CERES-ROMANSRIVIER 132KV LINE

LINE ROUTING AND ACCESS FEASIBILITY REPORT

FOR MOUNTAIN ROUTE AND EXISTING RIVER ROUTE

Prepared by Trans-Africa Projects (Pty) Ltd, an ISO 9001, ISO 14001 and OHSAS 18001 registered company.

Document No.
P1900-3798-08-001
Revision Number: 0
October 2015

Prepared by

Name	Function	Signature	Date
Robina Macario	Design Engineer		October 2015

Approved by

Name	Function	Signature	Date
Tiaan Lötter	Technical Review		October 2015
Pierre Marais	Corporate Line Design Specialist		October 2015
Leigh Stubbs	Regional Manager		October 2015

Accepted by Client

Name	Function	Signature	Date

Revision Control

Rev #	Date	Brief details of amendments	Approved by
0	October 2015	First Issue	LS

Executive Summary

Trans Africa Projects (Pty) Ltd was commissioned to perform a feasibility study on viable line routes over a mountain pass and through a river valley in the Ceres area. The line routes are required to build a proposed 132kV double circuit single Kingbird line needed to support the fragile Witzenberg network.

Access through the difficult terrain was a primary concern for both route corridors.

The associated costs to rehabilitate and upgrade existing access, or to create new access where needed would likely be significant and required detailed analysis to quantify.

In addition, construction in mountainous terrain is often supported by the use of helicopters. Assessing the extent to which this would be required was also a key objective in the study.

The study made use of a detailed three-dimensional terrain model created in PLS-CADD from LIDAR data obtained for each route corridor. The terrain model provided the means to assess and manage side slope as well as terrain and access constraints. Both routes were profiled with 247 and 245 lattice series as the use of lattice structures was believed to be favourable when constructing in difficult terrain. Where tower footing area was limited, monopole structures were specified. This however, was only required on the river route.

Optimal conductor attachment height (CAH) and leg extensions required at each tower position were established for each profile.

Access to each tower position (as profiled) was then identified based on typical access construction methods as described in *Guideline for Management of Access and Erosion Control on Eskom Servitudes* under Appendix A. The limited space available to place towers within the river corridor posed a challenge and saw more access creation requirements for this option. Access from the main R46 road was ruled as not feasible in most cases and added to the required amount of access roads.

This route also presented the need for two river crossings, which have been marked for pipe and gabion culverts to provide access that is more robust over the river at those points. Further challenges of constructing within this corridor would be the significant amount of traffic control needed to ensure safe construction and water use licences for towers near the river.

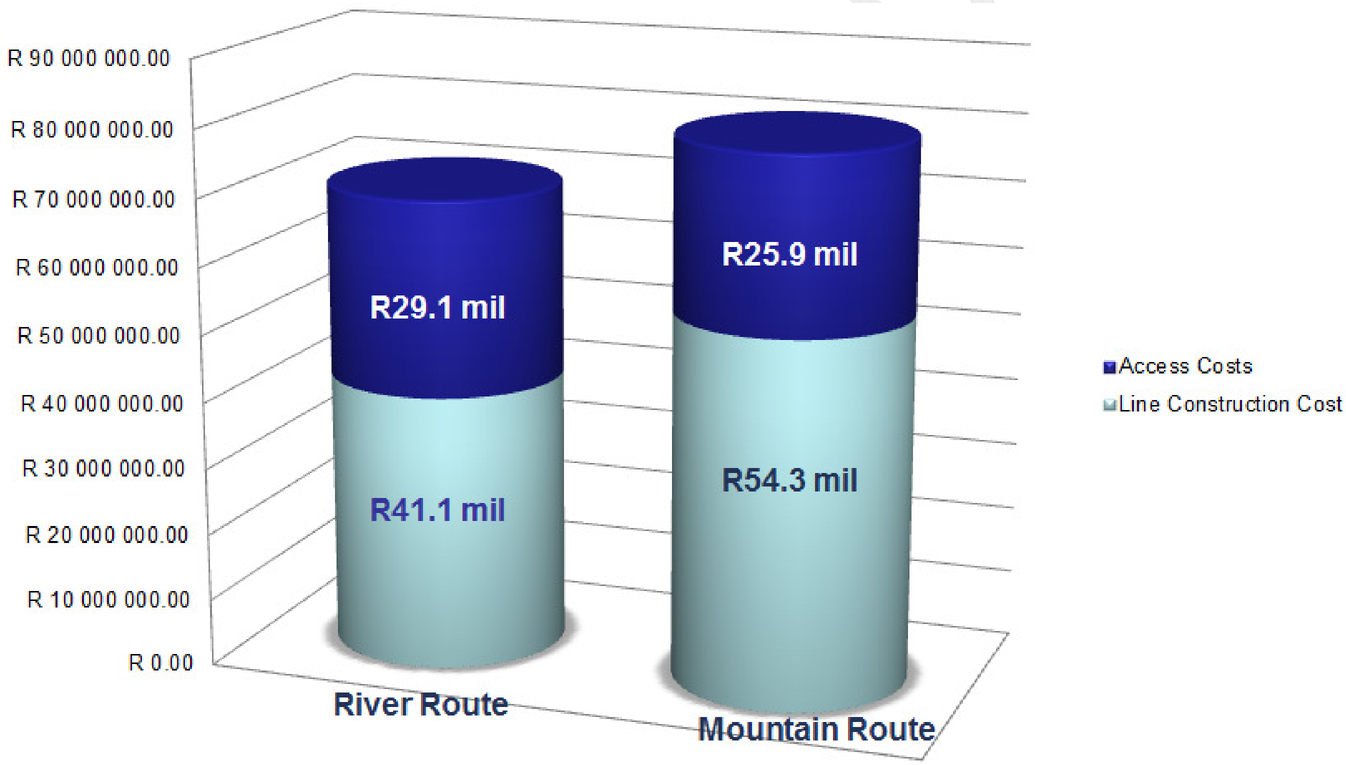
Both options require the use of helicopter assisted construction at two tower sites each. This assistance will provide for the transportation of material to tower sites where hand assembly and erection will take place.

Although the mountain pass route requires a substantial amount of access upgrading, the ability to construct away from the public is an advantage worth considering, even with the ~R 13 million premium when compared to the river route.

This large cost difference can be attributed to heavier and larger structures needed to traverse the steep and sloping mountain and to manage the side slope present on this route. Foundation footings are directly linked to the superstructure size and thus also accounts for a significant portion of this sum.

The total estimated costs to build the line and the associated access for both options is given in the graph below.

Further details of the profiling analysis and access stipulation for each route follow in the content of this report.



Contents

List of Figures

1 Introduction

The following report outlines two line routing options and the required accessibility for a proposed new double circuit Kingbird line as follows:

Option 1: River Valley Route (as per the old Ceres-Romansrivier 66kV Line which burned down)

Option2: Mountain Pass route, adjacent the existing 400kV Transmission lines

The line will be built as a 132kV line but will initially operate at 66kV until associated infrastructure at its connecting substations, Ceres and Romansrivier, is completed. The 132kV line will provide needed strengthening of the Witzenberg network.

2 Background

Witzenberg 132/66kV 2x80MVA substation provides support for agricultural, commercial and residential load. The substation is located at the end of a radial line and is currently supplied by a single circuit (SCt) 132kV Bear line from Romansrivier substation. In addition, its three-66kV feeders supply several 66/11kV and 66/22kV substations and there is limited interconnectivity to other 66kV lines.

