MOKOLO CROCODILE WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

ROADS AND TRAFFIC BASELINE ASSESSMENT REPORT

TCTA A new word for water

GBN JOINT VENTURE

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ROADS AND TRAFFIC BASELINE ASSESSMENT REPORT

February 2022

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RECORD OF REVISIONS

DATE	REVISION	AUTHOR	COMMENTS
13 August 2021	Rev 01		Issued to GBN-JV for comment. Draft traffic section.
2 November 2021	Rev 02		Draft Roads and Traffic Baseline Assessment Report
2 February 2022	Rev 03		Final Roads and Traffic Baseline Assessment Report

1 EXECUTIVE SUMMARY

1.1 Introduction

The GIBB Bigen Nyeleti Joint Venture (GBN-JV) is the appointed Service Provider to the Mokolo and Crocodile River Water Augmentation Project (MCWAP-2) for consulting engineering services. The project entails augmenting water supply from the Mokolo and Crocodile River West to the Waterberg coal fields in the Lephalale area.

The intended MCWAP-2 project is expected to impact the local road network with construction-related traffic, hence the environment authorisation requirement that "A traffic monitoring programme (TMP) must be implemented, and roads maintained. The TMP must form part of the amended EMPr to be submitted as per Condition 13 and 14".

The requirement for such a report covers:

- Pre-construction baseline monitoring to determine the pre-construction state which will serve as a reference for measuring later impacts,
- Assessment of the impact of pipeline construction (and associated construction) on the existing road infrastructure by evaluating existing conditions and possible deviations from baseline conditions and the significance of such adverse effects,
- Identifying mitigating measures for implementation during construction, and
- A roads and traffic baseline assessment report.

Following on from the above, Merchelles Collective (Pty) Ltd was appointed by GBN-JV to carry out a Roads and Traffic Baseline Assessment Report.

The roads forming part of the assessment are as listed in the Table 1-1 below. The roads include both surfaced and unsurfaced roads with the R-routes falling under the jurisdiction of South African National Roads Agency and the D-routes forming part of the Roads Agency Limpopo network. Gravel Roads 2, 3 and 4 are private farm access and service roads. The network of roads is shown graphically in Figure 1-1 to follow.

Table 1-1: Scope of Roads

Road No.	From		To		Length (km)	Authority
	km	Description	km	Description		
SURFACED ROADS						
R510-2	28.60	R511-3	37.20	R510-3	8.60	SANRAL
R510-3	0.00	R510-2	47.80	D2701	47.80	SANRAL
R511-3	98.50	R516-1	133.00	R510-2	34.50	SANRAL
R516-1	0.00	R511-3	22.10	Leeupoort Quarry Access	22.10	SANRAL
D2701	6.10	R510-3 km 47.8	7.00	D1925	0.90	RAL
D1675	0.00	D2649	13.00	Gravel Road 4	13.00	RAL
D1649	0.00	R510-2	9.20	D769	9.20	RAL
D2649	0.00	D1925	8.20	D1675	8.20	RAL
Road 1	12.95	Gravel Road 2	13.10	R510 - km 19.2	0.20	RAL
UNSURFACED/GRAVEL ROADS						
D769	0	D1649	6.75	Gravel Road 1	6.75	RAL

Road No.	From		To		Length (km)	Authority
	km	Description	km	Description		
D2701	0	R510-3 km 47.8	6.06	Start surfaced	6.06	RAL
D2701	7	End surfaced	23.50	D1925	16.50	RAL
D175	0	D1925	2.75	Pipeline/Railway	2.75	RAL
D1925	0	D2701	45.3	D2649	45.3	RAL
Gravel Road 2	8	Gravel Road 1	12.95	Road 1	4.95	Unknown
Gravel Road 3	0	R510-2 km 21.4	5.4	Pipeline	5.40	Unknown
Gravel Road 4	0	R510-3 km 38.6	56	Gravel Road 5	56.00	Rail Line Authority (Transnet)

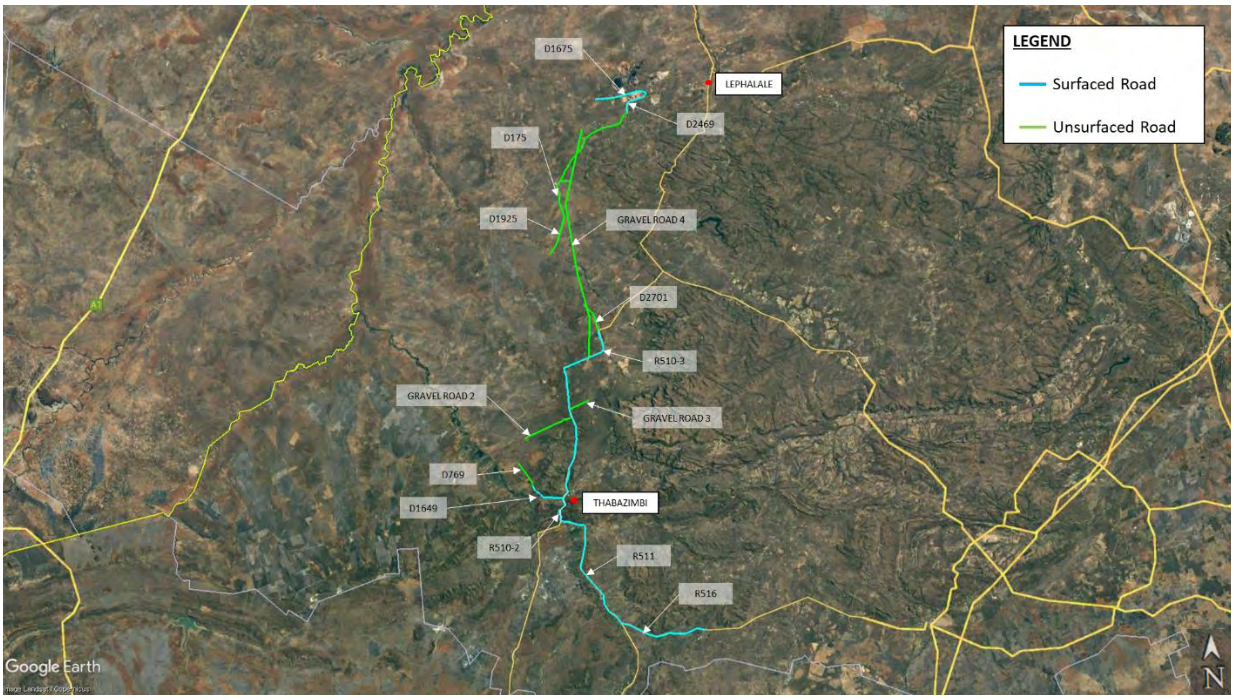

Figure 1-1: Road network possibly providing access to pipeline during construction (Google Earth)

1.2 Road Assessment

The road assessment undertaken has included the following activities:

- Visual surface condition assessment caried out in accordance with TMH 9 Pavement Management Systems: Standard Visual Assessment Manual for Flexible Pavements and TMH 12 Pavement Management Systems: Standard Visual Assessment Manual for Unsealed Roads,
- Dynamic Cone Penetrometer investigation / in-situ strength determination,
- In-situ layering / layer thickness survey, and
- Mechanical measurements (including riding quality and rut depth).

1.2.1 Visual Surface Condition Assessment

The data obtained from the visual surface condition assessment was used to calculate a Visual Condition Index (VCI) per road segment.

The average VCI result per surfaced road is summarised in the Table 1-2 below. These values indicated that the surfaced roads can be classified as fair to good in terms of their visual condition.

Table 1-2: Average VCI per Road (Surfaced)

Road	Average VCI	Condition Category
R510-2	69	Fair
R510-3	85	Good
R511-3	86	Good
R516-1	70	Good
D2701	60	Fair
D1675	74	Good
D1649	69	Fair
D2649	84	Good
Road 1	74	Good

The main measures found contributing to distress along the roads classified as fair included dry and brittle surfacing seal, surface cracks, potholes, block- and crocodile cracks, transverse cracks, patching, flushing of binder, rutting and surface failures.

As for the surfaced roads, a VCI was calculated for the unsurfaced/gravel roads per road segment. The average VCI results per road is summarised in Table 1-3 below. These values show that the gravel roads are classified as fair to poor in terms of their visual condition.

Table 1-3: Average VCI per Road (unsurfaced/gravel)

Road	Average VCI	Condition Category
D769	43	Poor
D2701	49	Poor
D175	50	Fair
D1925	39	Poor
Gravel Road 2	52	Fair
Gravel Road 3	38	Poor
Gravel Road 4	54	Fair

All unsurfaced roads show distress in the form of potholes with high severity although the extent thereof is limited. Erosion of the surface (wearing course) is generally a problem with transverse erosion prominent on all road sections. Longitudinal erosion was noted on several of the unsurfaced road sections. The degree of erosion is generally of high severity.

1.2.2 Dynamic Cone Penetrometer (DCP) Investigation / In-situ Strength Determination

To assess the in-situ strength a DCP survey was carried out on all roads. During this investigation one of the challenges experienced was refusal of the DCP when encountering rigid layers.

This turned out to be the case with most DCP positions. Normally with the assessment of pavement structure the one property that can be calculated is the total number of blows to penetrate 800 mm into the existing pavement structure. However due to the above DCP refusal aspect this property could not be calculated, hence the property of penetration rate (DN) in mm/blow was used to assess the pavement structures of the various roads.

From the assessment of the penetration rates on the surfaced roads (generally in the order of 3mm to 8mm), it was concluded that the pavements can be considered as structurally sound, with the in-situ material of G5 to G6 quality.

For the gravel roads DN values varied more but generally DN values were in the order of 6mm to 9mm with the odd value of 23 mm/blow and 30 mm/blow. Based on this and considering that these are gravel roads, the pavements can be considered as structurally sound with in-situ material of G6-qualilty or better. The higher DN values (generally encountered at lower levels in the pavement structure) indicate material of G9-quality or better.

In summary, the DCP penetration rates measured along the respective roads forming part of this project generally indicate good quality in-situ material within the respective pavement structures. It should be noted that this assessment considered only those layers that could be penetrated with the DCP instrument. Considering this, the findings indicate that material quality is acceptable.

1.2.3 In-Situ Layering / Layer Thickness

The in-situ layering is a quantitative assessment by measuring the thickness of wearing course layers for unsurfaced roads. It is expected that the increase in construction-related traffic will lead to gravel loss of the wearing course material over time, hence the reason to measure the thickness of wearing course at identified locations. As part of the assessment of the unsurfaced roads, wearing course thickness was measured at all locations identified for in-situ material strength determination.

The average wearing course layer thickness as determined per unsurfaced road is summarised in the Table 1-4 below.

Table 1-4 : Average wearing course thickness per gravel road (Unsurfaced D-Roads)

Road	Average wearing course thickness (mm)	Comments
D769	55	Wearing course layer thicknesses varied greatly. Riding quality was generally poor.
D2701	85	Wearing course layer thicknesses varied. Riding quality experienced as poor.
D175	0	Limited evidence of wearing course over this section.
D1925	65	Wearing course layer thicknesses varied greatly resulting in poor riding quality. A 10 km section is pure sand with no evidence of wearing course layer. A further section is hardly trafficable due to erosion etc.

Unsurfaced roads are expected at most times to have at least a 200 mm layer of gravel wearing course material in place to ensure a functional and reasonably smooth riding surface. Whilst G6/G7 quality material is normally utilised for gravel wearing course, very often the material that is available from local borrow areas is what ends up being used for the wearing course.

Contrary to the above, the layer thickness assessment found that the wearing course on all gravel roads varied greatly in thickness and rarely was of 200 mm thickness. In summary the following comments can be made in terms of findings:

- Wearing course material varied greatly in thickness and quality. Generally, where reasonable wearing course material was found, it appeared to be of G7/G8-quality.

- On many sections of road wearing course material is limited with traffic essentially travelling on subgrade material. In such instances the road had not been gravelled for quite some time, or it had been gravelled, with material having been displaced or washed away. In some places the subgrade material is sandy (possibly of G8/G9-quality) which at times can make traversing it, challenging. In the case of Road D1925 there is also a section of exposed calcrete-type material would normally constitute G7/G8 -quality.
- Sections of road have only sand as a surface layer which leads to windrows or tracks forming, rendering self-drainage of the roadway totally ineffective.
- The strictly service roads e.g. Gravel Road 3 and Gravel Road 4 have no wearing course layer and are essentially tracks with some sections made up of sand.

1.2.4 Road Roughness / Riding Quality

Riding quality was measured for each of the surfaced roads in both directions at 100 m intervals in terms of the International Roughness Index (IRI). The results were assessed in terms of TRH12 criteria, and for this purpose the R-Roads were classified as Class B roads and the D-Roads as Class C Roads.

The Road Surface Profilometer (RSP) was used to measure the IRI and as the RSP also computes rut depth, the latter have also been assessed for the surfaced roads.

In summary, the results from the mechanical survey are recorded in Table 1-5 below.

Table 1-5: Mechanical Survey Results - Riding Quality/RUT Depth

Road	IRI			Rut Depth		
	Classification - Percentage of Results			Classification - Percentage of Results		
	Sound	Warning	Severe	Sound	Warning	Severe
R510-2	72.67%	12.79%	14.53%	80.47%	6.69%	12.85%
R510-3	87.71%	8.33%	3.96%	86.03%	6.92%	7.05%
R511-3	91.62%	7.08%	1.30%	85.93%	7.20%	6.87%
R516-1	61.94%	24.32%	13.74%	46.60%	14.68%	38.72%
D2701	90.00%	0.00%	10.00%	91.00%	5.50%	3.50%
D1675	100.00%	0.00%	0.00%	97.48%	2.44%	0.08%
D1649	90.32%	6.45%	3.23%	77.57%	18.22%	4.22%
D2649	97.56%	2.44%	0.00%	99.51%	0.43%	0.06%

From the results it is concluded that in terms of riding quality and rut depth, both the R- and the D- Roads are in an acceptable condition which aligns with the visual assessment (VCI) which reported the surfaced roads in a fair to good condition.

1.2.5 Road Drainage

Road drainage of the surfaced roads seems adequate for all roads. In the case of the R-Roads, these are being maintained to a high standard with road reserves such that drainage structures are fully accessible to ensure proper maintenance and cleaning of drainage culverts etc. The D-Roads on the other hand are not that well maintained with accessibility to the drainage structures for maintenance a lot more challenging, resulting in maintenance being carried out less frequently and, in some instances not at all.

The gravel (unsurfaced) roads display little evidence of proper road drainage. Maintenance to these roads is limited with the only maintenance being the odd grading operation along the roadway. No maintenance is evident of the reserve beyond the edges of the roads. Hence all culverts are silted and blocked with no channels/ditches to accommodate stormwater off the road or to carry stormwater from the culverts.

In many instances pipe culverts are exposed due to the lack of gravel cover, some of which have been crushed by the passing traffic.

In summary, most of the gravel roads lack profile/shape to facilitate stormwater drainage from the roadway combined with all channels and formal drainage being totally ineffective.

Photo 1: Ineffective drainage of roadway

Photo 2: Culvert exposed and damaged

1.2.6 Bridges

The bridges along the R- and D- Roads were likely constructed in the 1960s when the BS 153 code was applicable for bridge design. It is therefore likely that these bridges were designed for HA and HB loading.

The R- and D- Road bridges are currently carrying normal vehicles with the occasional abnormally loaded vehicle. These bridges based on our network level assessment are more than adequate to accommodate the vehicle loads anticipated for the construction project under consideration.

Both road and river R-Road bridges are being well maintained on a regular basis and there are therefore no bridge related issues expected. The D-Road bridges however seem to enjoy less maintenance, and may therefore require monitoring and some attention, in particular the road-over-river bridge on Gravel Road D1925 which as a precautionary measure may at times require debris removal to negate any possible flooding of the road.

Notwithstanding the above, no challenges of a serious nature are expected in relation to the bridges.

1.2.7 Road Safety

The surfaced roads are generally maintained, particularly the R-Roads. D-Roads appear to be less well maintained and, in some instances, required grass cutting and bush clearing for passing and improve visibility.

In the case of the gravel roads, the following comments apply:

- Due to the lack of proper drainage some sections of gravel road, in particular Road D769, Gravel Roads 2 and 3, and Gravel Road D1925 are prone to becoming stormwater channels during rainy periods resulting in the roads becoming muddy and slippery, rendering them unsafe.
- In some instances, gravel roads are narrow e.g., Gravel Road 2 and Gravel Road 3 and may require widening as well as clearing of vegetation to provide safe passage for construction vehicles to pass one another.
- Gravel Road 4 is essentially a service road to the existing railway line. Construction vehicles would need to travel with caution due to the proximity of the road to the railway line.

- Currently gravel roadways, including intersections, service roads and farm accesses have little in terms of road signage. Once the envisaged routes for construction vehicles have been finalised effort will be required to make the roads safe e.g., regular maintenance, signage, road markings, construction-related signage, flagmen, etc.

1.3 Traffic Assessment

The traffic assessment was conducted in accordance with the Manual for Traffic Impact Studies of the Department of Transport and with reference to the COTO TIA Guidelines.

The approach for undertaking the traffic baseline assessment included:

- Site visits
- Traffic count surveys
- Road network assessment
- Base year capacity evaluation of intersections
- Construction related trip generation and distribution to the road network
- Assessment of traffic impacts against specified criteria
- Development of impact and risk mitigation measures

1.3.1 Data Collection

To determine baseline conditions on the road network, a significant data collection exercise was undertaken which included visual assessment of traffic patterns and road infrastructure and undertaking traffic count surveys at various intersections.

Site visits were undertaken by the project team to assess the road network surrounding the proposed pipeline infrastructure and some key observations of various roads within the study area were noted as follows:

Table 1-6: Summary of Site Observations

Road Name	Observations: Advantages	Observations: Defects/Problems
R516 (Surfaced)	i. Signage is very good ii. Grass/verge is well maintained along most of the road iii. Gravel shoulders available for emergency stopping	i. 2-lane cross section, no climbing lanes, insufficient overtaking opportunities for light vehicles to overtake slow moving trucks ii. Grass needs to be cut along certain sections to maintain visibility of road signs
R511 (Surfaced)	i. 2-lane cross section with good overtaking opportunities ii. Signage is good iii. Truck/rest stop just after the R511/R516 intersection iv. Grass/verge is well maintained along most of the road v. Gravel/grass shoulders available for emergency stopping vi. Low traffic volumes	i. Slow moving tractors/farm vehicles from adjacent properties make use of the road

Road Name	Observations: Advantages	Observations: Defects/Problems
R510 (Surfaced)	i. Gravel/grass shoulders available for emergency stopping ii. High pedestrian, minibus taxi and informal trading activity around the town area of Thabazimbi with some NMT safety measures present – street lighting, bollards to separate motorists from pedestrians, zebra crossings at intersections etc. iii. Intermittent sidewalks of various widths and material	i. 2-lane cross section with few overtaking opportunities as one approaches Thabazimbi from the south, overtaking improves past the town section ii. Grass verge at the R510/R511 Intersection needs to be kept short to maintain good sight distance at the intersection at all times iii. Edge breaks present iv. High volume of heavy vehicles present v. High volume of traffic in the Thabazimbi town area
D1649 (Surfaced)	i. Good sight distance at the R510/D1649 Intersection ii. 2-lane cross section with sufficient overtaking opportunities	i. Trolley pushers present – going to the rubbish dump close to km 3/4 ii. Grass along the verge needs to be cut
D769 (Gravel)	i. Good sight distance at the D769/D1649 Intersection, and an additional shared right/through lane on the eastern approach of D1649 improves safety at the junction ii. Fences present on either side of the road iii. Little to no traffic	i. Primary school adjacent to the road (just after intersection with D1649) – scholar patrol appears to be in operation (signage present) ii. Road is very wide – no drainage channels

As part of the data collection exercise, 12-hour manual classified traffic counts were commissioned at 20 identified sections of the surrounding road network. The counts were commissioned for both summer and winter months to establish the seasonal variability in traffic flow volumes due to the high agricultural activity in the area. Table 1-7 describes the intersection locations selected for the traffic counts within the study area.

Table 1-7 : Traffic Count Locations

No.	Intersection Name	Intersection Type
1	R101 and R516 (N1)	Signalised, T-junction
2	R516 and R511	Two-Way Stop Control (TWSC), T-junction
3	R511 and R510	TWSC, T-junction
4	R510 and D1649	TWSC, T-junction
5	D1649 and Local Road	TWSC, T-junction
6	D1649 and D769	TWSC, T-junction
7	D769 and Local Road	Informal gravel junction
8	R510 and P16/2	All-Way Stop Control (AWSC), T-junction

No.	Intersection Name	Intersection Type
9	P16/2 and Local Road	TWSC, T-junction
10	D336 and Local Road	TWSC, T-junction
11	P16/2 and R510	TWSC, 4-legged staggered junction
12	R510 and road to Rooiberg	TWSC, T-junction
13	R510 and D2701	TWSC, T-junction
14	R510 and R517	TWSC, T-junction
15	D2701 and D1925	TWSC, T-junction
16	D1925 and D175	AWSC, 4-legged junction
17	D175 and Access Road	TWSC, T-junction
18	Nelson Mandela Drive and D18	Signalised, T-junction
19	R510 and Nelson Mandela Drive	TWSC, T-junction
20	Nelson Mandela Drive and Access Road B	TWSC, 4-legged junction

The winter counts commenced first and were undertaken on the 6th and 7th May 2021, whilst the summer counts were undertaken on the 4th and 5th of November 2021. Figure 1-2 and Figure 1-3 below show the total 12-hour traffic flows at each of the intersections. The red through to green provides an indication of the flow intensity at each intersection and these volumes represent the baseline traffic flow at intersections prior to construction work.

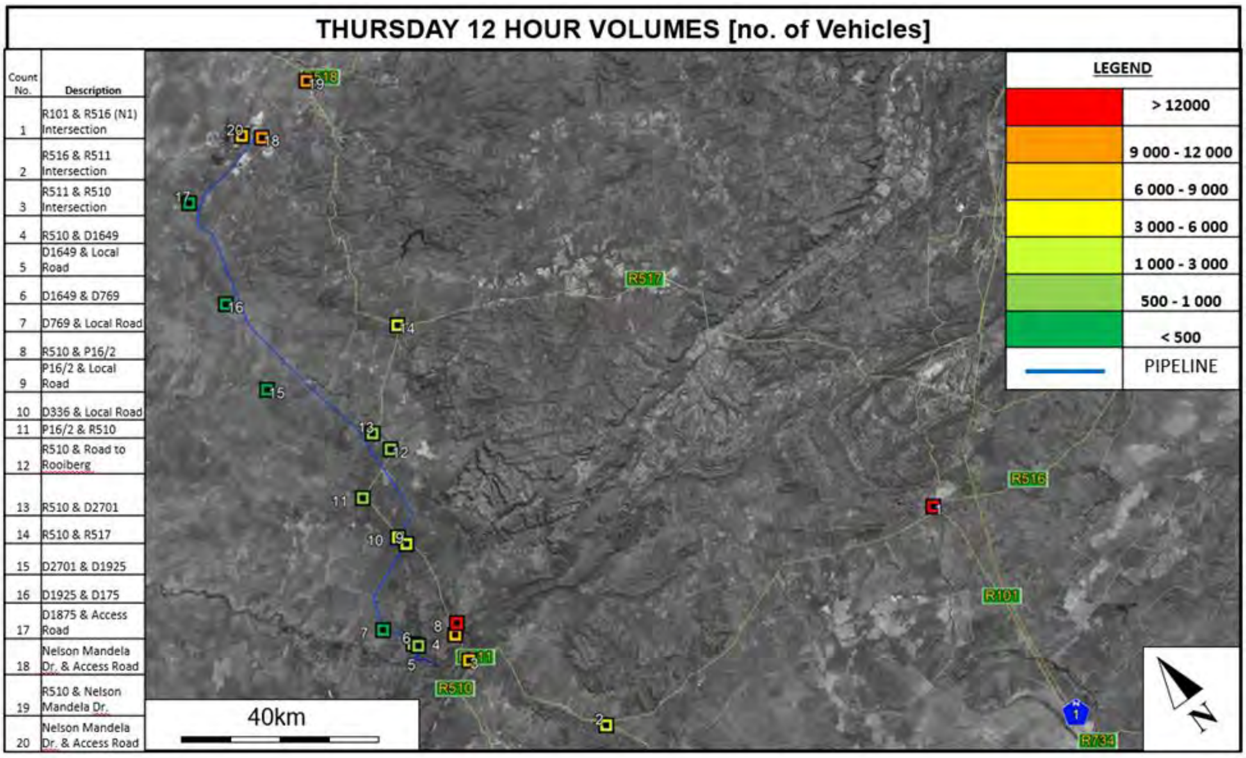

Figure 1-2: 12-Hour Count Volumes, Thursday

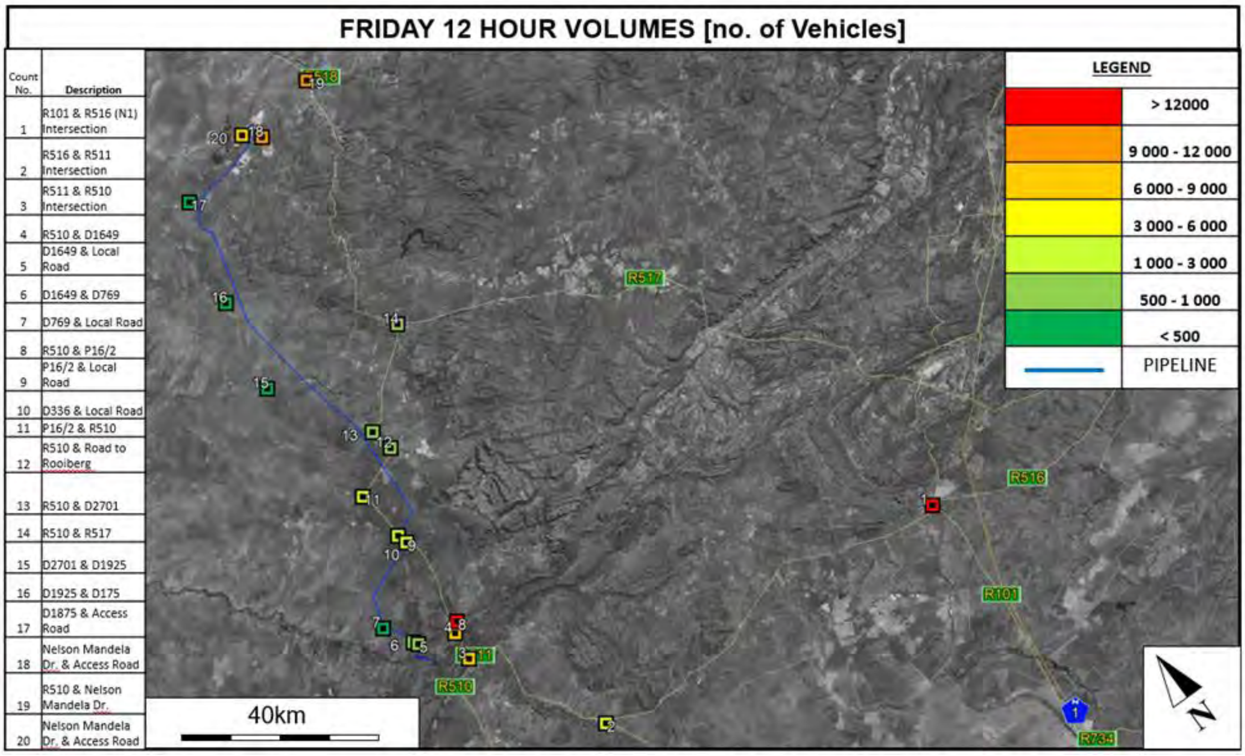

Figure 1-3: 12-hour Count Volumes, Friday

As can be seen from the figures, the intersections processing higher volumes due to regional travel movements have flows greater than 12000veh in a 12-hour period. Those intersections serving predominantly agricultural movements and being gravel roads (D1925 and D2701) have quite low volumes as can be.

1.3.2 Road Network and Connectivity

The pipeline starts at the weir site in Thabazimbi and from there runs in a northerly direction following the existing local road network and crossing the railway line until it reaches its destination to the west of the town of Lephalale, at Steenbokpan.

The road network of concern therefore comprises of roads that provide regional access to the towns of Lephalale and Thabazimbi as well as the local road network that provides access to the construction area. A description of the major roads of interest to the project as well as their functional hierarchy is described as follows:

Table 1-8 Description of connecting road network

Road Name	Functional Road Classification (TRH 26)	Responsible Authority	Function
R516	Class 3 Minor Arterial	RAL / SANRAL	East-west mobility route providing inter-regional access, intersecting with the N1 in the vicinity of the town of Bela Bela
R511	Class 3 Minor Arterial	RAL / SANRAL	North-south mobility route providing inter-regional access to towns such as Brits in the south and eventually ending in the heart of the Johannesburg metropolitan area
R510	Class 3 Minor Arterial	RAL / SANRAL	North-south mobility route providing inter-town access between Lephalale and Thabazimbi, connecting to the R517 which becomes the R33. The latter then intersects with the N1 corridor leading to the economic hub of Gauteng in the south
D1649	Class 4 Rural Collector	RAL	District road providing rural area access
D769	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D2701	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D1925	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D175	Class 4 Rural Collector	RAL	District road providing access to railway bridge (Gravel Road 4)
D2649	Class 4 Rural Collector	RAL	District road providing access to D1675 road
D1675	Class 4 Rural Collector	RAL	District road providing inter-town access and access to national resource areas (coal)

The provincial routes generally have good access management allowing for greater mobility levels. Thus, most project-related long distance, intertown trips will most likely be undertaken along the regional road network rather than the less travelled district road network. The two main towns where project-related activity will be concentrated, namely, Lephalale and Thabazimbi both enjoy good regional accessibility via the R510 and R511, both of which are in good condition. The national road network, i.e., the N1 and N11 can also easily be accessed via this network.

The pipeline itself runs along the local district road network for most of its alignment, thus local level access is also well established. Low traffic flows due to the rural nature of land use activity between the two towns will also make construction access and movement easier to achieve.

Critical access intersections were identified within the area of interest and are considered to be of strategic importance as they connect the site to important economic hubs where resources, labour and accommodation can be found. The capacity to process traffic flows depends on the intersection configuration (additional lanes imply higher capacity) and control type (stop controlled or signalised, the latter capable of processing higher volumes).

The identified critical access intersections are described below.

1. R516/R511 Intersection, T-junction (Side ID No .2)
    - o Two-way stop-controlled intersection, major road R511
    - o Additional intersection capacity is provided on the R511 with an exclusive left turn lane on the northern approach and shared through/right turn lane on the southern approach
    - o Provides regional access to the site as well as between Leeupoort Quarry and Thabazimbi
2. R511/R510 Intersection, T-junction (Site ID No .3)
    - o Two-way stop-controlled intersection, major road R510
    - o Additional intersection capacity is provided on the R510 with a slip lane on the northern approach and shared through/right turn lane on the southern approach
    - o Provides regional access to the site as well as access between Swartklip mine (potential concrete aggregate supply) and Thabazimbi
3. R510/D1649 Intersection, T-junction (Site ID No .4)
    - o Two-way stop-controlled intersection, major road R510
    - o Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the southern approach and shared through/right turn lane on the northern approach
    - o Provides local access to the site
4. R510/P16/2 Intersection, T-junction (Site ID No .8)
    - o All way stop controlled intersection
    - o Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the western approach and shared through/right turn lane on the eastern approach
    - o Provides regional access to the site
5. R510/Nelson Mandela Dr. Intersection, T-junction (Lephalale) (Site ID No .19)
    - o Two-way stop-controlled intersection, major road R510
    - o Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the southern approach and shared through/right turn lane on the eastern approach
    - o Provides regional access to the site

1.3.3 Capacity Analysis

The 20 intersections surveyed, including the 5 critical intersections discussed above, were analysed using a traffic analysis software tool called SIDRA (Signalised and non-signalised Intersection Design and Research Aid). The operating performance of the intersections was evaluated under existing traffic conditions and lane configuration during the AM and PM peak hours.

The operational performance of each intersection was evaluated in terms of delay experienced on each approach as well as capacity of the junction to process the current traffic flows. The measurement for performance is the Level of Service (LOS) defined by the Highway Capacity Manual in which letters A through F are used. LOS A depicts free flow conditions while LOS F denotes a breakdown in traffic flow.

For rural intersections a LOS C is acceptable and for urban intersections a LOS D is deemed acceptable as per the TRH 16 Traffic Impact Assessment Manual.

The overall intersection LOS results were considered acceptable for all intersections except for Intersection No. 8 R510/P16/2. It is recommended that the intersection is monitored during the construction period and should queues greater than 4 vehicles form on any of the approaches (signal warrant as per SARTSM Vol. 3) then a temporary signal is installed by the Contractor.

Although a signal might be required under current conditions it is recommended that the local municipality is first consulted as they may not have the capacity or resources to maintain the signal. It was noted during the site investigation, that one of the signals along this section of road was switched off and the intersection had reverted to an AWSC, which could be owing to the aforesaid lack of resources.

The LOS summary for the intersection is provided below,

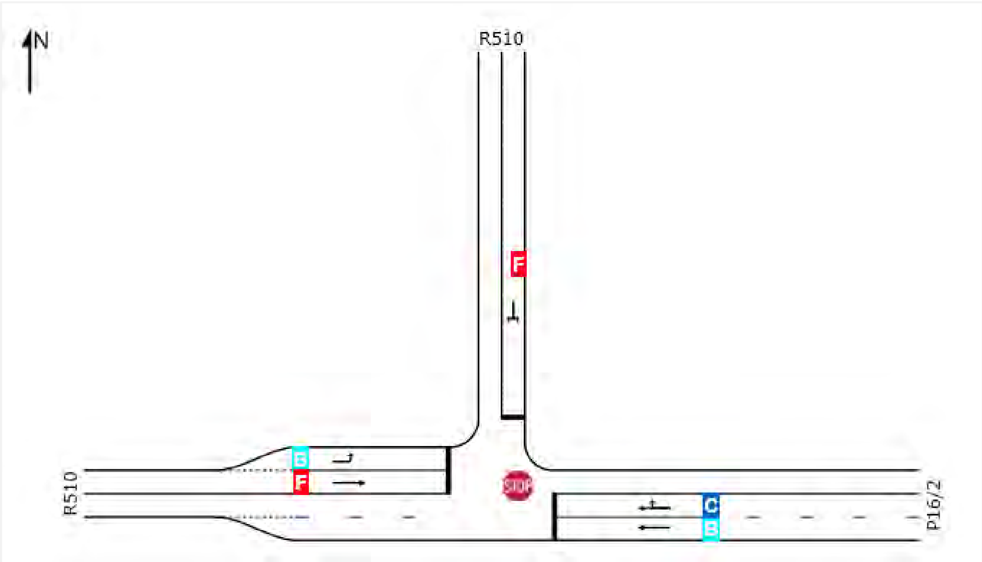

Figure 1-4 R510/P16/2 Intersection layout and LOS summary

1.3.4 Trip Generation and Distribution

The trip generation calculations have been based on the latest available information on construction activities and technical assumptions received from the GBN-JV team. Information was received from the technical team related to the envisioned labour force, construction schedule and movement of personnel and delivery vehicles during the construction phase.

The resultant trips generated by the project during construction were therefore calculated as shown in Table 1-9 and Table 1-10 for the workforce and heavy vehicles respectively. It was assumed that buses and taxis transporting the labour will make trips to/from the local towns of Lephalale, Thabazimbi, Vaalwater, Modimolle, Bela-Bela and Mokopane as well as from the surrounding residential settlements of Marapong and Onverwacht.

Table 1-9: Workforce Vehicle Trips

Workforce	Light Vehicle	Minibus Taxi	Bus
Local Labour	0	19	7
Semi-skilled Labour	0	21	6
Skilled Labour	7	27	5
Professionals	55	0	0

The heavy vehicle trip generation is split between delivery of construction material and the transport of material between sites.

Table 1-10: Estimated heavy vehicle trips

Construction Component	Trip Assumptions	Total HV Trips Generated	Annual HV Trips over a 60-month construction period	Average Daily HV Trips
Delivery of Materials to Site for Construction				
1. Fencing	1 truck load every 200m of pipeline length	682	136	1
2. Pipe Deliveries	Delivered in 18m long pipes			
DN900	6 pipes per load	59	12	1
DN1000 to DN1200	4 pipes per load	257	51	1
DN1400	3 pipes per load	889	178	1
DN1500	2 pipes per load	847	169	1
DN1600	1 pipe per load	1833	367	2
3. Material for Valve Chambers	1 chamber every 500m of pipeline length @ 7 trucks for each	1909	382	2
4. Material for Shuttering	Allow for 50 truck loads	50	10	1
5. Materials for Wier and Pump Stations	Allowance for 200 truck loads	200	40	1
6. Material for Break Pressure Reservoir	Allow for 50 truck loads	50	10	1
7. Material for Ancillary Works	Allow for 100 truck loads	100	20	1
Mass Haulage between Construction Activities				
1. Pipeline	Approximately 300000 cubic metres to be transported	29991	5998	27
2. Balancing Reservoir	Approximately 650000 cubic metres to be transported	65000	13000	59
3. Break pressure Reservoir	Approximately 90000 cubic metres to be transported	9000	1800	8
			Total ADTT	**106**

1.3.5 Sketch Plan Model

A Simple sketch plan model was developed to gain understanding on the extent of traffic movements that can be attributed to the construction of the project and the impacted routes and intersections.

The most viable routes between possible origins and destinations were identified and any issues in terms of condition of the roadway, presence of vulnerable road users and social services were highlighted.

Potential sources of accommodation, skilled and unskilled labour, materials and other resources were assessed and are shown graphically in Figure 1-5.

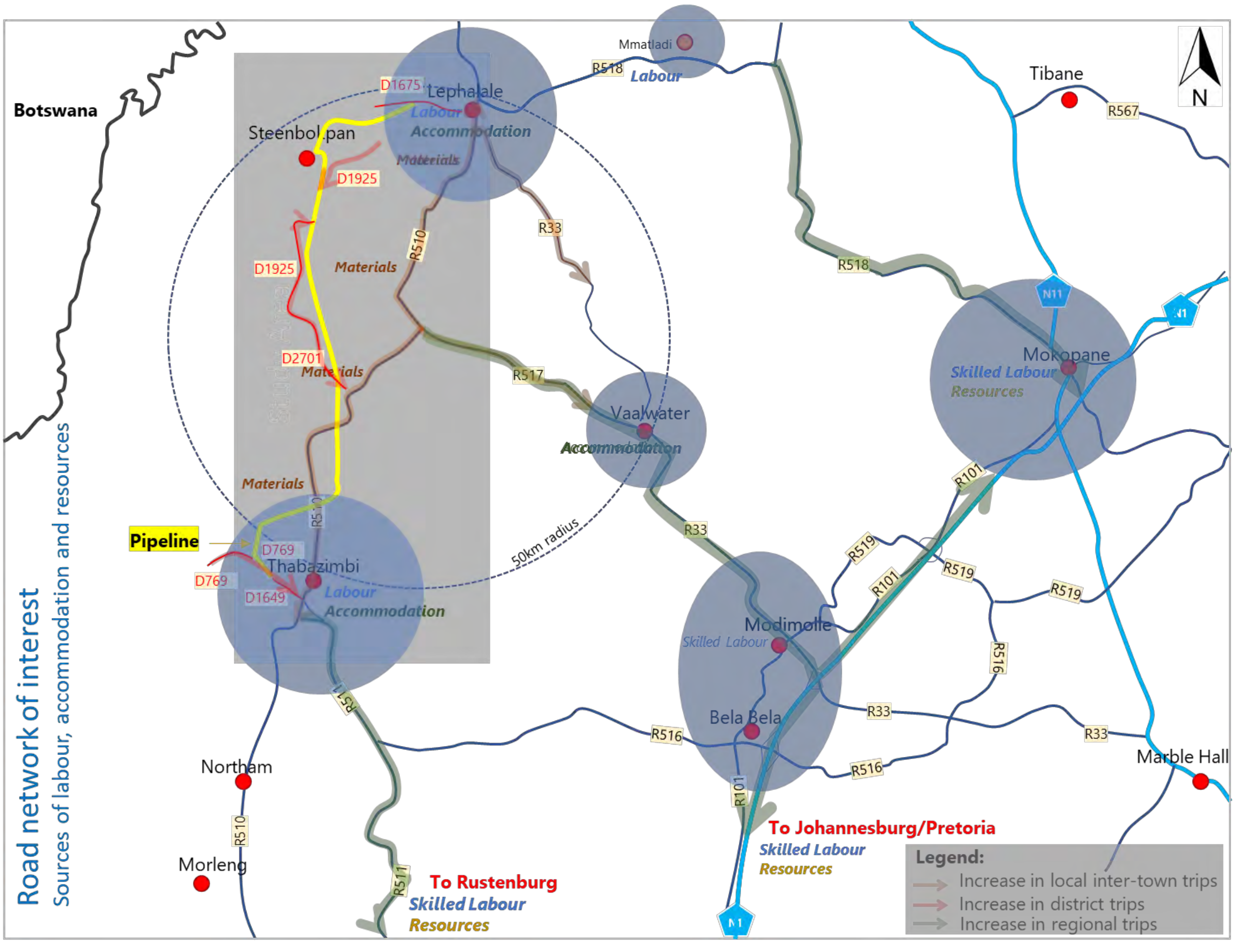

Figure 1-5: Trips sources and increase on the road network

1.3.6 Assessment of Impacts

The GBN-JV provided an impact rating scale with which to rate the existing and potential future impacts that were identified by the Specialists. This was done in accordance with Government Notice R.326, promulgated in terms of Section 24 of the NEMA and the criteria drawn from the Integrated Environmental Management (IEM) Guidelines Series, Guideline 5: Assessment of Alternatives and Impacts, published by the Department of Environmental Affairs (DEAT) (April 1998).

During the construction phase there would be an increase in vehicle movement to and from the area of construction along the pipeline route. This increased vehicle movement is largely associated with the delivery of construction material, pipework and associated infrastructure and has the potential to impact on traffic using the existing road network in the area.

The increase in traffic could generate additional noise, dust and safety impacts for fauna, other road users and people living or working within close proximity to the roads used for accessing the construction site.

The impact of the project will occur over the medium-term construction period (6 years) and with the low level of use of the provincial and secondary roads and the limited disturbance of the road crossings the impact is assessed to have a MEDIUM significance. However, with implementation of mitigation measures this can be reduced to a LOW significance.

These potential impacts are summarised below.

Table 1-11: Summary of Impacts

No.	Receptor/ Resource	Process/ Activity	Environmental Impact	Nature	Residual Risk
1.	Capacity on the road network	Additional vehicle trips generated by construction activity	• Congestion • Unsafe driving conditions on the road network • Frustration of local motorists due to increase in vehicle activity especially the presence of slow-moving construction vehicles	Negative Impact	Moderate
2.	CO^2 Emissions	Additional vehicle trips generated by construction activity	• Increase in CO^2 emissions	Negative Impact	Low
3.	Vulnerable road users – VRU's (pedestrians, informal traders, learners and trolley pushers)	Additional vehicle trips generated by construction activity close to human settlements	• Hazardous road safety conditions and loss of life due to inattentive/reckl-ess driving	Negative Impact	Low
4.	• General road users	Reduced lane widths during construction at pipe jack areas and the weir site adjacent R510	• Reduced road safety	Negative Impact	Low
5.	• Pavement Condition	Increase in heavy vehicle volumes during construction	• Deterioration in pavement quality (increase in potholes) resulting in unsafe driving conditions	Negative Impact	Moderate
6.	• Dust Generation	Increase in vehicle volumes along gravel district roads	• Dust inhalation by staff walking to work and other VRU's living close to construction activity	Negative Impact	Low
7.	• Noise generation by heavy vehicles and construction activity	Construction activity	• Noise Pollution to nearby residential areas within earshot	Negative Impact	Low
8.	• Disturbance to Fauna and Flora	Removal of vegetation and trees at construction sites	• Fragmentation of habitat for native fauna and flora	Negative Impact	Moderate

1.4 Conclusions

1.4.1 Road Assessment

VCI results demonstrate that the **surfaced roads** are currently in a fair-to-good condition and the DCP DN-values confirm that the surfaced roads can be considered structurally sound. The surfaced roads were also investigated for riding quality (IRI) and rut depth. The results indicated that apart from Road R510-2 and Road R516-1, more than 80% of each road has an IRI index of less than 3.5. (72.67% of Road R510-2 recorded an IRI index of less than 3.5 whilst Road R516-1 recorded 61.94% for the same).

The South African Pavement Engineering Manual (Figure 24) shows that the expected IRI range for older surfaced roads is between 2.2 and 7.5 and generally all the surfaced roads are within this acceptable range.

As per the surfaced roads, the **gravel roads** are also found to be structurally sound, however it needs to be borne in mind that in many instances the in-situ subgrade layer is in fact serving as a wearing course layer. Therefore, when reference is made to the gravel roads being structurally sound, it refers more to the subgrade layer and the layers below. Further to this, with reference to the visual assessment and the DCP results, indications are that the quality of the current subgrade material is acceptable. In summary, the VCI results demonstrate that the gravel roads are in a poor-to-fair condition.

Roads D769, D2701, D175, and D1925 were each tested for layer thickness and were all found to be well below the minimum required thickness of 200 mm and in some instances the gravel roads had virtually no wearing course layer. The little (if any) wearing course layer was mostly found to consist of loose, sandy material which in some instances needs to be modified and re-graded with a good quality wearing course material.

