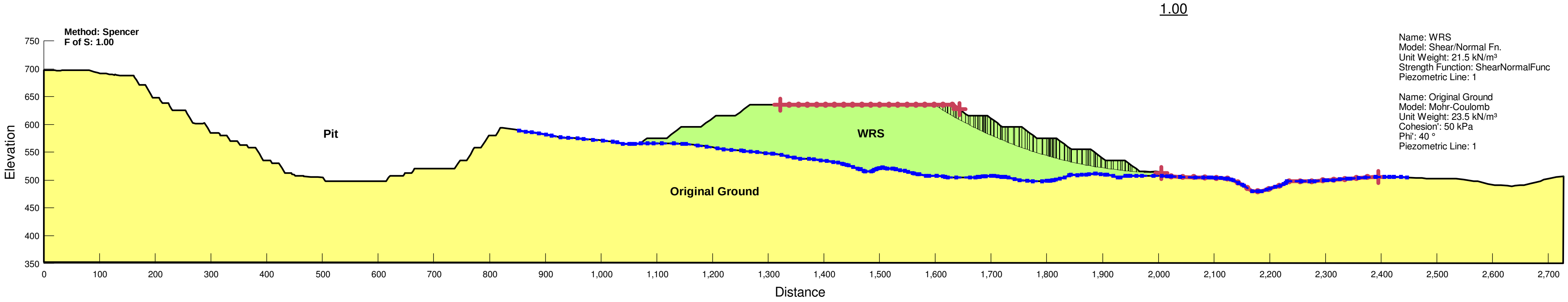
Coronation North WRS
Section C-C'
Seismic MDE - Failure Surface located 1/3H below Crest (Yield Acceleration)
Horz Seismic Coef.: 0.41

Figure A22



Coronation North WRS
Section C-C'
Seismic MDE - Failure Surface located 2/3H below Crest (Yield Acceleration)
Horz Seismic Coef.: 0.37

Figure A23



Coronation North WRS
Section C-C'
Seismic MDE - Full Depth Failure Surface (Yield Acceleration)
Horz Seismic Coef.: 0.37

Figure A24