According to Eskom Western Cape Operating Unit's (WCOU) planning report, the total loss of load is approximately 80MVA should a fault occur on the SCt Bear supply line. Furthermore, the line cannot afford any structural failures. The planning report cites that no spares or fabrication drawings are available for the line's structures and should two towers fail, the line would be out of service and would not be able supply Witzenberg substation and its dependent network of almost 3000 customers for several months. Figure 2-1 indicates the substation's position relative to Ceres substation and its main 132kV supply from Romansrivier.

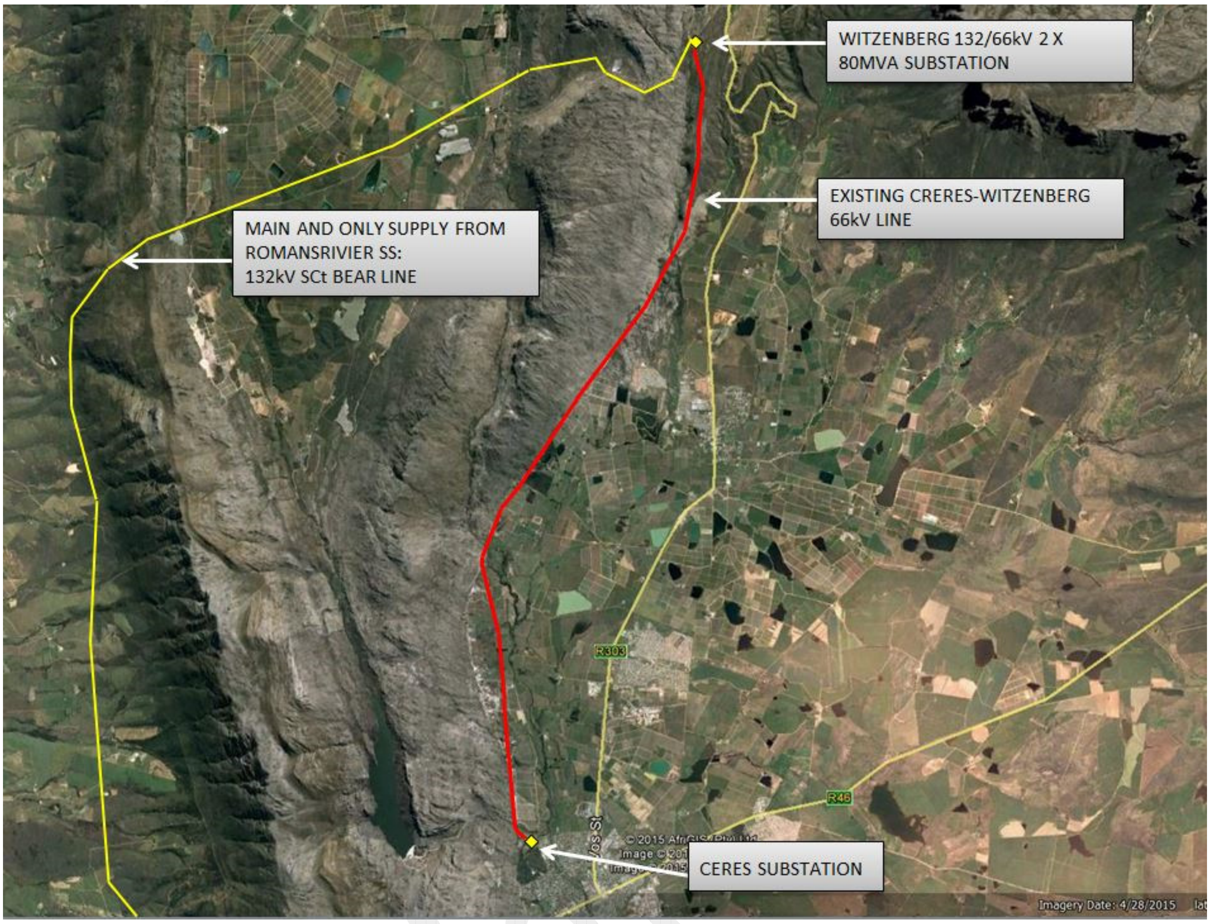


Figure 2-1: Witzenberg substation with main 132kV supply from Romansrivier substation

In addition to the fragility of the network, a 66kV wood pole line connecting Ceres substation to Romansrivier substation that provided some reliability in the area partially burnt down (See Figure 3-1).

Based on these considerations, the planning report's assessment of several solutions concluded that building Ceres-Romansrivier 132kV line and Romansrivier-Witzenberg 132kV line was the most technically and financially viable option.

The content that follows provides more detail concerning the technical feasibility of building Ceres-Romansrivier 132kV line and the associated costs of access through both route corridors investigated.

The capital costs involved and the construction constraints and practices specifically required to build in the difficult terrain evident on both routes, is provided as a high-level cost comparison for each conceptual design at the end of this report.

3 Mountain Pass Line Route

A line walk down was conducted with Eskom Land Development on 10 March 2015 to mark feasible tower positions and assess the existing access routes over the mountain pass.

The mountain corridor currently hosts two 400kV lines that traverse past a large water catchment created within a cradle area of the mountain range. An access route to the dam on the eastern slope of the mountain is available however; the 13.4km proposed line route requires new and upgraded access to several tower positions as the line ascends the mountain and descends the western slope. The image below illustrates an overview of the most feasible line route over the mountain relative to other powerlines and major land features.

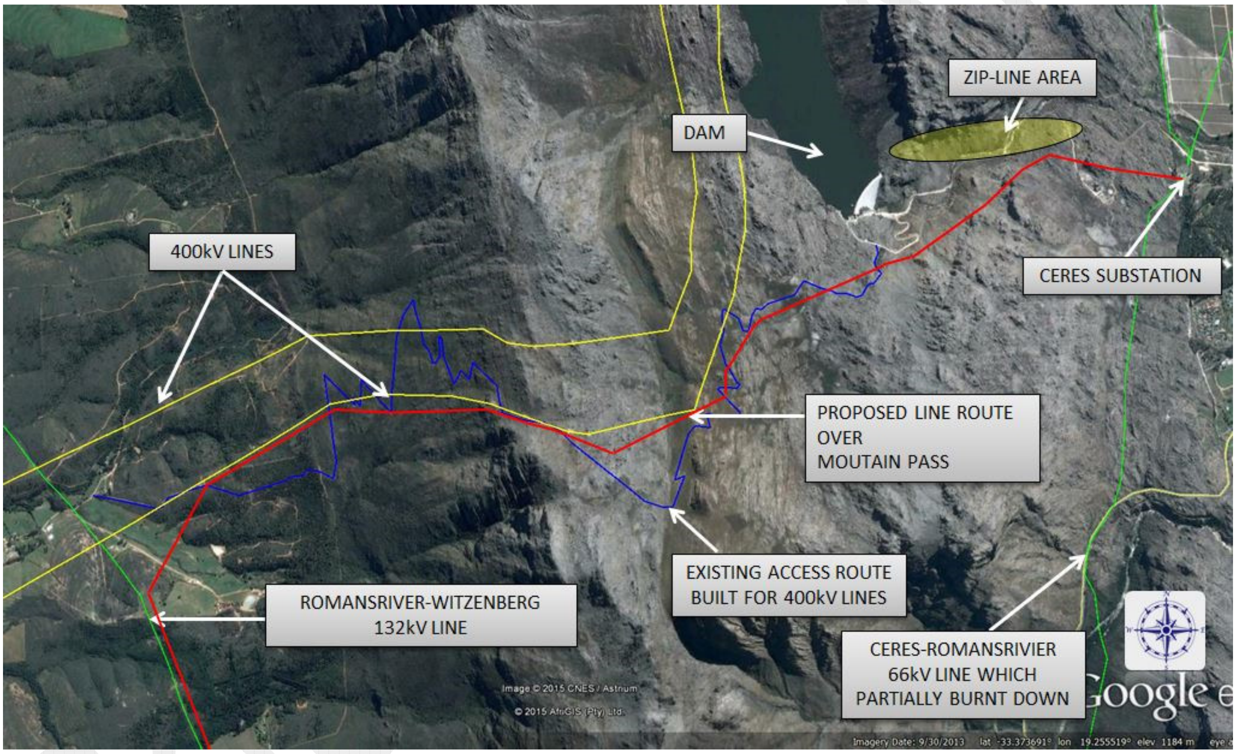


Figure 3-1: Mountain pass line route relative to other powerlines and major land features