It is evident from the visual assessment of the gravel roads that the profile of the roads is inadequate for the drainage of stormwater from the roads, that neither the gravel roads nor their drainage culverts have been adequately maintained and, in most cases show little to no signs of maintenance. Generally, culverts are silted, blocked and totally ineffective. In addition, in many instances, culverts have limited or no cover, with evidence of much damage to the culvert barrels. The lack of cover to the culverts may have resulted from subgrade layers and wearing course material being displaced over time. In some instances, the lack of cover may even be from maintenance grading over the years.

1.4.2 Traffic Assessment

The results of the baseline traffic assessment indicate that during the construction phase the district roads providing access to the construction activities will experience increased heavy vehicle volumes over the duration of the construction due to the **movement of personnel and construction materials** whilst the provincial roads allowing for inter-regional movements will experience increased heavy vehicle volumes attributed to the delivery of imported materials to site. The **increased heavy vehicle trips** have potential to impact on the traffic using the road network and may increase the wear and tear on these roads and possibly lead to deterioration in road conditions.

Trips generated from the transportation of abnormal loads have been considered negligible compared to the number of heavy vehicle trips as they will occur less frequently and are typically generated due to abnormal sizes of materials and not necessarily the weight of the material.

Furthermore, the labour force will cause an **increase in public transport trips** and the increased traffic volumes on the road network could generate noise, dust and road safety impacts for other road users and those working or living in close proximity to the project site. It is anticipated that local labourers will originate from surrounding residential settlements in Thabazimbi, Lephalale, Vaalwater, Marapong and Onverwacht.

The traffic count survey data indicates that intersections such as R516/R101 and R511/r510 tend to process higher traffic volumes in excess of 12000 vehicles over a 12-hour period, whilst the gravel road intersections serving predominantly agricultural movements such as D1649/D769 and D1925/D175 process much smaller volumes less than 500 vehicles over a 12-hour period.

The capacity evaluation of critical intersections indicate that most intersection operate well within the acceptable conditions at Level of Service A or B, except for the intersection of R510/P16/2, where consideration should be made for possibly temporarily signalising the intersection for the duration of the project, as the intersection is currently already under significant traffic strain and the addition of heavy construction vehicles is likely to have a further negative impact on the traffic.

During the operational phase of the project, the generated trips will reduce significantly with only a few vehicles expected for the purpose of maintaining the pipeline infrastructure.

The overall impact of the project on traffic and the associated road network is assessed to be **MEDIUM** and may be reduced to LOW with the implementation of mitigation measures. Traffic calculations and impact assessment should be refined for critical road infrastructure elements if more accurate construction information in future suggests that certain impacts may have been underestimated.

1.5 Recommendations

1.5.1 Surfaced Roads

The R-Roads, namely R510-2, R510-3, R511-3 and R516-1 are well maintained and in good condition with no additional work required. All drainage culverts including inlet and outlet structures and side drains are also in good order and require no additional work.

The D-Roads, on the other hand, namely D1649, D2701, D1675, D1649 and D2649 are not well maintained, and although the roads drive reasonably well, significant restorative action is required, which may include some or all of the following:

- Repairs to road edge breaks,
- Sealing of surface cracks with a modified sealant,
- Painting of new road markings and replacement of signage where necessary,
- Installation of centre line road studs,
- Grass cutting and bush clearing between the edge of road and boundary fences as well as in the vicinity of kilometre markers,
- Reinstatement of headwalls and wingwalls and the unblocking of pipe culverts,
- Provision of inlet and outlet channels and stone pitching where necessary to negate erosion, and
- Reinstatement and grading of gravel shoulders.

Apart from the above actions, consideration should be given to the resurfacing of Roads D1649 and D2649 as both these sections of road, although driving well at present, exhibit extensive cracking which may lead to failure especially considering the increased number of construction vehicles which will be traversing these roads.

In the case of Road D1675 which is severely cracked over its entire length of approximately 13 km, consideration should be given, as a minimum, to carrying out extensive crack sealing and if this proves to be ineffective then in-situ recycling, in particular to the last 3 km followed by resurfacing should be considered.

It should be noted that any remedial action carried out to the above-mentioned D-Roads should be planned in coordination with RAL, the responsible road authority.

1.5.2 Gravel Roads

The most common issues relating to the gravel roads include the lack of maintenance, road profile/shape for effective drainage, the varying thickness of the wearing course or its absence and damage to the existing pipe culverts due to the lack of cover. In dealing with these issues, the following actions are to be considered:

- Improve the profile/shape of gravel roads by adding gravel layers (including a wearing course layer layer) thereby elevating the gravel roads to improve riding quality, road drainage as well as providing adequate cover to pipe culverts,
- Replacement of damage pipe culverts and where necessary extending culverts to beyond the road profile,
- Unblocking and cleaning of culverts and providing drainage channels for effective drainage,
- Providing headwalls and wingwalls to culverts and installing the necessary warning signage,
- Grass cutting and bush clearing between the edge of the road and road reserve fences to enable regular maintenance of inlet and outlets to culverts and drainage channels,
- Due to the varying thickness of the wearing course layer of the gravel roads, ensuring a wearing course layer of 200 mm minimum in thickness for all gravel roads and maintaining this layer thickness for the duration of the construction period. At no stage should the wearing course layer be allowed to reduce to less than 150 mm thick, and
- Regular maintenance of the gravel roads for the duration of the construction period which could with ease be achieved by involving local communities.

Further to the above, within the gravel roads there are sections of road which may require total reconstruction, e.g. Road D175 (currently a sand track), Road D1925 (currently a sand track with absolutely no defined shape) and Gravel Road 2, km 1.8 to km 2.8 (an extremely rocky section of road).

Gravel Roads 2, 3 and 4 are essentially non-public farm access service roads. These roads are narrow in places and may need widening to facilitate the safe passing of construction vehicles. In addition, these roads have very limited drainage and may require a combination of pipe culverts and diagonal gravel mounds to facilitate improved drainage. In the case of Gravel Road 4 which is a service road running parallel to an existing railway line it is essential that drainage be provided across this road at regular intervals which would then also accommodate drainage from the railway line.

With respect to the roads, it is anticipated that most challenges from local communities may relate to the gravel roads where any perceived deterioration to their condition will be regarded as construction related. It is therefore considered essential that effort be devoted to improving and maintaining the condition of the gravel roads.

1.5.3 Traffic Management

The following traffic mitigation measures are recommended to reduce impact on traffic operations, roads and the surrounding environment:

- Reduce the speed limit for construction vehicles to 40 km/hr through town areas (on the R510 around Thabazimbi and Nelson Mandela Drive in Lephalale).
- Provision of a temporary right turn lane on the R510 northern approach at Intersection No. 9 (R510 and Road A) to accommodate high right turn movement of trucks (heavily loaded trucks will require a longer gap in oncoming traffic, thus frustrating drivers behind them which may trigger reckless driver behaviour).
- Conduct a warrant for a temporary signal at Intersection No. 8 (R510/P16/2) to reduce delays and improve safety by reducing the number of conflict points.
- Provision of public transport services such as a bus service to/from the construction camps for staff from surrounding settlements to reduce number of car and minibus taxi trips on the network. This will reduce number of car and minibus taxi trips on the network and subsequent reduction in CO_2 emissions.
- Conduct education and awareness training amongst site personnel regarding safe driving practices.
- Restriction of night shift work to remove construction traffic from the road during the night. Should the need for night shift work arise, ensure that areas close to human activity are well-lit

- Implementation of traffic calming measures and pedestrian facilities in the vicinity of Kesarona Primary School located along road D769 as there will be higher than usual volumes of heavy construction vehicles on this road which may compromise safety for school learners that walk or cycle to the school.
    - Install speed bumps in the vicinity of the school.
    - Install additional road signage warning of scholar activity.
    - Provide pedestrian crossing facilities.
    - Reduce speed limit to 20km/h in the vicinity of the school.
    - Assist with scholar patrol duty to ensure learners cross the roads safely.

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LIST OF ACRONYMS	
DCP	Dynamic Cone Penetrometer
DFFE	Department of Forestry, Fisheries, and the Environment
EA	Environmental Authorisation
EMP	Environmental Management Plan
EMPr	Environmental Management Programme
GBN-JV	GIBB Bigen Nyeleti - Joint Venture
HSE	Health Safety and Environment
IRI	International Roughness Index
MCWAP-2	Mokolo and Crocodile River (West) Water Augmentation Project (Phase 2)
OH&S	Occupational Health and Safety
RSP	Road Surface Profilometer
SAPEM	South African Pavement Engineering Manual
TCTA	Trans-Caledon Tunnel Authority
TMP	Traffic Monitoring Programme
VCI	Visual Condition Index

2 INTRODUCTION

1.1 Appointment

The GIBB Bigen Nyeleti Joint Venture (GBN-JV) was appointed by the Trans-Caledon Tunnel Authority (TCTA) to provide Consulting Services for the Mokolo and Crocodile River Water Augmentation Project Phase 2 (MCWAP-2). Merchelles Collective (Pty) Ltd was subsequently appointed as sub-consultant by the GBN-JV for the Roads and Traffic Baseline Assessment on the above-mentioned project.

2.1 Project Background

Major developments are planned for the Waterberg coal fields located in the Lephalale area. As a direct result of the aforementioned developments, the demand for water in the Lephalale area is expected to increase significantly in the future. The purpose of MCWAP-2 is to augment the supply of water to this area from the Mokolo and Crocodile River (West) with an initial delivery capacity of 75 million m^3/annum.

The above-mentioned MCWAP-2 project is expected to impact the local road network with construction-related traffic. In addition, as developments get underway in the Waterberg coal fields traffic volumes are expected to increase and also impact the local road network.

2.2 Purpose and Scope of Study

The GBN-JV requires a Roads and Traffic Baseline Assessment in order to be compliant in terms of the conditions of the Environmental Authorisation (EA) issued for the project by the Department of Forestry, Fisheries and the Environment (DFFE) on 18 March 2019. The EA Condition 43 states that:

"A traffic monitoring programme (TMP) must be implemented, and roads maintained. The TMP must form part of the amended EMPr to be submitted as per Condition 13 and 14".

The road and traffic-related requirements will include:

- o Pre-construction baseline monitoring to determine the pre-construction state which will serve as a reference for measuring later impacts,
- o Assessment of the impact of pipeline construction (and associated construction) on the existing road infrastructure by evaluating existing conditions and possible deviations from baseline conditions and the significance of such adverse effects,
- o Identifying mitigating measures for implementation during construction, and
- o A roads and traffic baseline assessment report.

In summary, the assignment comprises monitoring, assessment (in terms of data gathering, analysis and reporting) and the preparation of the assessment report.

2.3 Study Area

The proposed pipeline route starts at the Vlieëpoort Mountains, West of Thabazimbi, at the identified Weir site in the Crocodile River, in the south-western portion of the project area. From there it runs in a predominantly northerly direction along existing roads, farm boundaries and a railway line, until it reaches its destination at the Medupi and Matimba Power Stations between Steenbokpan and Lephalale. The proposed pipeline route is shown in Figure 2-1.

The project infrastructure is mostly located on privately-owned properties that are primarily used for agricultural practices and game farming. There is also a direct reliance on the water from the Crocodile River (West), up- and downstream of the proposed Vlieëpoort abstraction point, for irrigation purposes.

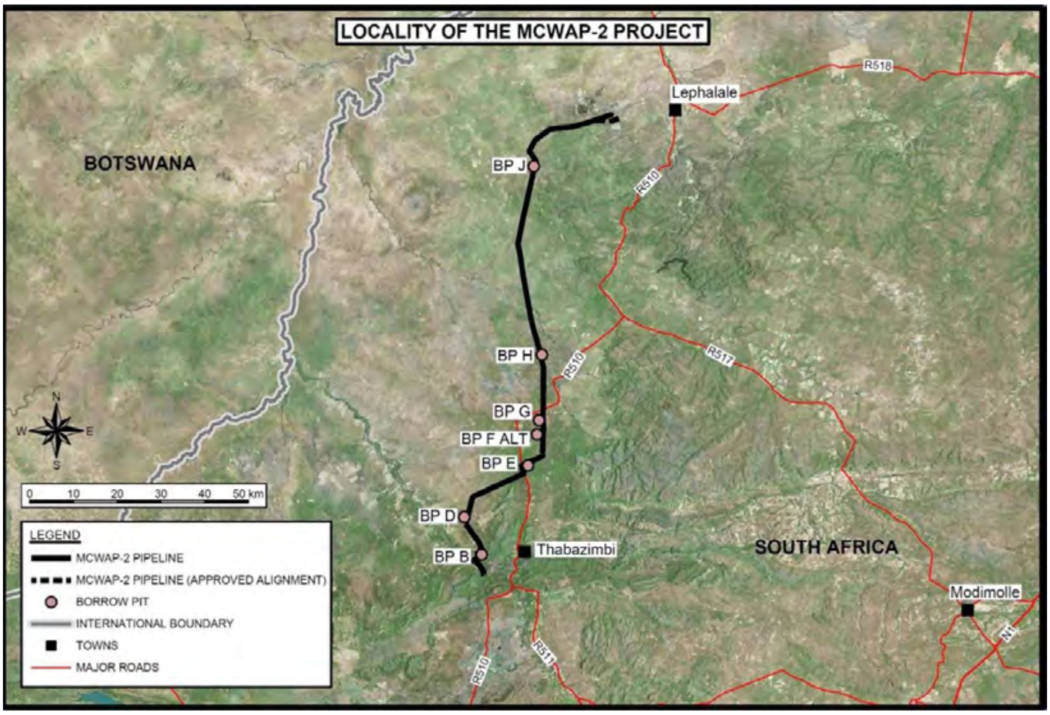


Figure 2-1: Locality map showing the proposed pipeline route

3 ROAD ASSESSMENT

3.1 Scope

Using the list of roads provided in the original Terms of Reference a desktop study using Google Earth was carried out followed by a site inspection on 2 March 2021 to confirm the scope of roads included. These roads and extents are summarised in Table 3-1. These roads include both surfaced and unsurfaced roads, with three of the roads (R-routes) falling under the jurisdiction of the South African National Roads Agency (SOC) Limited (SANRAL). Most of the remaining roads form part of the Roads Agency Limpopo (RAL) network. The network of roads is shown graphically in Figure 3-1.

As agreed during the Discussion Meeting held on 19 January 2021, the Condition Assessment would not include farm roads. However, the Traffic Impact Assessment will include the public roads as well as the farm roads.

Table 3-1: Scope of Roads

Road No.	From		To		Length (km)	Authority
	km	Description	km	Description		
SURFACED ROADS						
R510-2	28.60	R511-3	37.20	R510-3	8.60	SANRAL
R510-3	0.00	R510-2	47.80	D2701	47.80	SANRAL
R511-3	98.50	R516-1	133.00	R510-2	34.50	SANRAL
R516-1	0.00	R511-3	22.10	Leeupoort Quarry Access	22.10	SANRAL
D2701	6.10	R510-3 km 47.8	7.00	D1925	0.90	RAL

D1675	0.00	D2649	13.00	Gravel Road 4	13.00	RAL
D1649	0.00	R510-2	9.20	D769	9.20	RAL
D2649	0.00	D1925	8.20	D1675	8.20	RAL
Road 1	12.95	Gravel Road 2	13.10	R510 - km 19.2	0.20	RAL
Sub-Total					144.50	
UNSURFACED ROADS						
D769	0	D1649	6.75	Gravel Road 1	6.75	RAL
D2701	0	R510-3 km 47.8	6.06	Start surfaced	6.06	RAL
D2701	7	End surfaced	23.50	D1925	16.50	RAL
D175	0	D1925	2.75	Pipeline/Railway	2.75	RAL
D1925	0	D2701	45.3	D2649	45.3	RAL
Gravel Road 2	8	Gravel Road 1	12.95	Road 1	4.95	Unknown
Gravel Road 3	0	R510-2 km 21.4	5.4	Pipeline	5.40	Unknown
Gravel Road 4	0	R510-3 km 38.6	56	Gravel Road 5	56.00	Rail Line Authority (Transnet)
Sub-Total					**143.71**	

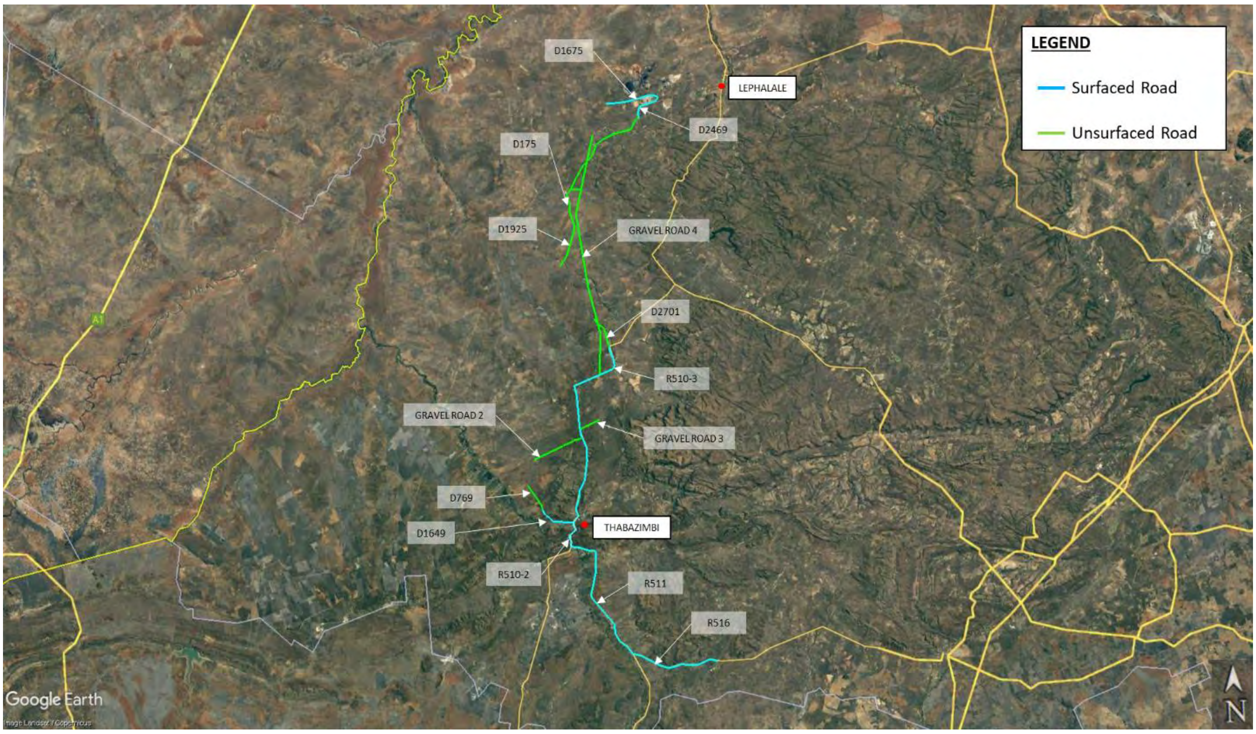


Figure 3-1: Road network possibly providing direct access to pipeline during construction (Google Earth)

3.2 Road Assessment Team

The Merchelles team/service providers utilised for the assessment of the roads has included:

- John Hodgson, Pr Eng – Specialist Pavement and Materials Engineer,
- Ariadne Albanis, BSc (Civil) – Engineer,
- Louw Mposi, Pr Tech (Civil) – Road Technologist,
- Terence Dodd, BSc (Civil) – Senior Road Engineer,
- Rob Maguire – Data Collection Specialist,
- Roadlab Laboratories Pty Ltd (Lephalale), and
- Specialised Road Technologies.

3.3 Road Assessment

The visual assessment of the roads was carried out in accordance with the following standards:

- TMH 9 Pavement Management Systems; Standard Visual Assessment Manual for Flexible Pavements.
- TMH 12 Pavement Management Systems; Standard Visual Assessment Manual for Unsealed Roads.

Visual conditions assessments were carried out from 15 March 2021 to 18 March 2021. While unsurfaced roads were assessed in 2 km sections (also referred to as links), surfaced roads were assessed in 200 m sections. Distress along the segments is captured in terms of degree and extent using a scale of 0 to 5. In terms of degree of distress 0 represents no distress while 5 represents the highest level of severity. An extent of 1 indicates localised distress, whereas extent of 5 indicates distress along most of the segment.

In addition to the visual assessment, functional measurements of the surfaced roads were carried out using the Road Surface Profilometer (RSP). The RSP records data including riding quality, rut depth and texture depth. These measurements were conducted by Specialised Road Technologies (SRT). The functional measurements are reported separately under Section 3.7 of this report.

3.4 Baseline Parameter: Visual Surface Condition Assessment

3.4.1 Surfaced Roads

As indicated above, visual assessments along surfaced roads were carried out in terms of TMH 9 and done for each 200m segment of road. Degree and extent of each distress were noted per segment and captured in electronic format.

The data was used to calculate a visual condition index (VCI) per road segment. The VCI is calculated in accordance with the guidelines contained in TRH 22 and represents a value from 0 to 100 with 100 representing a perfect road. The VCI is also used to categorise the road segment, the details of which are indicated in Table 3-2.

Table 3-2: VCI Categories (TRH 22)

Category	VCI	Colour
Very good	90≤VCI<100	Green
Good	70≤VCI<90	Blue
Fair	50≤VCI<70	Yellow

Category	VCI	Colour
Poor	30≤VCI<50	Orange
Very poor	<30	Red

Average VCI results per road is summarised in Table 3-3. These values show that the roads are classified as fair to good in terms of its visual condition.

Table 3-3: Average VCI per Road (Surfaced)

Road	Average VCI	Condition Category
R510-2	69	Fair
R510-3	85	Good
R511-3	86	Good
R516-1	70	Good
D2701	60	Fair
D1675	74	Good
D1649	69	Fair
D2649	84	Good
Road 1	74	Good

Although it is not the intention of this report to focus on the distress and repair measures, it is important to note the main contributing distress along the roads classified as fair to very poor:

- The seal surfacing along Road R510-2 is dry and brittle. This tends to cause surface cracks, which in turn lead to surface failures over time (refer Photo 3.1 and Photo 3.2). If this distress is not addressed in time, potholes will form as evident from the assessment, although very limited at this stage. In addition to the surface cracks, block- and crocodile cracks are also evident along this road section. Flushing of binder was evident along most of this road section.
- The visual condition along Road D2701 is very similar to Road 510-2. Surface cracks, surface failures and potholes were noted. In addition to the surface cracks, block- and crocodile cracks are also evident along this road section.
- Similar to Road D2701, the seal surfacing along Road D1649 also appears dry and brittle. Flushing of the binder, although low degree, was also recorded. Block- and crocodile cracking with degree 1-3 are evident along most of the extent with localised transverse cracks as shown in Photo 3.3**.**

Photo 3.1: Road R510-2 (km 29,6): Surface cracks

Photo 3.2: Road R510-2 (km 33,7): Surface cracks, surface failures and transverse cracks

Photo 3.3: Road D1649 (km 6,88): Longitudinal crack as well as crocodile/surface cracks

A graphical representation of the VCI along each road section together with a visual representation in plan are provided in the Figures to follow.

Road R510-3 is generally in good to very good condition and consists of a seal surfacing. Flushing with a low degree was noted along most of the route (Photo 3.5). Along the first 600 m surface failures (Photo 3.4) and patching were visible. This section also showed distress in the form of transverse (degree 3), crocodile cracking (degree 4), minor rutting and patching. The latter is an indication that this section required some maintenance in the past and that it is worse compared to the remaining portion of this road section.

The remaining portion has undulation (degree 2) along most of the section but very few other defects, therefore the average VCI of 85.

Photo 3.4: Road R510-3 (km 0,1): Surface cracks

Photo 3.5: Road R510-3 (km 33,1): Flushing in wheel tracks along both lanes

Similar to Road R510-3, **Road R511-3** is also classified as good to very good and also has a seal surfacing. The assessment revealed localised surface related distress (Photo 3.6), limited structural cracking (transverse and crocodile cracking, degree 1&2) as well as undulation (degree 1-2).

Photo 3.6: Road R511-3 (km 100,6): Surface failure in left lane and surface patches along right lane

Road R516-1 consists of a seal surfacing and is classified as poor to very good. This section of road shows distress in the form of surface failures (degree 2-3), and frequent longitudinal, block, transverse, and crocodile cracking (degree 2-4). Pumping of fines were visible in many of these cracks and are normally associated with structural failure of the pavement structure. Examples of distress are shown in Photo 3.7 and Photo 3.8. It should however be noted that this section of road forms part of an improvement project currently in design phase. SANRAL have appointed BVi Consulting Engineers for this improvement project.

Photo 3.7: Road R516-1 (km 5,37): Surface failure and longitudinal cracks.

Photo 3.8: Road R516-1 (km 5,67): Crocodile cracking and pumping

Road D1675 consists of an asphalt surfacing along the first 8,8 km, whereafter it changes to a seal surfacing. This also represents the limit of two uniform sections with the asphalt portion classified as being in good condition while the seal portion is classified as poor to good. The assessment showed that the seal section contains distress in the form of surface failures. Block-, long- (Photo 3.10) and crocodile cracking with degree 3 are also frequent together with rutting with a degree of 3 to 4. Patching and potholes are also present.

The asphalt section shows distress in the form of block- (degree 2-4) and very localised longitudinal- and crocodile cracking (degree 3); an example of block cracks is indicated in Photo 3.9.

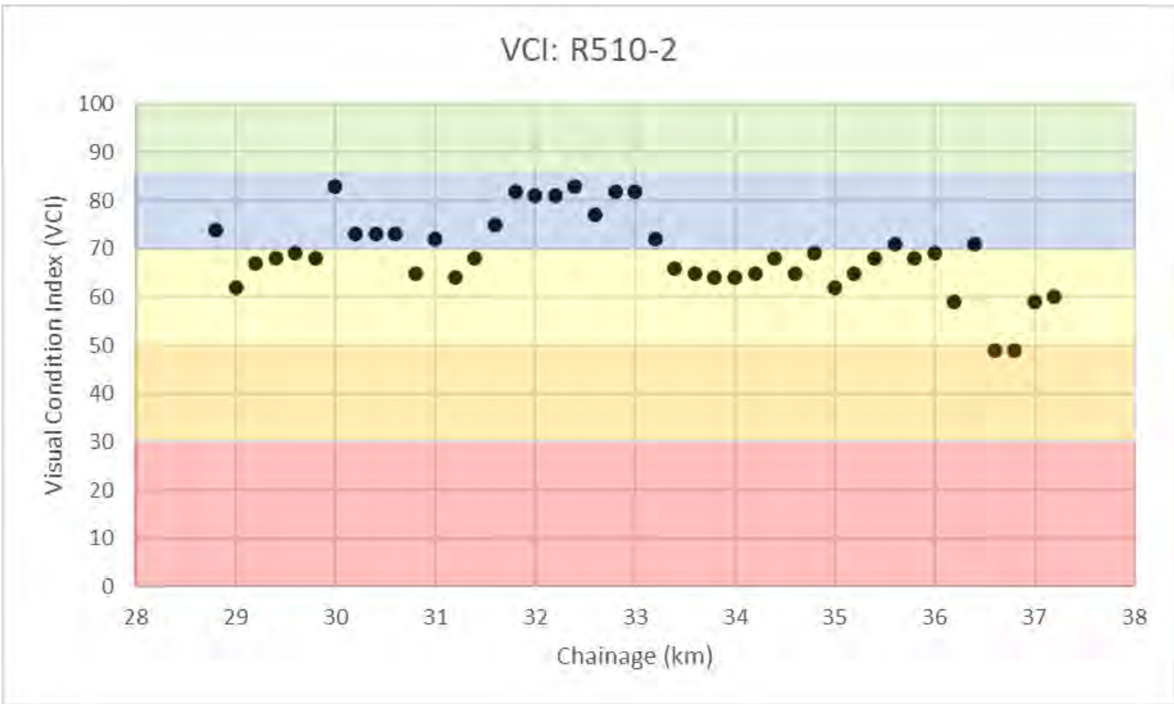
Photo 3.9: Road D1675 (km 3,0): Block cracks along asphalt section

Photo 3.10: Road D1675 (km 11,6): Longitudinal cracks along seal section

Road D2649 is classified as good to very good. It consists of a seal surfacing with localised surface failures and surface patches. Flushing of the binder is visible along most of the road section. Localised block-transverse and longitudinal cracks (degree 2), as shown in Photo 3.11 are visible. Minor undulation (degree 2) is visible especially along the last 2 km of this road section. Localised patching and potholes were also noted.

Photo 3.11: Road D2649 (km 0,15): Longitudinal crack in middle of left lane

Road 1 is a 200 m section of surfaced road along **Gravel Road 2**. This portion consists of a seal surfacing which appears dry and brittle. Aggregate loss with degree 4 is evident along the entire portion together with localised longitudinal cracking (degree 3).



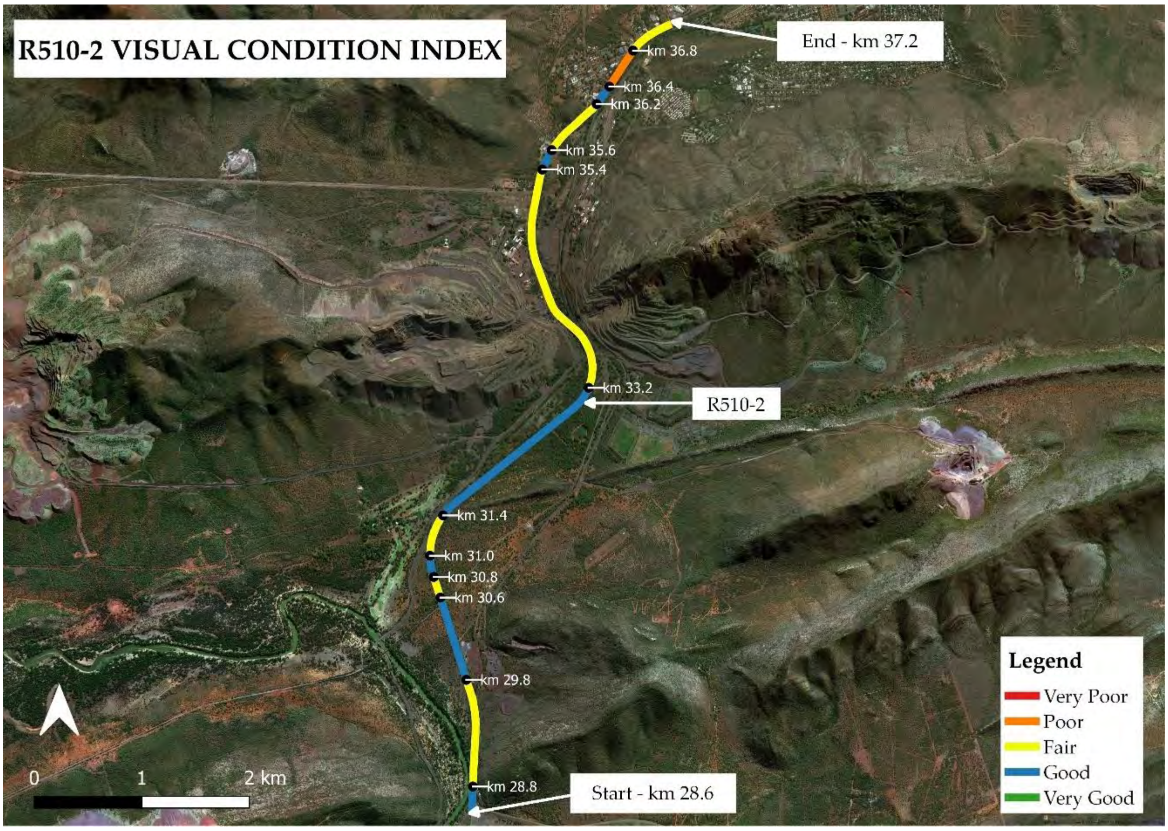
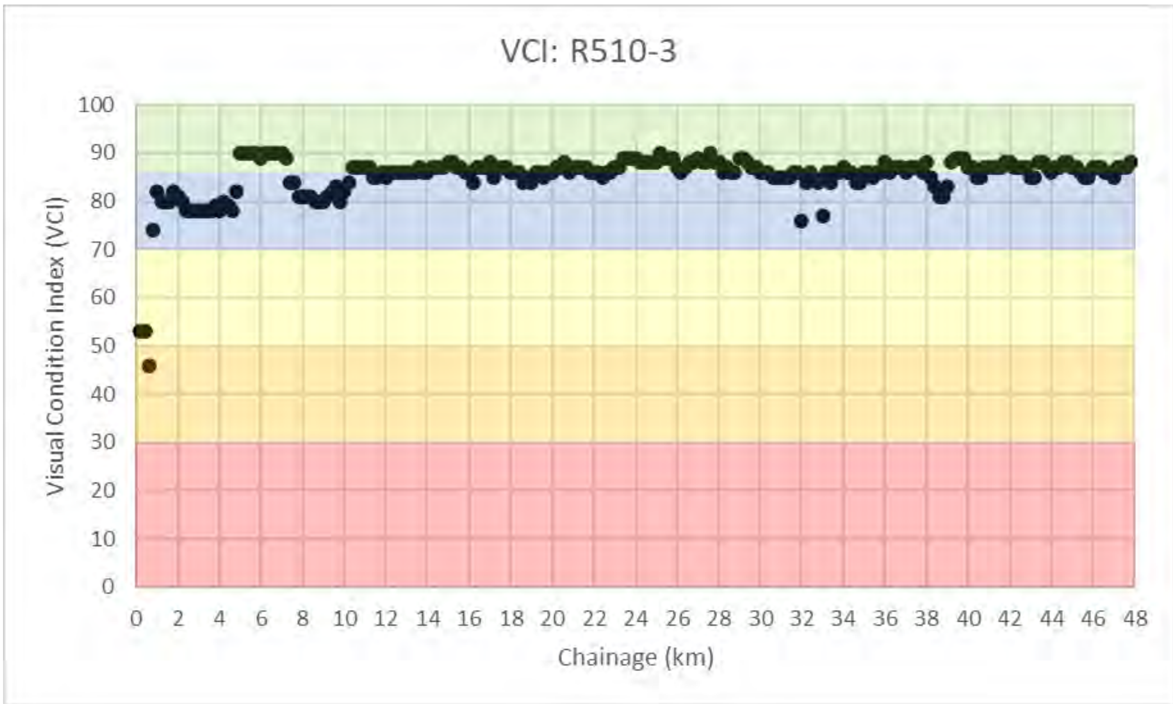
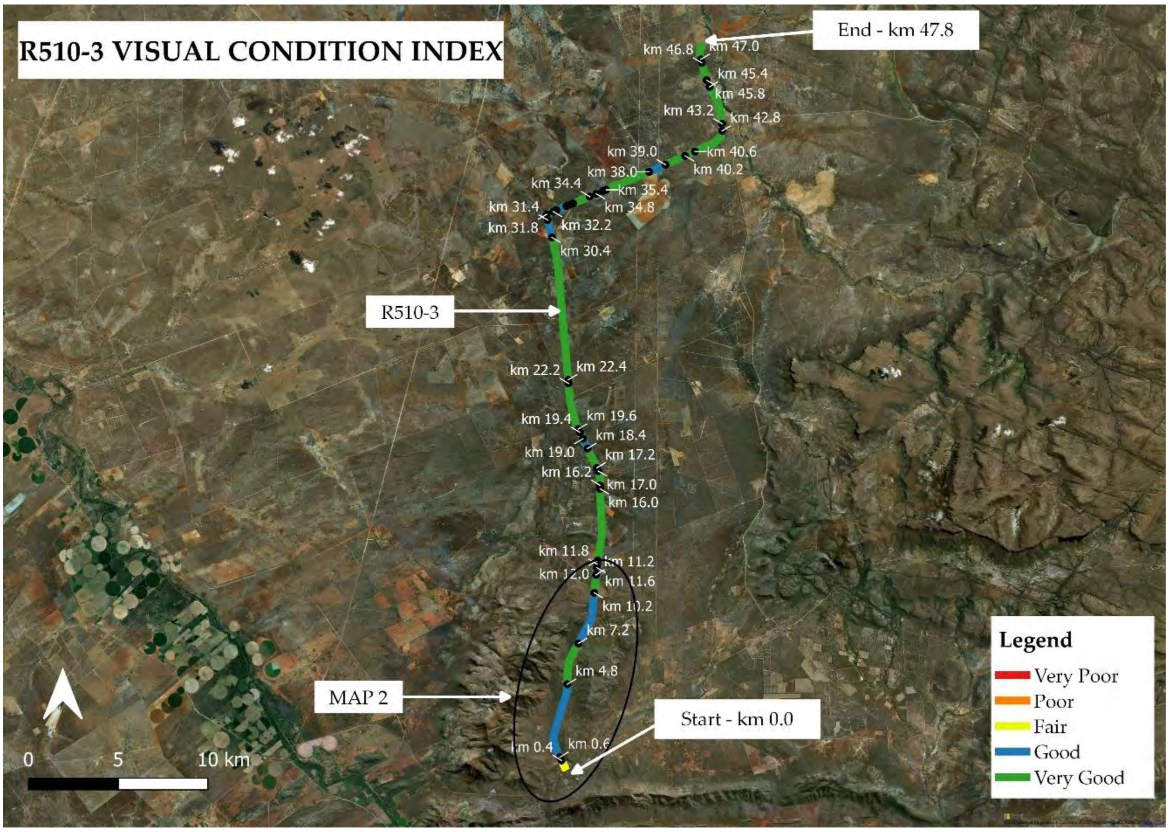


Figure 3-2: VCI along Road R510-2


VCI: R510-3
Visual Condition Index (VCI)
Chainage (km)
100
90
80
70
60
50
40
30
20
10
0
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48


R510-3 VISUAL CONDITION INDEX
End - km 47.8
km 46.8
km 47.0
km 45.4
km 45.8
km 43.2
km 42.8
km 39.0
km 40.6
km 38.0
km 40.2
km 34.4
km 35.4
km 31.4
km 34.8
km 31.8
km 32.2
km 30.4
R510-3
km 22.2
km 22.4
km 19.4
km 19.6
km 18.4
km 19.0
km 17.2
km 16.2
km 17.0
km 16.0
km 11.8
km 11.2
km 12.0
km 11.6
km 10.2
km 7.2
km 4.8
MAP 2
Start - km 0.0
km 0.4
km 0.6
0
5
10 km
Legend
Very Poor
Poor
Fair
Good
Very Good

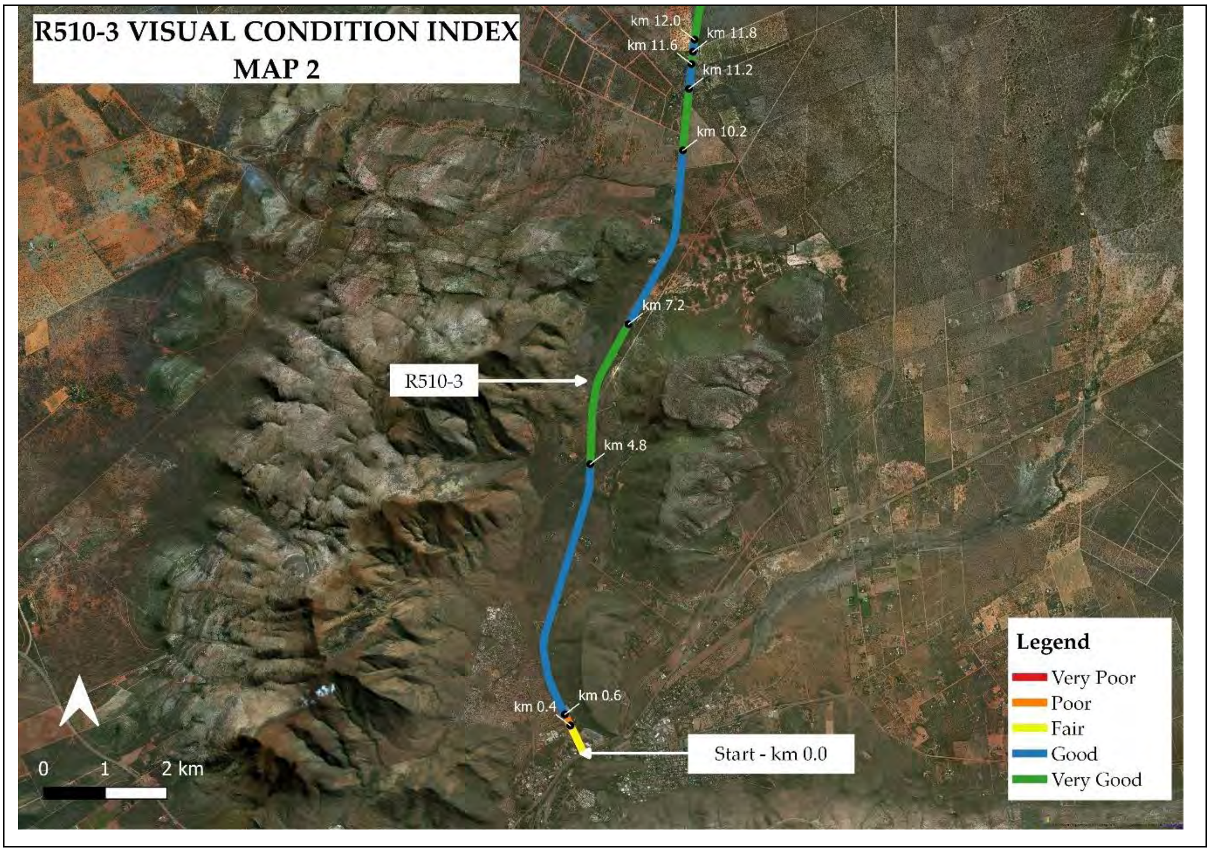
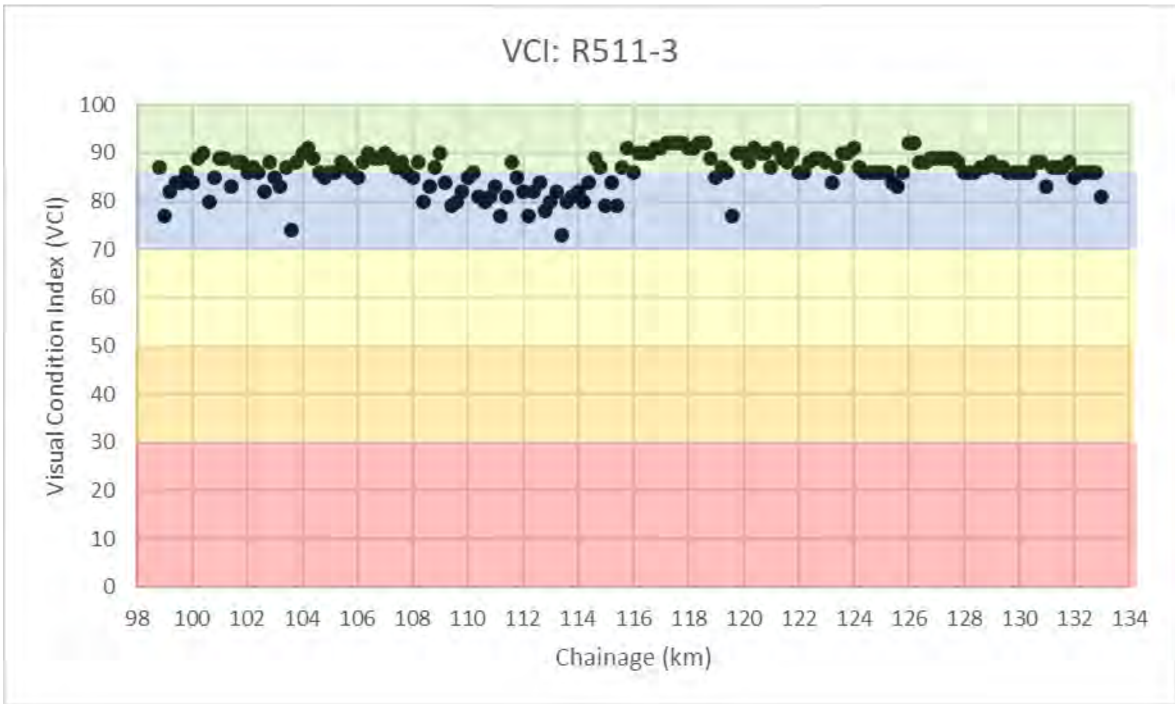