3.1 Line Routing and Profiling

3.1.1 Line routing constraints

The line walk revealed the following routing constraints:

- The presence of a Zip-line meant that routing through areas close to or over the Zip-line was not preferable and has been avoided in the final line routing. The Zip-line is constructed through a portion of the valley on the northern side of the existing access road to the dam (See Figure 3-1).
- A large steel water pipeline built above ground from the dam and through the valley towards Ceres substation would require additional road strengthening or the creation of bridge crossings where access to tower positions required crossing over the pipeline. Figure 3-2 shows a portion of the abovementioned pipeline. The final route does not cross this pipeline.

Figure 3-2: Above ground steel pipeline

3.1.2 Line Profiling

For this study profiling and costing of each line and its respective access requirements has been completed to a common point from which both options will follow the same line route to Romansrivier substation.

The provision of LIDAR survey data enabled the creation of a critical virtual terrain model in PLS-CADD. In the virtual environment route options, tower positions and structural capabilities could be assessed in detail. The profile made use of the 247 and 245 lattice structure series as construction of lattice structures is more suited in difficult terrain such as this.

Of importance when routing through mountainous terrain is the management of side slope and assessment of what cable attachment height (CAH) is achievable with the leg extensions available for a particular tower type. The model in this instance was able to provide this information when assessing a viable tower position.

The profile took advantage of the mountain pass' terrain features by positioning towers, where possible, on higher precipices which provided longer spans. This was most beneficial in particular when routing down the western slope of the mountain.

Routing from the mountain crest down the western mountain face offered two options. The first required a 400kV underpass comprising of four cruciform monopole structures and several lattice towers positioned in close proximity to the existing 400kV access route.
The second option took advantage of a depression along the mountain face, which provided an approximately 600m long span to a viable tower position adjacent to the existing access route. Along this route, a second and the longest span on the line route of almost 1km could also be achieved. This option meant an elimination of seven towers and two line crossings when compared to the underpass routing option. See Figure 3-3.

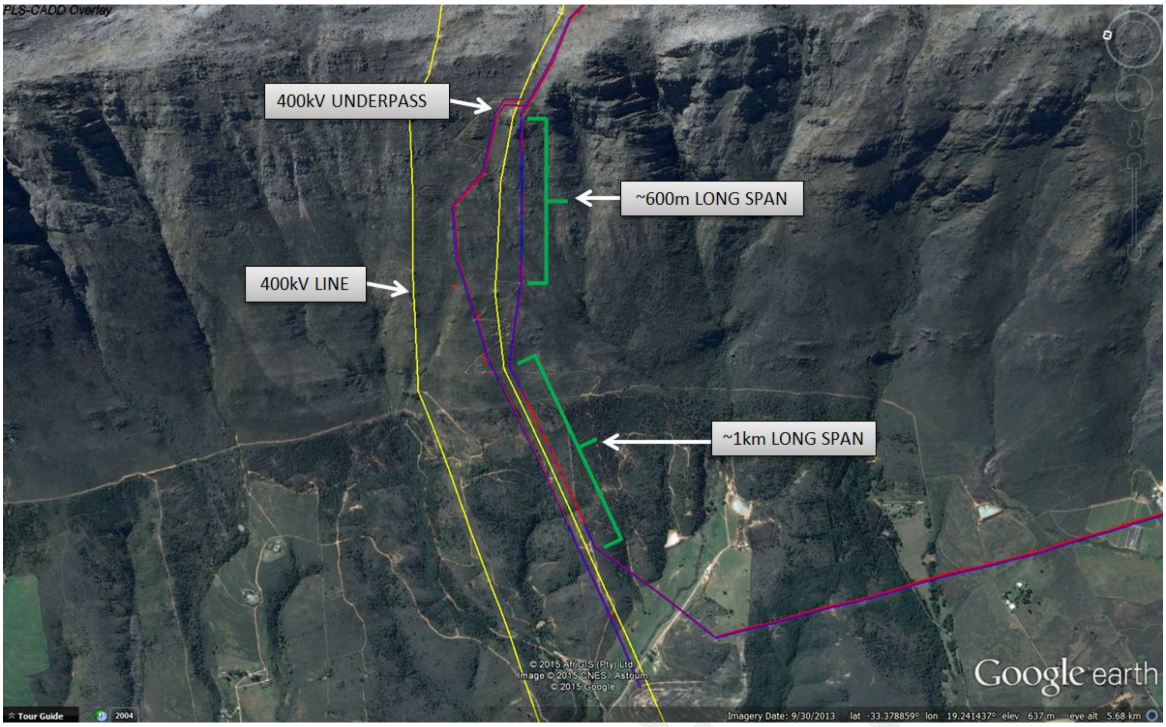


Figure 3-3: Line routing options considered down the western face of the mountain

From the conceptual analysis, it is possible to achieve these long spans with the structure series selected. It is however, prudent in the detail design phase to conduct further detailed finite element (FEM) analysis on the structure cross-arms, which may need additional strengthening to carry the associated weight-span and uplift experienced by the structures. Ice loading is also an applicable load case for this route and appropriate design consideration should be given in the detailed design phase.

3.2 Mountain Pass Access Requirements and Helicopter Assisted Construction

Observations during the line route walk down revealed that the access routes on both sides of the mountain required rehabilitation, upgrading and new access in some parts to access certain tower positions. For instance, the eastern ascent access road was closed post construction and much of the soil had eroded away creating large erosion dongas in the road. The image which follows shows one of several knee deep dongas present.

Typical access construction practices are given in the document *Guideline for Management of Access and Erosion Control on Eskom Servitudes* under Appendix A.

With this reference, access and erosion requirements along the proposed line route and at each tower position were assessed and associated costs estimated.

Figure 3-4: Knee-deep donga on access road up eastern side of mountain

Careful consideration was given to routing the line out of Ceres substation. Rock outcrops cover the terrain in this particular area and viable tower positions were limited. Figure 3-5 indicates the chosen positions for towers 1 to 5 (conceptual profiling tower numbers). Concrete pumping has been cited for tower positions within 200m of an access road. Tower 2 in this case adheres to this criterion and in addition requires a footpath to be constructed. Towers 1, 3 to 5 remain within areas which are easily accessed.

Figure 3-5: Tower positions and line routing out of Ceres substation

Towers 7 and 8 have been positioned on mountain precipices and provide opportunities for long spans as the line traverses up the mountain. These tower positions will however, require helicopter assisted construction as well as earth retaining systems to secure the tower footing and mitigate soil erosion. Helicopter assisted construction will provide material transportation to the tower site where hand assembly and erection of the tower will take place. Figure 3-6 that follows indicates the access requirements for towers 6 to 8.

Figure 3-6: Access and construction requirements structures 6 to 8

Tower 9 is located adjacent to the existing dam access road that is in good condition. Figure 3-7 highlights the required rehabilitation and upgrade of access between towers 10 and 15. Access between towers 14 to 15 is very steep with an inclination of ~27° measured in some parts during the line walk down. Provision for concrete strip roads and full concrete roads (3m wide), both with the required number of berms, have been made to allow access for at least 2 wheel drive LDV's.

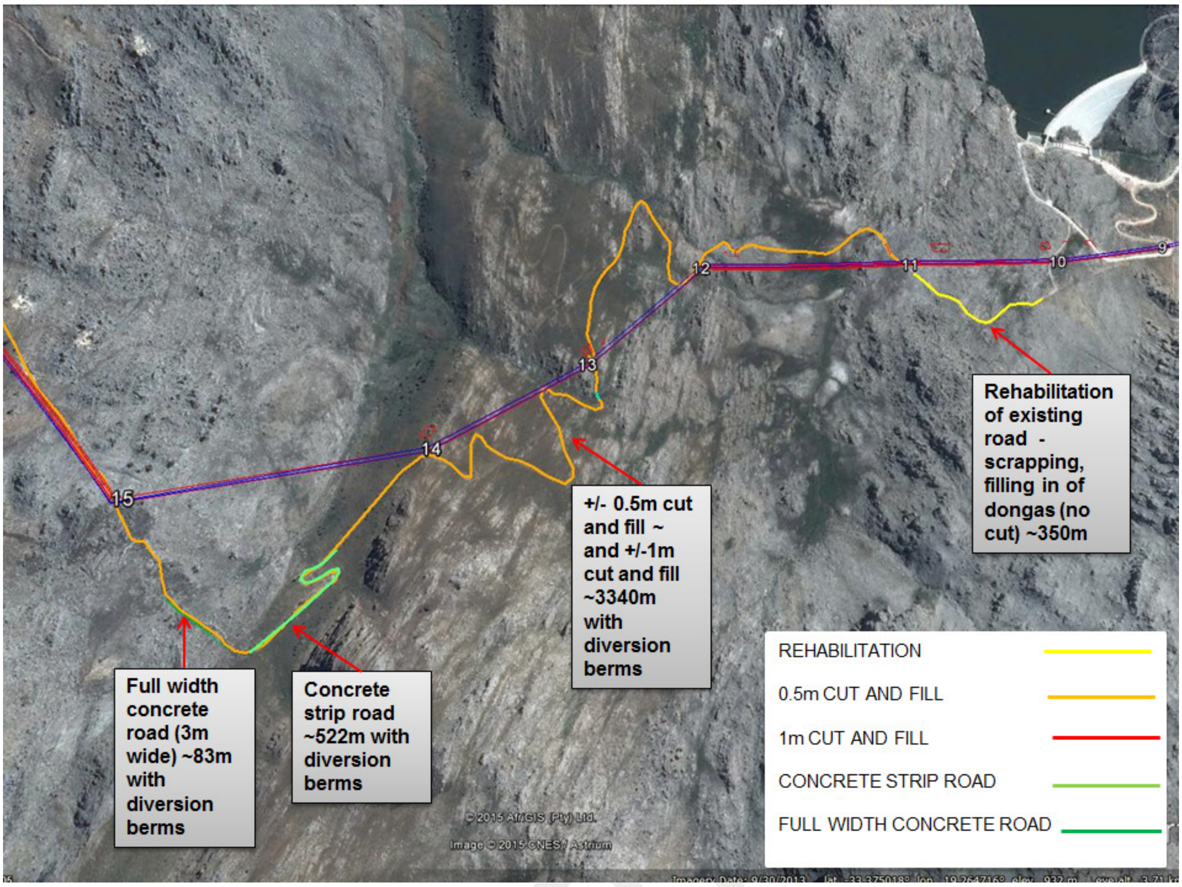


Figure 3-7: Access requirements from tower 10 to 15

Figure 3-8: Concrete strip road before and after

The crest of the mountain is relatively flat and towers situated here require little access attention bar some cut and fill and footpaths to their respective locations.

Towers positioned on the western slope of the mountain will be accessed from existing dirt roads used for forestry activities at the base of the mountain. Tower terracing and gabion wall protection of tower footings at structures 32 to 34 have been marked to stabilise the footing and mitigate any caving of soils. Stone filling from rock in the surrounding environment is encouraged where possible. See figure 3-9.

A large stretch of ~1.6km of 0.5m cut and fill with respective diversion berms is required in addition to backfilling of large, sometimes knee-deep, dongas. Some provision for concrete strip road has been marked where access is steep. See Figure 3-11.

Once the line has traversed the mountain, it runs through a number of farms as it heads toward Romansrivier substation. The costing has considered this factor by providing for an estimated number of gates along this route.

Figure 3-9: Gabion wall protecting tower leg and pole foundation(1)(2)