Figure 3-3: VCI along Road R510-3



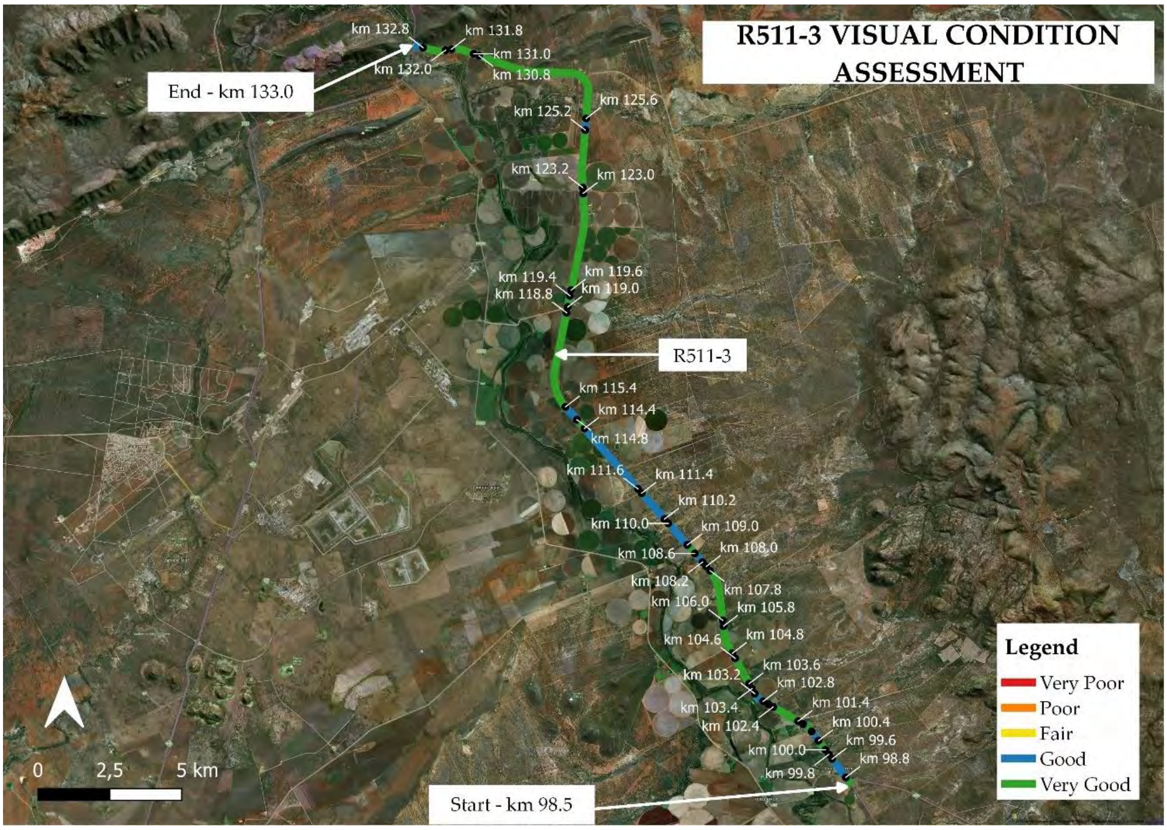
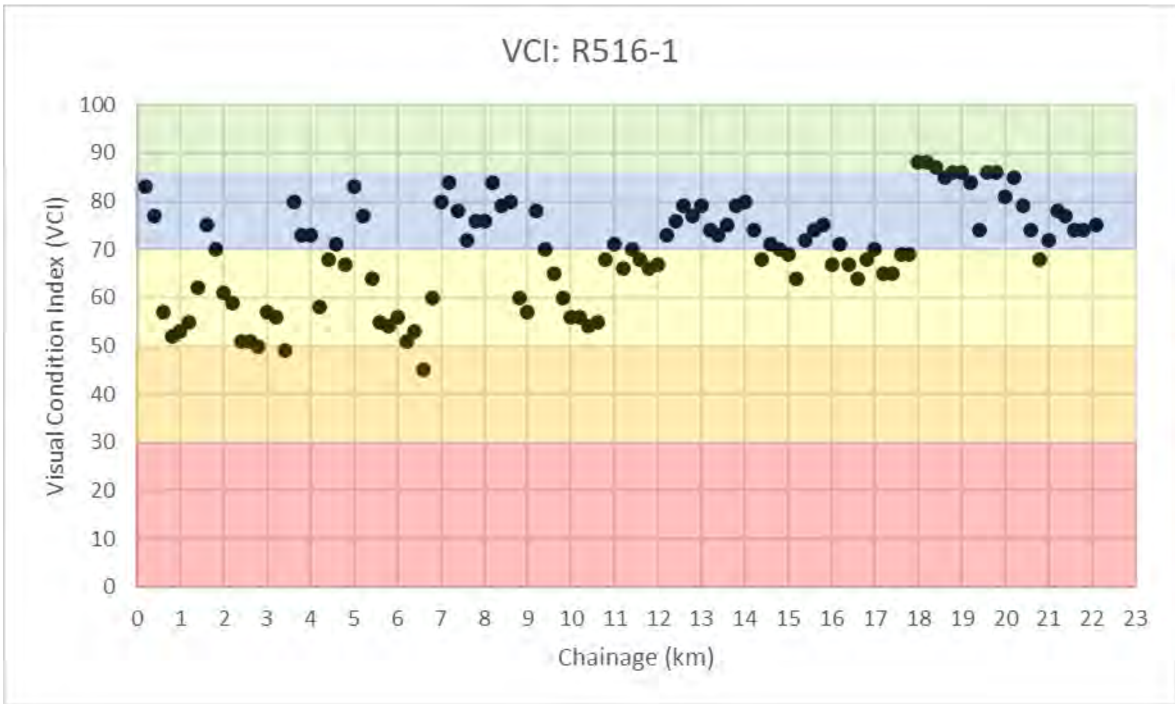
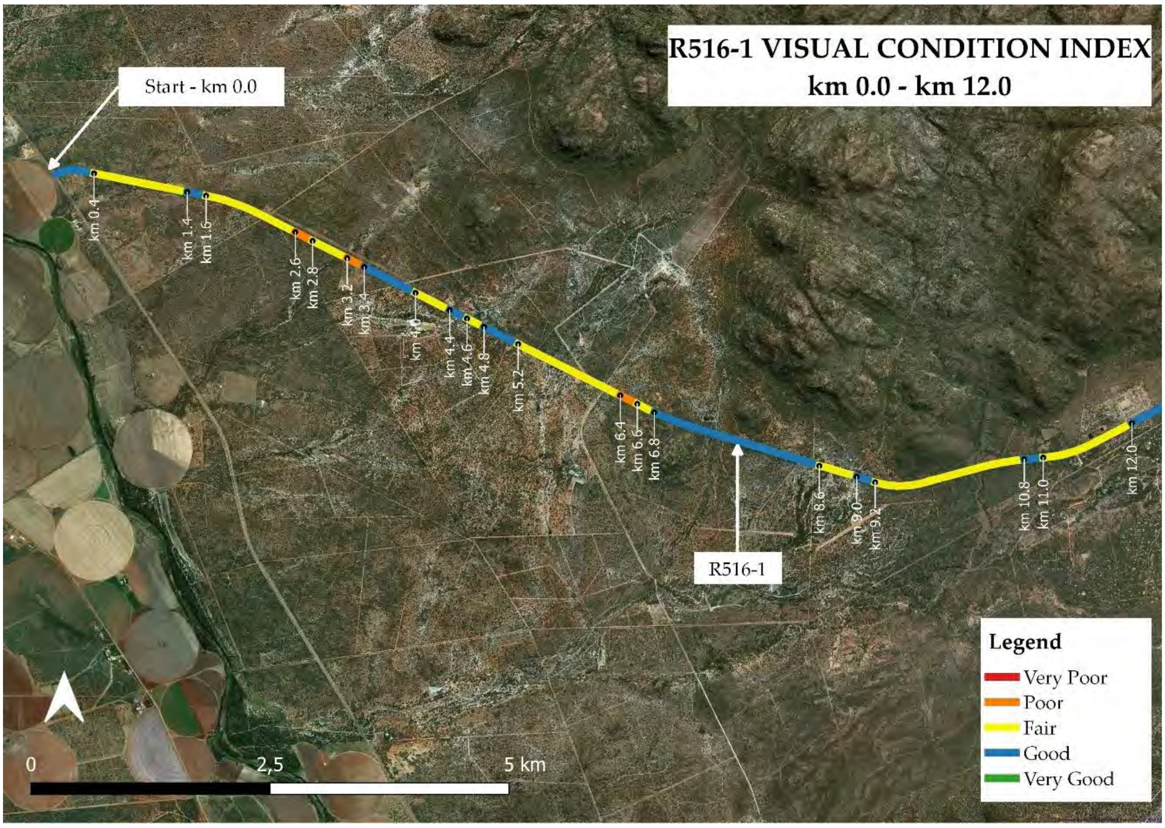


Figure 3-4: VCI along Road R511-3



VCI: R516-1
Visual Condition Index (VCI)
Chainage (km)



R516-1 VISUAL CONDITION INDEX
km 0.0 - km 12.0
Start - km 0.0
R516-1
Legend
Very Poor
Poor
Fair
Good
Very Good
0
2,5
5 km

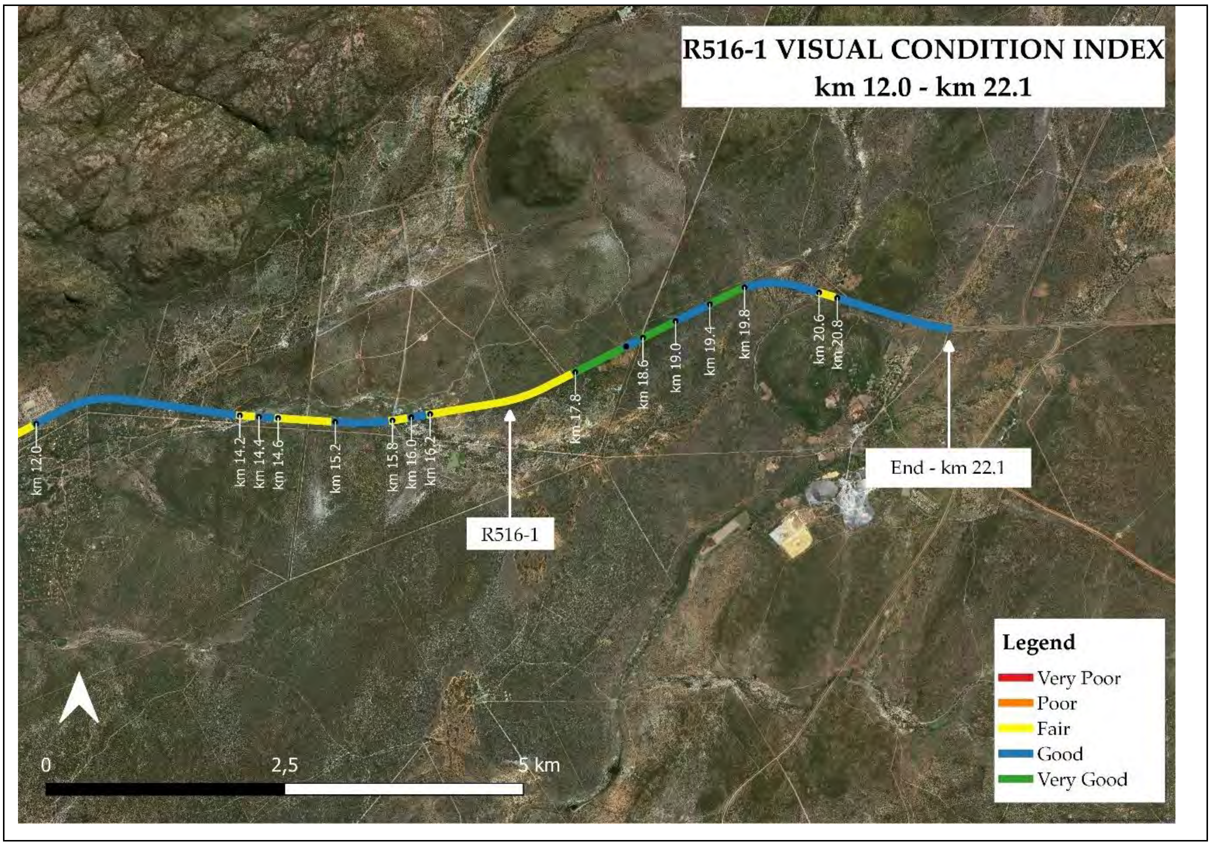
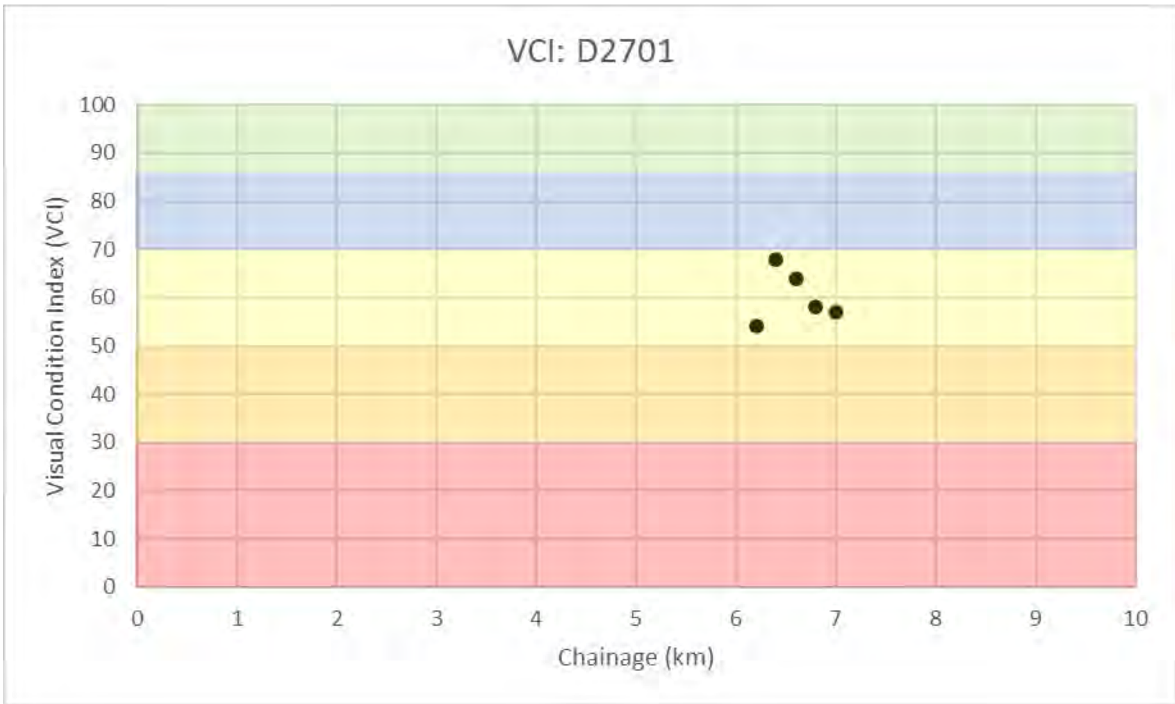


Figure 3-5: VCI along Road R516-1



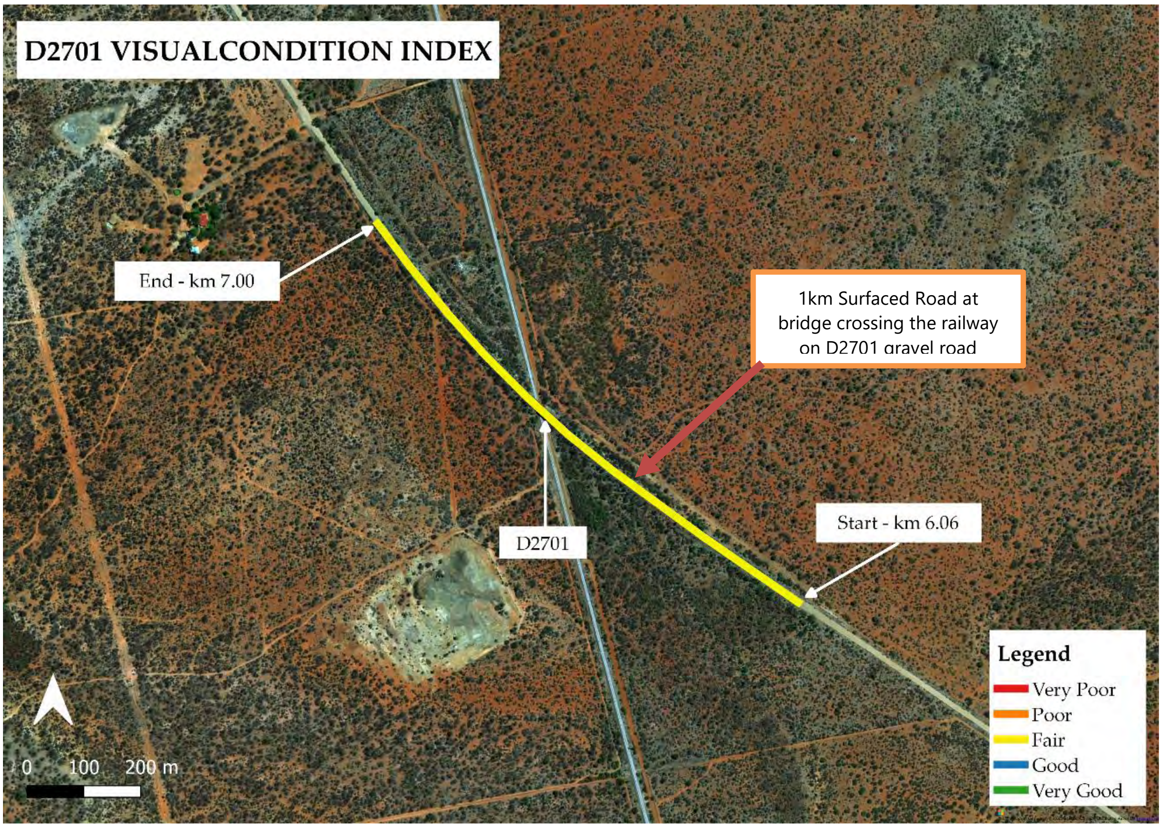
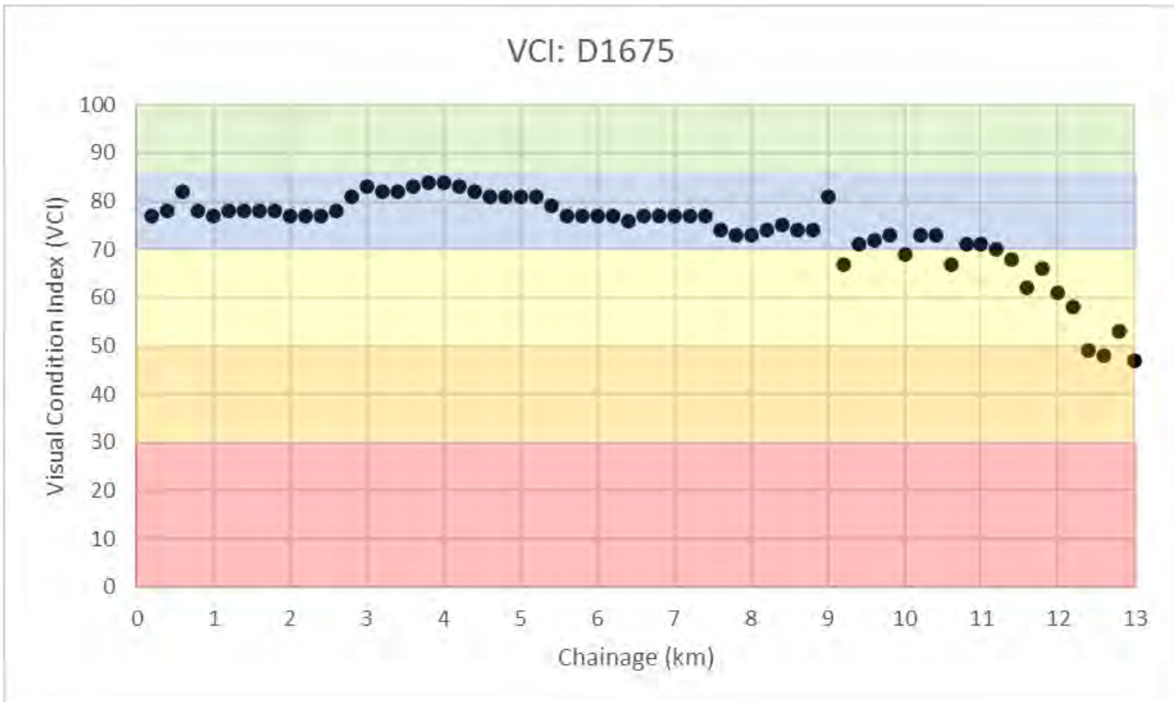
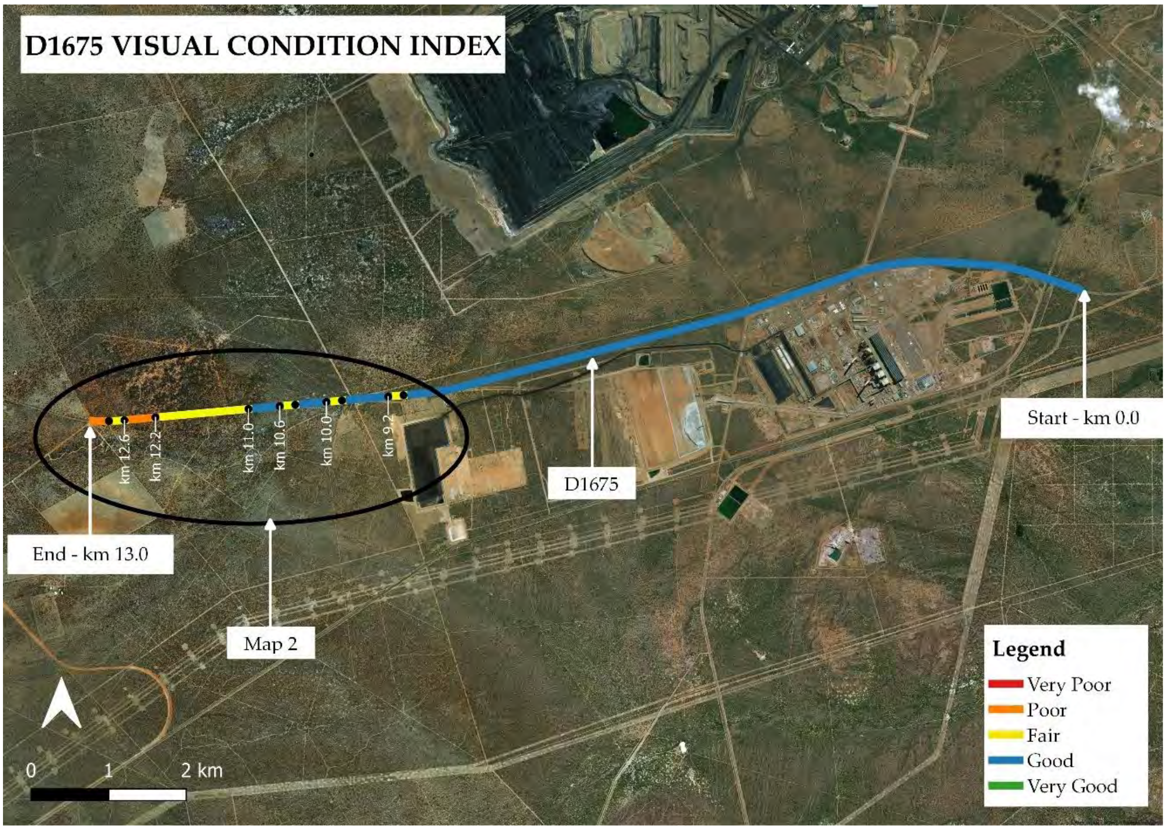


Figure 3-6: VCI along Road D2701



VCI: D1675
Visual Condition Index (VCI)
0
10
20
30
40
50
60
70
80
90
100
Chainage (km)
0
1
2
3
4
5
6
7
8
9
10
11
12
13



D1675 VISUAL CONDITION INDEX
Start - km 0.0
D1675
End - km 13.0
Map 2
km 12.6
km 12.2
km 11.0
km 10.6
km 10.0
km 9.2
Legend
Very Poor
Poor
Fair
Good
Very Good
0
1
2 km

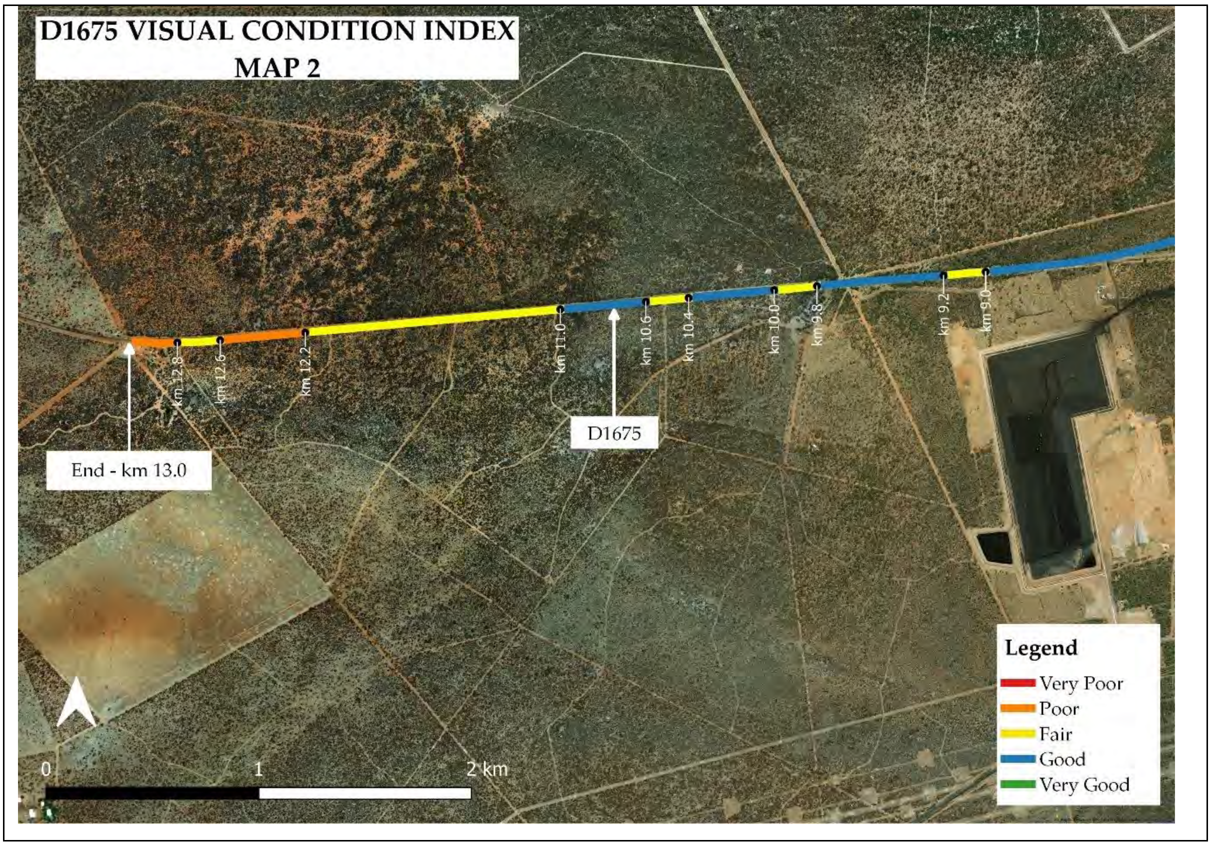


Figure 3-7: VCI along Road D1675

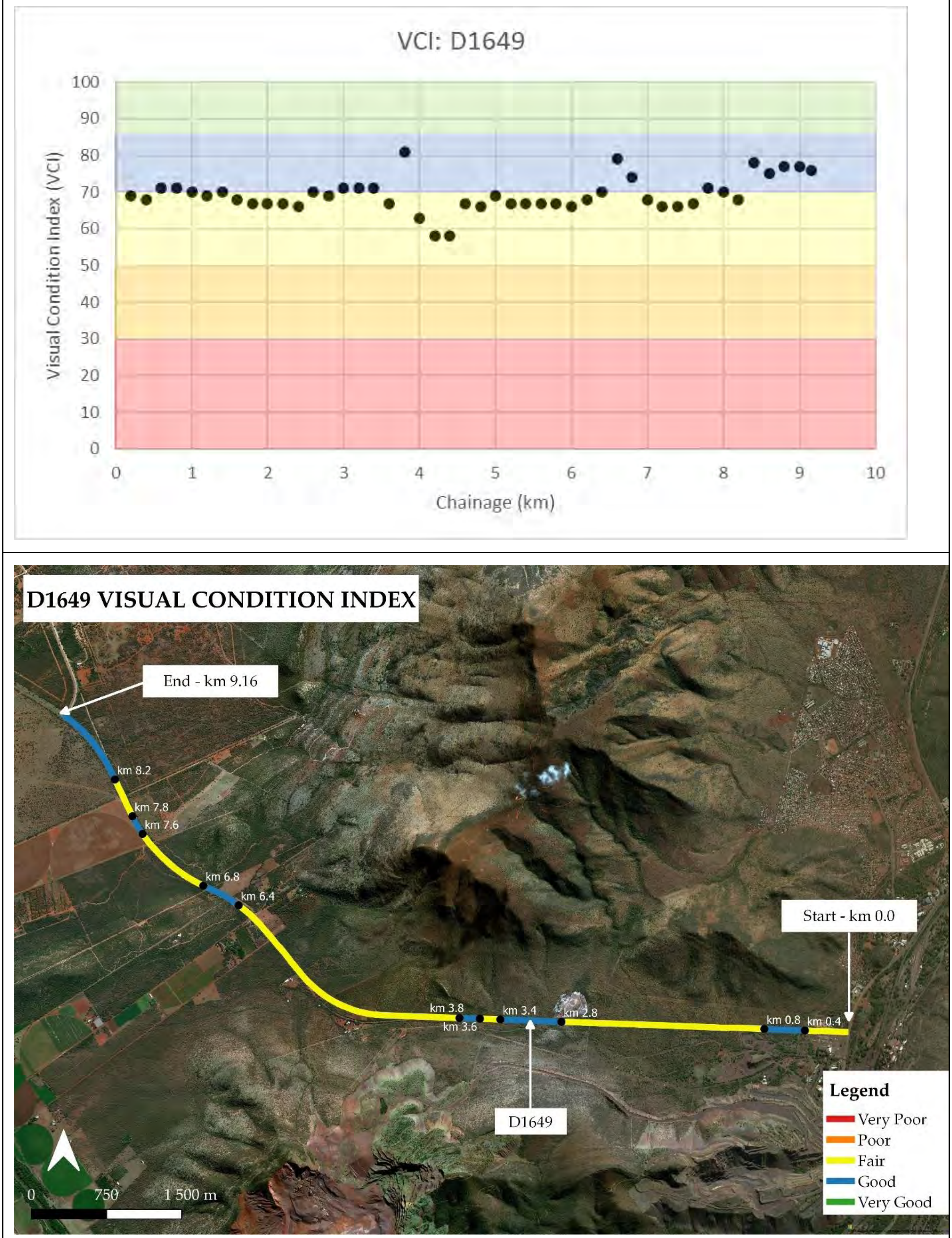
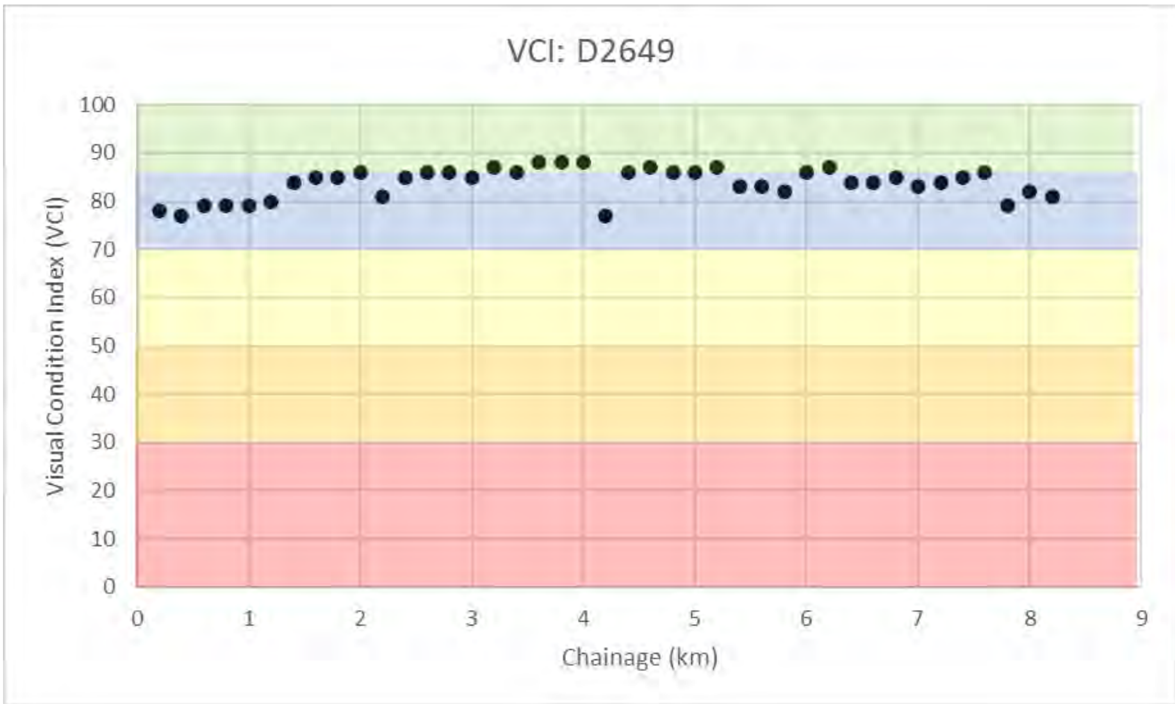


Figure 3-8: VCI along Road D1649



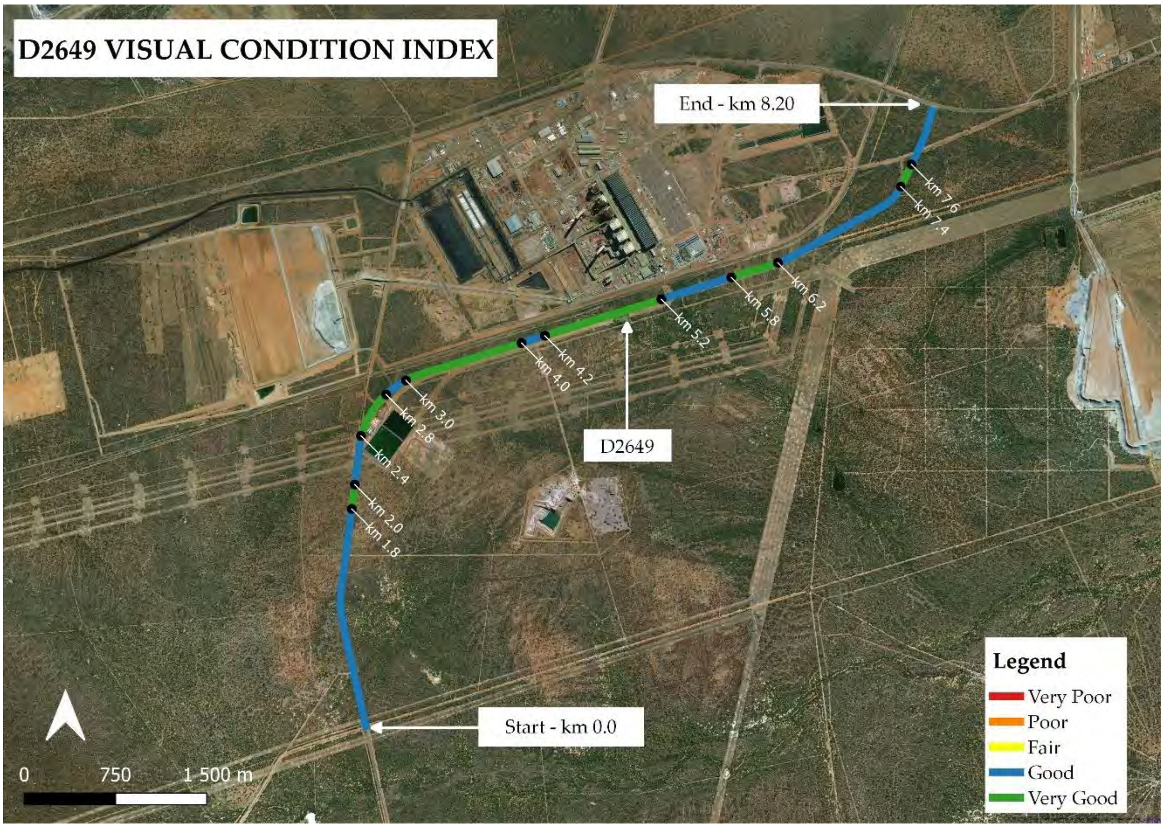


Figure 3-9: VCI along Road D2649

3.4.2 Unsurfaced Roads

Visual assessments along unsurfaced roads were carried out in terms of TMH 12 and done for each 2000 m segment of road. The ratings in terms of degree and extent of each distress were noted and are included in the support data to this report.

A VCI similar to that for surfaced roads was calculated per road segment. Average VCI results per road is summarised in Table 3-4. These values show that the roads are classified as poor to fair in terms of its visual condition.

Table 3-4: Average VCI per Road (Unsurfaced)

Road	Average VCI	Condition Category
D769	43	Poor
D2701	49	Poor
D175	50	Fair
D1925	39	Poor
Gravel Road 2	52	Fair
Gravel Road 3	38	Poor
Gravel Road 4	54	Fair

A graphical representation of the VCI along each road section together with a visual representation in plan are provided in the Figures to follow.

It follows from Table 3-4 that the gravel roads are classified as being in fair to poor condition based on the visual assessment conducted. A summary of the main contributing factors to the classification is provided in Table 3-5.

Table 3-5: Summary of distress contributing to condition classification

	Degree and distress per Road Section						
Characteristic/ Distress	**D769**	**D2701**	**D175**	**D1925**	**Gravel Road 2**	**Gravel Road 3**	**Gravel Road 4**
Road width (m)	7.0 – 8.0	5.5 – 6.0	5.0	4.0 – 6.0	3.0	3.5	5.0
Potholes	5/1	4/1	5/1	1/3	5/2	4/3	5/1
Rutting	3/1	2/1 (local)	3/3	4/4	4/3	3/3	3/3
Erosion	3/1 (T)	2/1 (T) – local	4/1 (T)	4/1 (T) 4/2 (L)	4/1 (T) 3/1 (L)	3/1 (T) 3/1 (L)	3/1 (T) 3/1 (L)
Corrugation	3/5	3/3	3/2	3/4	2/2	3/4	3/3
Drainage	4	2	4	5	5	4	4
Trafficability	3	2-3	4	4	4	3	4
Riding Quality	4	3	3	4	4	3	3
General Condition	4	3	4	4	3-4	4	3

Notes: (T) – Transverse erosion

(L) – Longitudinal erosion

All unsurfaced roads show distress in the form of potholes with high severity although the extent thereof is limited. Erosion of the surface (wearing course) is generally a problem with transverse erosion prominent on all road sections. Longitudinal erosion was noted on four of the seven unsurfaced road sections. The degree of erosion is generally 4, indicating high severity.

Loose material, which leads to dustiness as shown in **Photo 3.12** is also evident.

Photo 3.12: Road D769 (km 0,6): Dustiness and loose material

It should be noted that the visual assessment along **Road D1925** was carried out shortly after the area experienced heavy rainfall, which caused a dam wall to break resulting in surface flow. Severe erosion was noted along this road section between km 4.0 and km 14.0 as a result thereof. This section of road has subsequently partially been repaired. Loose material along this section of road is shown in Photo 3.13

Photo 3.13: Road D1925 (km 19,8): Loose material, overgrown

Riding quality and trafficability is fair to poor, indicating difficult conditions for road users. While riding quality is rated as a function of the estimated comfortable and safe driving speed (unaffected by geometric constraints or road width) that could be driven in a car, trafficability (or passability) refers to the capacity of a car to negotiate the road without losing traction or without excessive use of low gears (TMH 12).

It follows from the assessment and the summarised results that these gravel roads will require maintenance in order to provide roads that can be used effectively for transport and haulage of materials along the pipeline route.

It was noted during the assessment that six of the unsurfaced roads should be raised in order to improve drainage. One of the main contributing factors to this situation is the loss of wearing course material, which is discussed in more detail in the following section. In general terms, the gravel wearing course is driven off over time, which is dependent on material quality, climate, and traffic volume. As wearing course material is driven off, it tends to end up in windrows along the sides of the road with the road level lower than the original design. If these windrows are not bladed frequently, they limit effective drainage of the road surface, and the road becomes a channel as indicated in Photo 3.14.

Photo 3.14: Road D769 (km 4,6): Loose material, corrugation, and windrows of gravel material along edge

Without some form of maintenance this process continues until the entire wearing course is driven off with the road users having to drive on the subgrade. The subgrade is generally not suitable as the grading may be coarse, which could lead to damage to vehicles. The important rule is to maintain the gravel wearing course to ensure a trafficable and safe driving surface and also for drainage.

Unfortunately, many of these unsurfaced roads were constructed to similar levels of the natural ground line. Therefore, as the wearing course thickness reduces, the road surface over time will be lower than the surrounding area.

A section of **Gravel Road 2** has a rough surface with little evidence of a wearing course layer as indicated in Photo 3.15. Whilst this section of road is trafficable, it by no means provides a smooth driving surface. Essentially the coarse subgrade layer serves as the driving surface.

Photo 3.15: Gravel Road 2 (km 1,8): Large rocks in roadway

Gravel Road 3 follows a boundary fence line separating two farm properties and appears to traverse private property. The roadway has potholes in places as well as corrugated sections. See Photo 3.16 and Photo 3.17

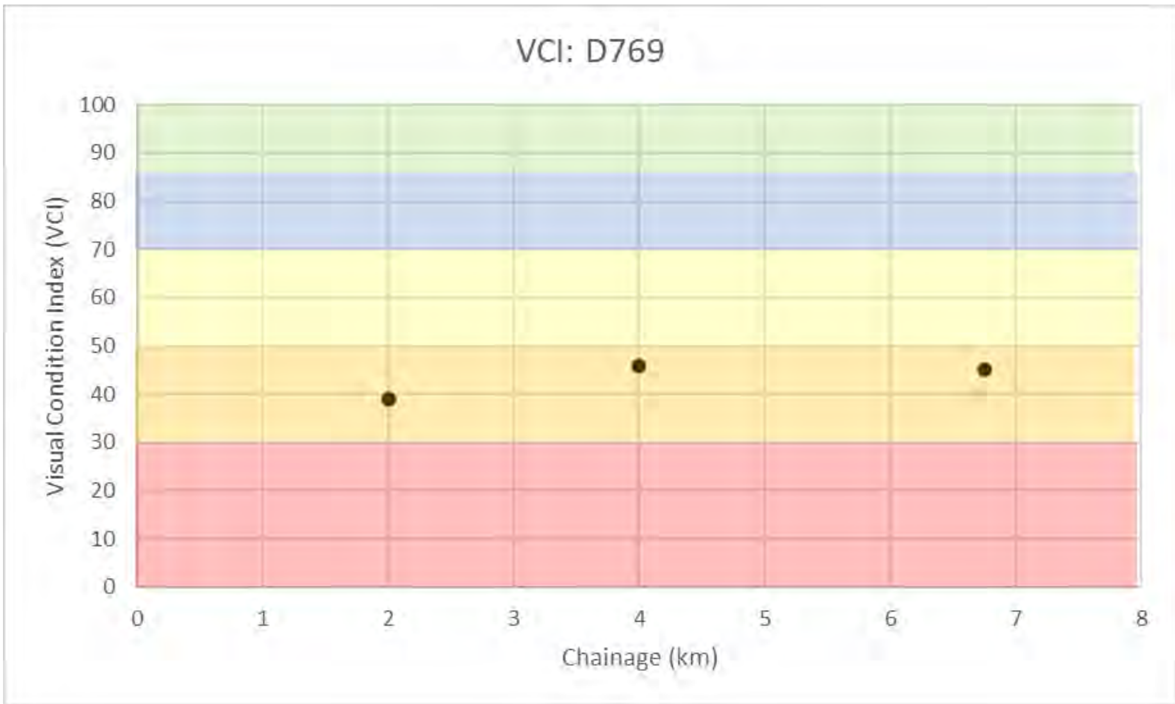
Photo 3.16: Gravel Road 3 (km 0,0): Potholes in road, narrow roadway

Photo 3.17: Gravel Road 3 (km 0,9): Corrugation, Narrow roadway

Gravel Road 4 is located within a rail line servitude, and over some sections the road reduces to two-wheel tracks. The road has no surfacing layer of any kind with vehicles essentially driving over natural ground. Some places potholes are evident. See Photo 3.18 and Photo 3.19.