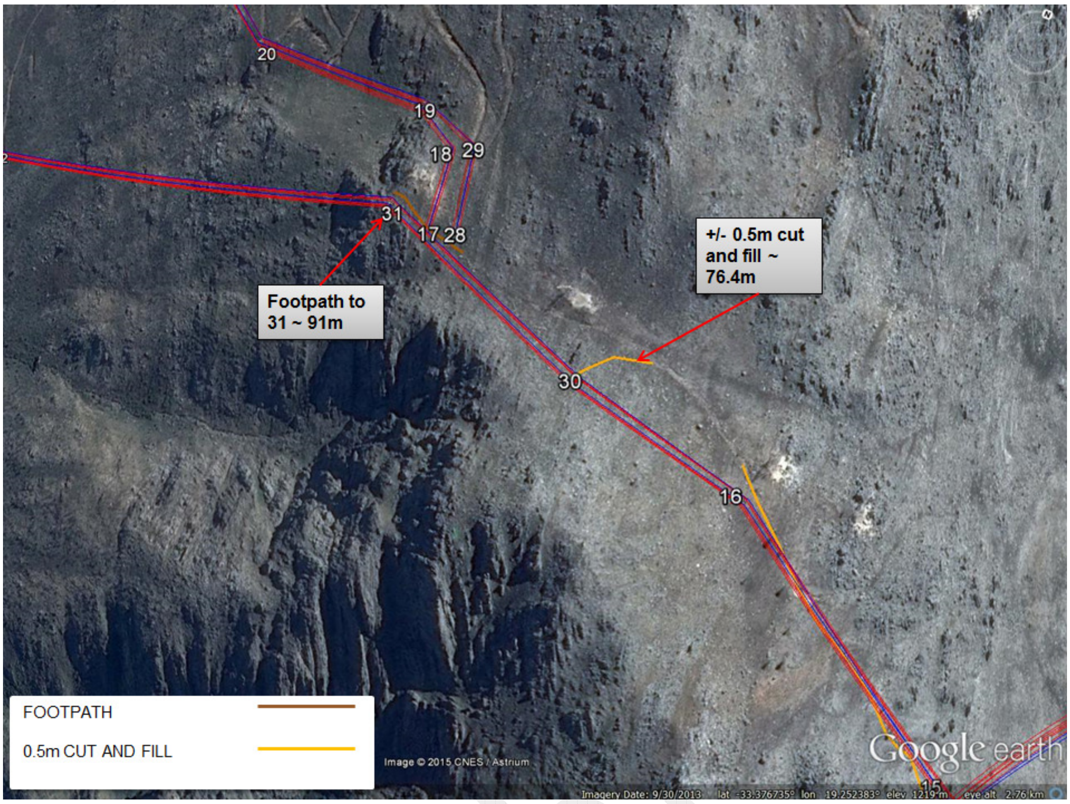


Figure 3-10: Access requirements at the crest of the mountain

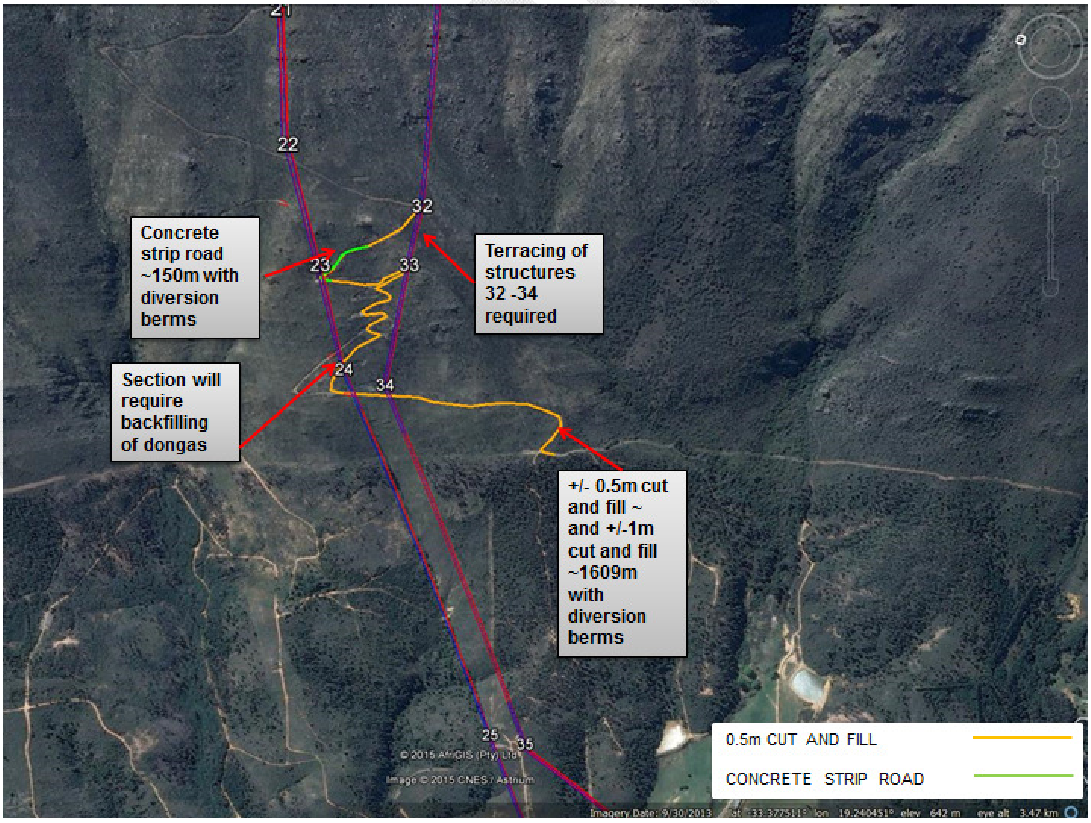


Figure 3-11: Access and erosion control required at towers 32 to 34

4 River Line Route

The alternative river corridor hosted the now partially burnt down Ceres-Romansrivier 66kV line. The route was feasible for construction of the 66kV wood pole line, however, the larger structures required to carry a double circuit Kingbird line has restricted the routing through this corridor. These constraints are discussed in the following paragraphs.

4.1 Line Routing and Profiling

4.1.1 Line routing constraints

- Line routing closest to the road was preferable from an access perspective and limited the need to create large stretches of access road on the opposite side of the river. Where side slope and limited space exist to place a tower adjacent to the road, the line needs to cross the river.
- Several viewpoints exist along the scenic road and concern over visual impacts of tower structures has been highlighted in stakeholder discussions. As far as possible, the design has accommodated this with the use of lattice structures, however, several tower positions did require the use of monopoles where footing space is limited.
- Restricted space and severe side slope in this corridor has meant that some towers have been placed within 20m of the road edge in some instances and possibly within the water flood line areas and buffer zones in others. These positions would require appropriate authorisation and permits from the relevant governing bodies.
- An old non-electrified rail line traverses through the valley and will be operational in future. In some areas, the rail line runs in close proximity to the road and has further constrained areas where towers could be placed.

4.1.2 Line Profiling

The proposed line route is approximately 11.4km. The terminal tower position and termination onto the gantry at Ceres substation is yet to be confirmed. Based on discussions with Eskom Distribution, the new substation layout, which will make provision for a 132kV line connection, has not yet been detailed. This would likely be addressed in the final detailed design and has for this report's purpose been assumed as such.

Similar to the mountain route, advantage has been taken of elevated areas and depressions in the terrain to provide long spans where possible. The constraints mentioned above makes tower placement through the corridor more onerous when compared to the mountain pass route. The image below shows an overview of the line route through the river valley to the profile common point of the study.

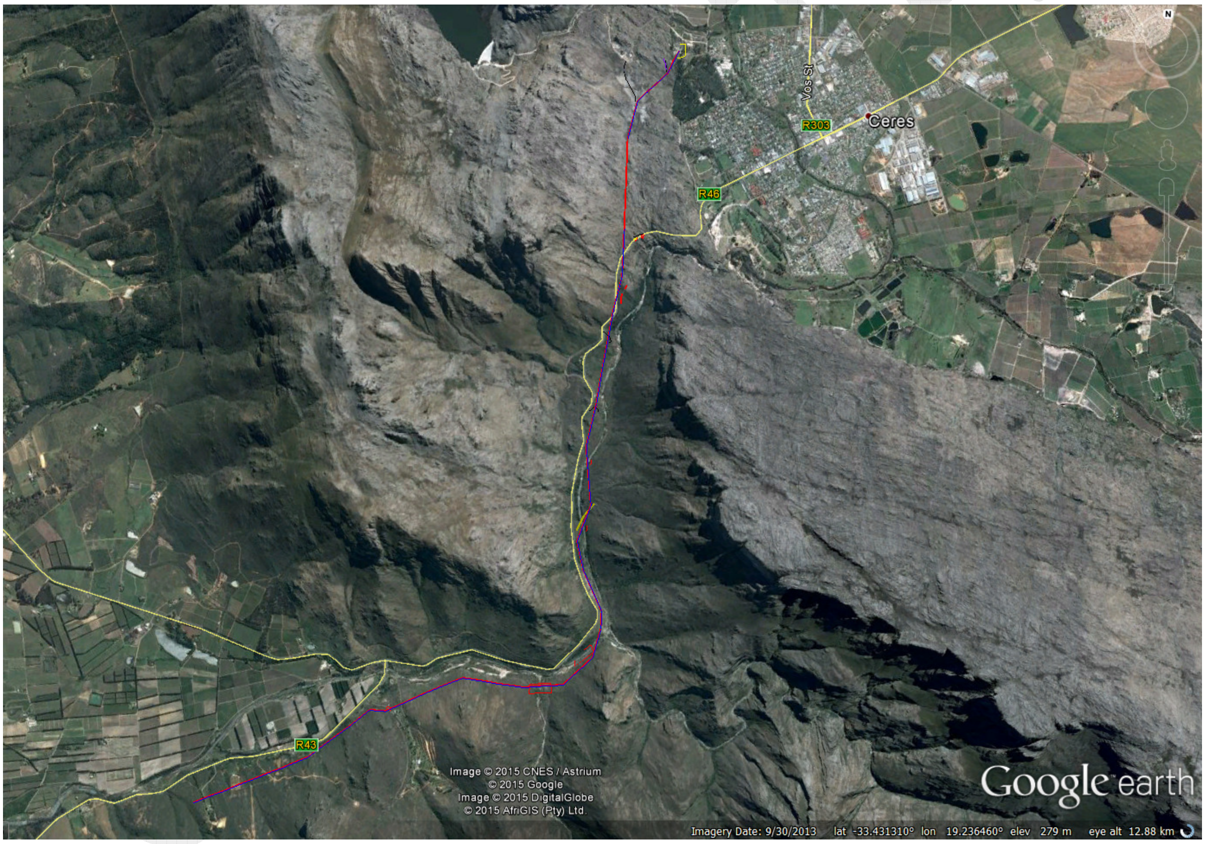


Figure 4-1: Proposed river line route

4.2 River Line Route Access Requirements and Helicopter Assisted Construction

Access to tower 2 will be possible by the construction of ~150m length of ~1m cut and fill. The tower is positioned in a steep area and will require tower footing protection. Access routes to towers 3 to 7 are possible with some cut and fill work off the existing dirt road which rounds old reservoirs at the top of the mountain. The area is fairly flat with some narrow necked areas at towers 6 and 7. Figure 4-2 and Figure 4-3 indicate the marked access requirements from towers 2 to 7.

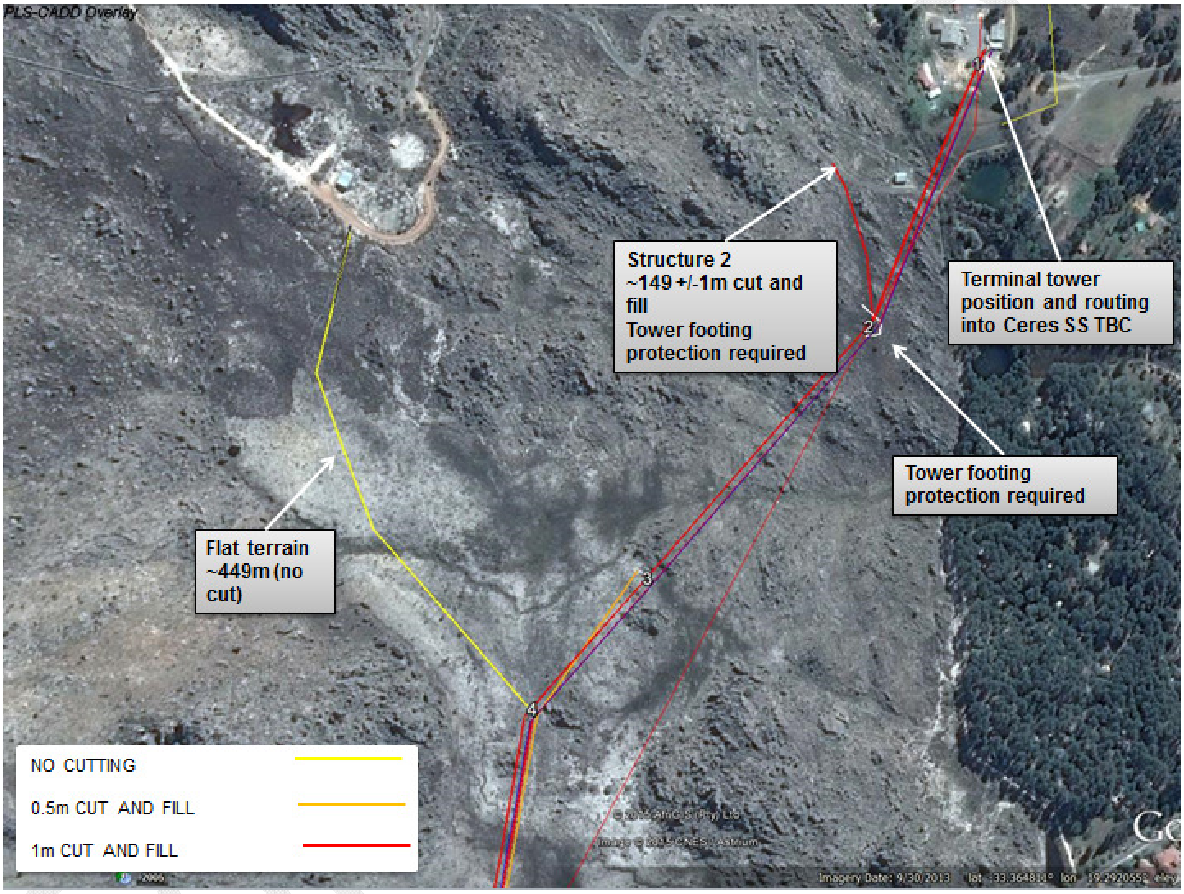


Figure 4-2: Access requirements for towers outside Ceres substation

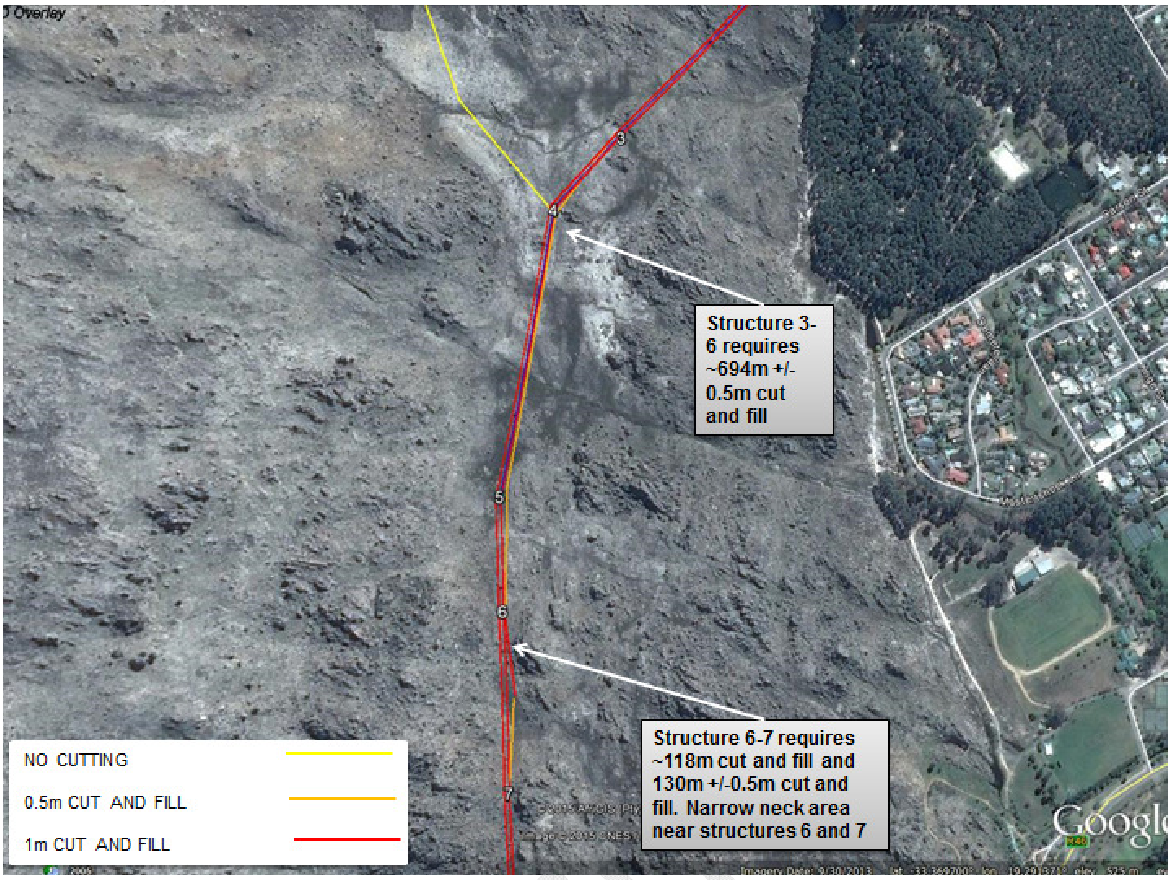


Figure 4-3: Access requirements from towers 3 to 7

The narrow necked terrain at tower 7 makes further road construction to towers 8 and 9 not feasible. In addition, the towers have been placed on higher ground where slopes are steep down toward the R46. Road construction from this main road was ruled as not feasible. Helicopter assisted construction to these positions has therefore been specified.