Photo 3.18: Gravel Road 4 (km 12.2): Photo taken facing the North-direction

Photo 3.19: Gravel Road 4 (km 0.00) Photo taken facing the North-direction, Potholes and damage seen along roadway



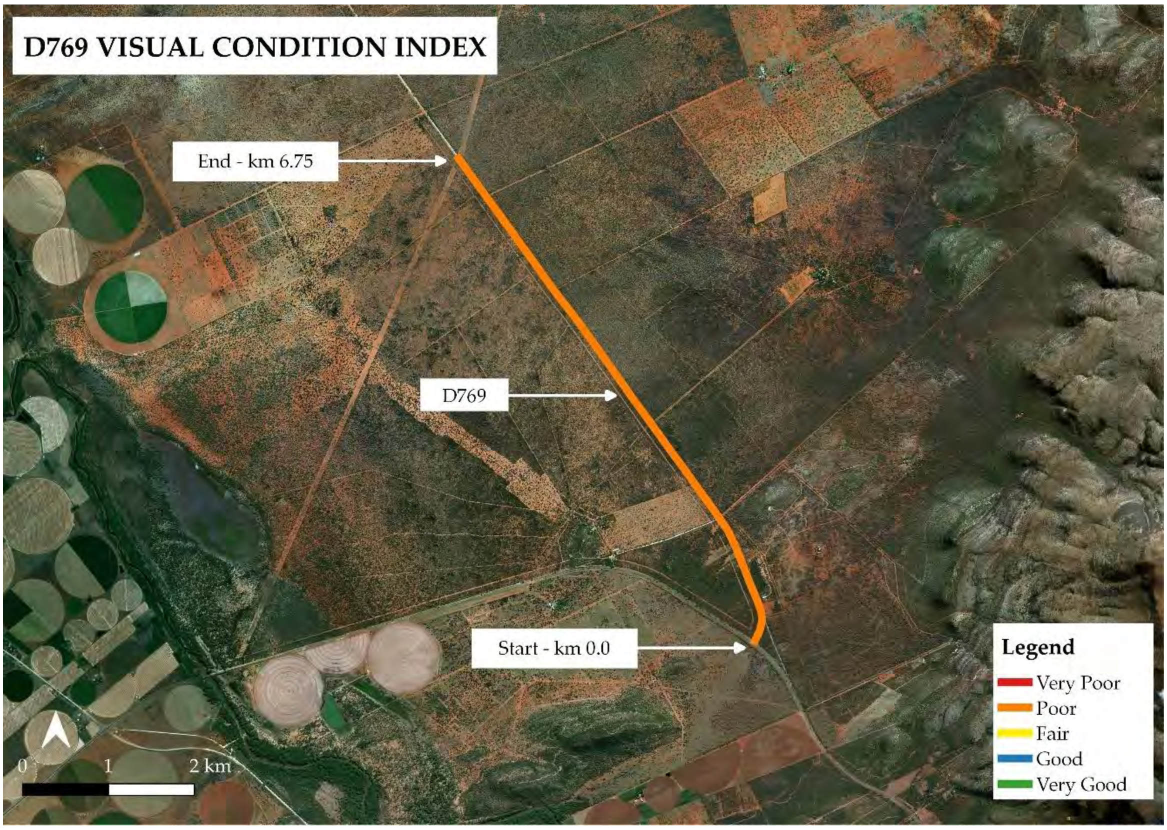


Figure 3-10: VCI along Road D769

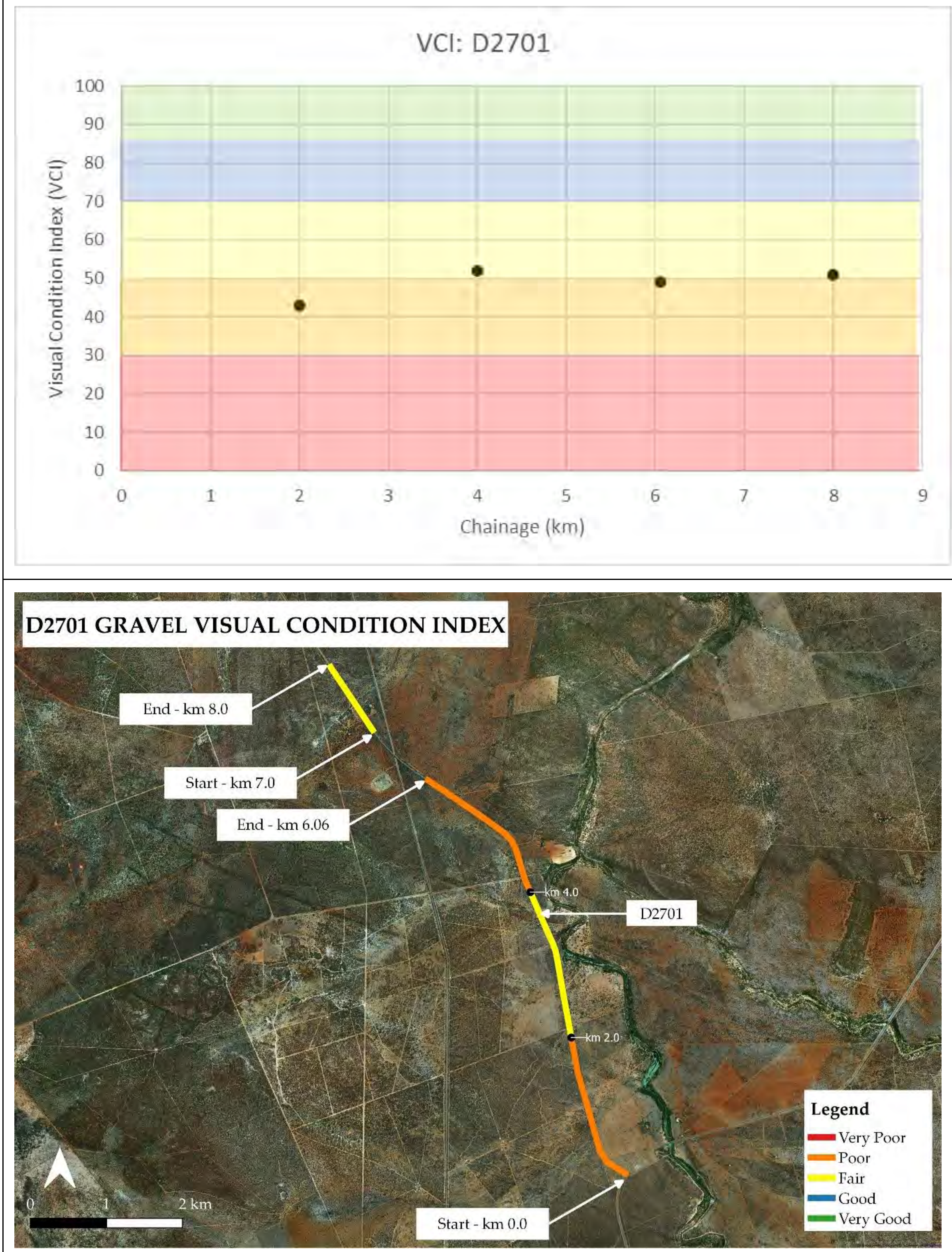
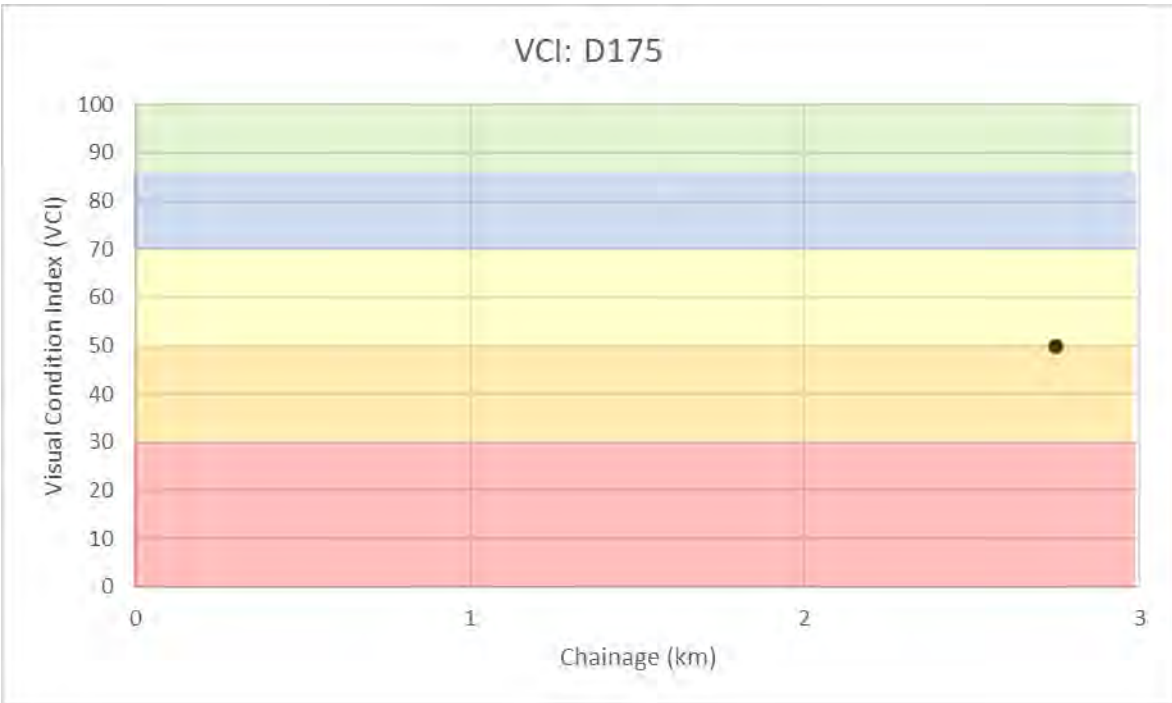


Figure 3-11: VCI along Road D2701



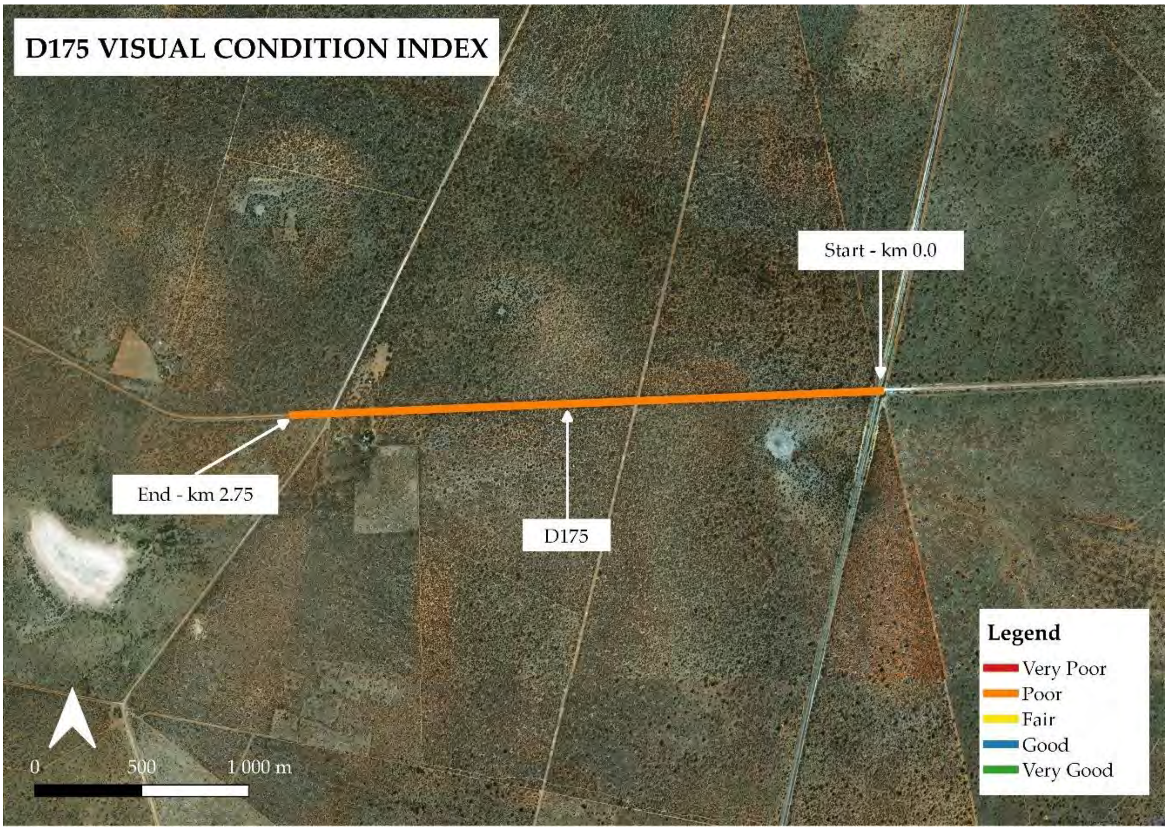


Figure 3-12: VCI along Road D175

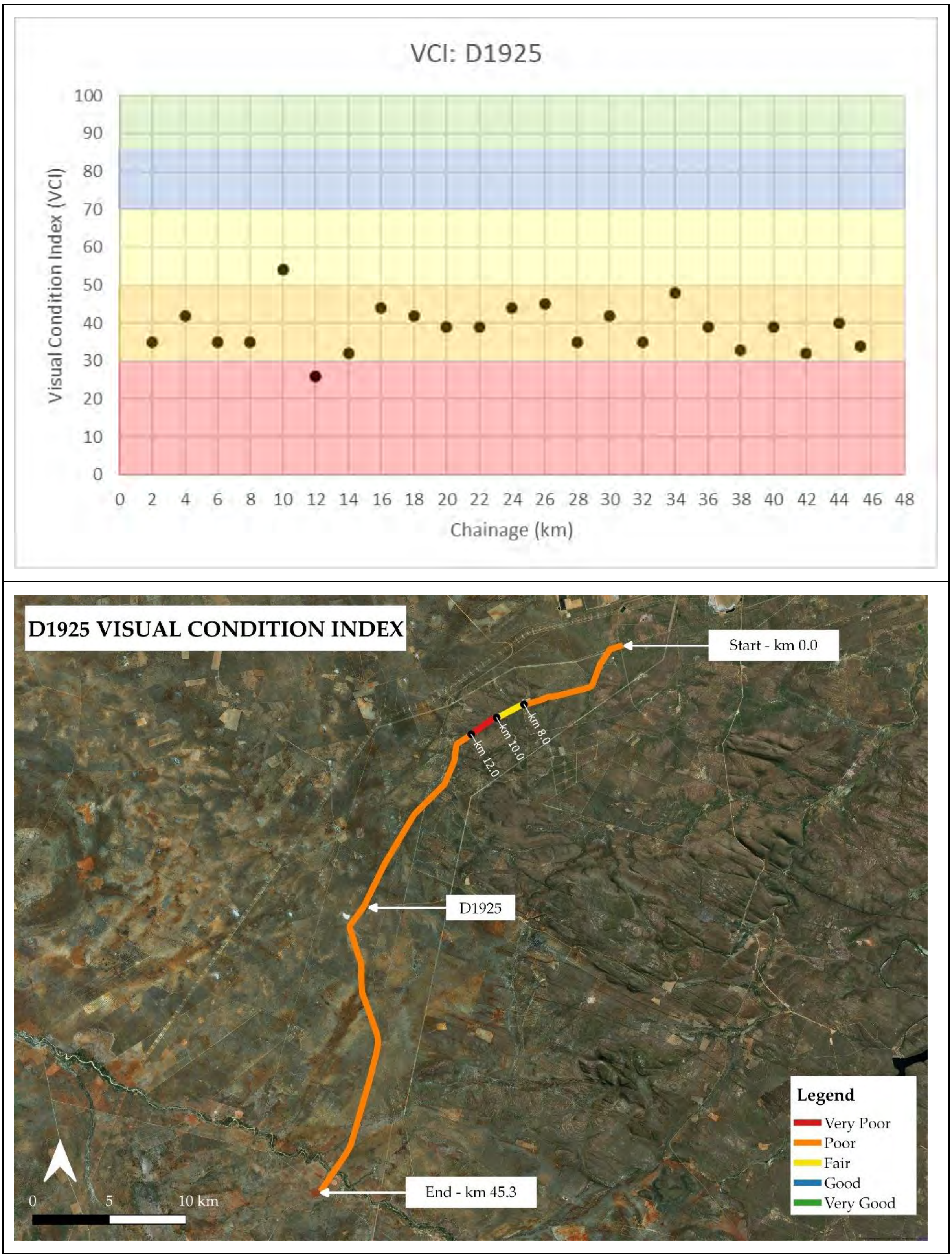


Figure 3-13: VCI along Road D1925

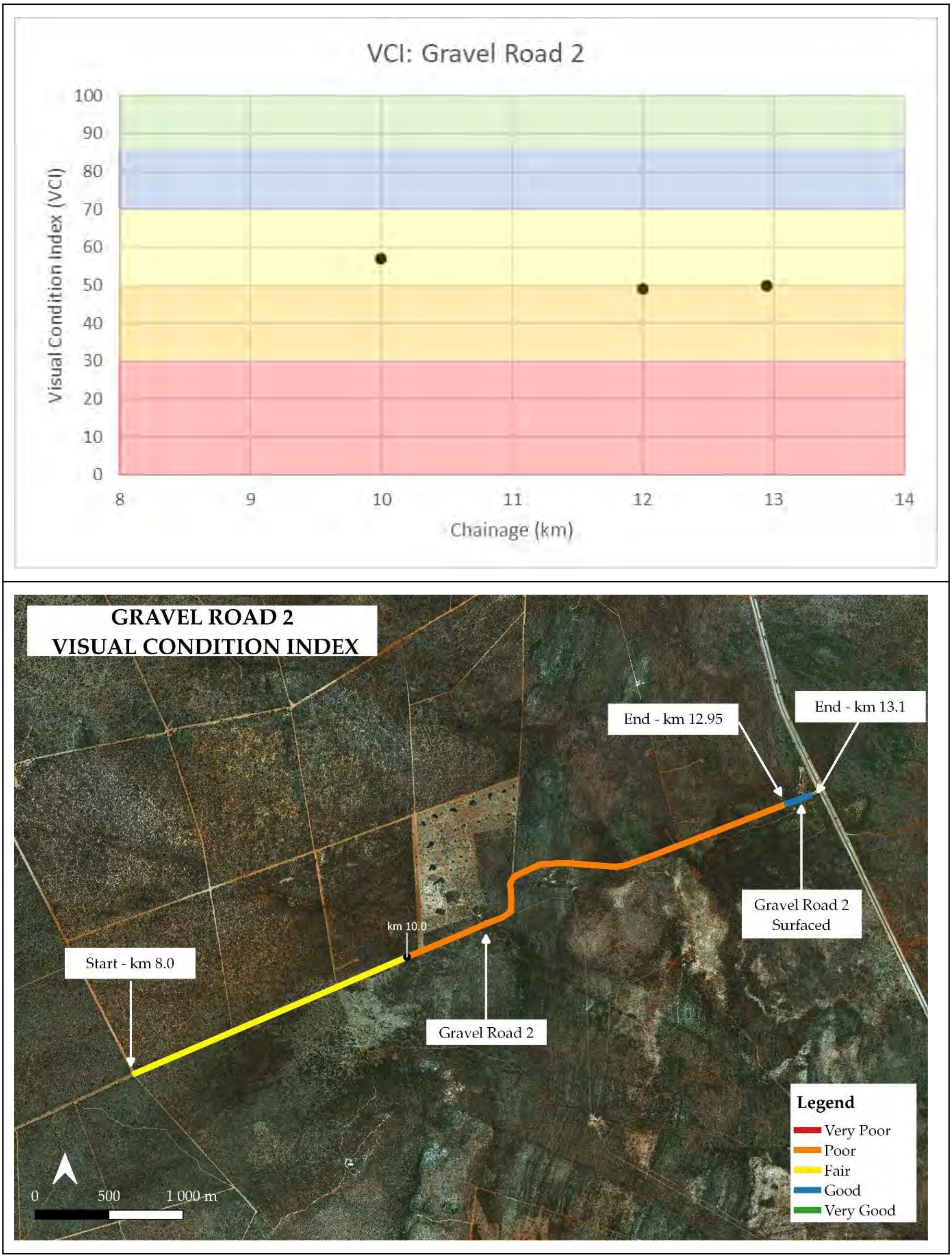


Figure 3-14: VCI along Gravel Road 2

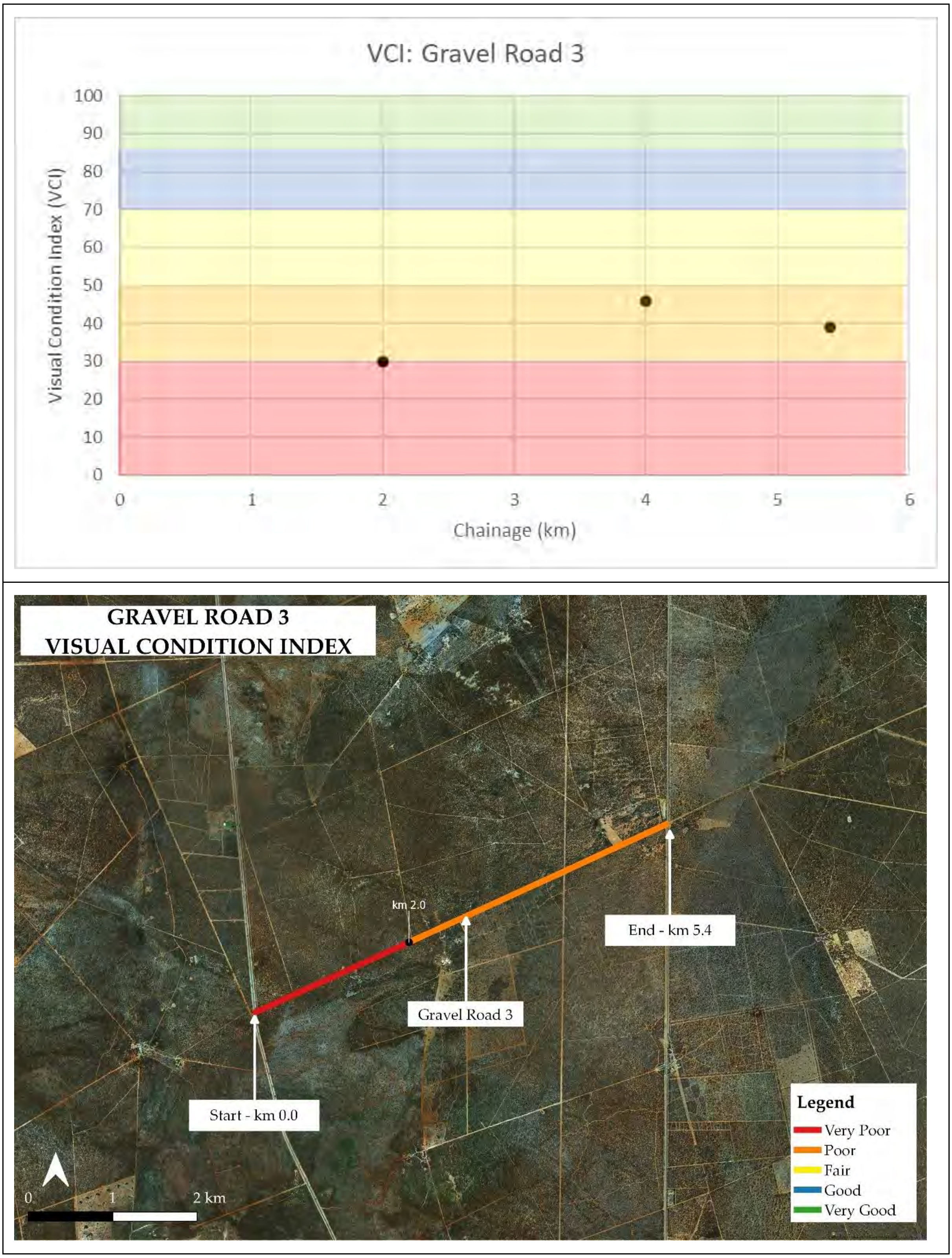
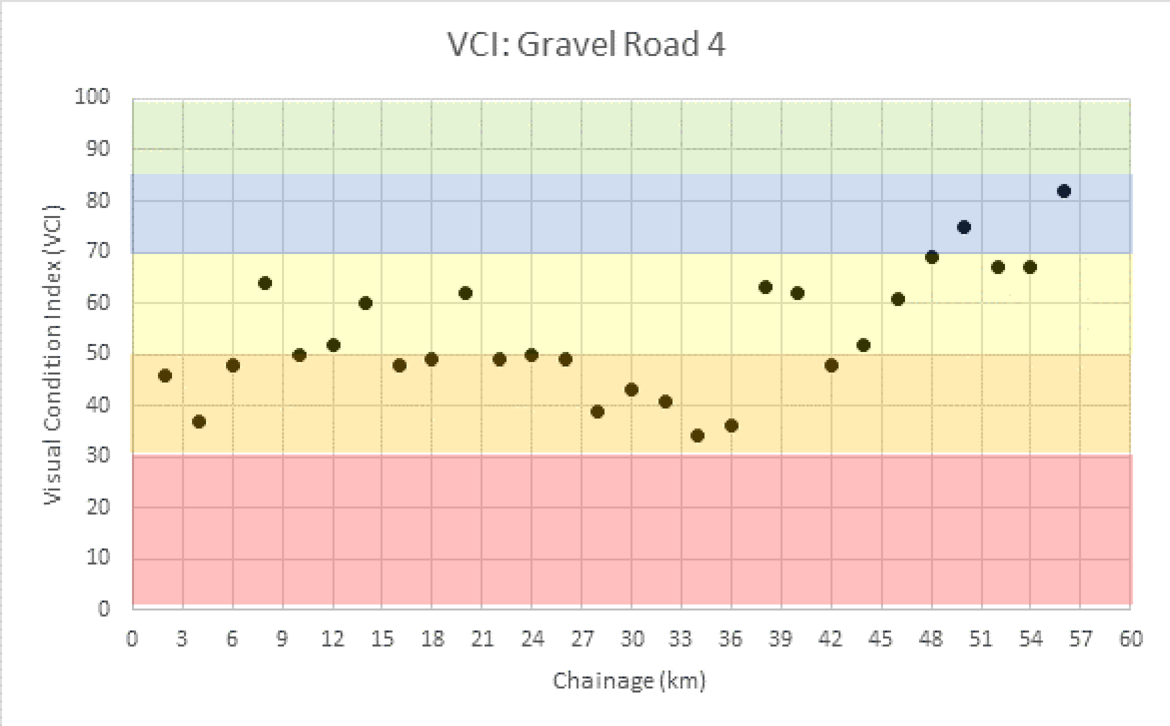


Figure 3-15: VCI along Gravel Road 3



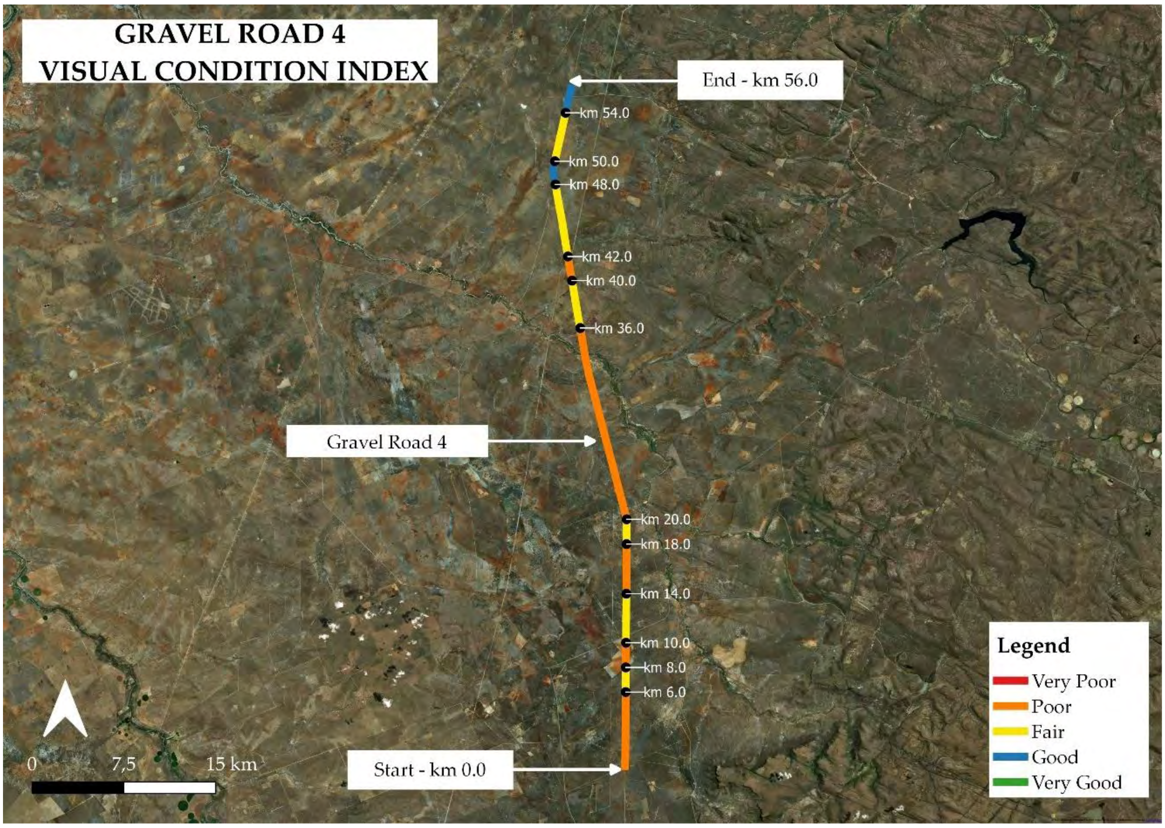


Figure 3-16: VCI along Gravel Road 4

3.5 Baseline Parameter: In-Situ Material Strength Determination

Dynamic Cone Penetrometer (DCP) tests are non-destructive and ideal for obtaining a measure of the in-situ strength of road pavements. DCP tests were generally conducted at 1 km intervals along the identified road network and were done along both surfaced and unsurfaced roads.

One of the challenges that was experienced during this assessment was refusal of the DCP instrument. Refusal typically occurs when the DCP encounters rock or very rigid layers. Refusal is also often found in crushed stone layers due to the closely compacted and interlocked aggregate, as well as with stabilised layers due to the rigid nature thereof.

The assessment showed that refusal occurred in most DCP positions. The normal procedure for doing DCP measurements allow for the operator to try two alternative positions should the first and second test refuse. In the case where the third measurement also refuses, it is usually stated as such and moved to the next position. However, for this project where refusal was found in the upper ±300 mm, some of the upper layers were removed to attempt to penetrate the selected and subgrade layers.

This however resulted in many DCP measurements which did not include the base and subbase layers, and in particular in the case of the surfaced roads.

One of the properties that can be calculated from the DCP measurements is the total number of blows to penetrate 800 mm (DSN_{800}) into the existing pavement structure. However, due to the above problem where the upper pavement layers showed refusal, this property could not be calculated.

Another property calculated from the measurements is the penetration rate (DN) in mm/blow. The penetration rate is often used to calculate what is known as a DCP-CBR. This should not be confused with the laboratory CBR and is used in technical guidelines to assist with pavement design. More importantly, the penetration rate provides a good indication of the quality of the in-situ material, which is correlated to the material classification (G1-G10). Chapter 10 of the South African Pavement Engineering Manual (SAPEM) provides and serves as a guideline on this, which is summarised in Table 3-6.

Table 3-6: Typical DCP penetration rates (DN-values) for pavement materials

Material Type	Material code or description	DN-values
Crushed stone	G1	1.25 (1.1 – 1.4)
Crushed stone	G2	1.6 (1.4 – 1.8)
Crushed stone	G3	<2.0
Natural gravel	G4	<3.7
Natural gravel	G5	<5.7
Natural gravel	G6	<9.1
Gravel	G7	<14
Gravel	G8	<19
Gravel	G9	<25
Gravel	G10	<48
Lightly stabilised material	C3	1.2 (0.6 – 1.8)

Material Type	Material code or description	DN-values
Lightly stabilised material	C4	2.6 (1.8 – 3.4)

Graphical plots of the minimum, maximum and average penetration rates at each DCP measuring point were made for each road and are provided below.

3.5.1 Surfaced Roads

Average DN-values along Road R510-2 as indicated in Figure 3-17 generally show that the penetration is less than 5 mm/blow with only one position where this value is exceeded. This indicates that the typical material quality in the lower layers of the pavement is G5-quality or better. When the maximum values are considered, material quality can be estimated as G6-quality or better. The single high maximum value of 27 mm/blow is indicative of a G10-quality layer, which is not uncommon in the lower layers of the pavement structure.

Based on the above the pavement along Road R510-2 can therefore be considered as structurally sound.

Average values along **Road R510-3** vary from 2 to 13 (Figure 3-18), indicating in most instances material quality of G6 or better. Maximum values between 3 and 43 were determined, again indicating that some material can be classified as G10-quality.

Although not as good compared to the DN-values along Road R510-2, the values indicate that the pavement is sound.

DN-values along **Road R511-3** (Figure 3-19) are similar to that along Road R510-2 with average penetration rates below or equal to 5 mm/blow. Maximum rates were generally below 12 with only two measurements at 15 mm/blow and 21 mm/blow. The latter is indicative of G9-quality material and better.

Road R511-3 can therefore also be described as structurally sound.

Similar to the above, average DN-values along **Road R516-1** (Figure 3-20) indicate material of G5-quality or better, while maximum values indicate material of G9-quality or better. This is again indicative of a structurally sound pavement.

Average DN-values along **Road D2701 (**Figure 3-21), **Road D1675** (Figure 3-22) and **Road D2649** (Figure 3-24) are below 3 mm/blow with maximum values below 8 mm/blow, indicative of G5-quality material and better. These values are better compared to those along the previous road sections however, it can also be indicative of a highly consolidated pavement structure.

DN-values along **Road D1649 (**Figure 3-23) are similar to those for Road D2701 and Road D1675 with one measurement having an average DN-value of 7 mm/blow and a maximum value of 28 mm/blow.

It shows that these pavements can be considered structurally sound.

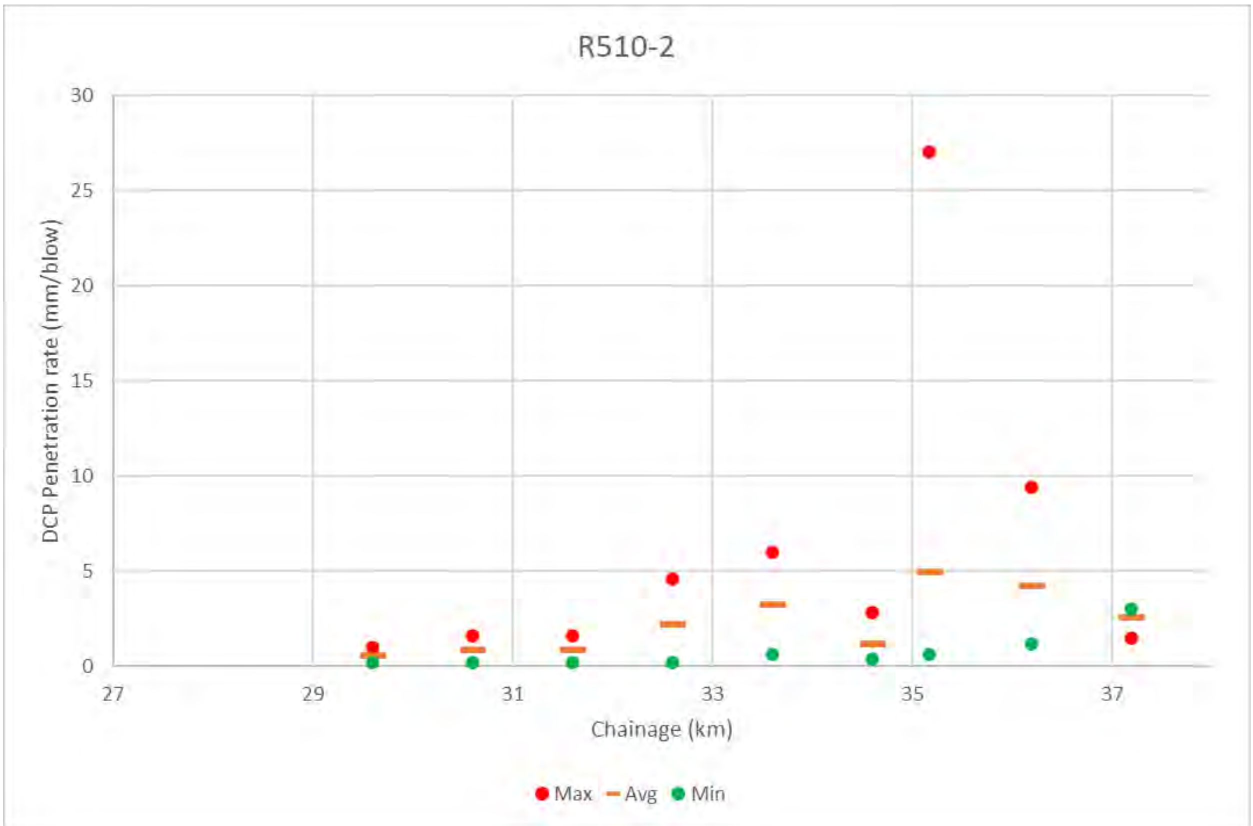


Figure 3-17: Road R510-2 DN-values

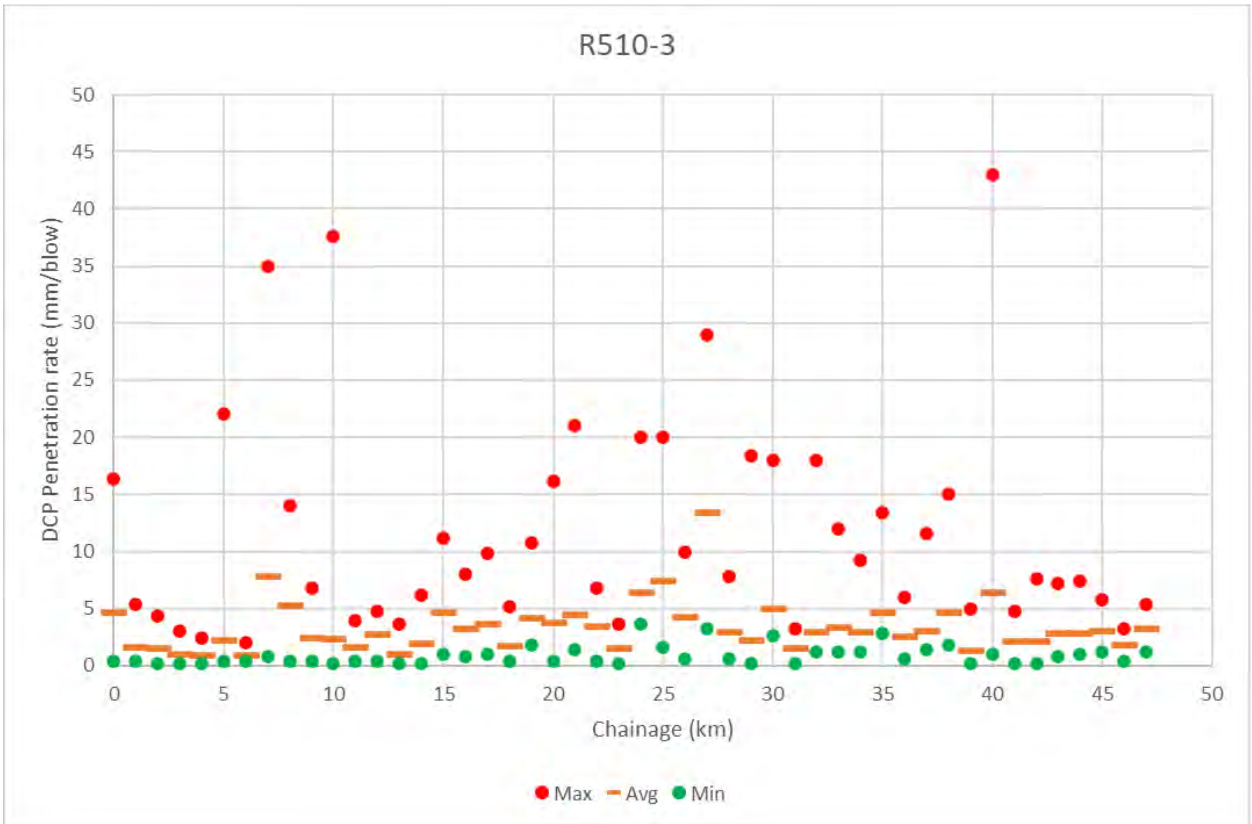


Figure 3-18: Road R510-3 DN-values

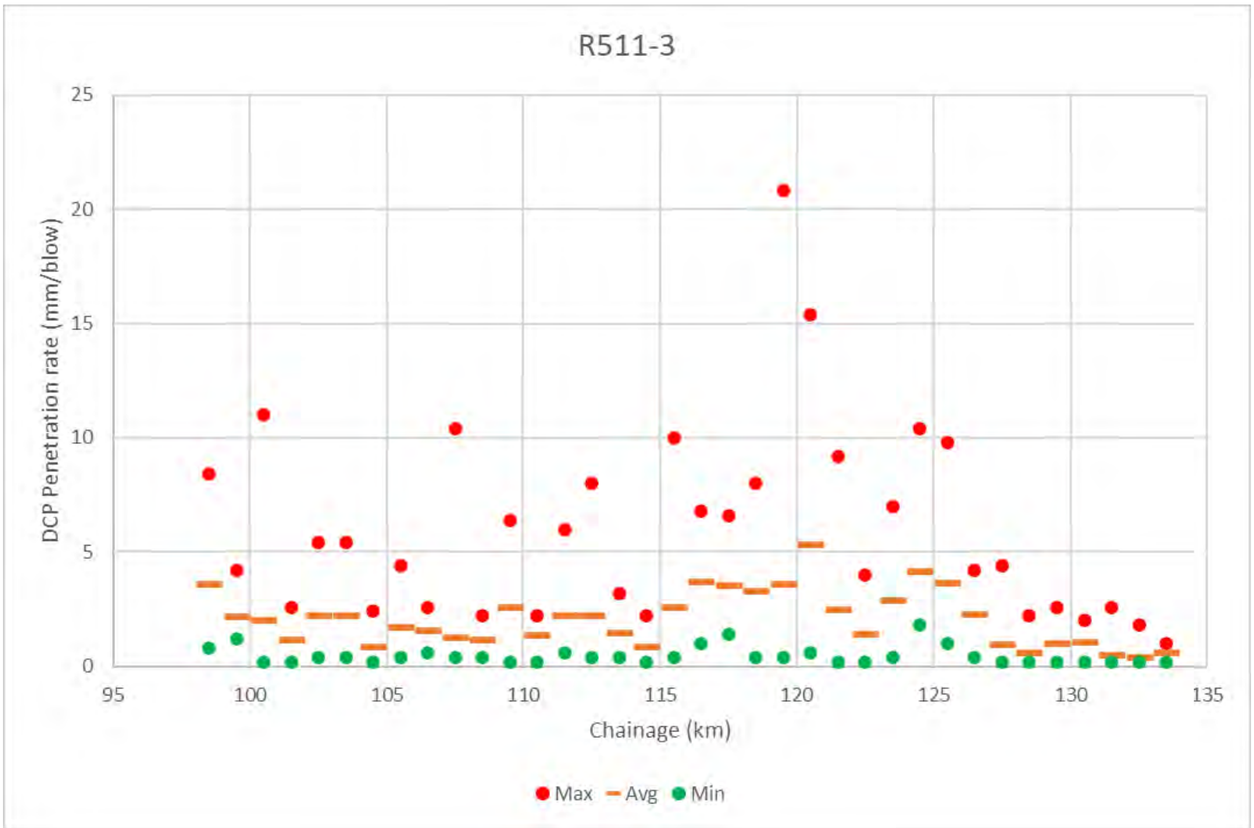


Figure 3-19: Road R511-3 DN-values

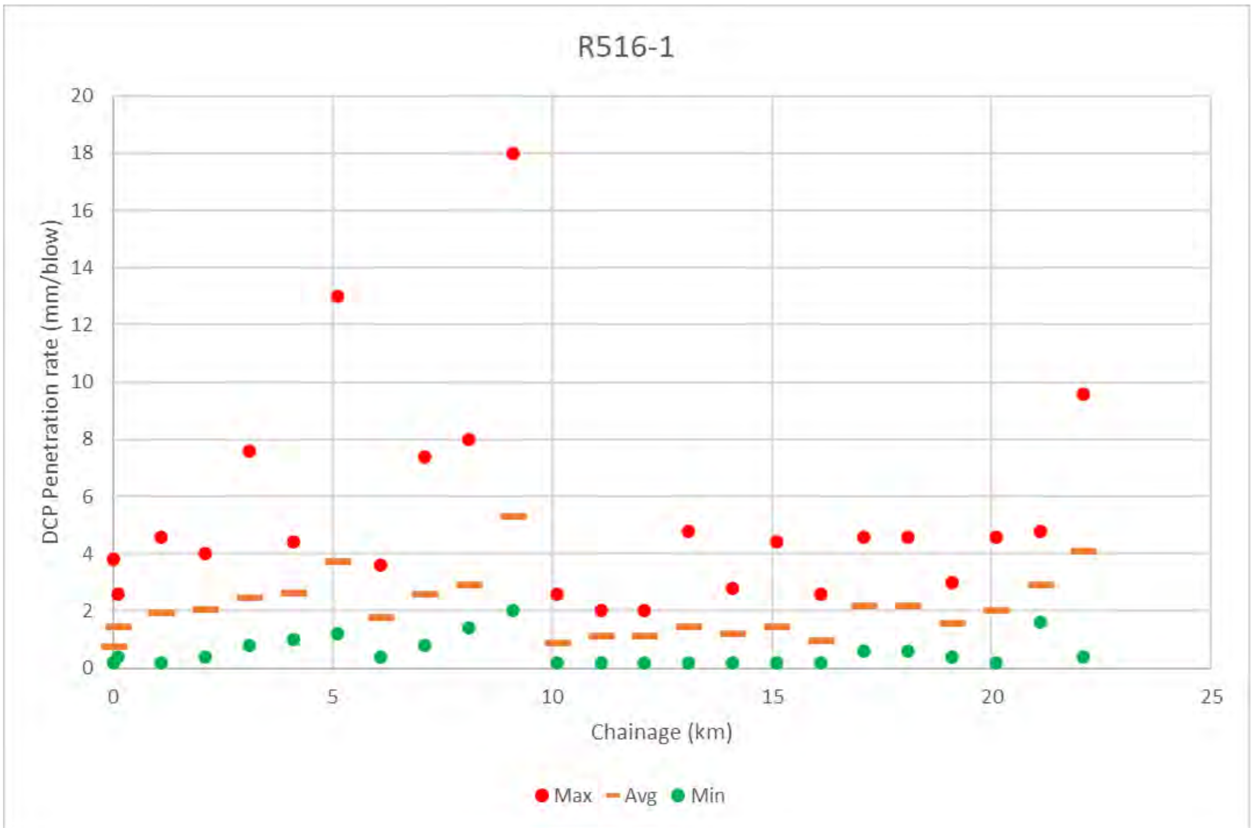


Figure 3-20: Road R516-1 DN-values

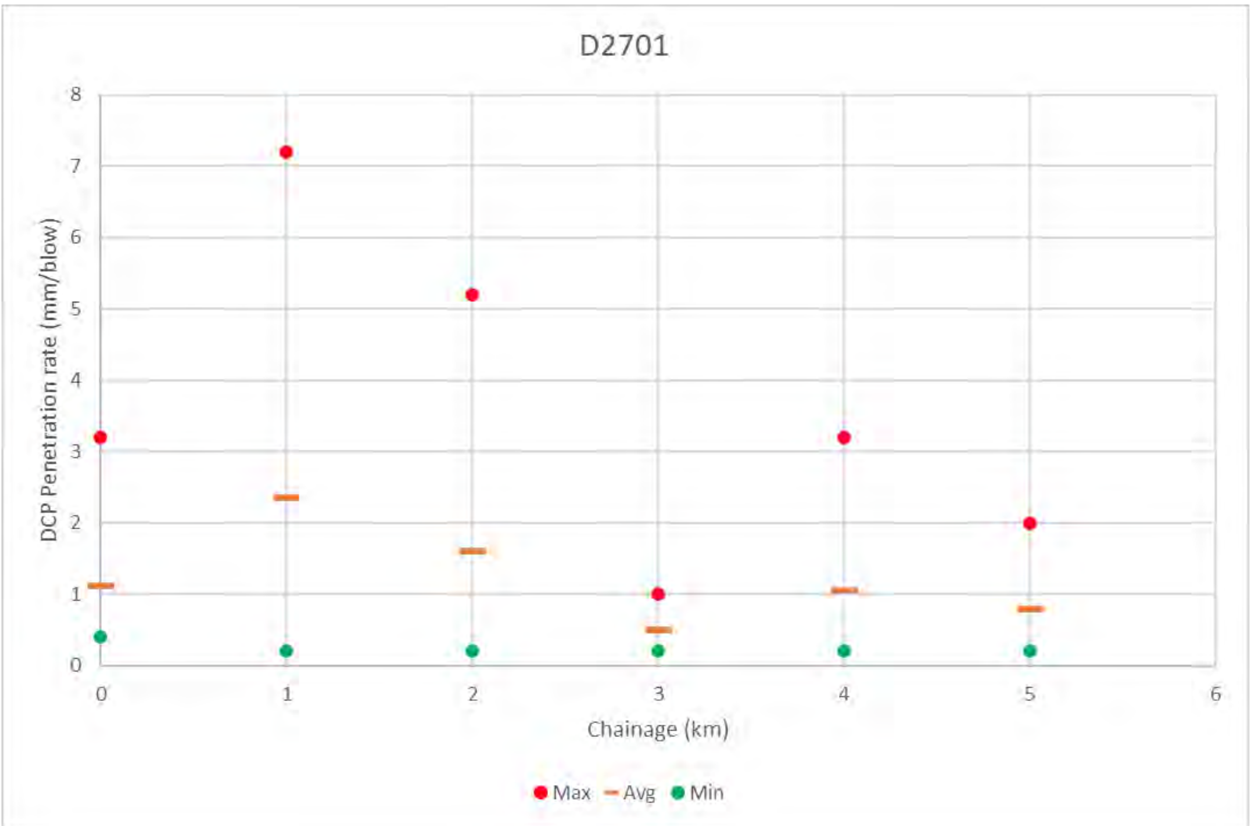


Figure 3-21: Road D2701 DN-values

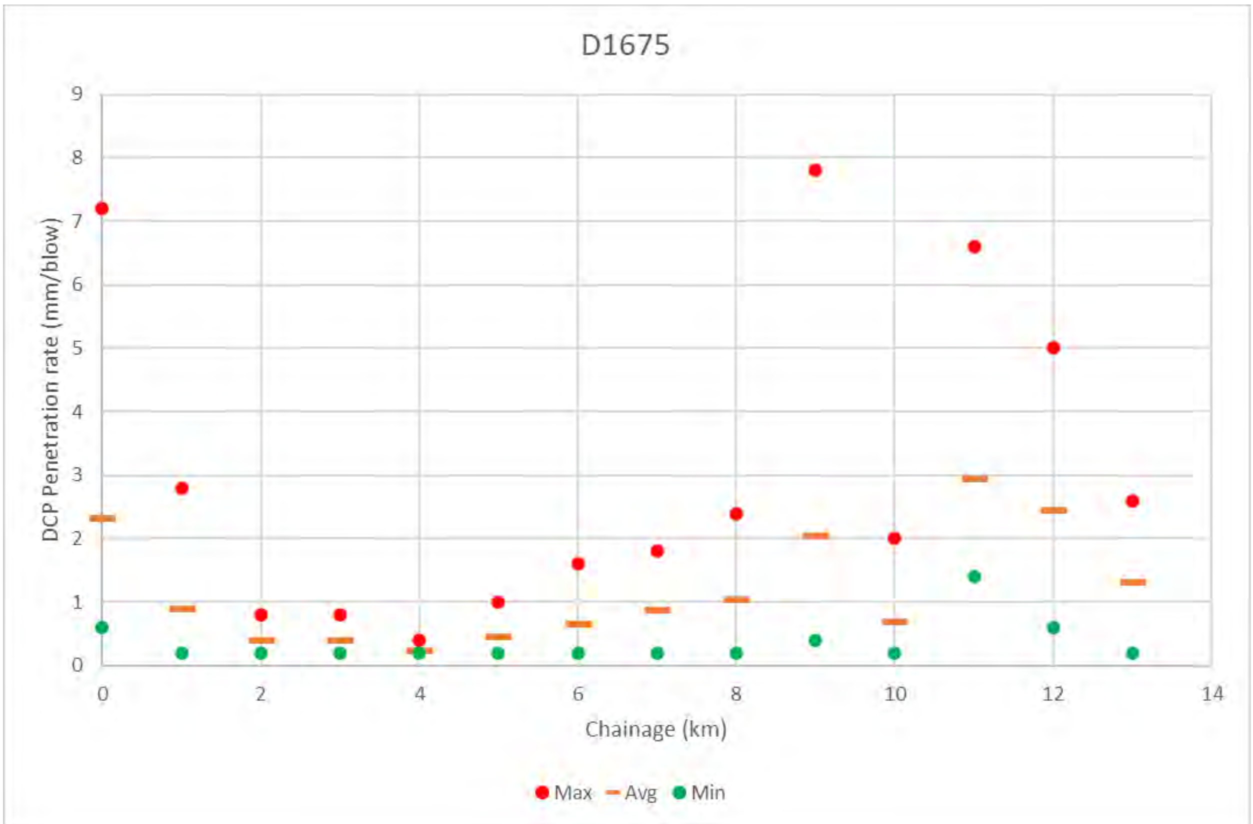


Figure 3-22: Road D1675 DN-values

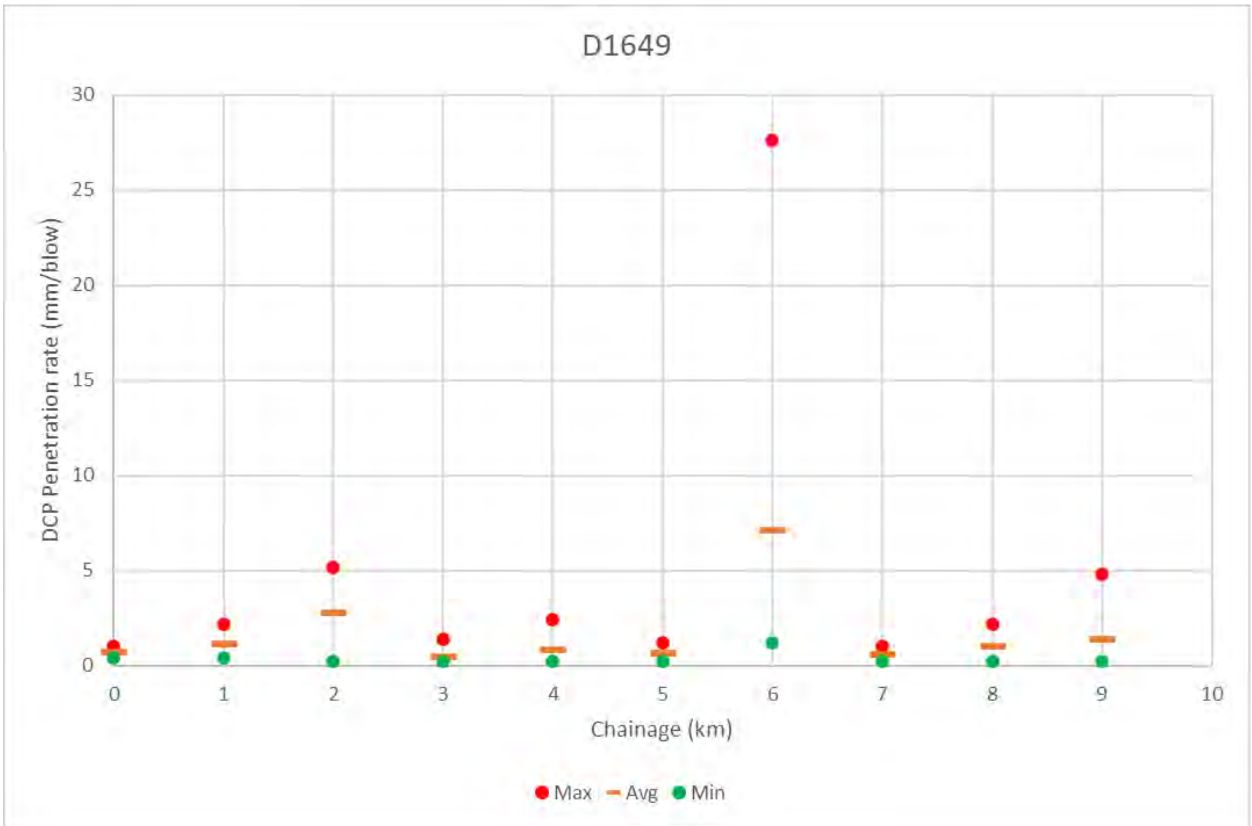


Figure 3-23: Road D1649 DN-values

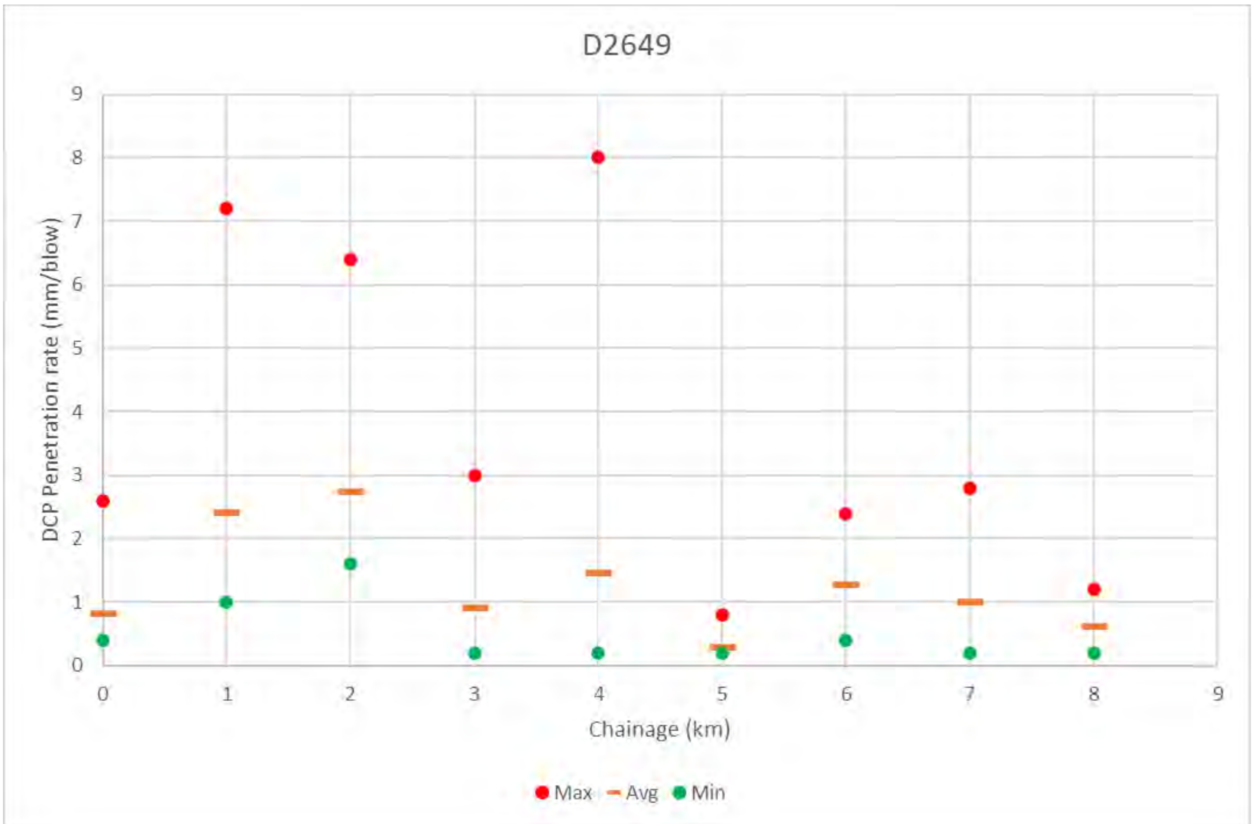


Figure 3-24: Road D2649 DN-values

3.5.2 Unsurfaced Roads

Average DN-values along **Road D769** (Figure 3-25) and **Road D2701** (Figure 3-26) generally show that the penetration is less than 9 mm/blow. This indicates that the typical material quality in the lower layers of the pavement is G6-quality or better. When the maximum values are considered, material quality can be estimated as G9-quality or better.

Based on the above and considering that these are gravel roads, the pavements can be considered as structurally sound.

DN-values along **Road D175** as indicated in Figure 3-27 vary along its length, however due to the short section only three measurements were done. The measurement at km 0,0 is at the intersection with Road D1925, the results of which are described below. With the exception of this result, average DN-values are below 6 mm/blow with a maximum penetration rate of 23 mm/blow.

Considering that the measurement at km 0,0 is at an intersection with Road D1925, this result was compared to those along Road D1925. Although the maximum value is slightly higher than those along Road D1925, it generally appears to be similar, and it can therefore be argued that the pavement at this intersection was probably constructed at the same time as that along Road D1925.

Average DN-values along **Road D1925** (Figure 3-28) are in the order of 2 mm/blow to 14 mm/blow, indicating material quality of G7 or better. Maximum values vary from 2 mm/blow to 30 mm/blow indicating material quality of G9 or better.

3.5.3 Summary

DCP penetration rates measured along the respective roads forming part of this project generally indicate good quality in-situ material within the respective pavement structures. It should be noted that this assessment considered only those layers that could be penetrated with the DCP instrument. These typically excluded the base and in some cases the subbase layers.

Considering this, the findings indicate that material quality is acceptable.

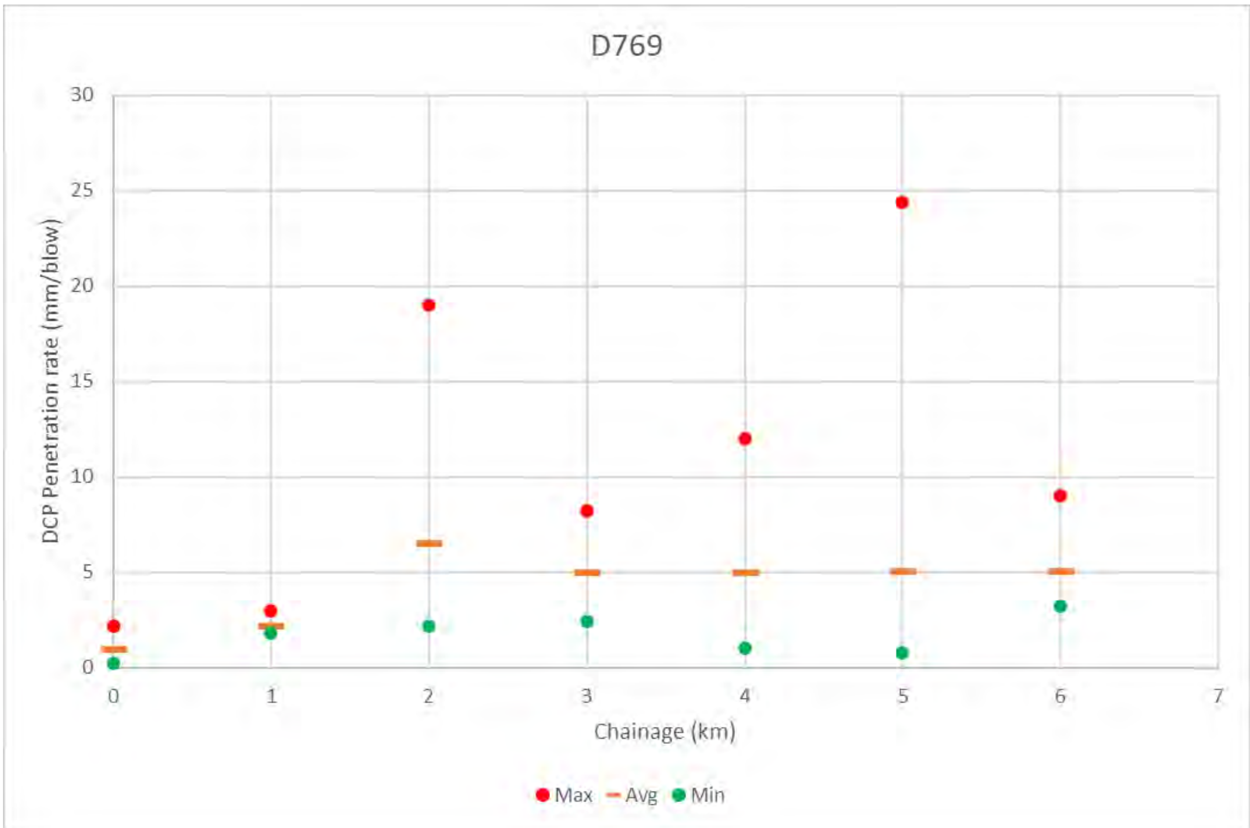


Figure 3-25: Road D769 DN-values

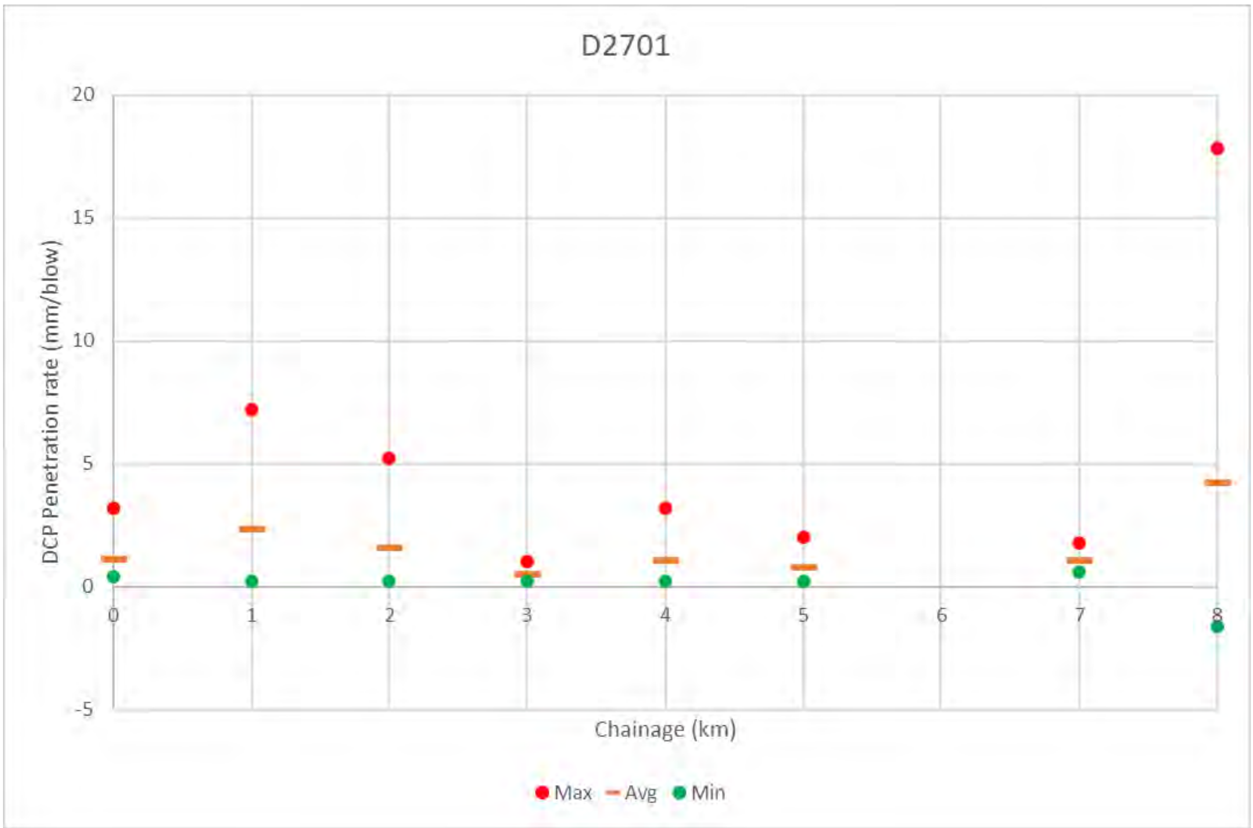


Figure 3-26: Road D2701 DN-values

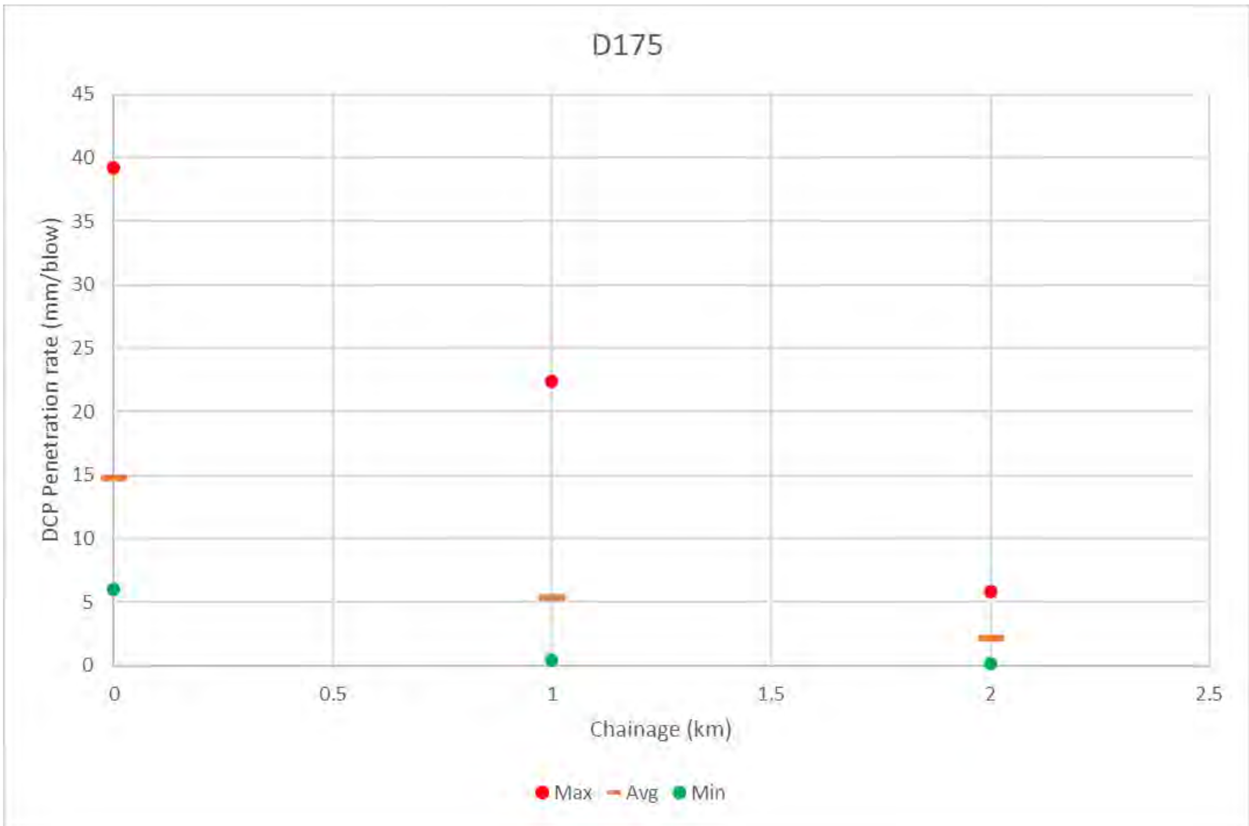


Figure 3-27: Road D175 DN-values

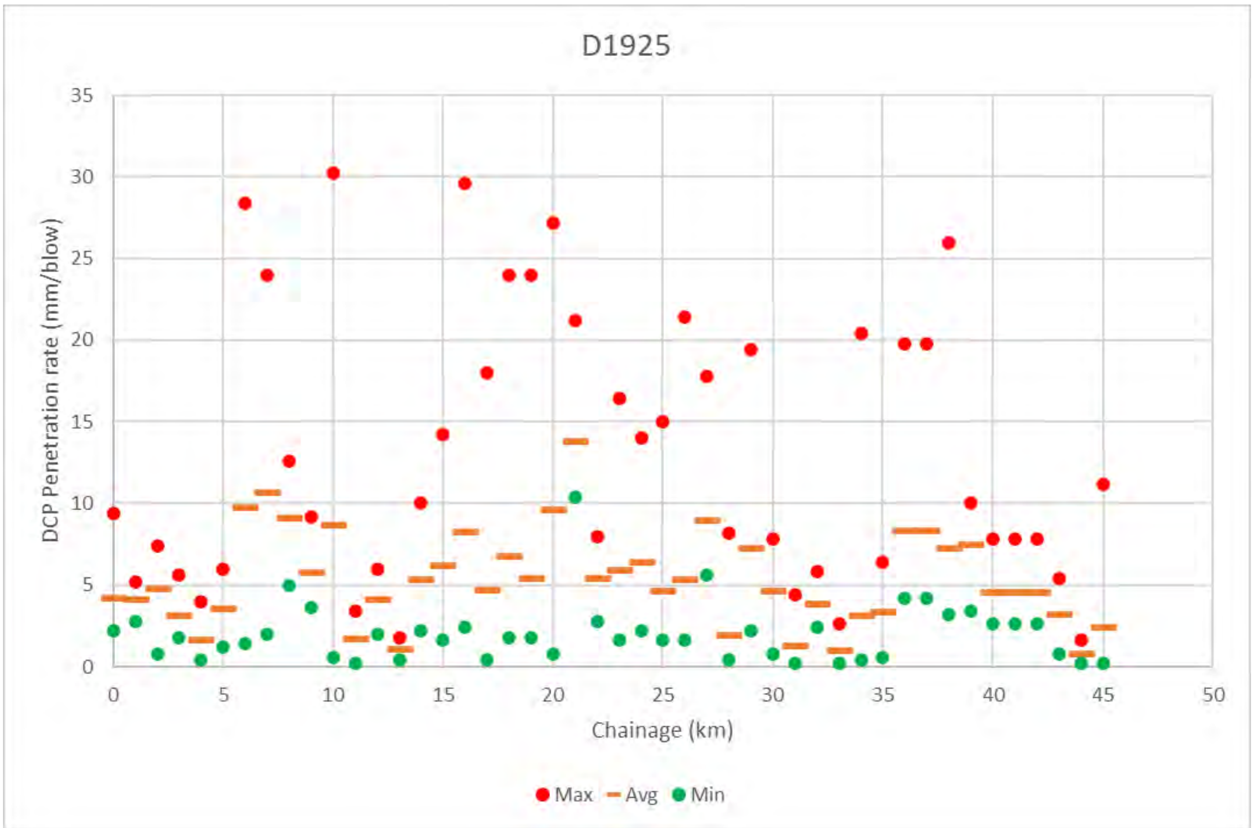


Figure 3-28: Road D1925 DN-values

3.6 Baseline Parameter: In-Situ Layering/ Layer Thickness

The baseline parameter of in-situ layering is a quantitative assessment by measuring the thickness of wearing course layers for unsurfaced roads.

It is expected that the increase in construction-related traffic will lead to gravel loss of the wearing course material over time, hence the reason to measure the thickness of wearing course at identified locations.

As part of the assessment of the unsurfaced roads, wearing course thickness was measured at all locations identified for in-situ material strength determination using a pickaxe and tape measure. At each of the locations, coordinates were recorded as well as photos taken.

Unsurfaced roads are expected at most times to have at least a 200 mm layer of gravel wearing course material in place in order to ensure a functional and reasonably smooth riding surface. Whilst G6/G7 quality material is normally utilised for gravel wearing course, very often the material that is available from local borrow areas is what ends up being used for the wearing course.

The average wearing course layer thickness per unsurfaced road is summarised in the Table 3-7 below.

Table 3-7 : Average wearing course thickness per gravel road (Unsurfaced)

Road	Average wearing course thickness (mm)	Comments
D769	55	Wearing course layer thicknesses varied greatly. Riding quality was generally poor.
D2701	85	Wearing course layer thicknesses varied. Riding quality experienced as poor.

D175	0	Limited evidence of wearing course over this section.
D1925	65	Wearing course layer thicknesses varied greatly resulting in poor riding quality. A 10 km section is pure sand with no evidence of wearing course layer. A further section is hardly trafficable due to erosion etc.
Gravel Road 2	N/A	Private road – non public
Gravel Road 3	N/A	Only tracks as service road
Gravel Road 4	N/A	Tracks as service road for rail line

The wearing course thickness measurements for each road are graphically presented on the figures to follow:

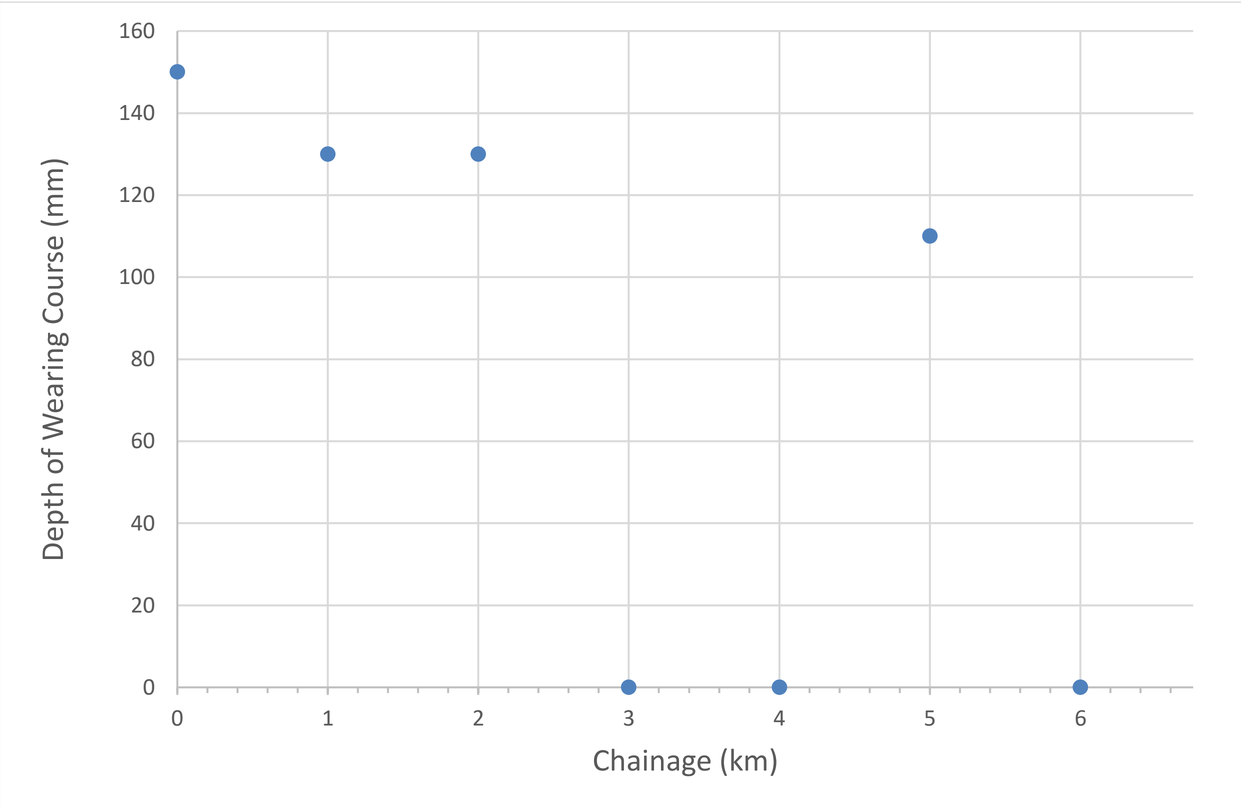


Figure 3-29: D769 Wearing Course Thickness

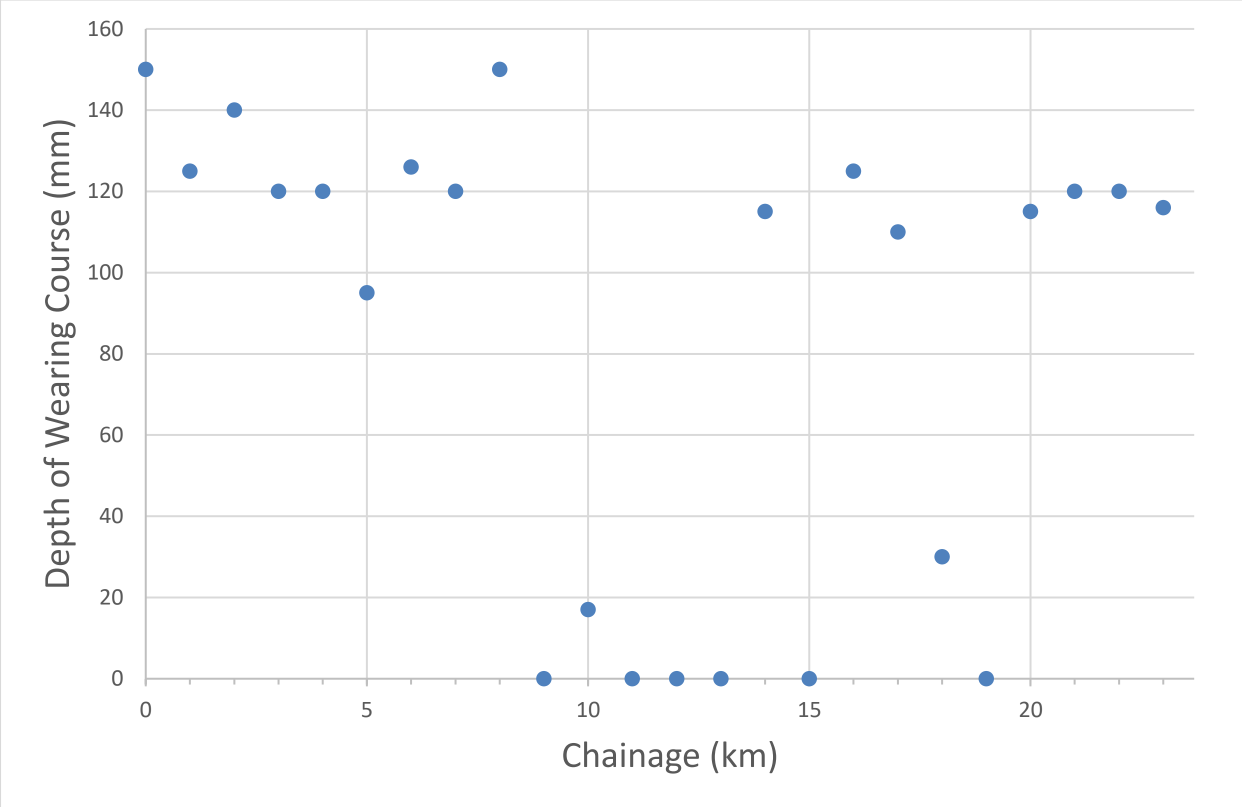


Figure 3-30: D2701 Wearing Course Thickness

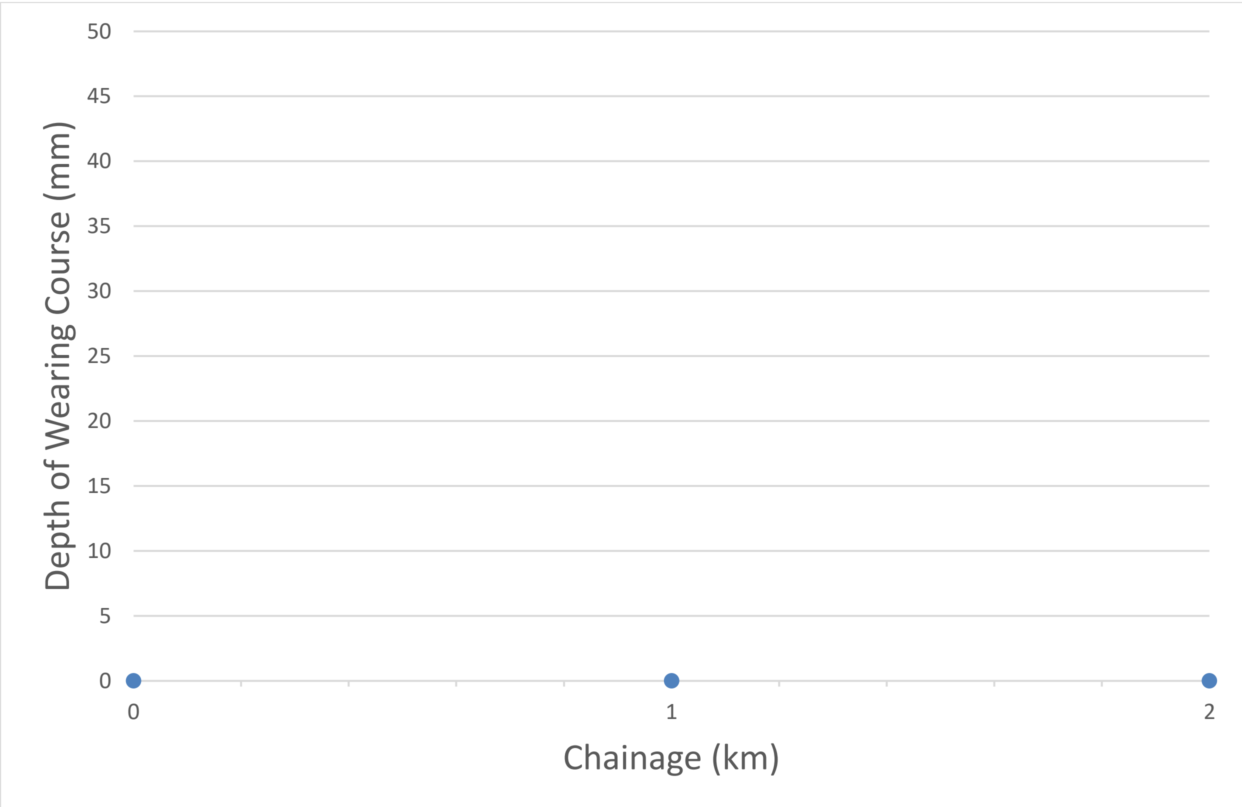


Figure 3-31:D175 Wearing Course Thickness

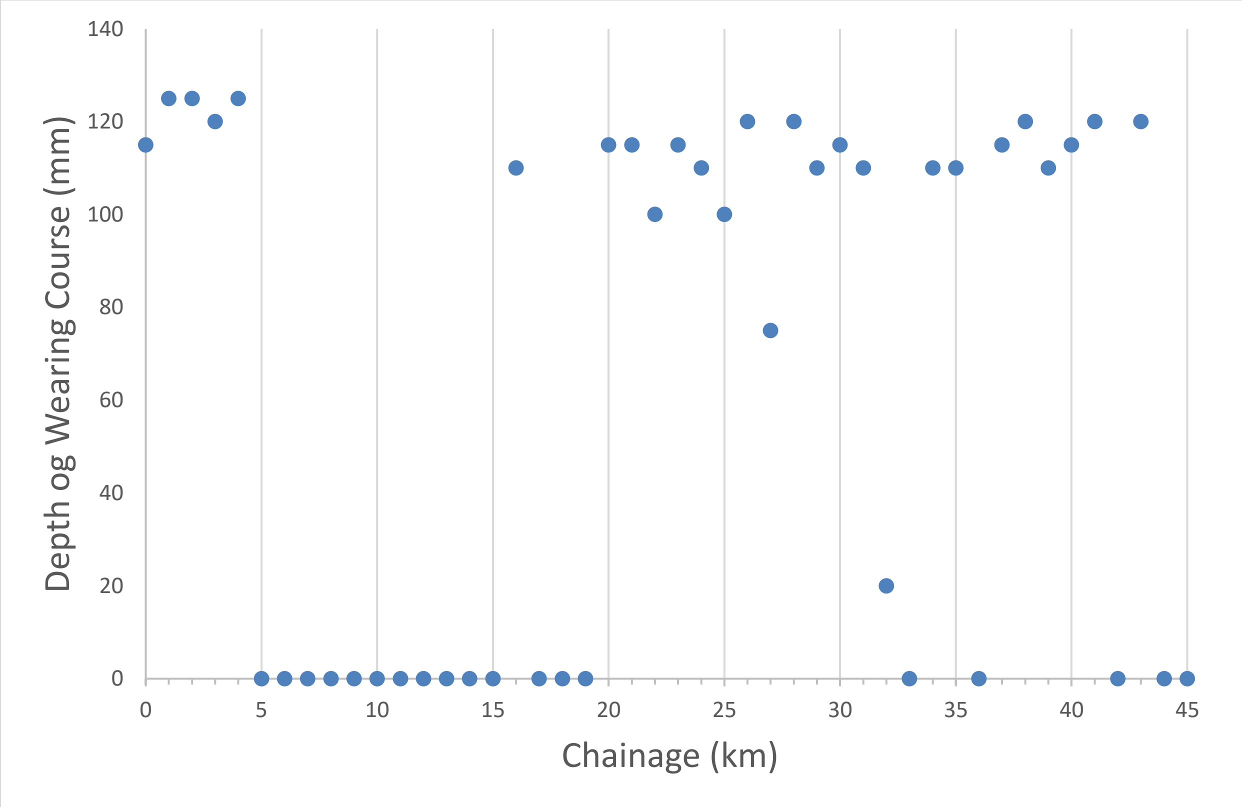


Figure 3-32: D1925 Wearing Course Thickness

With reference to the above graphs, the following comments are made:

- The first 2.9 km of **Road D769** contains good gravel wearing course of around 130 mm thick and although a full classification of the material has not been carried out, visually the material looks like a G7/G8 quality. The remaining section of the road has either not been gravelled for some time, or if it has been previously gravelled, the material has been displaced or washed away. In the areas where the subgrade is exposed, it is mainly sand which would meet the requirements of G8/G9 quality if properly compacted.
- The first 9 km of **Road D2701** has a good gravel wearing course averaging 120 – 150 mm in thickness, and again the material seems to be of G7/G8 quality. From km 9 to km 20, although the road is trafficable, the gravel wearing course varies between 0 and 120 mm thick. From km 20 to the end of the section, the road is very sandy with an approximate depth of 120 mm which at times makes traversing it challenging, especially with smaller vehicles. A 3 km section, between km 11 and km 13, the subgrade is exposed but still drives well.
- **Road D1925** has very little gravel wearing course over most of its length with the exception of the first 4 km where the gravel varies between 115 mm and 125 mm thick and appears to be of a G8 quality. The rest of the road is generally sandy with a section of exposed calcrete-type material which would normally constitute a G7/G8 quality. Other than the first 4 km, the road is generally extremely uneven and in need of re-gravelling. It is essentially a sand track with windrows built up along the edges of the road over most of the section.
- **Road D175**, a 2.6 km section of road, has no gravel wearing course and has only sand as a surface layer. The road is smooth in some sections and rough in others.
- In the case of **Gravel Road 2**, over which no wearing course thickness measurements were taken (due to it being a semi-private road), from km 0.2 to km 1.8 the road constitutes a loose gravel course material which was visually assessed as G8 quality. From km 1.8 to km 2.8 the road is built of rockfill resulting in a very rough surface. From km 2.8 to km 5.1 the road surface is sandy but trafficable as opposed to the previous section being less trafficable. A fence across the road at km

5.1 rendered it inaccessible. In summary, apart from the first 200 m, Gravel Road 2 is rough and would require a gravel wearing course for ease of travel.

- **Gravel Road 3** is essentially a sand track without any visible wearing course layer. The road is trafficable over its entire length, but with rough sections within.

3.7 Baseline Parameter: Road Roughness / Riding quality

Riding quality was measured for each of the surfaced roads along the left, middle and right wheel track, in both directions at 100 m intervals in terms of the International Roughness index (IRI). These measurements were carried out by Specialised Road Technologies (Pty) Ltd utilising a Road Surface Profilometer (RSP).

For assessment of the road roughness the average IRI results have been plotted for each road in both directions in terms of TRH 12 criteria. For this purpose, the R-roads have been classified as Class B and the D-roads as Class C. The figures that follow indicate the plotted IRI values for the various roads.