Tower 9's position has enabled an approximate 350m span to tower 10, situated on the opposite side of the R46 and just outside of a layover area. Tower footing protection here has been specified to stabilise the tower footing as the terrain is steep towards the river below. See Figure 4-4. Access to tower 11 is possible from a rail service road. Footing area at both tower 10 and 11 is limited and monopole structures have been suggested for both positions.

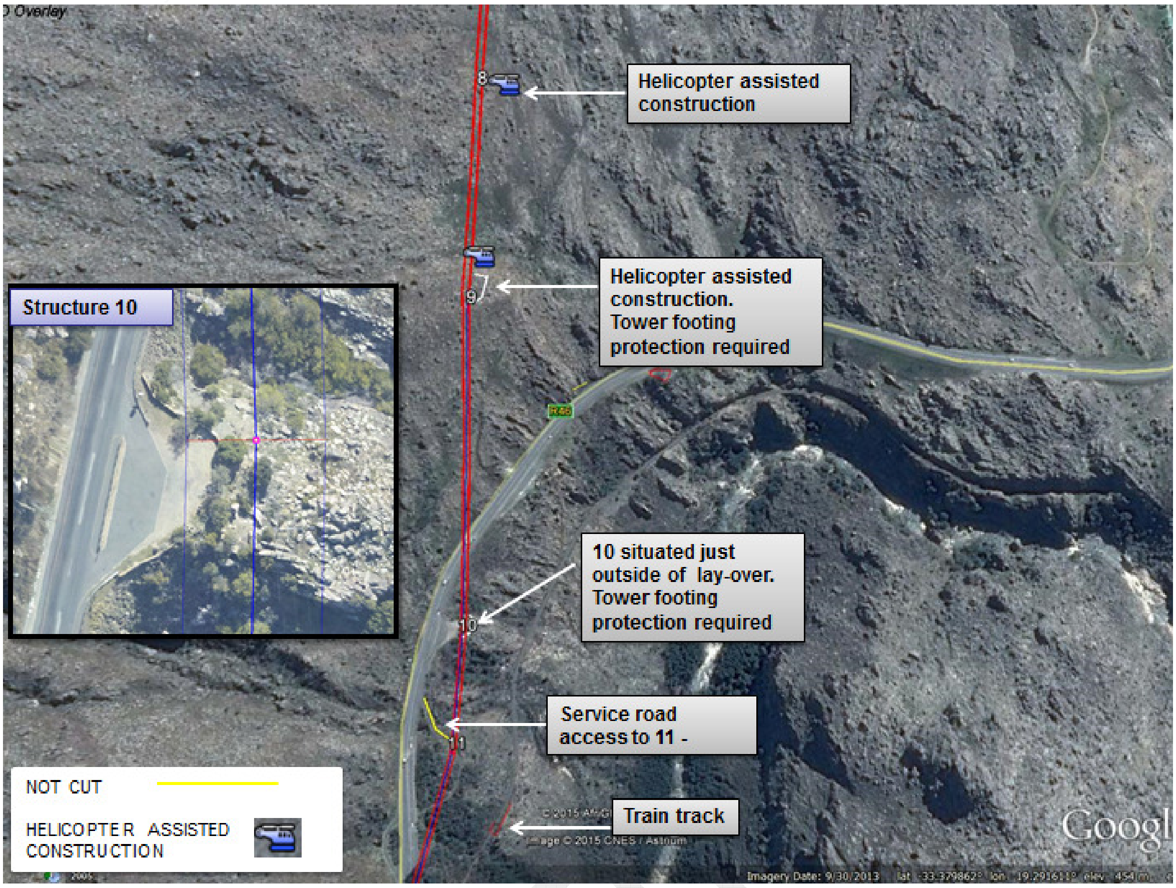


Figure 4-4: Tower positions requiring helicopter assisted construction

Line routing on the same side of the road from tower 11 was preferable to eliminate any further road crossings, however, the close proximity of the railway line to the R46 around tower 12 made placement of this tower very difficult in the limited and sloping area available. To ensure clearances and practicality of construction, this tower has been placed across the road on an embankment and will require 1m cut and fill access construction off the R46 towards the structure position. Terracing for both the structure and crane has been specified.

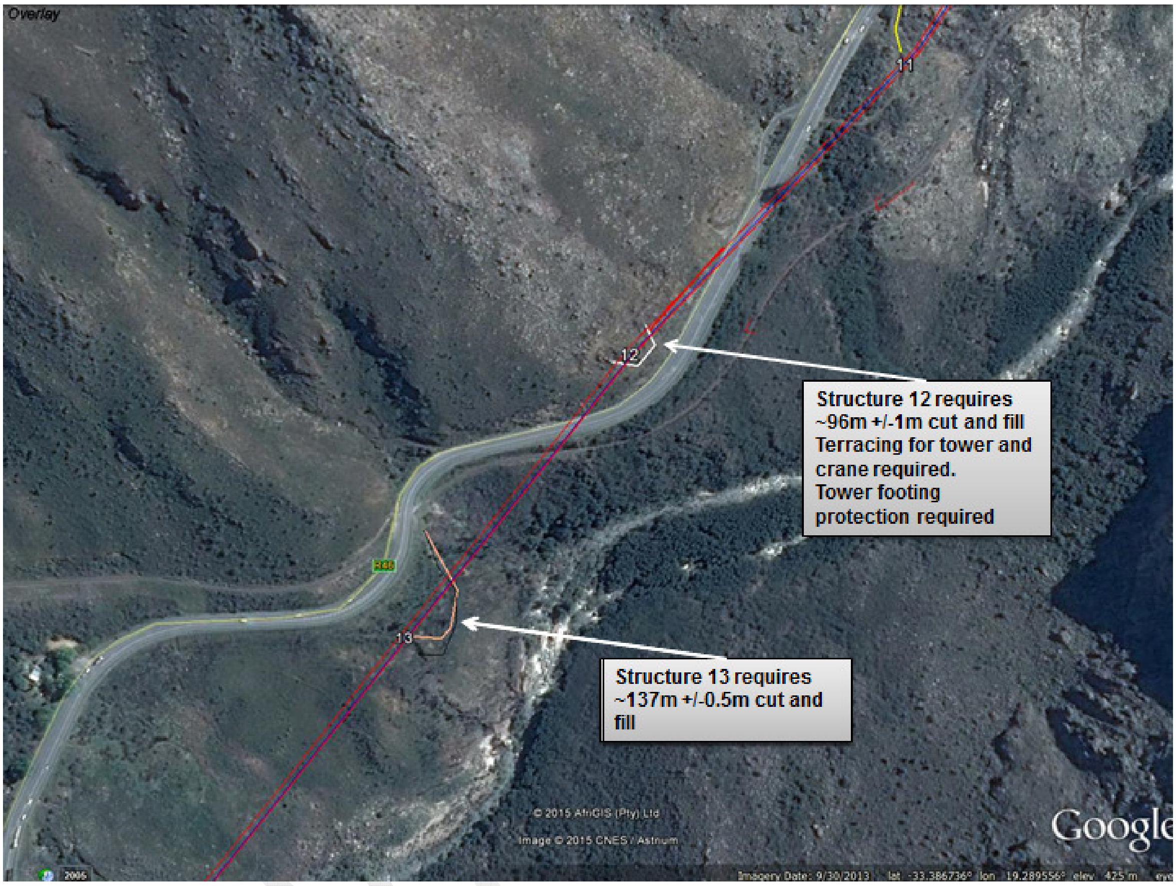


Figure 4-5: Placement of tower 12 and 13 introducing two additional road crossings

A pipes and gabions culvert crossing between structures 16 and 17 and between structures 26 and 27 is required to ensure safe and sustainable access over the river at these spans. There are times of year where river flow is very strong and therefore a more robust crossing type has been chosen. The figures that follow illustrate an example of the costed culvert and a Reno mattress drift crossing.