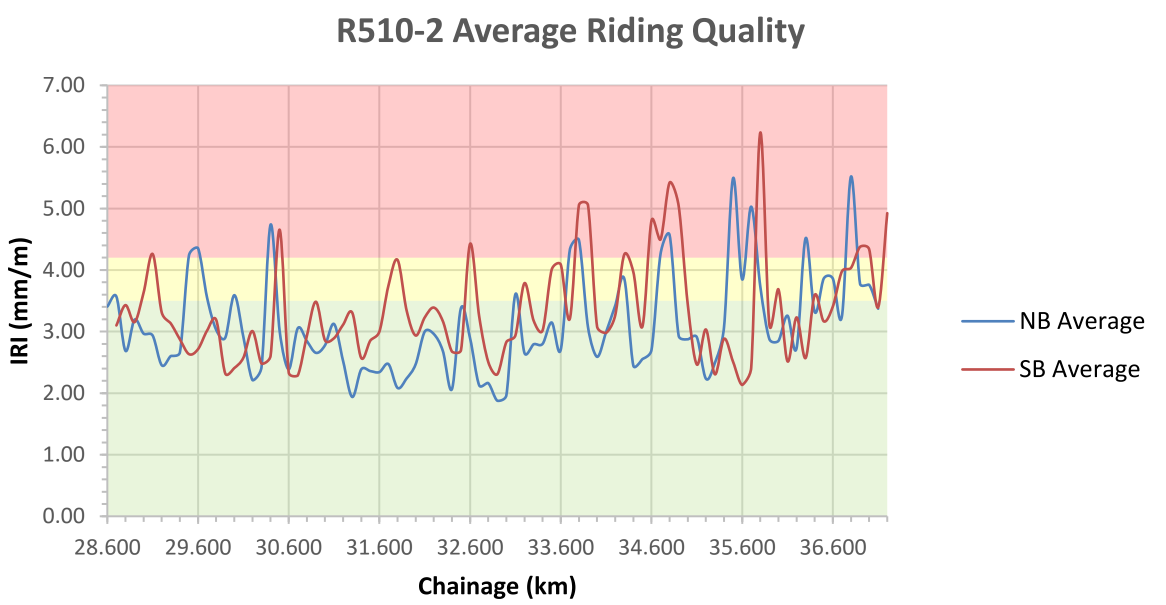
As the RSP also computes rut depth (amongst other measurements and data), rut depths have also been plotted for each road in both directions.

For each data set, measurements have been compared to the road surface condition criteria specified in SAPEM and TRH 12. The criteria are summarised in Table 3-8.

Table 3-8: TRH Performance Criteria

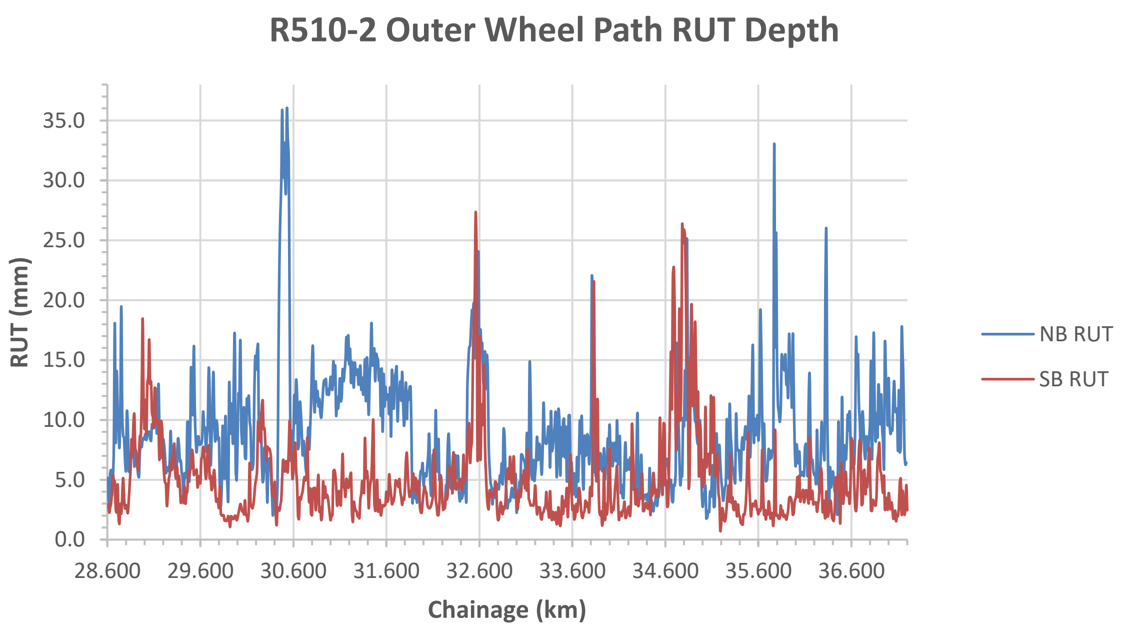
Road Category	Riding Quality (IRI)		Rut Depth (mm)	
	X	**Y**	**X**	**Y**
Class B (R-roads)	3.5	4.2	10	20
Class C (D-roads)	4.2	5.1	10	20

Kindly note: Results below the specified X values are classified as being sound, while results between the X and Y values are classified as a warning and those above the Y value as a severe warning.



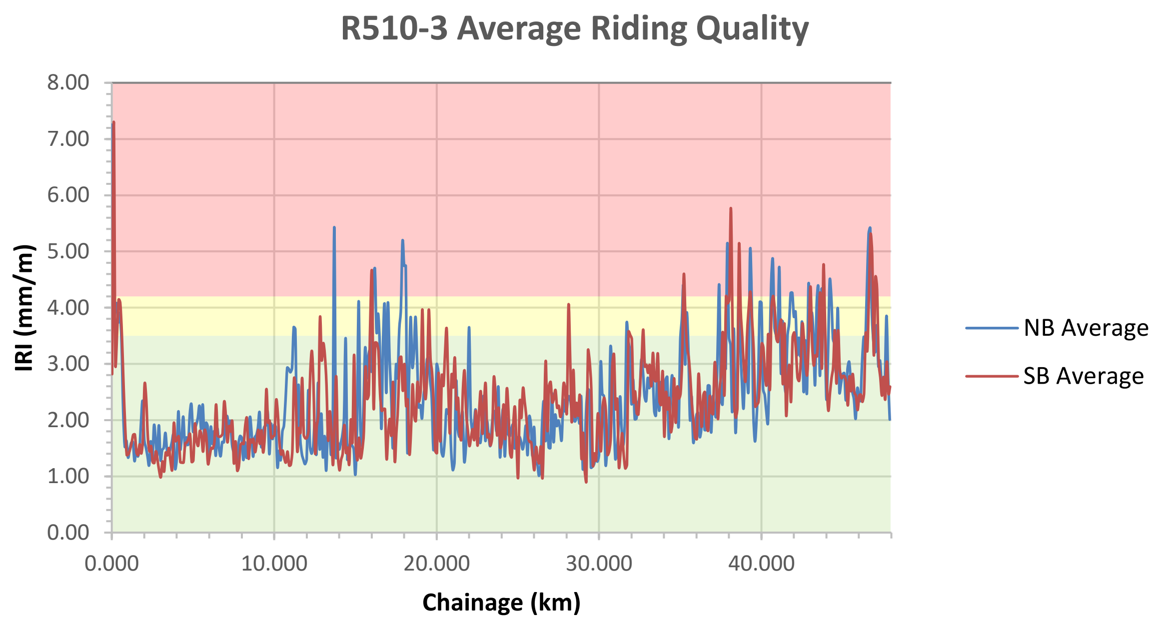
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>4.2	13.37%	16.86%	14.53%
3.5-4.2	10.47%	16.86%	12.79%
<3.5	76.16%	66.28%	72.67%

A: R510-2 Average riding quality (IRI)



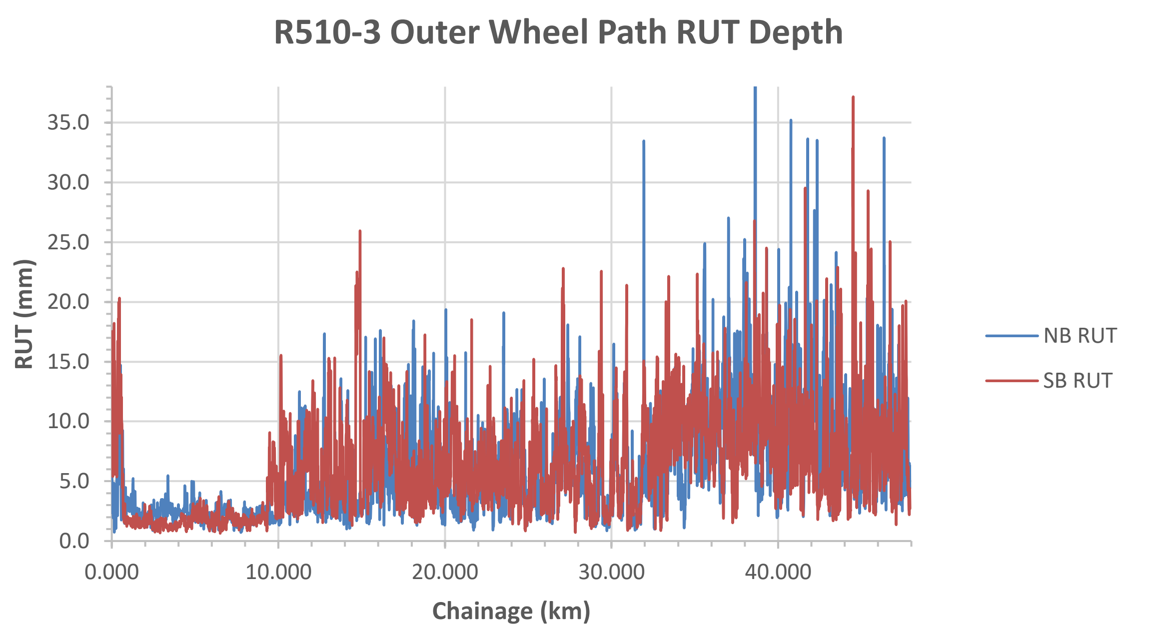
B: R510-2 RUT Depth at outer wheel path

Figure 3-33: R510-2



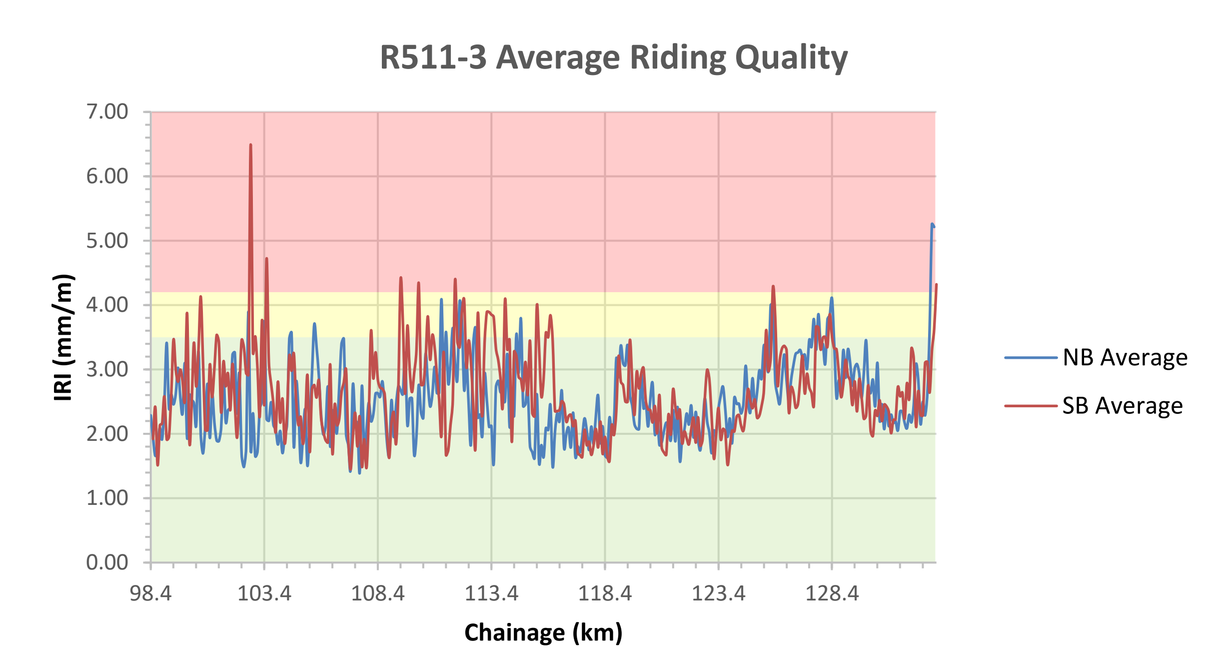
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>4.2	5.31%	4.90%	3.96%
3.5-4.2	7.50%	7.19%	8.33%
<3.5	87.19%	87.92%	87.71%

A: R510-3 Average riding quality (IRI)



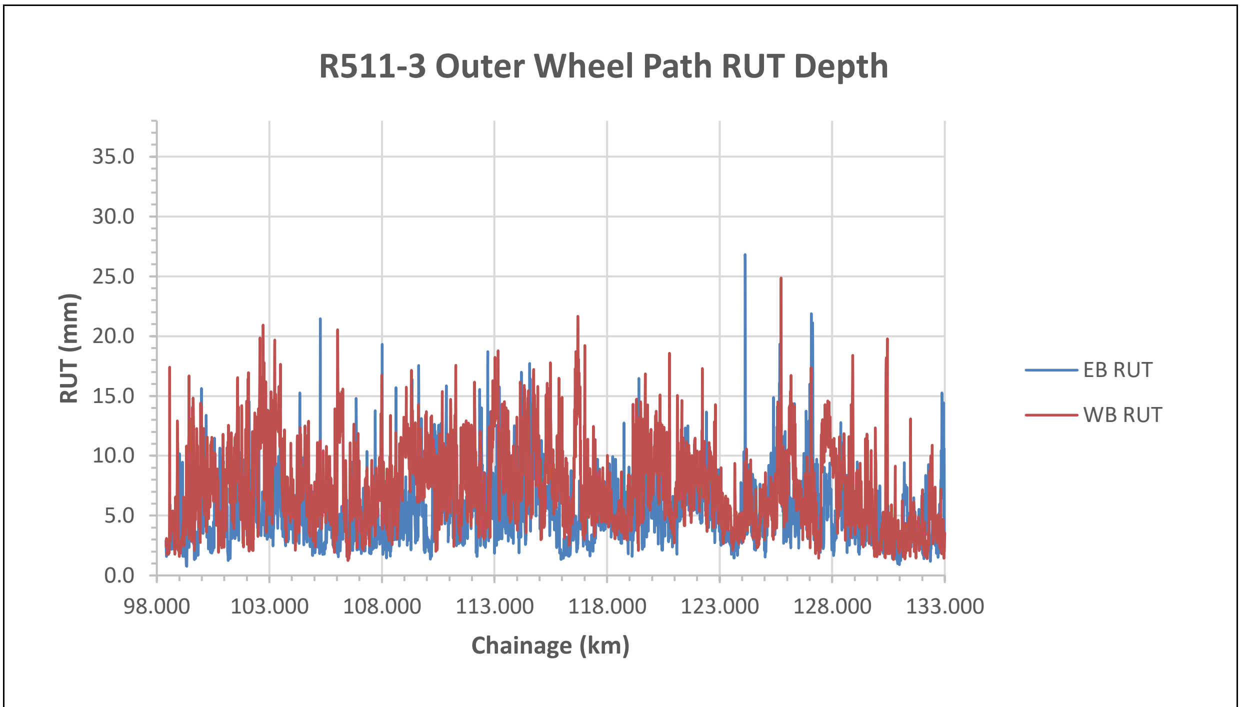
B: R510-3 RUT Depth at outer wheel path

Figure 3-34: R510-3



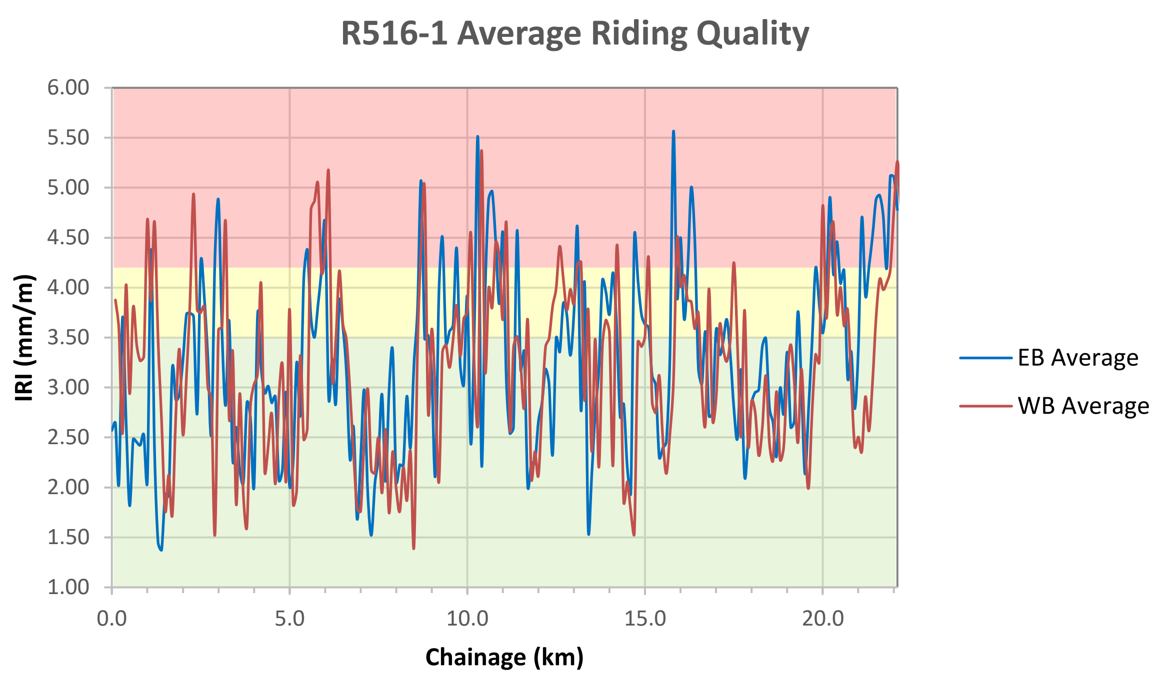
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>4.2	6.94%	0.87%	1.30%
3.5-4.2	13.29%	4.48%	7.08%
<3.5	79.77%	94.65%	91.62%

A: R511-3 Average riding quality (IRI)



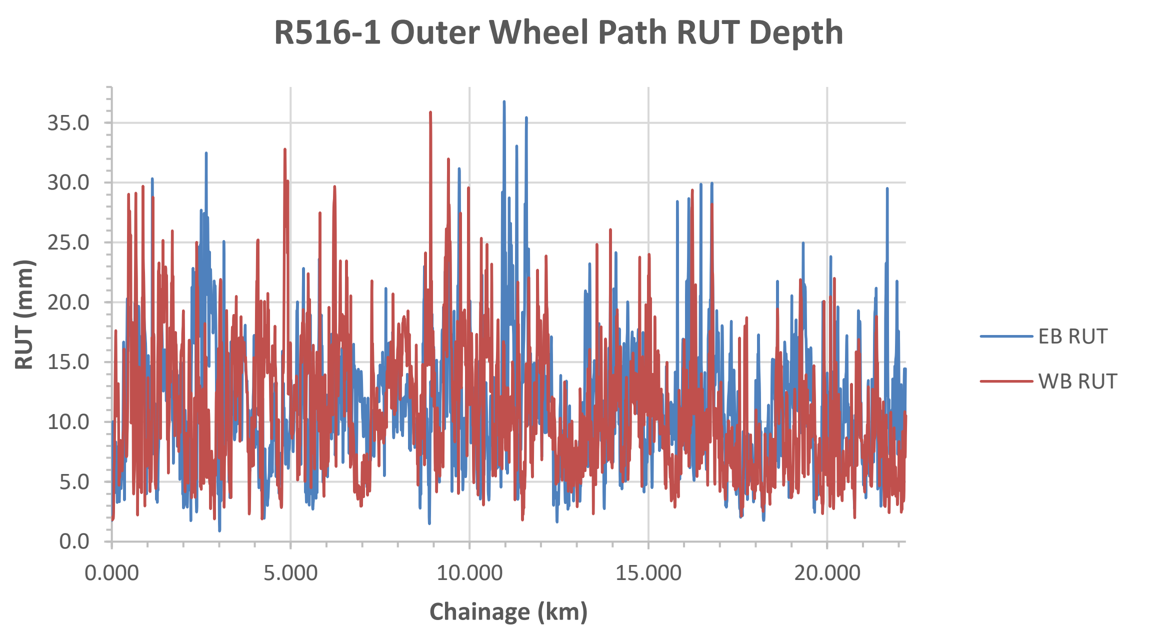
B: R511-3 RUT Depth at outer wheel path

Figure 3-35: R511-02



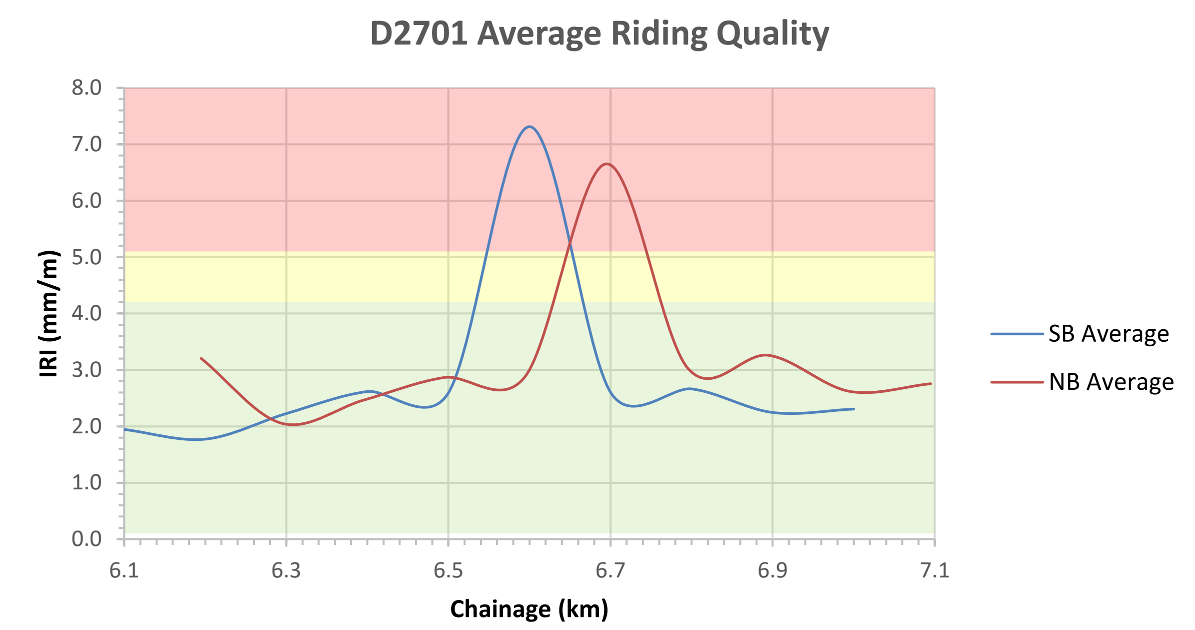
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>4.2	14.19%	19.37%	13.74%
3.5-4.2	20.95%	20.50%	24.32%
<3.5	64.86%	60.14%	61.94%

A: R516-1 Average riding quality (IRI)



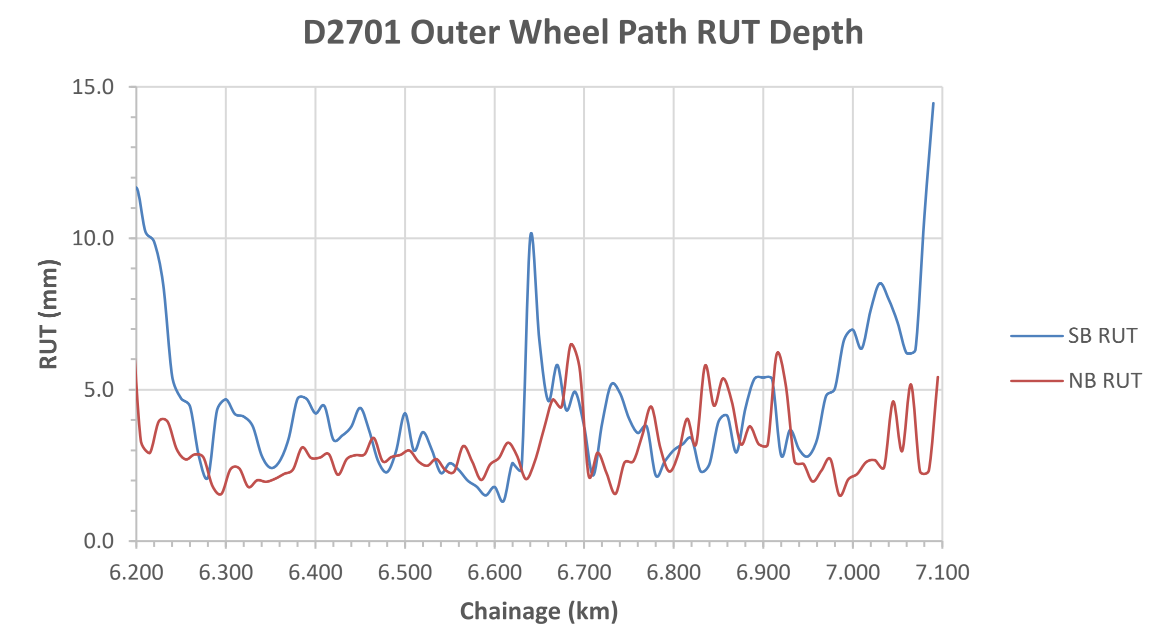
B: R516-1 RUT Depth at outer wheel path

Figure 3-36: R516-1



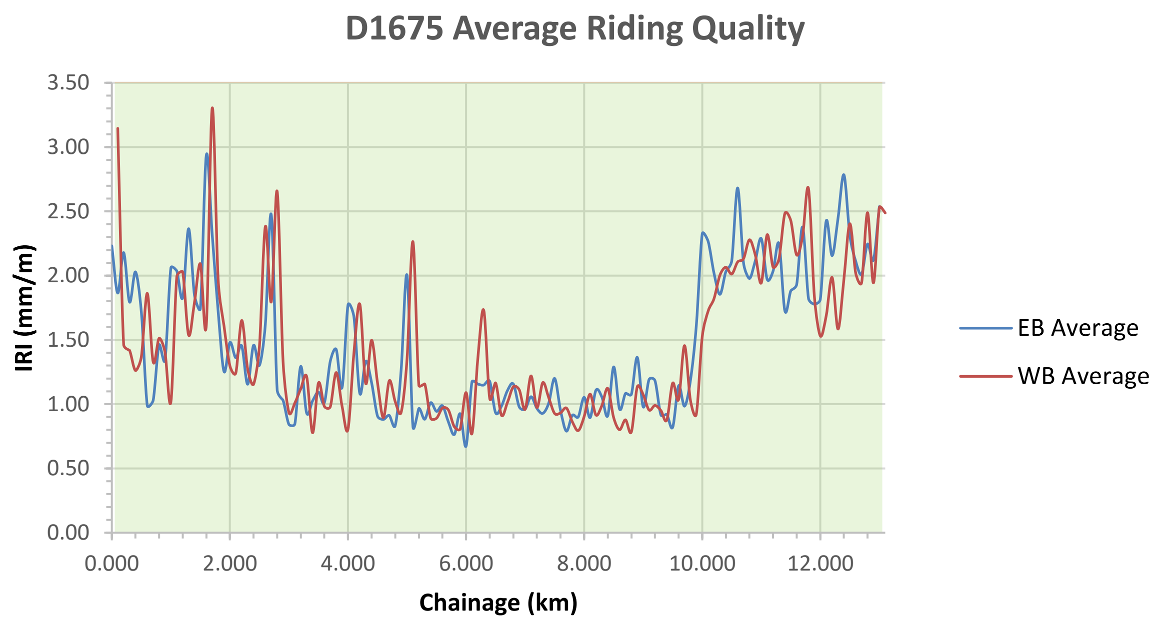
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>5.1	10.00%	10.00%	10.00%
4.2-5.1	0.00%	5.00%	0.00%
<4.2	90.00%	85.00%	90.00%

A: D2701 Average riding quality (IRI)



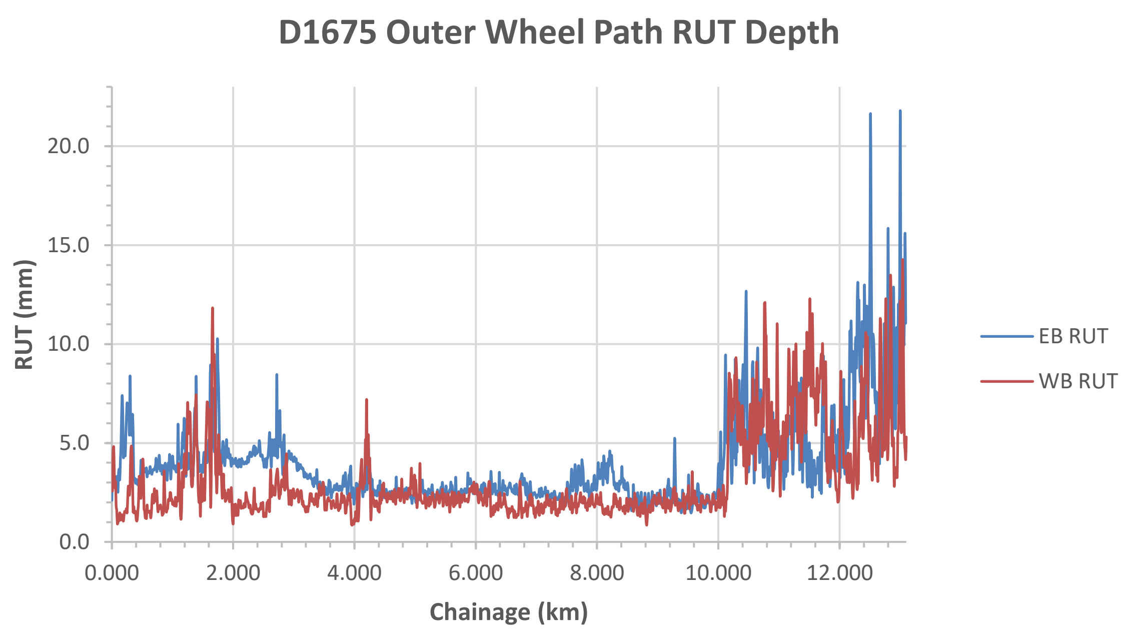
B: D2701 RUT Depth at outer wheel path

Figure 3-37: D2701



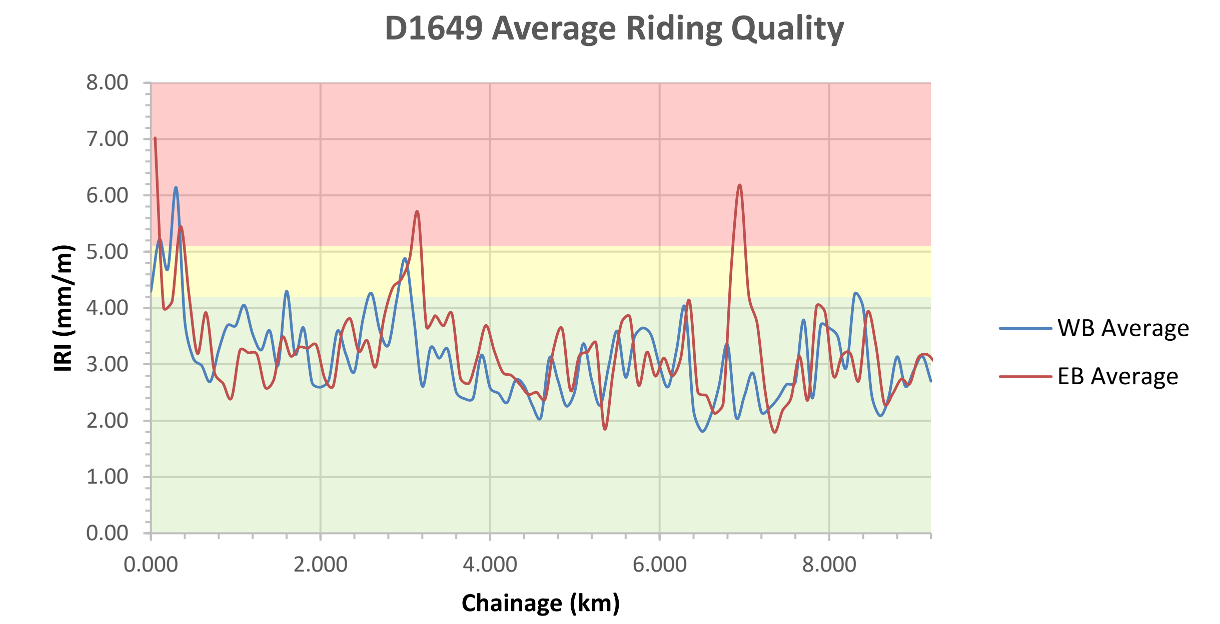
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>5.1	0.00%	0.00%	0.00%
4.2-5.1	0.00%	0.00%	0.00%
<4.2	100.00%	100.00%	100.00%

A: D1675 Average riding quality (IRI)



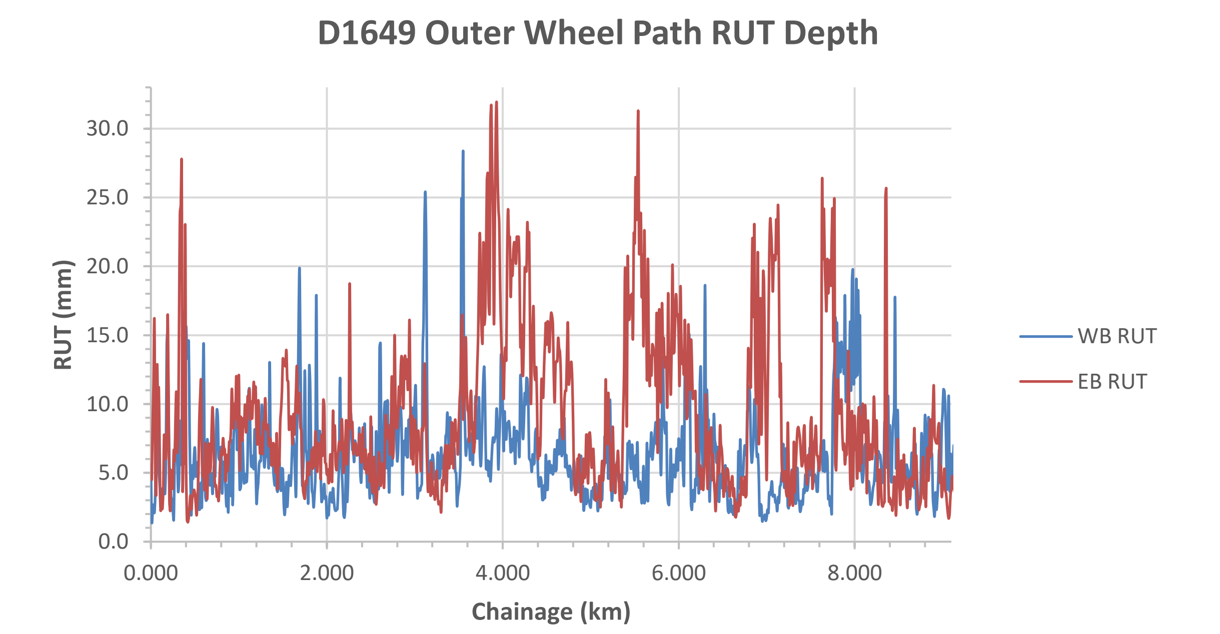
B: D1675 RUT Depth at outer wheel path

Figure 3-38: D1675



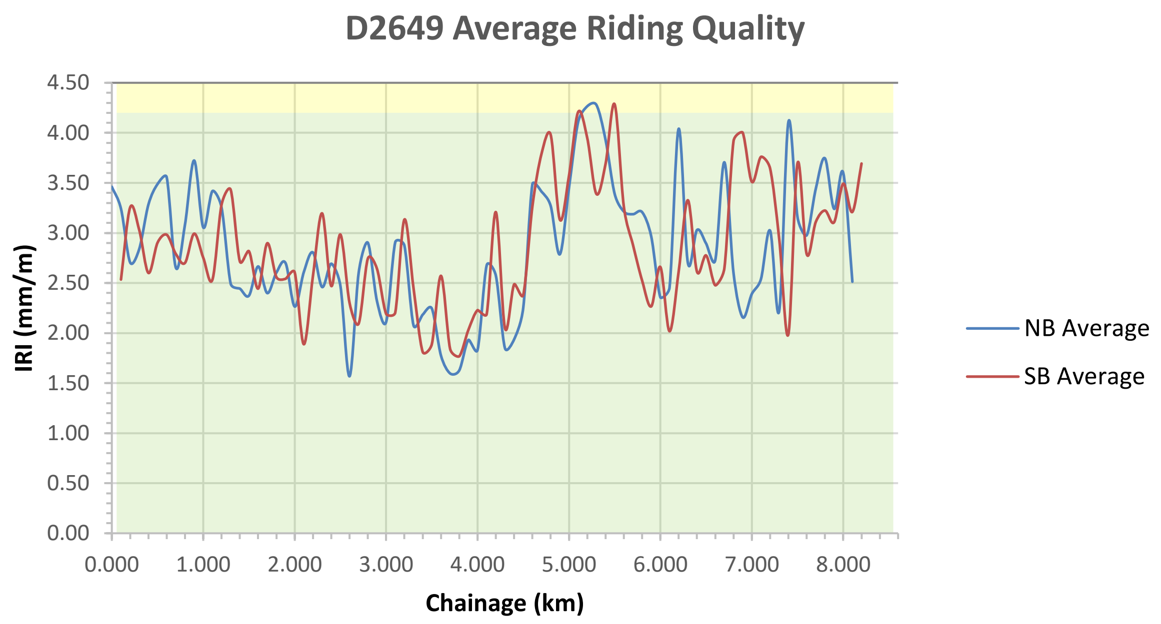
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>5.1	3.23%	4.84%	3.23%
4.2-5.1	6.99%	9.14%	6.45%
<4.2	89.78%	86.02%	90.32%

A: D1649 Average riding quality (IRI)



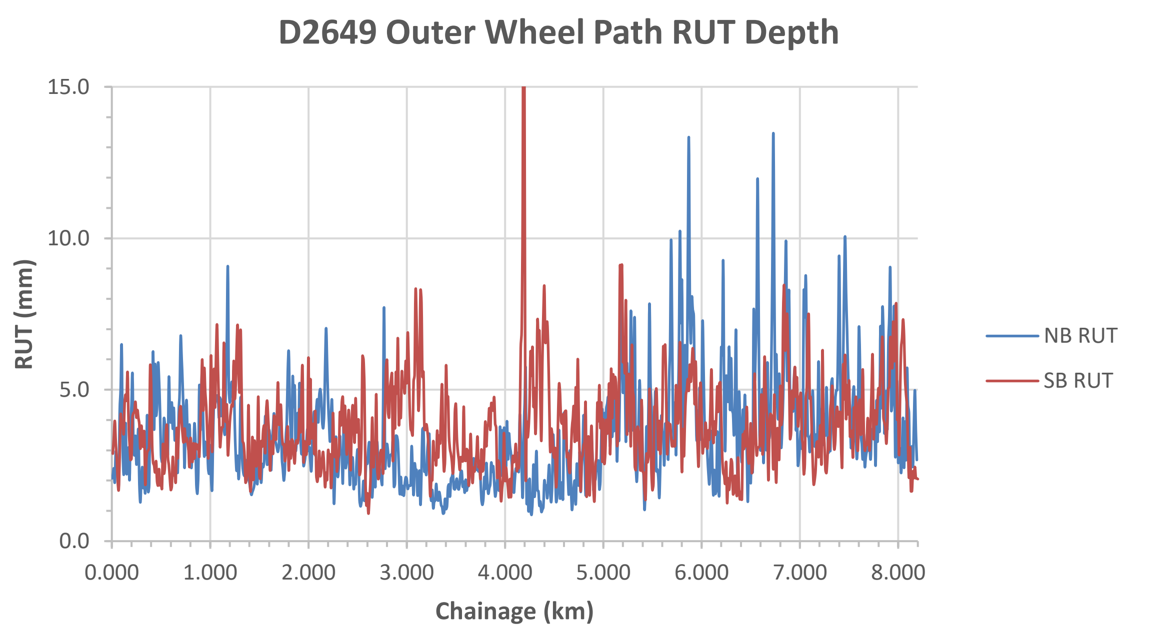
B: D1649 RUT Depth at outer wheel path

Figure 3-39: D1649



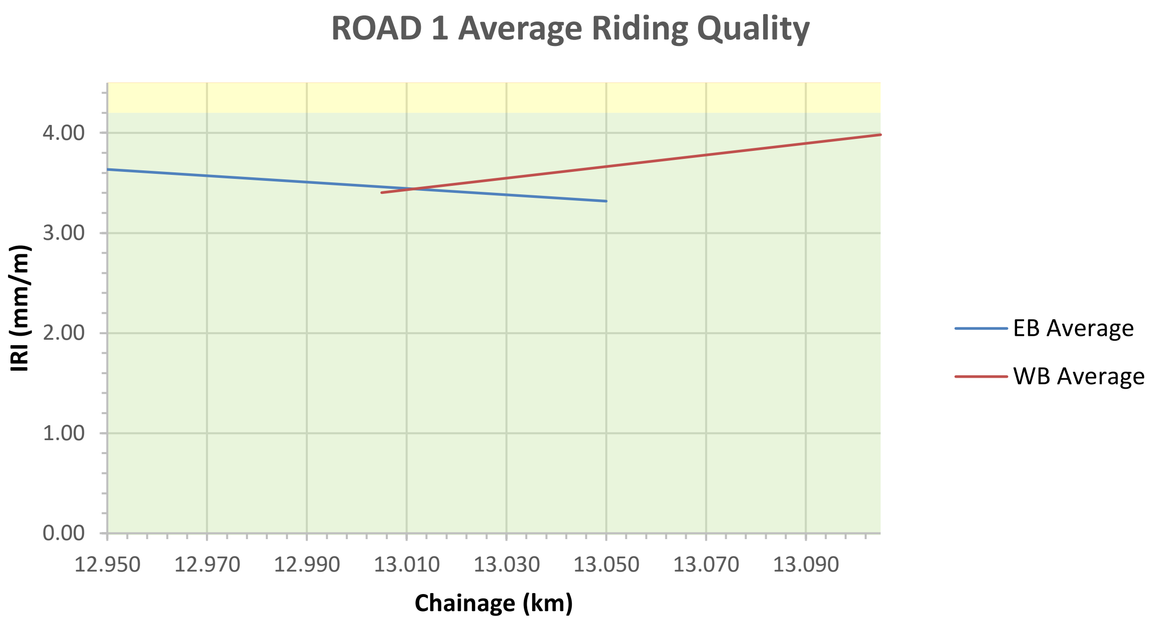
AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>5.1	0.00%	0.00%	0.00%
4.2-5.1	2.44%	3.05%	2.44%
<4.2	97.56%	96.95%	97.56%

A: D2649 Average riding quality (IRI)



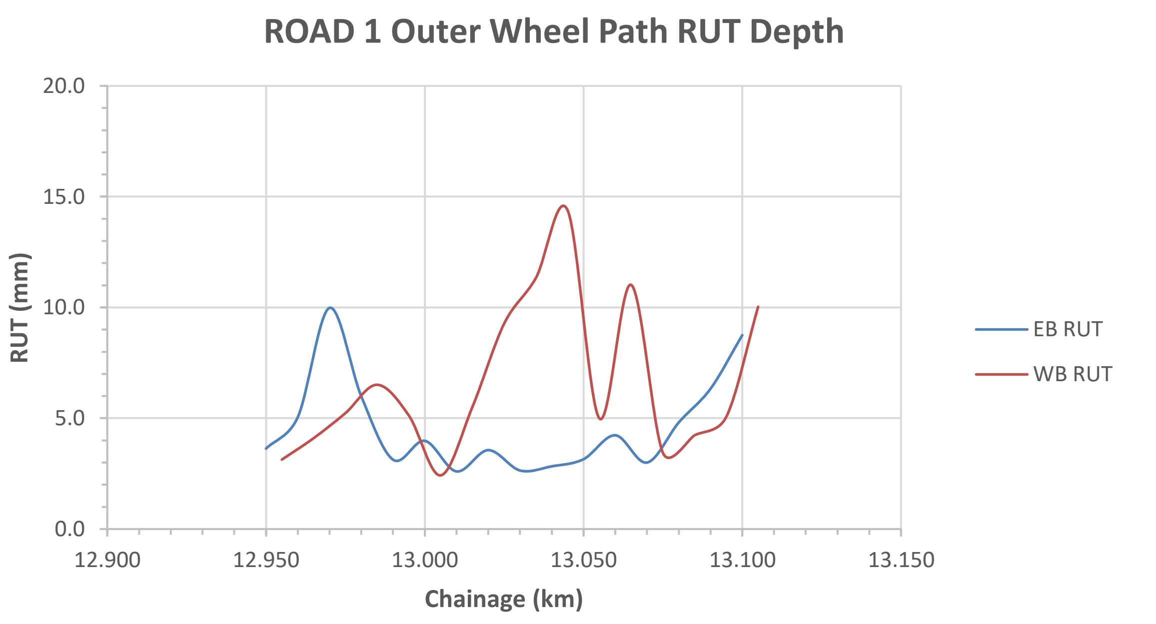
B: D2649 RUT Depth at outer wheel path

Figure 3-40: D2649



AVERAGE			
IRI (mm/m)	Left IRI	Right IRI	Average
>5.1	0.00%	0.00%	0.00%
4.2-5.1	25.00%	0.00%	0.00%
<4.2	75.00%	100.00%	100.00%

A: ROAD 1 Average riding quality (IRI)



B: ROAD 1 RUT Depth at outer wheel path

Figure 3-41: ROAD 1

In summary, the results from the mechanical survey are reflected in **Table 3-9.**

Table 3-9: Mechanical Survey Results - Riding Quality/RUT Depth

Road	IRI			Rut Depth		
	Classification - Percentage of Results			Classification - Percentage of Results		
	Sound	Warning	Severe	Sound	Warning	Severe
R510-2	72.67%	12.79%	14.53%	80.47%	6.69%	12.85%
R510-3	87.71%	8.33%	3.96%	86.03%	6.92%	7.05%
R511-3	91.62%	7.08%	1.30%	85.93%	7.20%	6.87%
R516-1	61.94%	24.32%	13.74%	46.60%	14.68%	38.72%
D2701	90.00%	0.00%	10.00%	91.00%	5.50%	3.50%
D1675	100.00%	0.00%	0.00%	97.48%	2.44%	0.08%
D1649	90.32%	6.45%	3.23%	77.57%	18.22%	4.22%
D2649	97.56%	2.44%	0.00%	99.51%	0.43%	0.06%

From the above it is concluded that in terms of riding quality and rut depths, both the R- and the D-Roads are in an acceptable condition.

3.7.1 Riding Quality:

- Of the Class B (R-roads) assessed, 93.47 km (82,73%) fall within the sound range
- Of the Class C (D-roads) assessed, 30.12 km (96.26%) fall within the sound range

3.7.2 Rut Depth:

- Of the Class B, R-Roads assessed, 87.99 km (77.87%) fall within the sound range
- Of the Class C D-Roads assessed, 28.78 km (91.95%) fall within the sound range

3.8 Road Drainage

3.8.1 Unsurfaced Roads

Ideally a gravel road will function well if maintained properly. The three basic components to a well performing gravel road are: a crowned driving surface, a shoulder area that slopes directly away from the edge of the driving surface and a ditch/channel on each side of the road. The gravel roads assessed displayed very little (if any) of the above essential components, hence the drainage issues relating to the assessed roads as outlined in the paragraphs to follow.

As has been mentioned earlier in this report several of the gravel roads are lower lying than the surrounding area resulting in poor drainage, with stormwater running along the roadway. In this instance the roadway serves as a channel and after years of erosion and maintenance grading, it becomes lower than its original elevation. Coupled with maintenance grading, the situation is further exacerbated as traffic displaces gravel from the roadway surface to the shoulder area, in many instances forming windrows along the edges of the road, thus preventing stormwater from draining off the road. This pooling of water on the roads is one of the major reasons for distress and failure of gravel roads.

Also noticed during the assessment of the gravel roads is that stormwater culverts were installed very close to the road surface for drainage as the surrounding area in many instances is flat. This in many instances is however not working as planned, as there are no gradients to facilitate drainage away from the road. Not only have the shallow culverts often been ineffective, but many of the culverts have been damaged or even crushed by passing vehicles due to the lack of gravel cover.

In addition, all culverts are without headwalls, most are blocked and inaccessible due to a total lack of maintenance. This has resulted in many culverts being exposed due to the displacement of gravel and ongoing grading over the years.

Road D769 does not have any shape or profile over its entire length, which is also evident on most of the other gravel roads. Ongoing grading has by implication flattened the road surface and created windrows with no evidence of outlet channels for drainage from the road surface, hence stormwater is trapped on the roadway leading to erosion and potholes.


A: Roadway surface - rough **B: Blocked culvert**


C: Corrugation on roadway **D: Windrows and pothole in roadway**

Figure 3-42: Road D769

Road D2701 has signs of erosion especially around some of the drainage culverts, but overall, not much damage is evident as a result of lack of drainage. This is possibly due to most of the road having a hard and coarse subgrade layer which unfortunately contributes to the road surface being rough over most of its length, together with some corrugation.

In terms of culverts, inlet and outlet structures, and channels, the same applies as for **Road D769**.

A: Top of culvert exposed and damaged on roadway

B: Sandy roadway

A: Gravel Road

B: Blocked culvert; Little cover

Figure 3-43: Road D2701

Road D175 shows signs of erosion in many places over its entire length which may prove to be challenging to traverse during the rainy season unless rebuilt and properly gravelled. The roadway has little shape with windrows at various places along the route.

A: Roadway

B: Top of culvert exposed on roadway

Figure 3-44: Road D175

Like most of the gravel roads, **Road D1925** has little shape or profile with the road itself serving as a drainage channel during rainy periods. Windrows are evident over various sections of the road, together with sections showing advanced erosion. As for the other roads, culverts are blocked, and in some instances damaged due to the lack of gravel cover. Road D1925 will prove difficult to traverse with normal vehicles during rainy seasons.

A: Sandy roadway

B: Sandy roadway showing water damage

C: Top of culvert exposed and damaged on roadway

D: Sandy roadway showing water damage

E: Windrows scoured away by stormwater

F: Roadway damaged by stormwater

Figure 3-45: Road D1925

Gravel Road 2 essentially provides access to a couple of farms. The road has no structured drainage of any kind. There is little sign of any erosion with the exception of the section around the koppie (km 1.80 to km 2.80) where the road is very rough.

A: Gravel roadway; Big stones on surface

B: Road blocked by gate

Figure 3-46: Gravel Road 2

Gravel Road 3, like **Gravel Road 2**, has no structured drainage, but shows little sign of any erosion.

A: Entrance to Gravel Road 3; Pothole

B: Narrow Road; Corrugated

Figure 3-47: Gravel Road 3

3.9 Bridges

Bridges along the R- and D- Roads were generally built in the 1960s when the BS 153 bridge code was the applicable bridge design code. It is therefore likely that these bridges were designed for HA and HB loading.

It is observed that the R- and D- Roads currently carry normal vehicles with the occasional abnormal load vehicle. As per the BS 153 design code, the HA loading assumes the equivalent of three vehicles, each 22 tons in weight, closely spaced in each of the two carriageway lanes followed by 10-ton and 5-ton vehicles. This is normally equivalent to 20 units of HB abnormal loading (or roughly 80-ton load per axle, spaced 2 m apart) for spans less than 30 m. To confirm the load capacity of bridges, a basic assessment is normally carried out by reviewing the available as-built drawings.

It is our view, based on our visual assessment of the above-mentioned bridges and considering the current traffic utilising the roads, that the bridges are more than adequate to accommodate the vehicle loads anticipated for the construction project under consideration. It is to be noted that some of the roads taken over from Provincial Government by the South African National Roads Agency (SANRAL), e.g. the R516, are currently under investigation/design development for their upgrading which in some instances will include the widening and possibly even the strengthening of the bridges should this be required.

In the case of the R-Roads under the management of SANRAL, both road- and river bridges are well maintained on a regular basis. It is therefore not expected that any major bridge-related issues will arise during the envisaged construction project. It would however appear that the bridges under the management of Road Agency Limpopo (RAL) enjoy less maintenance and may therefore require some attention, in particular the road-over-river bridge on Gravel Road D1925 which as a precaution may at times require debris removal to negate any possible flooding of the road.

Notwithstanding the above, no challenges of a serious nature are expected in relation to the bridges.

3.10 Road Safety

The surfaced roads are generally well maintained, particularly the R-Roads. As previously mentioned, the D-Roads appear to be less well maintained and, in some instances, require grass cutting and bush clearing for passing and improved visibility. Such clearing will also make kilometre markers more visible and usable for reference purposes.

In the case of the gravel roads, the following comments apply:

- Due the lack of proper drainage some sections of the gravel roads are prone to becoming stormwater channels during rainy periods resulting also in the roads being muddy and slippery making them unsafe. This applies in particular to Roads D769, Gravel Road 2, Gravel Road 3 and

D1925. However, should the gravel roads be lifted, a wearing course applied as well as drainage improved as suggested elsewhere in this report, the mentioned issues would be alleviated.

- In some instances, gravel roads are narrow (e.g. Gravel Road 2 and Gravel Road 3) and may require widening as well as the clearing of vegetation to provide safe passage for construction vehicles to safely pass one another.
- There are very few cases of the roads having high embankments except for Road D175 (km 2.6) and Road D2701 (km 6.3) which have elevated railway crossings where guardrails need to be maintained for the safety of the road users.
- In the case of Gravel Road 4, which is essentially a service road to the existing railway line, construction vehicles would need to travel with caution considering the proximity of the adjacent active railway line.
- Once the route of construction vehicles has been finalised, it will be necessary to ensure that intersections are adequate and safe and include all the necessary signage and road markings, e.g. the intersection of Gravel Road 3 with Gravel Road 4 will need to be improved for large vehicles to safely manoeuvre.

4 TRAFFIC ASSESSMENT

This section of the report investigates the impact of the development-related traffic on existing traffic conditions on the immediate road network surrounding the development site.

The traffic assessment therefore has the following objectives:

- To determine the traffic impact during the construction and operational phases of the MCWAP 2.
- To provide feasible measures to mitigate the traffic impact of the project on the surrounding road network to acceptable levels.

4.1 Methodology

The traffic assessment is conducted in accordance with the **Manual for Traffic Impact Studies of the Department of Transport** and with reference to the **COTO TIA Guidelines**. In addition, the methodology makes provision for the assessment of impacts against the criteria that apply to environmental assessments, as provided by GBN-JV.

The following methodology was therefore adopted to assess the impact associated with MCWAP-2 on the surrounding road network and environment:

- A site visit to assess the road network around the study area, including the accesses on to the external road network and key intersections on to the public road network including local farm roads.
- Traffic Data Collection:
  - o The undertaking of classified traffic count surveys at key sections of the road network, specifically at intersections between main roads and secondary/tertiary roads that would be used as primary access routes. The traffic counts were to be undertaken during the winter and summer months of May and November 2021 to account for seasonal variation of traffic patterns.
  - o Confirmation of transport methods of the raw materials to/from site.
  - o Obtaining technical information from the engineering team regarding the construction, and operations of the MCWAP-2, as follows:
    - ▪ Details of the traffic/truck volumes expected to operate during construction
    - ▪ Origin / Destination of the traffic/truck volumes

- Sources of raw material that will be transported to and from site
- Location of and delivery methods of the final products
- Details of staff movements and transport means
- Details regarding abnormally dimensioned machine components required during the construction and operation of the plant (if any).

- Conducting a desktop assessment of the existing road network, connectivity, and traffic patterns
- Undertaking base year capacity assessment of the road network based on collected traffic data
- Estimating development related trips from the technical information received and assigning the trips to the road network
- Determining composition of heavy vehicles based on the expected tonnage of construction material to be transported
- Impact Assessment - Determining environmental impacts of the development-related traffic, identifying road safety hazards and any other issues, and making recommendations on road infrastructure improvements that will be required to mitigate impacts

4.1.1 Traffic Assessment Team

The Merchelles' team/service providers utilised for the assessment of traffic and related impacts has included:

- o Rochelle Rajasakran, Pr Eng – Traffic Engineer,
- o Lerato Kgoa, BSc Eng (Civil) – Transport Engineer, and
- o Trafsol Data Specialists

4.2 Data Collection

To determine baseline conditions on the road network, a significant data collection exercise was undertaken as outlined hereunder.

4.2.1 Site Observations

Site visits were undertaken to assess the network of roads as listed in the project brief to/from the site, borrow pits and concrete aggregate supply, including the access on to the external road network and key intersections along the routes.

The road network surrounding the proposed pipeline infrastructure was driven on 2 March 2021 and observations worth noting are provided in **Table 4-1** below.

Table 4-1 Traffic site investigation

Road Name	**Observations:** **Advantages**	**Observations:** **Defects/Problems**
R516 (Surfaced) 	iv. Signage is very good v. Grass/verge is well maintained along most of the road vi. Gravel shoulders available for emergency stopping	iii. 2-lane cross section, no climbing lanes, insufficient overtaking opportunities for light vehicles to overtake slow moving trucks iv. Grass needs to be cut along certain sections to maintain visibility of road signs

Road Name	Observations: Advantages	Observations: Defects/Problems
R511 (Surfaced) 	vii. 2-lane cross section with good overtaking opportunities viii. Signage is good ix. Truck/rest stop just after the R511/R516 intersection x. Grass/verge is well maintained along most of the road xi. Gravel/grass shoulders available for emergency stopping xii. Low traffic volumes	ii. Slow moving tractors/farm vehicles from adjacent properties make use of the road
R510 (Surfaced) 	iv. Gravel/grass shoulders available for emergency stopping v. High pedestrian, minibus taxi and informal trading activity around the town area of Thabazimbi with some NMT safety measures present – street lighting, bollards to separate motorists from pedestrians, zebra crossings at intersections etc. vi. Intermittent sidewalks of various widths and material	vi. 2-lane cross section with few overtaking opportunities as one approaches Thabazimbi from the south, overtaking improves past the town section vii. Grass verge at the R510/R511 Intersection needs to be kept short to maintain good sight distance at the intersection at all times viii. Edge breaks present ix. High volume of heavy vehicles present x. High volume of traffic in the Thabazimbi town area
D1649 (Surfaced) 	iii. Good sight distance at the R510/D1649 Intersection iv. 2-lane cross section with sufficient overtaking opportunities	iii. Trolley pushers present – going to the rubbish dump close to km 3/4 iv. Grass along the verge needs to be cut
D769 (Gravel)	iv. Good sight distance at the D769/D1649 Intersection, and an additional shared right/through lane on the eastern approach of D1649	iii. Primary school adjacent to the road (just after intersection with D1649) – scholar patrol appears to be in operation (signage present)

Road Name	Observations: Advantages	Observations: Defects/Problems
	improves safety at the junction v. Fences present on either side of the road vi. Little to no traffic	iv. Road is very wide – no drainage channels

Significant non-motorised and public transport related activity was observed in and around the Thabazimbi area, and is shown spatially in **Figure 4-1** below.

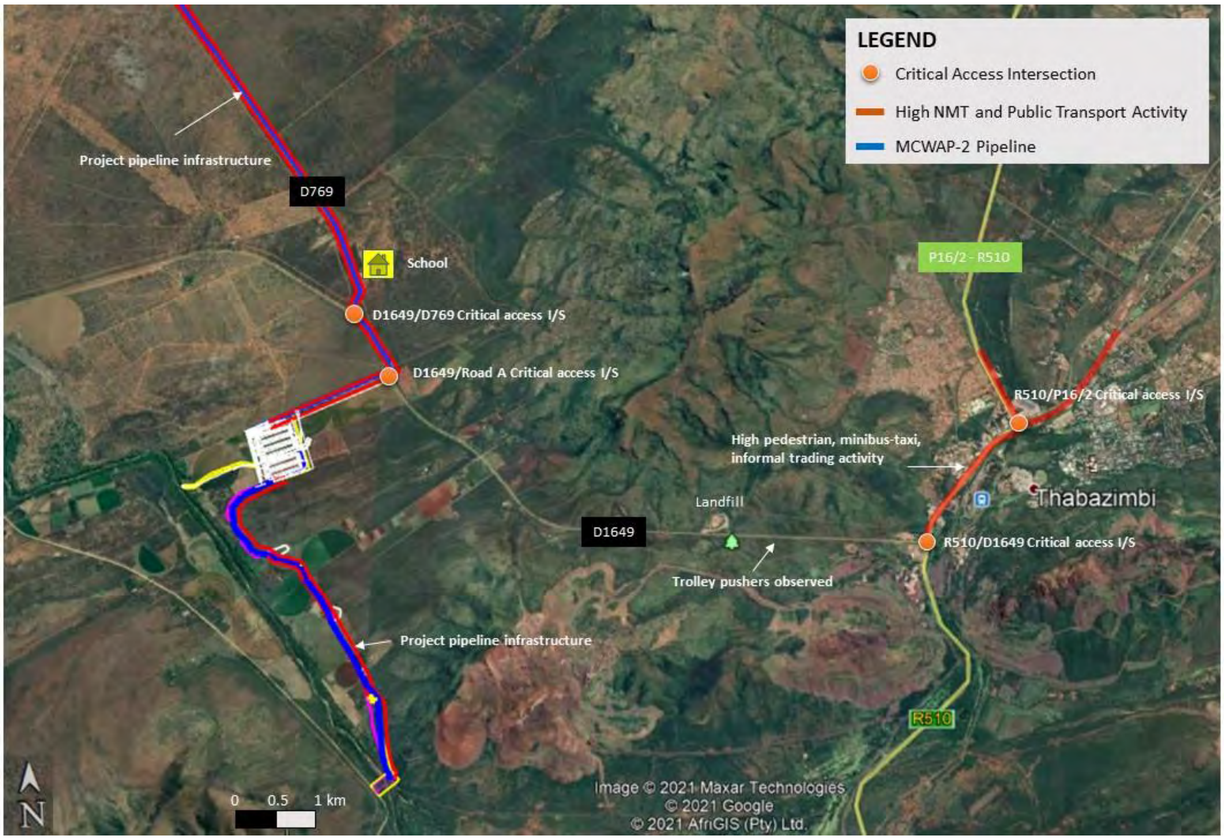


Figure 4-1 Highlights of site investigation around the Thabazimbi area

4.2.2 Manual Classified Count Surveys

12-hour manual classified traffic counts were commissioned for both summer and winter months to establish the seasonal variability in traffic flow volumes due to the high agricultural activity in the area. The counts were commissioned at 20 identified intersections of the road network to be conducted on a typical workday, covering a 12-hour period from 06:00 to 18:00 and comprising turning movement volumes classified according to vehicle type, namely, light vehicles, minibus taxis, buses, and heavy vehicles in 15-minute intervals. The counts were carried out on two consecutive days as a control measure.

The count sites were chosen based on the level of impact that construction activity would have on the road network. The increase in traffic flow volumes was deemed to occur at mainline roads, access to construction camps, main access roads to the towns of Thabazimbi and Lephalale where labour, supplies and accommodation would come from as well as points where the pipeline crosses the road.

The traffic counts were undertaken at the following intersections described in Table 4-2.

Table 4-2: Traffic Count Locations

No.	Intersection Name	Intersection Type
1	R101 and R516 (N1)	Signalised, T-junction
2	R516 and R511	Two-Way Stop Control (TWSC), T-junction
3	R511 and R510	TWSC, T-junction
4	R510 and D1649	TWSC, T-junction
5	D1649 and Local Road	TWSC, T-junction
6	D1649 and D769	TWSC, T-junction
7	D769 and Local Road	Informal gravel junction
8	R510 and P16/2	All-Way Stop Control (AWSC), T-junction
9	P16/2 and Local Road	TWSC, T-junction
10	D336 and Local Road	TWSC, T-junction
11	P16/2 and R510	TWSC, 4-legged staggered junction
12	R510 and road to Rooiberg	TWSC, T-junction
13	R510 and D2701	TWSC, T-junction
14	R510 and R517	TWSC, T-junction
15	D2701 and D1925	TWSC, T-junction
16	D1925 and D175	AWSC, 4-legged junction
17	D175 and Access Road	TWSC, T-junction
18	Nelson Mandela Drive and D18	Signalised, T-junction
19	R510 and Nelson Mandela Drive	TWSC, T-junction
20	Nelson Mandela Drive and Access Road B	TWSC, 4-legged junction

The winter counts commenced first and were undertaken on 6th and 7th May 2021. The summer counts were undertaken on the 4th and 5th of November 2021. Figure 4-2 and Figure 4-3 show the total 12-hour traffic flows at each of the intersections. The figures are indicative of both the winter and summer traffic volumes. The red through to green provides an indication of the flow intensity at each intersection.

The AM and PM peak hour turning movement volumes are provided in the support documentation. These volumes represent the baseline traffic flow at intersections prior to construction work.

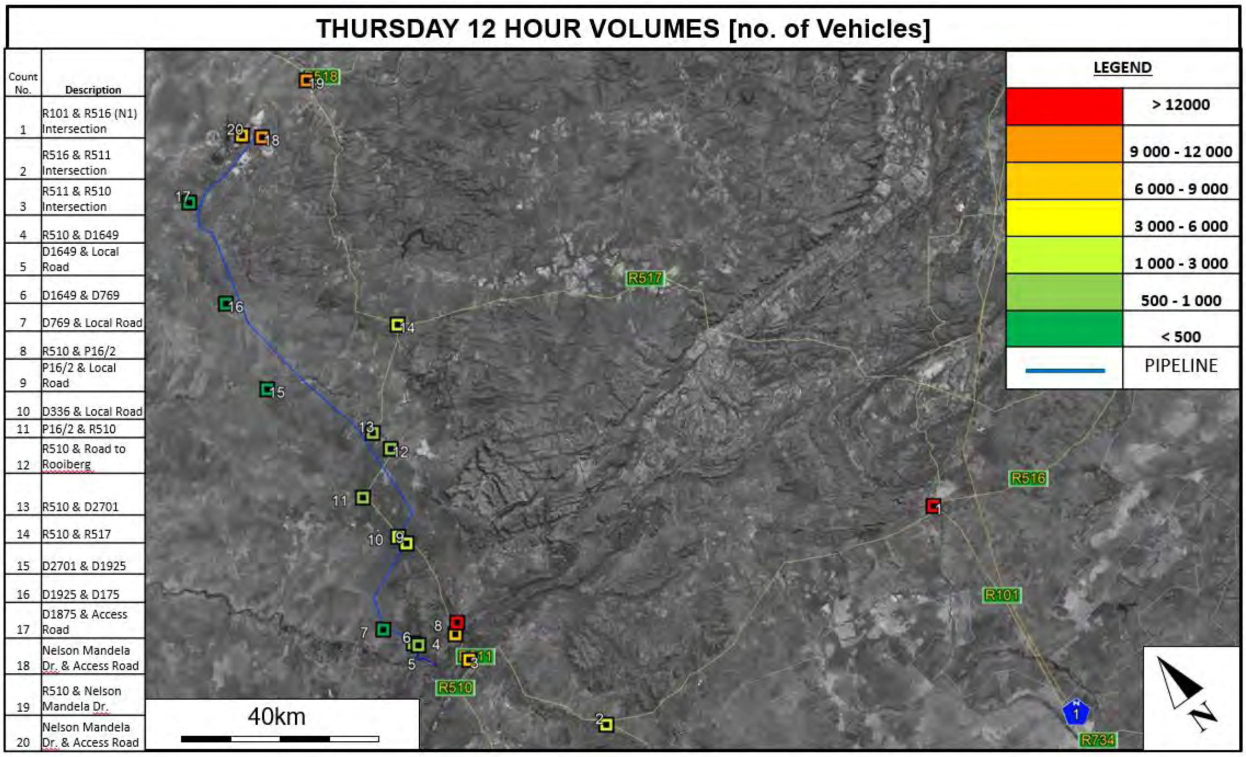


Figure 4-2 Thursday 12- Hour count volumes

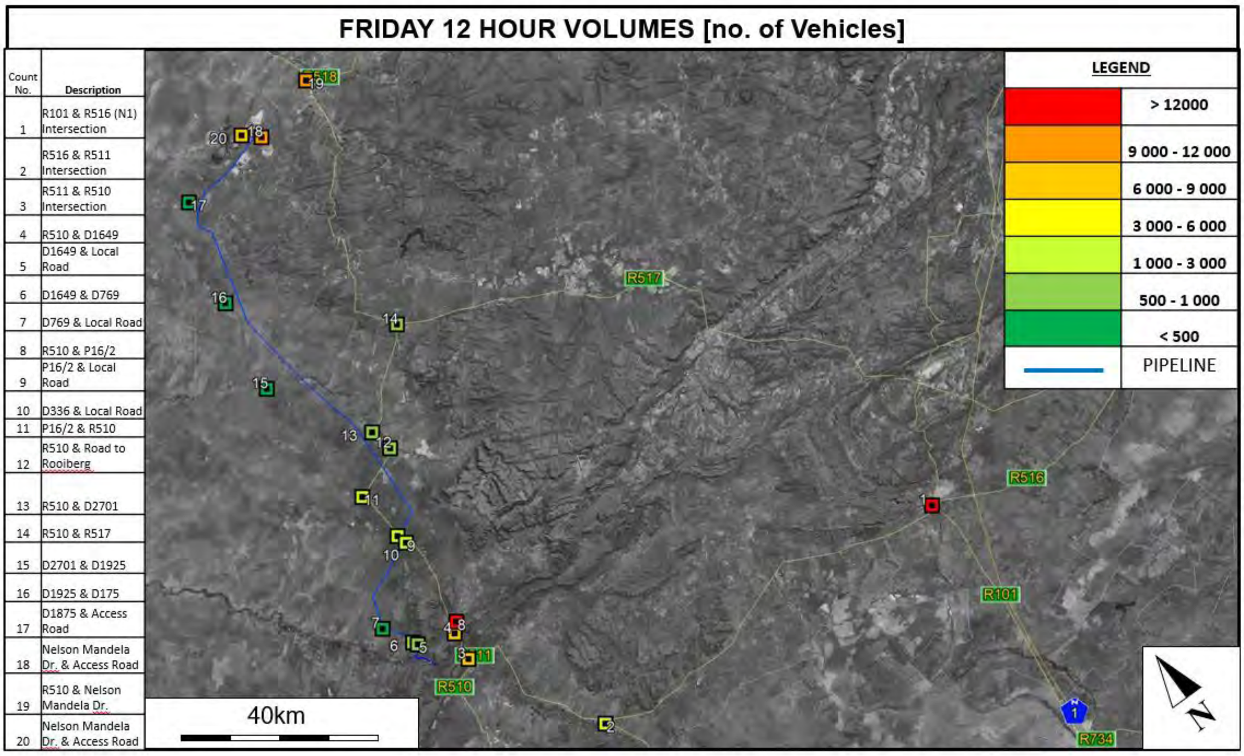


Figure 4-3 Friday 12 - Hour count volumes

As can be seen from the figures, the intersections processing higher volumes due to regional travel movements have flows greater than 12000 vehicles in a 12-hour period. The intersections serving predominantly agricultural movements and being gravel roads (D1925 and D2701) have fairly low volumes as can be expected.

The difference in traffic flows between the Winter Thursday and Friday count is shown in Table 4-3 to follow. The variation can be attributed to the fact that more travel occurs on a Friday on regional routes. Typically, the design hour for these routes (30th highest flow in a year) occurs on a Friday hence the count provides a good comparison between a normal day and a Friday flow.

Table 4-3 Difference between Thursday and Friday count volumes – Winter Count

I/S No.	Thursday 12-Hour Volumes	Friday 12-Hour Volumes	Difference	% Increase/ Decrease
1	14032	15053	1021	7%
2	2300	2808	508	22%
3	6331	7168	837	13%
4	7140	7854	714	10%
5	832	876	44	5%
6	871	881	10	1%
7	236	243	7	3%
8	12329	13042	713	6%
9	1018	1029	11	1%
10	1008	1051	43	4%
11	997	1085	88	9%
12	639	764	125	20%
13	626	755	129	21%
14	1040	911	-129	-12%
15	65	73	8	12%
16	25	20	-5	-20%
17	390	276	-114	-29%
18	9462	10167	705	7%
19	9849	9940	91	1%
20	6562	8269	1707	26%

The difference in traffic flows between the Summer Thursday and Friday count is shown in Table 4-4. Similarly, the data indicates higher volumes on Fridays for most of the intersections which is consistent with the winter counts.

Table 4-4 : Difference between Thursday and Friday count volumes – Summer Count

I/S No.	Thursday 12-Hour Volumes	Friday 12-Hour Volumes	Difference	% Increase/ Decrease
1	15387	16445	1058	7%
2	2648	3205	557	21%
3	7043	7837	794	11%
4	8395	8683	288	3%
5	955	910	45	-5%
6	972	1013	41	4%
7	180	211	31	17%
8	12337	12848	511	4%
9	846	1031	185	22%
10	842	1030	188	22%
11	868	1109	241	28%
12	567	832	265	47%
13	571	779	208	36%
14	767	1018	251	33%
15	18	39	21	53%
16	27	26	1	-4%
17	235	333	98	42%
18	7621	8240	619	8%
19	9882	11359	1477	15%
20	7147	6130	1017	-14%

The seasonal variation of traffic volumes within the study area is shown graphically in Figure 4-4 and Figure 4-5 below. Notably higher volumes are observed in the summer for both Thursday and Friday counts at intersections No. 1, No. 3 and No. 4. Intersection 3 and 4 are located in Thabazimbi and the increase in summer traffic demand may be attributed to the increased demand in tourism activity related to the game lodges around Thabazimbi. Intersection 1 is on the R101 near Bela-Bela which also tourism activity.

At intersections No. 18 and No. 20, located in the Lephalale area on Nelson Mandela Dr., depicts winter volumes higher than in summer. The intersection facilitates access to the Medupi power station and some coal mines. The increase in traffic volumes may therefore be attributed to higher demand of coal supply for electricity production during winter.

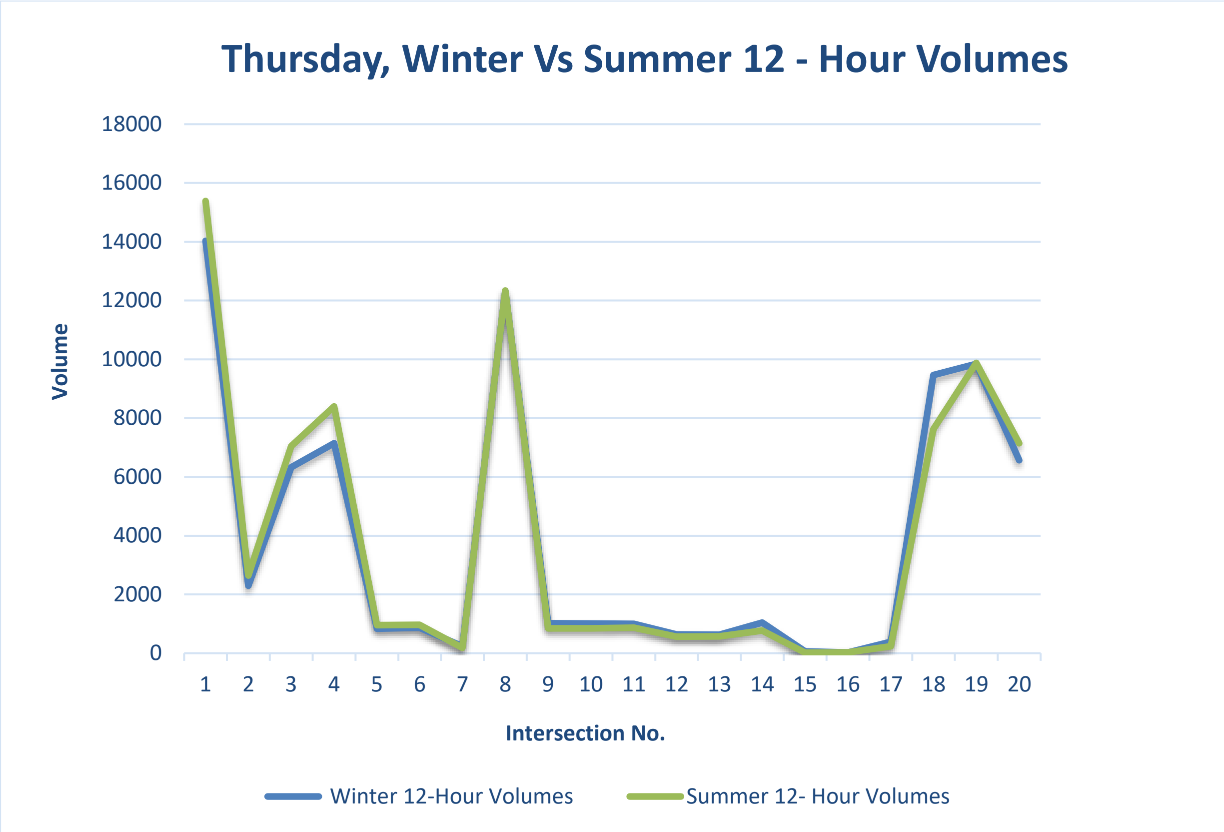


Figure 4-4 : Thursday Winter Vs Summer 12-Hour Volumes

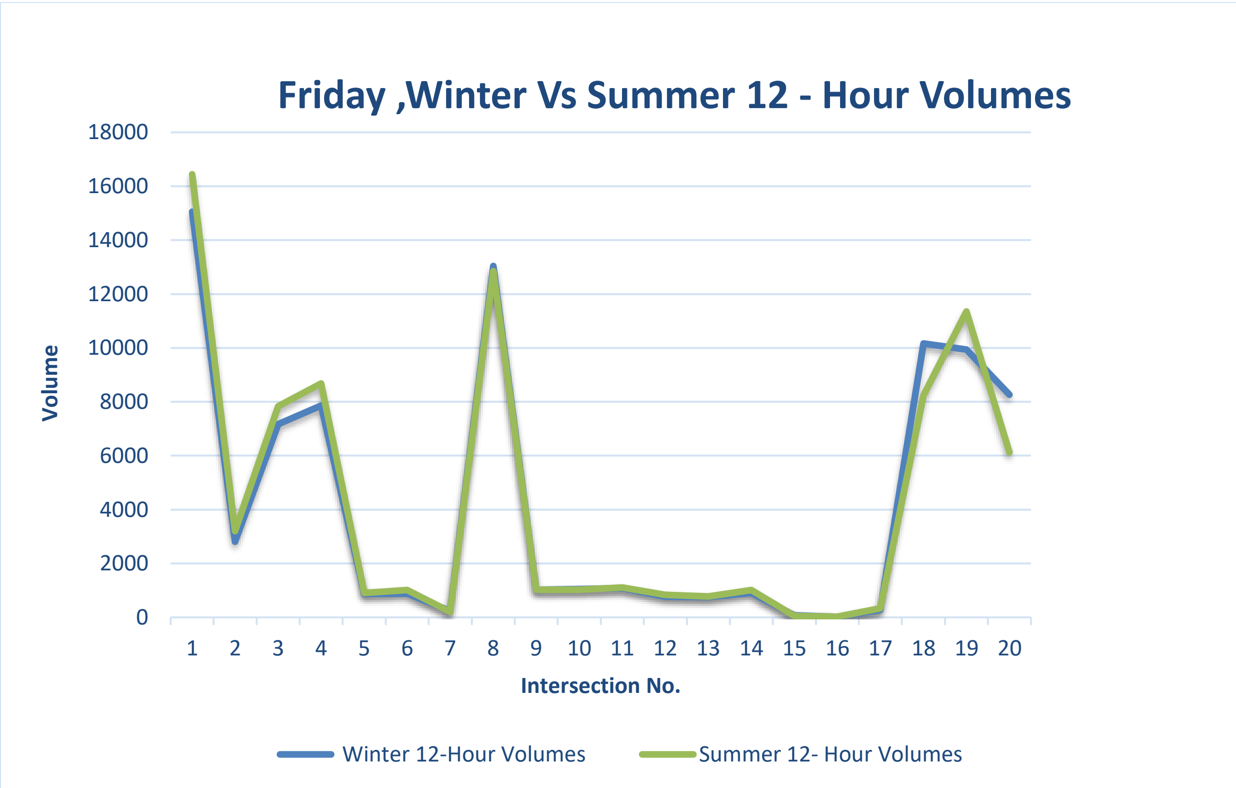


Figure 4-5: Friday Winter Vs Summer 12-Hour Volumes.

4.3 Road Network and Connectivity

4.3.1 Connecting Roads

The footprint of the proposed water transfer infrastructure traverses the area between the towns of Lephalale and Thabazimbi.

The road network of concern is therefore the roads that provide regional access to these towns as well as the local road network that connects the two towns and provides access to the construction area.

The pipeline starts at the weir site in Thabazimbi and from there runs in a northerly direction following the existing local road network and crossing the railway line until it reaches its destination to the west of the town of Lephalale, at Steenbokpan. The pipeline infrastructure is mostly located on privately-owned properties that are predominantly used for agricultural practices and game farming.

Figure 4-6 below provides an appreciation for the wider road network servicing the two local towns as well as the district road network running close to the pipeline footprint.

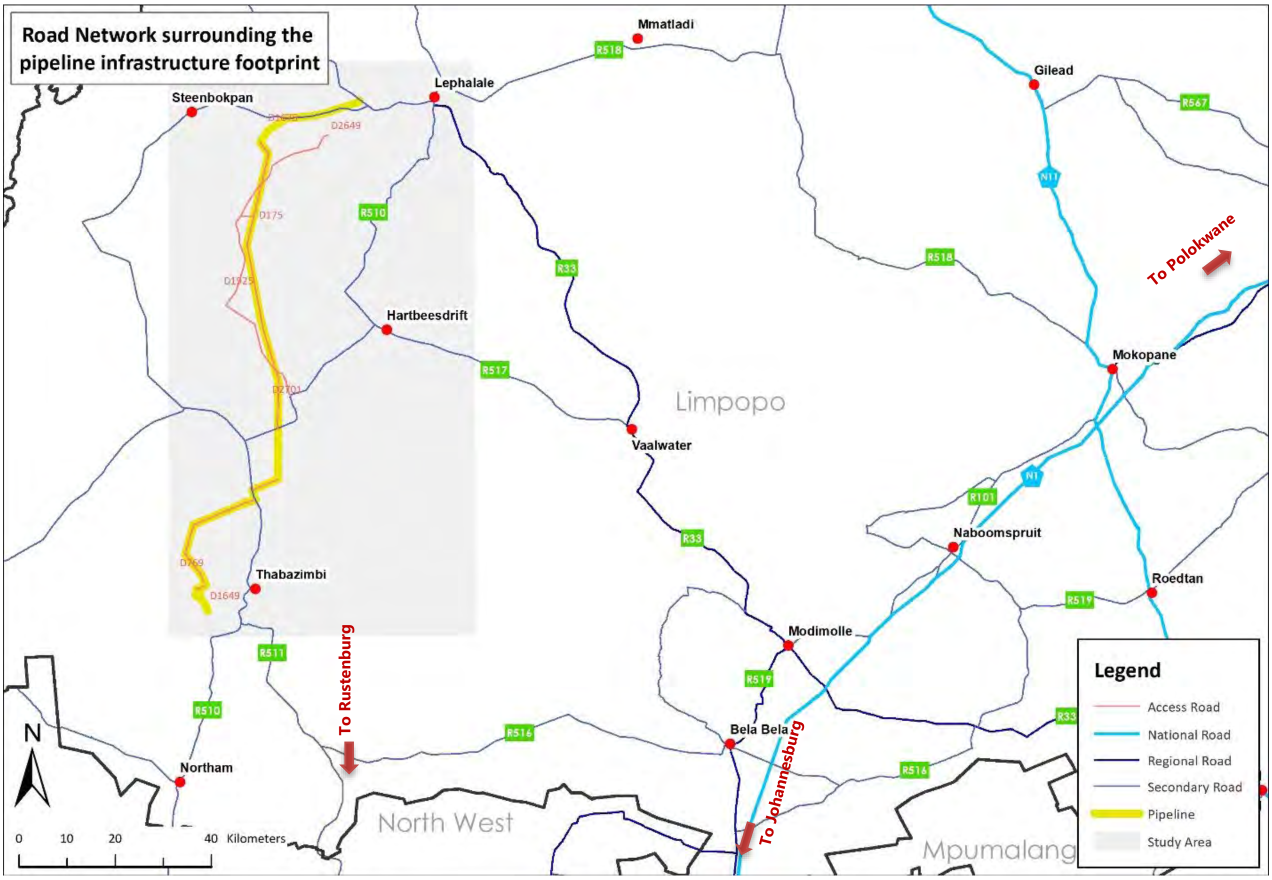


Figure 4-6 Road network surrounding the pipeline infrastructure footprint

A description of the major roads of interest to the project as well as their functional hierarchy is described as follows:

Table 4-5 Description of connecting road network

Road Name	Functional Road Classification (TRH 26)	Responsible Authority	Function
R516	Class 3 Minor Arterial	RAL / SANRAL	East-west mobility route providing inter-regional access, intersecting with the N1 in the vicinity of the town of Bela Bela

Road Name	Functional Road Classification (TRH 26)	Responsible Authority	Function
R511	Class 3 Minor Arterial	RAL / SANRAL	North-south mobility route providing inter-regional access to towns such as Brits in the south and eventually ending in the heart of the Johannesburg metropolitan area
R510	Class 3 Minor Arterial	RAL / SANRAL	North-south mobility route providing inter-town access between Lephalale and Thabazimbi, connecting to the R517 which becomes the R33. The latter then intersects with the N1 corridor leading to the economic hub of Gauteng in the south
D1649	Class 4 Rural Collector	RAL	District road providing rural area access
D769	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D2701	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D1925	Class 4 Rural Collector	RAL	District road providing access to agricultural land
D175	Class 4 Rural Collector	RAL	District road providing access to railway bridge (Gravel Road 4)
D2649	Class 4 Rural Collector	RAL	District road providing access to D1675 road
D1675	Class 4 Rural Collector	RAL	District road providing inter-town access and access to national resource areas (coal)

The provincial routes generally have good access management allowing for greater mobility levels. Thus, most project-related long distance, intertown trips will most likely be undertaken along the regional road network rather than the less travelled district road network. The two main towns where most project-related activity will be concentrated namely Lephalale and Thabazimbi both enjoy good regional accessibility via the R510 and R511, both of which are in good condition. The national road network, i.e. the N1 and N11 can also easily be accessed via this network.

The pipeline itself runs along the local district road network for most of its alignment, thus local level access is also well established. Low traffic flows due to the rural nature of land use activity between the two towns will also make construction access and movement easier to achieve (potential local community issues aside).

4.3.2 Critical Access Intersections

Five critical access intersections within the area of interest are described in Table 4-6 below. These intersections are considered to be of strategic importance as they connect the site to important economic hubs where resources, labour and accommodation can be found.

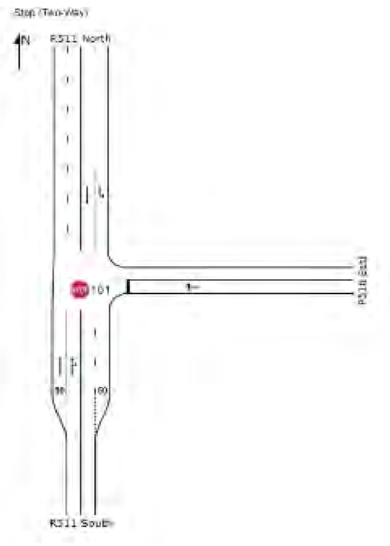
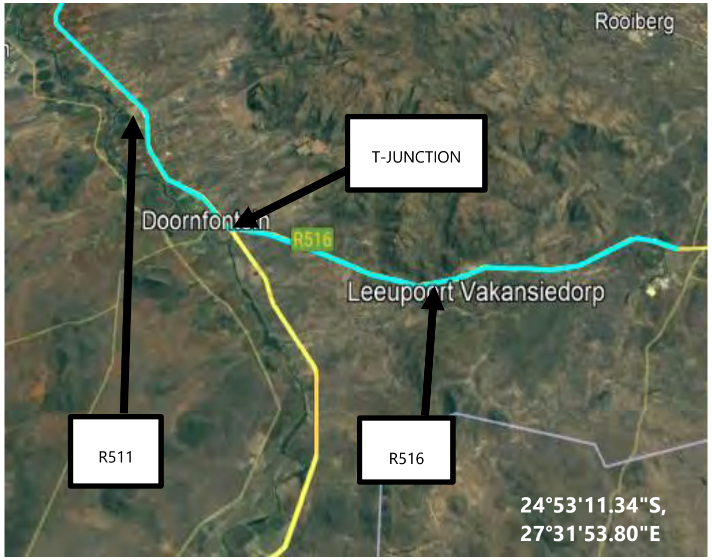
The capacity to process traffic flows depends on the intersection configuration (additional lanes imply higher capacity) and control type (stop controlled or signalised, the latter capable of processing higher volumes). An intersection capacity analysis is conducted under Section **4.4** of this report.