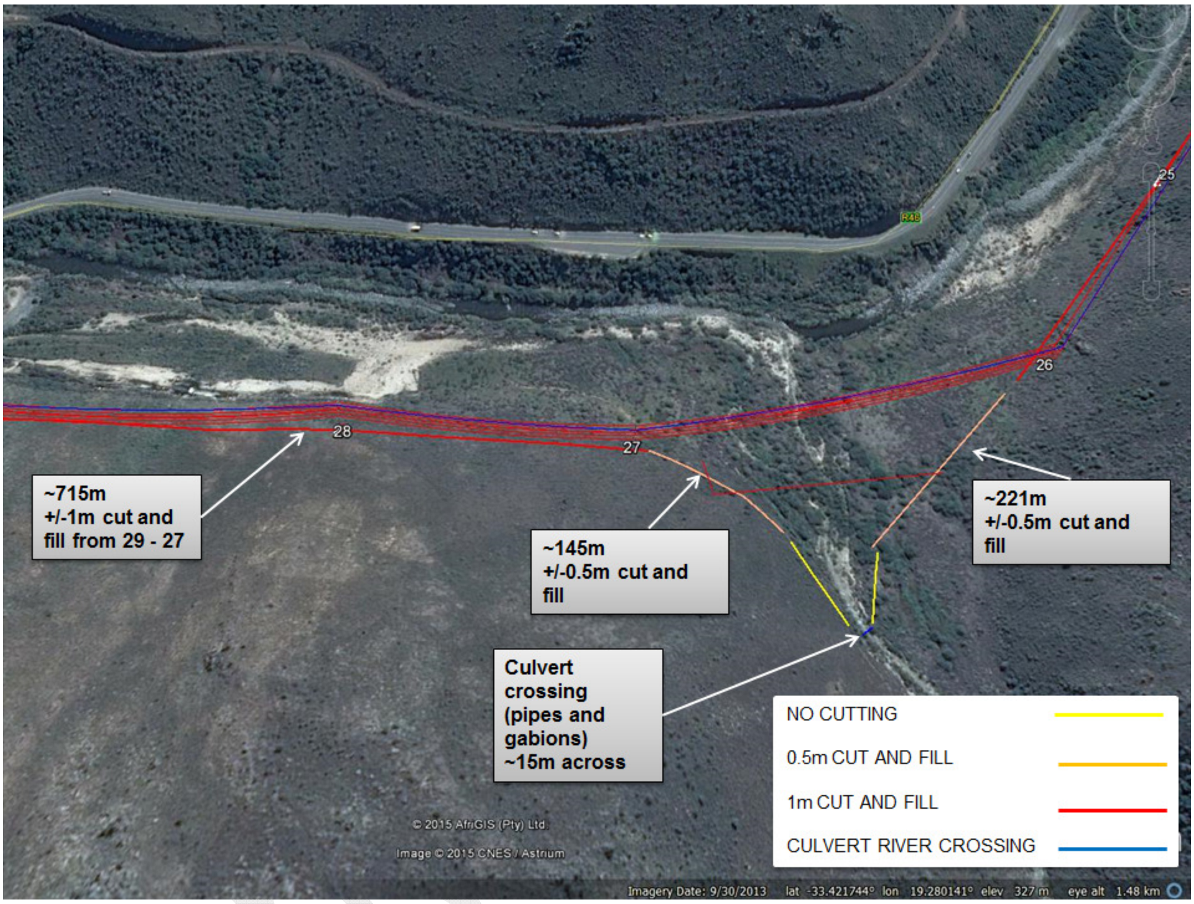


Figure 4-6: Marked river crossing and cut and fill requirements to tower positions

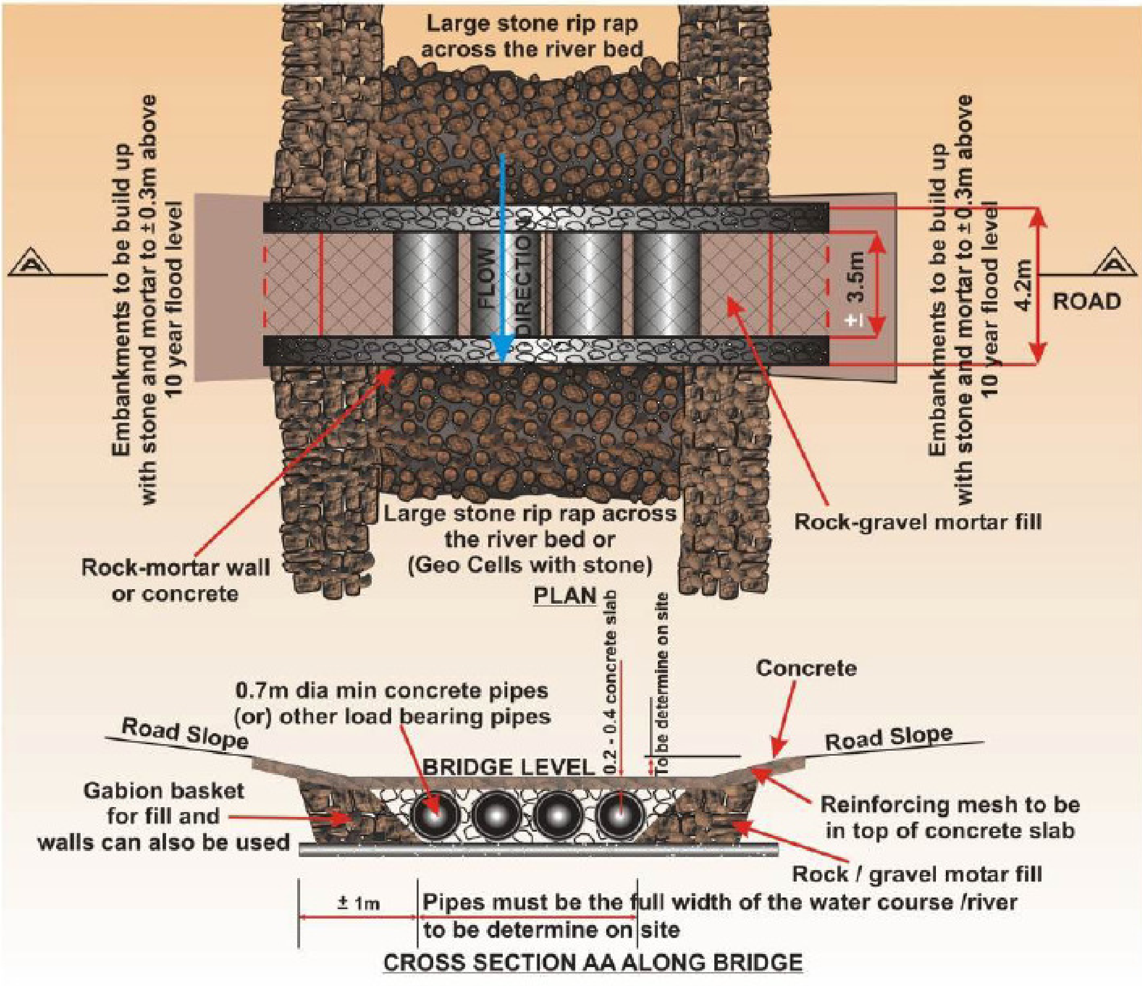


Figure 4-7: Pipes and gabions culvert crossing[(1)]

Figure 4-8: Reno mattress drift crossing[(1)]