Table 4-6 Critical intersections within the area of interest

<table>
<tr><th>Intersection</th><th>Layout</th><th>Geographic Location</th></tr>
<tr><td>R516/R511

T-junction

• Two-way stop-controlled intersection, major road R511
• Additional intersection capacity is provided on the R511 with an exclusive left turn lane on the northern approach and shared through/right turn lane on the southern approach
• Provides regional access to the site as well as between Leeupoort Quarry and Thabazimbi

Co-o</td><td></td><td>
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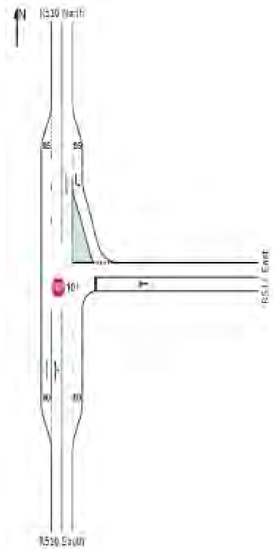
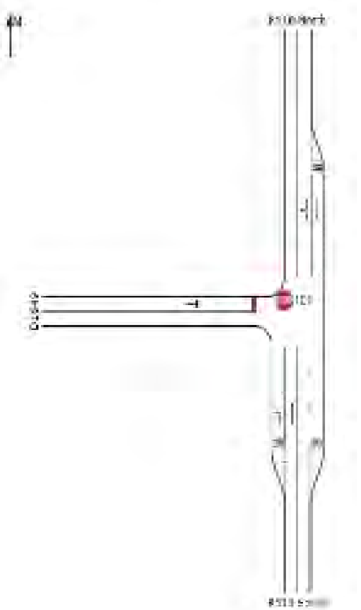
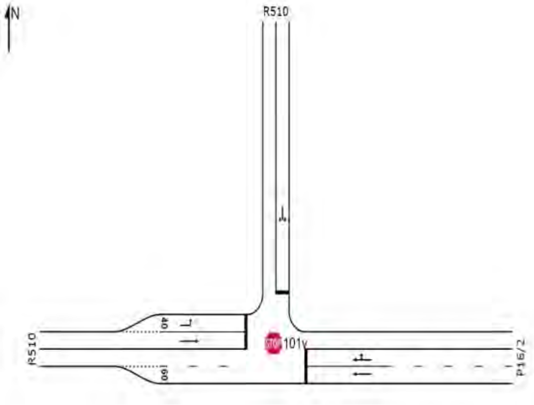
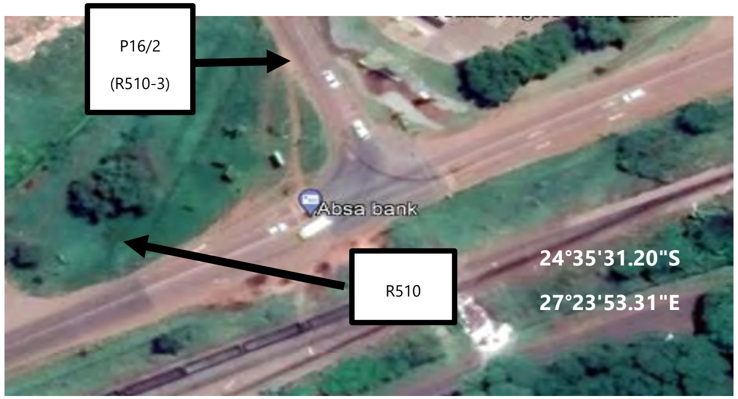
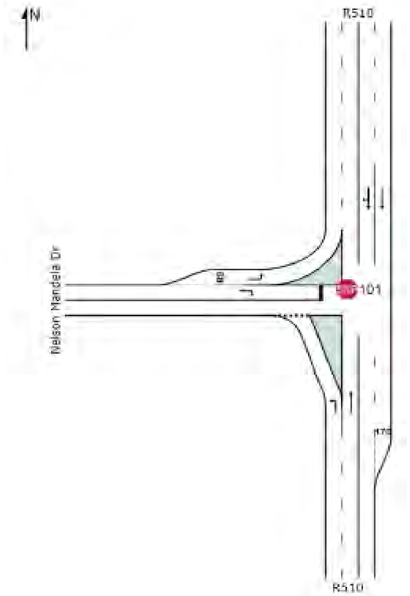
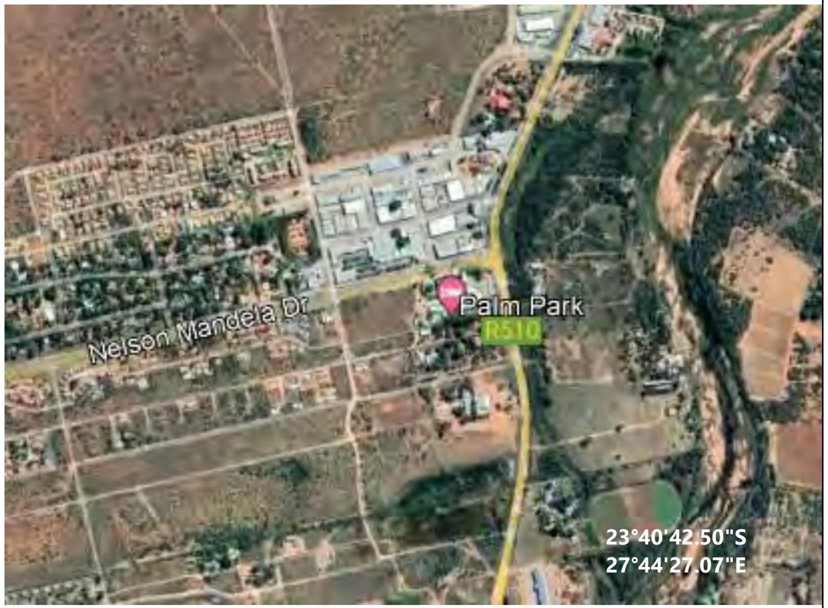
Intersection	Layout	Geographic Location
R511/R510 T-junction • Two-way stop-controlled intersection, major road R510 • Additional intersection capacity is provided on the R510 with a slip lane on the northern approach and shared through/right turn lane on the southern approach • Provides regional access to the site as well as access between Swartklip mine (potential concrete aggregate supply) and Thabazimbi		

Intersection	Layout	Geographic Location
R510/D1649 T-junction • Two-way stop-controlled intersection, major road R510 • Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the southern approach and shared through/right turn lane on the northern approach • Provides local access to the site		
R510/P16/2 T-junction • All way stop controlled intersection • Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the western approach and shared through/right turn lane on the eastern approach • Provides regional access to the site		

Intersection	Layout	Geographic Location
R510/Nelson Mandela Dr., Lephalale T-junction • Two-way stop-controlled intersection, major road R510 • Additional intersection capacity is provided on the R510 with an exclusive left turn lane on the southern approach and shared through/right turn lane on the eastern approach • Provides regional access to the site		

4.4 Capacity Analysis

The 20 surveyed intersections, including the 5 critical intersections discussed above, were analysed using a traffic analysis software tool called SIDRA (Signalised and non-signalised Intersection Design and Research Aid). The operating performance was evaluated under existing traffic conditions and lane configuration during the AM and PM peak hours. The AM Peak Hour and PM Peak Hours were modelled as follows:

- Thursday AM Peak Hour: 06:45-07:45
- Thursday PM Peak Hour: 16:00 – 17:00
- Friday AM Peak Hour: 06:30 – 07:30
- Friday PM Peak Hour: 15:30 – 16:30

The operational performance of each intersection was evaluated in terms of delay experienced on each approach as well as capacity of the junction to process the current traffic flows. The performance measurement is the Level of Service (LOS) defined by the Highway Capacity Manual in which letters A through F are used. LOS A depicts free flow conditions while LOS F denotes a breakdown in traffic flow. These definitions are based on Measures of Effectiveness (MoE) for the type of facility, which in this case is an intersection. Typical MoE's include speed, travel-time, density and delay for the associated volume of vehicles that use the facility.

The Volume Demand to Capacity Ratio (v/c) is a measure that compares roadway demand (vehicle volumes) with roadway supply (carrying capacity). For example, V/C = 1.00 indicates that the roadway facility is operating at its capacity. The LOS and V/C criteria is outlined in Table 4-7 below.

Table 4-7: LOS and V/C Criteria

LOS	Average Overall Delay per Vehicle (seconds)		Volume/Capacity Limits
	Signals and Roundabouts	Stop Signs and Give-Way (Yield) Signs	
A	<= 10	<= 10,0	<0.6
B	10,1 to 20,0	10,1 to 15,0	<0.7
C	20,1 to 35,0	15,1 to 25,0	<0.8
D	35,1 to 55,0	25,1 to 35,0	<0.9
E	55,1 to 80,0	35,1 to 50,0	<1.0
F	> 80,0	> 50,0	N/A

The results for the capacity assessment for the existing situation are shown in Table 4-8 and Table 4-9 below.

For rural intersections a LOS C is acceptable and for urban intersections a LOS D is deemed acceptable as per the TRH 16 Traffic Impact Assessment Manual.

The overall intersection LOS results are considered acceptable for all intersections except for Intersection No. 8 R510/P16/2. This intersection is discussed in more detail below.

The summer LOS analysis shows similar results and is included in the annexed traffic data.

Table 4-8: Intersection capacity results for Thursday, 6 May 2021

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
1	R101 and R516 (N1)	SIGNALISED	AM	South	0.340	25.70	C	0.343	18.60	B
				East	0.340	21.40	C			
				North	0.230	12.00	B			
				West	0.040	45.50	D			
			PM	South	0.410	21.60	C	0.408	21.70	C
				East	0.400	71.80	C			
				North	0.350	44.00	B			
				West	0.400	49.10	D			
2	R516 AND R511	STOP (TWO-WAY)	AM	South	0.020	0.70	A	0.126	5.50	A
				East	0.130	9.60	A			
				North	0.020	3.40	A			
			PM	South	0.010	2.20	A	0.069	5.30	A
				East	0.070	9.10	A			
				North	0.040	3.70	A			
3	R511 and R510	STOP (TWO-WAY)	AM	South	0.046	0.80	A	0.185	3.20	B
				East	0.185	13.00	B			
				North	0.139	1.10	A			
			PM	South	0.208	0.20	A	0.364	3.10	C
				East	0.364	24.80	C			
				North	0.103	1.70	A			
4	R510 and D1649	STOP (TWO-WAY)	AM	South	0.118	0.20	A	0.158	1.70	B
				North	0.158	1.30	A			
				West	0.080	10.30	B			
			PM	South	0.296	0.10	A	0.296	1.70	C
				North	0.122	2.00	A			
				West	0.151	16.30	C			
5	D1649 and Local Road	STOP (TWO-WAY)	AM	South	0.022	0.10	A	0.022	0.70	A
				North	0.019	0.20	A			
				West	0.004	7.90	A			
			PM	South	0.022	0.20	A	0.022	0.60	A
				North	0.022	0.20	A			
				West	0.003	8.00	A			
6	D1649 and D769	STOP (TWO-WAY)	AM	South	0.019	1.70	A	0.019	1.60	A
				East	0.006	8.20	A			
				North	0.018	0.20	A			
			PM	South	0.018	0.60	A	0.018	1.50	A
				East	0.010	9.60	A			
				North	0.018	0.20	A			
7			AM	South	0.008	0.40	A	0.008	1.00	A

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
	D769 and Local Road	STOP (TWO-WAY)		East	0.008	0.40	A			
				North	0.006	0.50	A			
			PM	South	0.007	0.50	A	0.008	1.00	A
				East	0.002	7.80	A			
				North	0.008	0.40	A			
8	R510 and P16/2	STOP (ALL-WAY)	AM	East	0.661	19.90	C	0.710	21.70	D
				North	0.710	27.80	D			
				West	0.320	14.20	B			
			PM	East	0.482	17.10	C	1.250	190.80	F
				North	1.195	215.30	F			
				West	1.250	190.80	F			
9	P16/2 and Local Road	STOP (TWO-WAY)	AM	South	0.035	0.10	A	0.035	0.30	A
				North	0.029	0.10	A			
				West	0.002	8.10	A			
			PM	South	0.033	0.10	A	0.033	0.30	A
				North	0.022	0.20	A			
				West	0.002	8.10	A			
10	D336 and Local Road	STOP (TWO-WAY)	AM	South	0.031	0.20	A	0.031	0.40	A
				East	0.003	8.10	A			
				North	0.027	0.10	A			
			PM	South	0.037	0.10	A	0.037	2.20	A
				East	0.002	7.90	A			
				North	0.023	5.70	A			
11	P16/2 and R510	STOP (TWO-WAY)	AM	East	0.037	3.70	A	0.037	5.50	A
				North	0.031	9.70	A			
				West	0.006	0.40	A			
			PM	East	0.040	3.60	A	0.040	4.60	A
				North	0.015	9.50	A			
				West	0.003	0.80	A			
12	R510 and road to Rooiberg	STOP (TWO-WAY)	AM	South	0.010	0.70	A	0.015	1.10	A
				East	0.005	8.10	A			
				North	0.015	0.20	A			
			PM	South	0.013	0.50	A	0.013	0.70	A
				East	0.002	8.10	A			
				North	0.008	0.40	A			
13	R510 and D2701	STOP (TWO-WAY)	AM	South	0.012	0.30	A	0.022	0.50	A
				North	0.022	0.20	A			
				West	0.002	8.10	A			
			PM	South	0.016	0.60	A	0.016	0.60	A
				North	0.010	0.40	A			

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
				West	0.002	8.10	A			
14	R510 and R517	STOP (TWO-WAY)	AM	South	0.018	10.00	B	0.029	5.10	B
				East	0.007	0.30	A			
				West	0.029	5.20	A			
			PM	South	0.048	9.20	A	0.048	5.90	A
				East	0.009	1.00	A			
				West	0.018	3.70	A			
15	D2701 and D1925	STOP (TWO-WAY)	AM	East	0.001	2.70	A	0.002	4.40	A
				North	0.002	7.80	A			
				West	0.001	2.80	A			
			PM	East	0.005	2.10	A	0.005	3.10	A
				North	0.002	7.80	A			
				West	0.001	2.80	A			
16	D1925 and D175	STOP (ALL-WAY)	AM	South	0.007	13.60	B	0.008	13.10	B
				East	0.006	12.70	B			
				North	0.007	13.60	B			
				West	0.008	12.50	B			
			PM	South	0.006	13.10	B	0.006	13.10	B
				East	0.006	13.10	B			
				North	0.006	13.10	B			
				West	0.006	13.10	B			
17	D175 and Access Road	STOP (TWO-WAY)	AM	South	0.320	33.10	C	0.316	19.30	A
				East	0.230	15.90	B			
				West	0.310	17.90	B			
			PM	South	0.810	29.20	D	0.807	29.20	A
				East	0.210	17.70	B			
				West	0.791	27.10	C			
18	Nelson Mandela Drive and Access Road	SIGNALISED	AM	South	0.32	33.10	C	0.316	19.30	B
				East	0.23	15.9	B			
				West	0.310	17.90	B			
			PM	South	0.810	29.20	A	0.807	29.20	D
				East	0.210	17.70	A			
				West	0.791	27.10	A			
19	R510 and Nelson Mandela Drive	STOP (TWO-WAY)	AM	South	0.130	3.00	A	0.276	5.10	B
				North	0.180	3.70	A			
				West	0.280	10.50	A			
			PM	South	0.080	2.50	A	0.317	5.90	A
				North	0.190	4.60	A			
				West	0.317	8.70	A			
20			AM	South	0.000	10.40	B	0.179	0.10	B

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
	Nelson Mandela Drive and Access Road	STOP (TWO-WAY)		East	0.180	0.00	A			
				West	0.180	0.00	A			
			PM	South	0.010	14.00	B	0.341	0.10	B
				East	0.240	0.00	A			
				West	0.341	0.00	A			

Table 4-9: Intersection capacity results for Friday, 7 May 2021

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
1	R101 and R516 (N1)	SIGNALISED	AM	South	0.456	12.80	B	0.456	12.10	B
				East	0.424	14.60	B			
				North	0.371	9.30	A			
				West	0.029	18.70	B			
			PM	South	0.812	23.30	C	0.812	20.00	C
				East	0.685	20.80	C			
				North	0.658	14.70	B			
				West	0.471	34.30	C			
2	R516 AND R511	STOP (TWO-WAY)	AM	South	0.015	2.00	A	0.092	5.60	A
				East	0.090	9.30	A			
				North	0.022	3.50	A			
			PM	South	0.053	3.20	A	0.108	4.90	A
				East	0.108	10.80	B			
				North	0.057	3.40	A			
3	R511 and R510	STOP (TWO-WAY)	AM	South	0.063	0.90	A	0.198	3.10	A
				East	0.198	15.70	C			
				North	0.162	1.20	A			
			PM	South	0.168	0.50	A	0.234	2.80	C
				East	0.234	17.70	C			
				North	0.096	2.30	A			
4	R510 and D1649	STOP (TWO-WAY)	AM	South	0.018	0.20	A	0.178	1.80	B
				North	0.018	0.20	A			
				West	0.002	7.90	A			
			PM	South	0.016	0.20	A	0.264	2.10	B
				North	0.016	0.20	A			
				West	0.002	8.00	A			
5	D1649 and Local Road	STOP (TWO-WAY)	AM	South	0.016	1.20	A	0.018	0.50	A
				North	0.006	8.20	A			
				West	0.022	0.10	A			
			PM	South	0.026	1.50	A	0.033	0.30	A

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
				North	0.008	8.20	A			
				West	0.015	0.20	A			
6	D1649 and D769	STOP (TWO-WAY)	AM	South	0.016	1.20	A	0.022	1.20	A
				East	0.006	8.20	A			
				North	0.022	0.10	A			
			PM	South	0.026	1.50	A	0.026	1.70	A
				East	0.008	8.20	A			
				North	0.015	0.20	A			
7	D769 and Local Road	STOP (TWO-WAY)	AM	South	0.005	0.80	A	0.005	1.80	A
				East	0.002	7.80	A			
				North	0.003	0.90	A			
			PM	South	0.008	0.40	A	0.008	1.00	A
				East	0.002	7.80	A			
				North	0.005	0.60	A			
8	R510 and P16/2	STOP (ALL-WAY)	AM	East	0.703	20.80	C	0.731	22.80	D
				North	0.731	29.20	D			
				West	0.230	13.70	B			
			PM	East	0.473	17.20	C	1.335	123.30	F
				North	1.191	122.70	F			
				West	1.335	170.70	F			
9	P16/2 and Local Road	STOP (TWO-WAY)	AM	South	0.021	0.20	A	0.021	0.50	A
				North	0.021	0.20	A			
				West	0.003	7.90	A			
			PM	South	0.035	0.10	A	0.035	0.30	A
				North	0.023	0.20	A			
				West	0.002	8.10	A			
10	D336 and Local Road	STOP (TWO-WAY)	AM	South	0.020	0.20	A	0.020	0.40	A
				East	0.002	7.90	A			
				North	0.018	0.20	A			
			PM	South	0.033	0.20	A	0.033	0.40	A
				East	0.002	8.00	A			
				North	0.018	0.20	A			
11	P16/2 and R510	STOP (TWO-WAY)	AM	East	0.021	4.50	A	0.023	6.50	A
				North	0.023	9.80	A			
				West	0.003	0.90	A			
			PM	East	0.041	4.30	A	0.041	5.80	A
				North	0.028	9.10	A			
				West	0.002	2.50	A			
12	R510 and road to Rooiberg		AM	South	0.007	0.30	A	0.013	0.80	A
				East	0.003	8.10	A			

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
		STOP (TWO-WAY)		North	0.013	0.20	A			
			PM	South	0.014	0.70	A	0.017	1.10	A
				East	0.005	8.30	A			
				North	0.017	0.60	A			
13	R510 and D2701	STOP (TWO-WAY)	AM	South	0.012	0.20	A	0.020	0.50	A
				North	0.020	0.20	A			
				West	0.002	8.10	A			
			PM	South	0.016	0.30	A	0.023	0.70	A
				North	0.023	0.60	A			
				West	0.002	8.20	A			
14	R510 and R517	STOP (TWO-WAY)	AM	South	0.016	9.10	A	0.028	4.20	A
				East	0.007	0.70	A			
				West	0.028	3.70	A			
			PM	South	0.035	4.90	A	0.035	4.90	A
				East	0.008	1.90	A			
				West	0.022	3.30	A			
15	D2701 and D1925	STOP (TWO-WAY)	AM	East	0.003	4.40	A	0.003	5.10	A
				North	0.002	7.90	A			
				West	0.001	2.80	A			
			PM	East	0.002	3.60	A	0.002	4.50	A
				North	0.002	7.90	A			
				West	0.002	1.80	A			
16	D1925 and D175	STOP (ALL-WAY)	AM	South	0.007	13.60	B	0.008	13.10	B
				East	0.006	12.70	B			
				North	0.007	13.60	B			
				West	0.008	12.50	B			
			PM	South	0.006	13.10	B	0.006	13.10	B
				East	0.006	13.10	B			
				North	0.006	13.10	B			
				West	0.006	13.10	B			
17	D175 and Access Road	STOP (TWO-WAY)	AM	South	0.001	5.70	A	0.008	8.10	A
				East	0.008	7.80	A			
				West	0.007	9.00	A			
			PM	South	0.001	5.70	A	0.014	8.10	A
				East	0.014	8.10	A			
				West	0.008	8.80	A			
18	Nelson Mandela Drive and Access Road	SIGNALISED	AM	South	0.277	43.90	D	0.304	12.50	D
				East	0.257	9.80	A			
				West	0.304	12.10	B			
			PM	South	0.564	44.30	D	0.564	16.90	D

SITE ID	INTERSECTION	CONTROL TYPE	PEAK PERIOD	OPERATIONAL CONDITIONS						
				APPROACH				INTERSECTION		
				Leg	V/C	Delay	LOS	V/C	Delay	LOS
				East	0.120	9.50	A			
				West	0.554	13.20	B			
19	R510 and Nelson Mandela Drive	STOP (TWO-WAY)	AM	South	0.094	2.40	A	0.258	5.50	A
				North	0.204	4.70	A			
				West	0.258	8.40	A			
			PM	South	0.100	2.40	A	0.326	5.70	A
				North	0.187	4.30	A			
				West	0.326	9.90	A			
20	Nelson Mandela Drive and Access Road	STOP (TWO-WAY)	AM	South	0.005	13.60	B	0.284	0.10	B
				East	0.284	0.00	A			
				West	0.276	0.00	A			
			PM	South	0.004	12.50	B	0.339	0.10	B
				East	0.173	0.00	A			
				West	0.339	0.00	A			

4.4.1 Site No. 8 Intersection R510/P16/2

This intersection shown in Figure 4-7 consistently fails during the PM Peak hour during both the Thursday and Friday capacity analysis. The intersection is an All-Way Stop Controlled (AWSC) junction with additional lane provision on the R510.

The junction could require an upgrade in control type from AWSC to signalisation. Once the construction work is underway, several workers may be expected to be accommodated in Thabazimbi and will use the P16/2 to access the northern sections of the pipeline.

It is recommended that the intersection is monitored during the construction period and should queues greater than 4 vehicles form on any of the approaches (signal warrant as per SARTSM Vol. 3) then a temporary signal is installed by the Contractor.

Although a signal might be required under current conditions it is recommended that the local municipality is first consulted as they may not have the capacity or resources to maintain the signal. It was noted during the site investigation, that one of the signals along this section of road was switched off and the intersection had reverted to an AWSC, which could be owing to the aforesaid lack of resources.

The LOS results summary for the winter and summer volume capacity analysis is proved in Figure 4-7 and Figure 4-8 below.

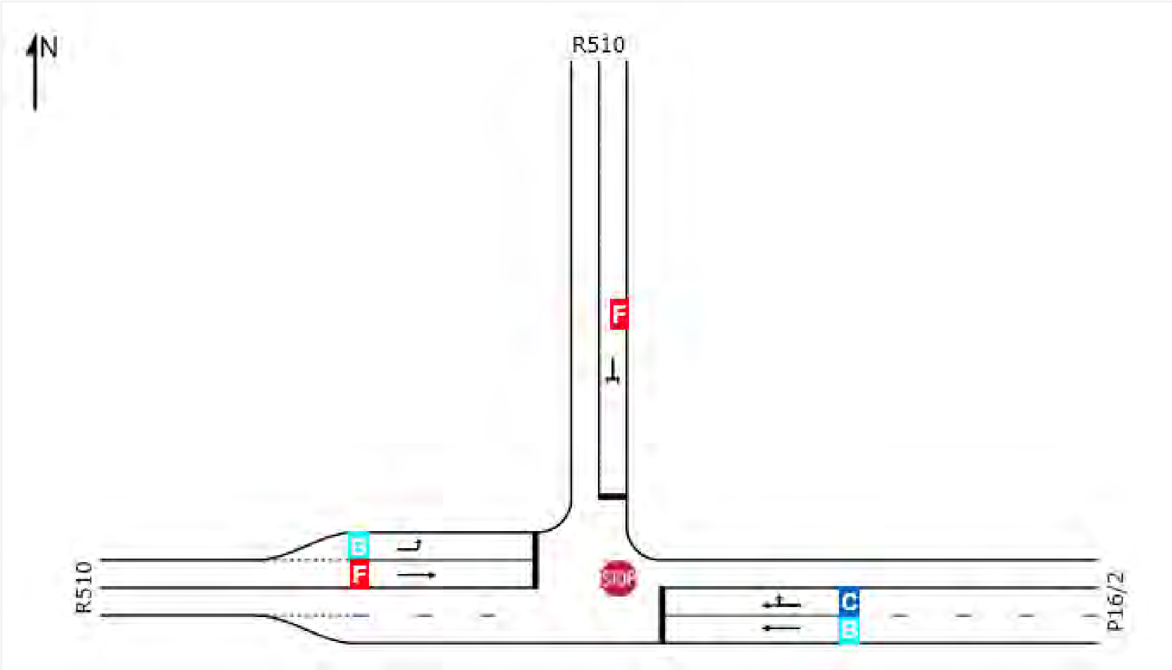


Figure 4-7 R510/P16/2 Intersection layout and LOS summary - Winter

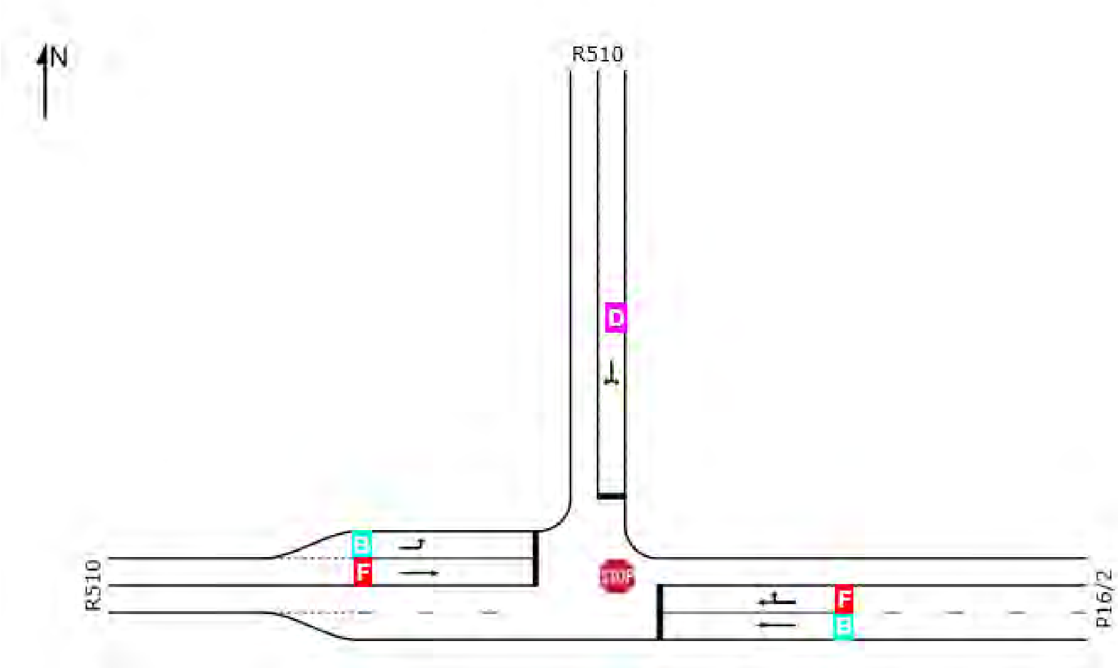


Figure 4-8 R510/P16/2 Intersection layout and LOS summary - Summer

4.5 Trip Generation and Distribution

The trip generation calculations are based on the latest available information on construction activities and technical assumptions provided below. The final quantities/volumes of material to be transported, personnel employed, construction methods and program information will only be available later and therefore realistic assumptions have been made related to the trip generations.

4.5.1 Locations of Construction Activity and Access Roads

The MCWAP-2 related vehicle trips will be made to/from and between the following locations of construction activity:

- The Vlieëpoort Abstraction Works in the Crocodile River (West) on the farm Mooivallei, south-west of Thabazimbi with an abstraction capacity of 125 million m^3/a. The Vlieëpoort Abstraction Works includes a diversion weir in the Crocodile River (West), boulder trap, gravel trap and various sand traps. The diversion weir includes a flow measuring section.
- A low-lift pump station at the Vlieëpoort Abstraction Works with an installed capacity of 75 million m^3/a that will transfer water via two low-lift rising mains (1000 mm diameter each), approximately 5.9 km long, to the sedimentation works and a 650 mega litre (Ml) balancing reservoir.
- A high-lift pump station with an installed capacity of 75 million m^3/a at the balancing reservoir will pump water over approximately 27 km through a 1400 mm diameter pipe, to a small break pressure tank.
- From the break pressure tank water will gravitate through a 1400 mm diameter pipe to the 90 Ml break pressure reservoir.
- From the break pressure reservoir, water will gravitate over approximately 82.09 km to Off-Take C (future users). The gravity pipeline comprises 33 km of 1600 mm diameter pipe, 30.5 km of 1500 mm diameter pipe and 18.59 km of 1400 mm diameter pipe.
- From Off-Take C water will gravitate through a 12.9 km of 1100 mm diameter pipeline to Off-Take B (Medupi Power Station).
- From Off-Take B water will gravitate through a 6.3 km of 900 mm diameter pipeline to Off-Take A (Matimba Power Station, Exarro, Grootgeluk and Thabametsi).
- Ancillary works that will comprise an Operational Control Centre, offices, housing and workshops.

The locations of the MCWAP-2 construction camps, borrow pits and spoil sites are indicated in Figure 4-9 below where majority of the construction related movements will occur.

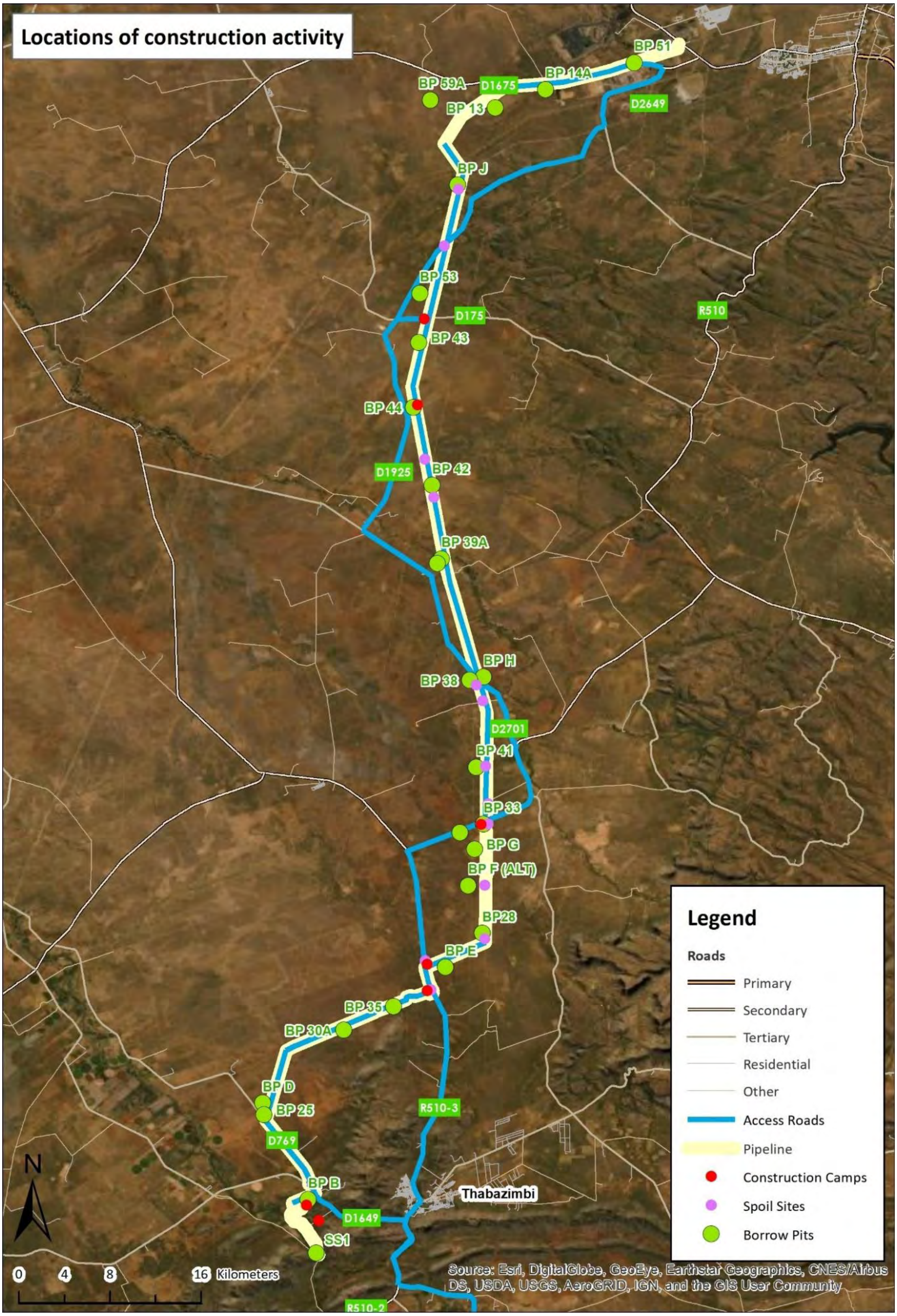


Figure 4-9: Locations of construction activity

4.5.2 Technical Assumptions

The following information was received from the GBN-JV technical team regarding envisaged transport activities to site.

Based on a high-level assessment, transport to site will include:

- Daily traveling of construction and monitoring personnel to site (Weir/High Lift Pumping Station, Break Pressure Reservoir and four pipeline construction fronts),
- Delivery of construction equipment at all construction areas/fronts:
    - Fencing material – allow for truck load every 200 m of pipeline length
    - Pipe deliveries (abnormal loads, 18 m long pipes – pipes per truck will vary, DN900 – 6 pipes per load, DN1000 to DN1200 – 4 pipes per load, DN1400 – 3 pipes per load, DN1500 – 2 pipes per load, DN1600 – 1 pipe per load (refer to attached long sections for pipe diameters)
    - Materials for valve chambers – one valve chamber every 500 m along pipelines (2 low lift pipelines in parallel). Allow one truck load for each of the following – concrete x 3, reinforcement, shuttering, pipe specials, valves, finishes, erosion protection
    - Weir and High Lift Pumping Station –
        - Aggregates/cement for concrete = 10 2000m^3
        - Reinforcement = 7000 tons
    - Shuttering - allow loads as per reinforcement, for pumps, pipe specials etc., allow for 50 truckloads
    - Bricks/windows/doors/sheeting/finishes etc. – allow for 100 truckloads
    - Break Pressure Reservoir – allow 50 truckloads for equipment and materials etc.

Hauling of borrow pit material, spoil material and construction water will mainly be on construction roads based on the current mass-haul (this may change depending on borrow pit/spoil site investigation and the confirmation of construction water locations).

4.5.3 Workforce Trips

The workforce vehicle trips apply to all persons employed on the MCWAP-2. The local labour and professional staff will generate trips during the peak periods.

An estimate of the number of local, skilled and professional labour is provided in Table 4-10.

Table 4-10: Estimated workforce

CONTRACT	MCWAP-2 Component	Local Labour	Semi-skilled Labour	Skilled Labour	Professionals
1	Vlieëpoort Abstraction Works	125	138	198	21
	650 Ml Balancing Reservoir	62	69	99	10
2	90 Ml Break Pressure Reservoir	28	24	37	2
	Pipeline Works	195	167	261	17
	Ancillary Works (Operational Control Centre, offices, housing and workshops)	150	100	75	5
	Total	**560**	**498**	**671**	**55**

A modal split was then assumed for buses, minibus taxis and private vehicles.

Table 4-11: Workforce modal split

Workforce	Light Vehicle	Minibus Taxi	Bus
Local Labour	0 %	40 %	60 %
Semi-skilled Labour	0 %	50 %	50 %
Skilled Labour	1 %	64 %	35 %
Professionals	100 %	0 %	0 %
Occupancy (Person Per Vehicle)	1	12	45

It has been assumed that light vehicles are made up of private vehicles and will have an occupancy of 1 person, the minibus taxi will have an occupancy of 12 people and the bus will have an occupancy of 45 people.

Taking into consideration the modal split and vehicle occupancy, the number of trips generated by the workforce was calculated as follows:

Table 4-12: Workforce Vehicle Trips

Workforce	Light Vehicle	Minibus Taxi	Bus
Local Labour	0	19	7
Semi-skilled Labour	0	21	6
Skilled Labour	7	27	5
Professionals	55	0	0

It is assumed that buses and taxis will make trips to and from the local towns of Lephalale, Thabazimbi, Vaalwater, Modimolle, Bela-Bela and Mokopane. The local labour will likely be attracted from the surrounding residential settlements of Marapong and Onverwacht as indicated below.

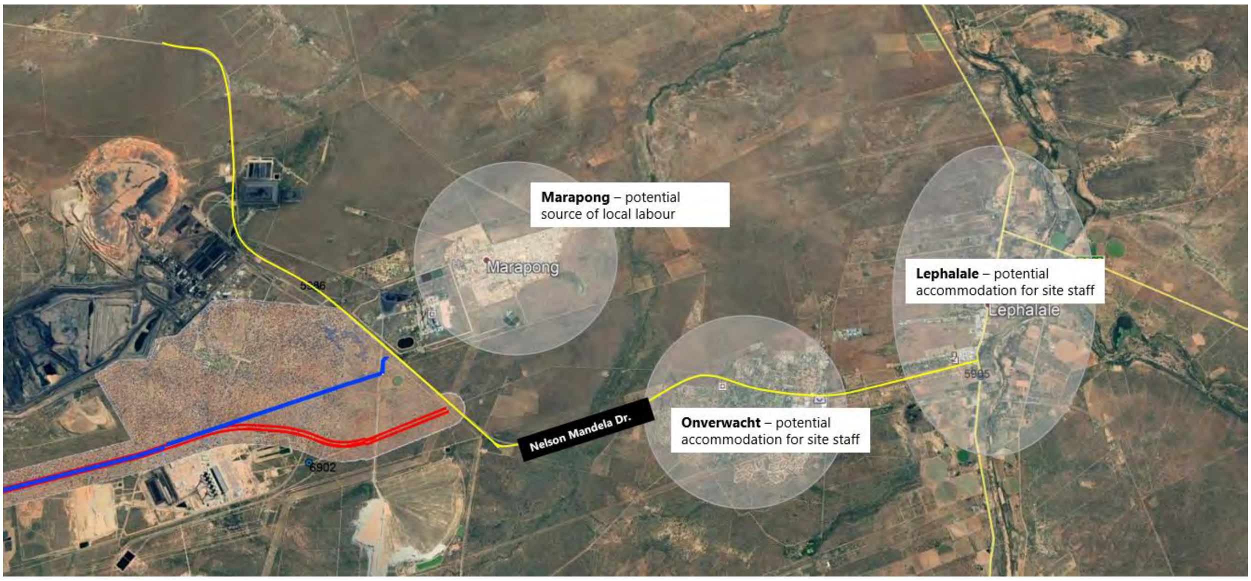


Figure 4-10: Local and semi-skilled labour communities

4.5.4 Heavy Vehicle Trips

The heavy vehicle trip generation is split between delivery of construction material and the transport of material between sites. The total volumes of heavy vehicle trips generated from the above assumptions and based on a projected peak construction period of 60 months have been worked out as shown in Table 4-13.

Table 4-13: Estimated heavy vehicle trips

Construction Component	Trip Assumptions	Total HV Trips Generated	Annual HV Trips over a 60-month construction period	Average Daily HV Trips
Delivery of Materials to Site for Construction				
1. Fencing	1 truck load every 200m of pipeline length	682	136	1
2. Pipe Deliveries	Delivered in 18m long pipes			
DN900	6 pipes per load	59	12	1
DN1000 to DN1200	4 pipes per load	257	51	1
DN1400	3 pipes per load	889	178	1
DN1500	2 pipes per load	847	169	1
DN1600	1 pipe per load	1833	367	2
3. Material for Valve Chambers	1 chamber every 500m of pipeline length @ 7 trucks for each	1909	382	2
4. Material for Shuttering	Allow for 50 truck loads	50	10	1
5. Materials for Wier and Pump Stations	Allowance for 200 truck loads	200	40	1
6. Material for Break Pressure Reservoir	Allow for 50 truck loads	50	10	1
7. Material for Ancillary Works	Allow for 100 truck loads	100	20	1
Mass Haulage between Construction Activities				
1. Pipeline	Approximately 300000 cubic metres to be transported	29991	5998	27
2. Balancing Reservoir	Approximately 650000 cubic metres to be transported	65000	13000	59
3. Break pressure Reservoir	Approximately 90000 cubic metres to be transported	9000	1800	8
			Total ADTT	**106**

4.5.5 Abnormal Heavy Vehicle Trips

Some abnormal loads will have to be transported to/from site. Most of these loads will be transported at the beginning and end of the construction period. These include temporary offices, lifting equipment and heavy machinery such as large cranes. The exact number of these abnormal heavy vehicles is not certain, but it is negligible compared to the number of normal heavy vehicles.

Abnormal load permits will be required for transporting abnormal loads which will include a route determination to ensure that they can be transported safely on the available routes. Such permits are issued on a case-by-case basis. No detailed assessments are therefore required as part of this study.

The trip generation calculations described above are considered to be reasonable estimates and are adequate to determine the traffic impact for planning purposes. Calculations should be refined for critical road infrastructure elements if more accurate construction information in future suggests that certain impacts may have been underestimated.

4.6 Sketch Plan Model

To have an understanding of the extent of traffic movements that can be attribued to the construction of the project and the impacted routes and intersections, a **simple sketch plan model** was developed.

The most viable routes between possible origins and destinations were identified and any issues in terms of condition of the roadway, presence of vulnerable road users and social services were highlighted.

Potential sources of accommodation, skilled and unskilled labour, materials and other resources were assessed. This information is shown graphically in Figure 4-11 below and described in Table 4-14 overleaf.

Note that the condition of the pavement is discussed in detail under the road assessment section of this report.

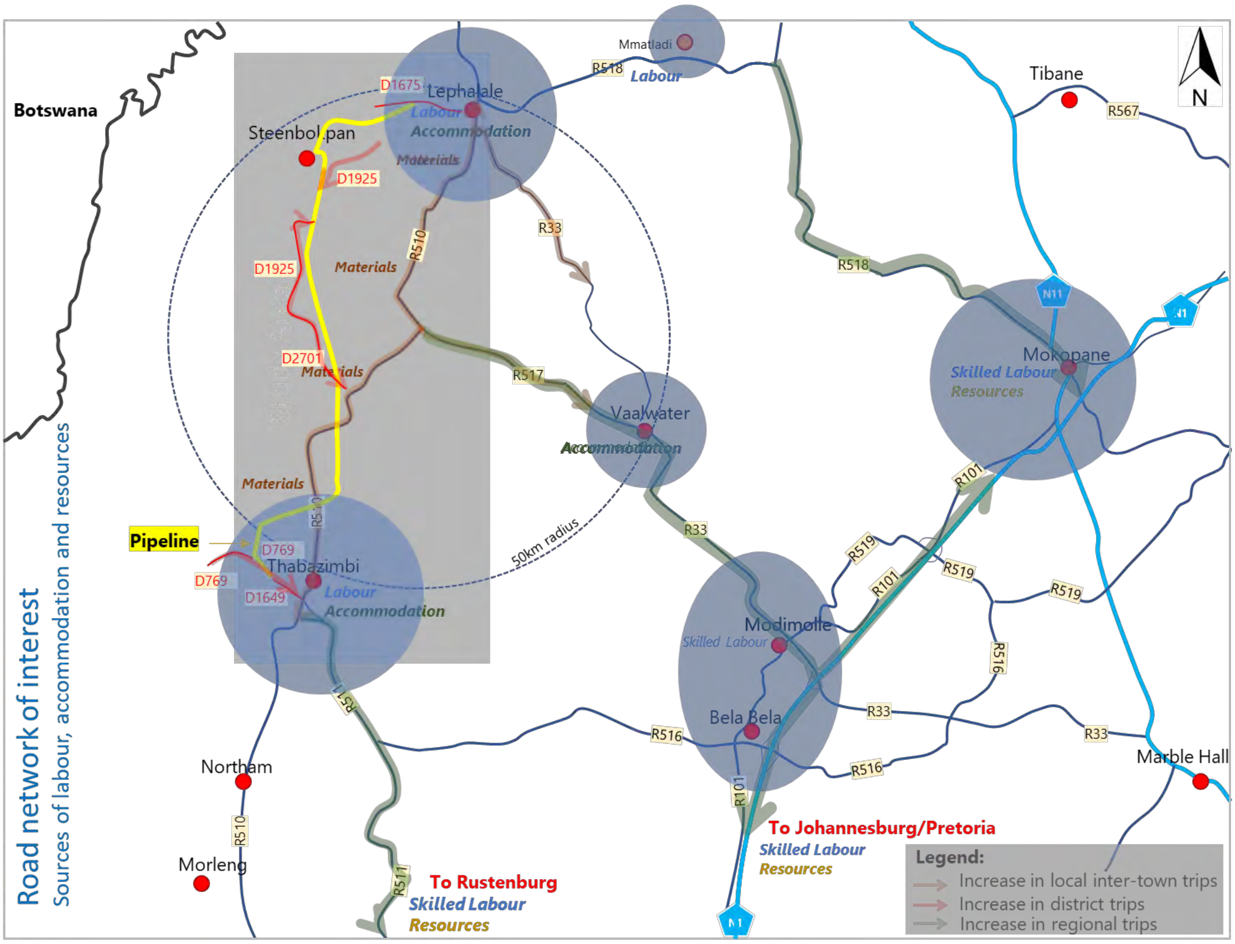


Figure 4-11: Trips sources and increase on the road network

The intersections referenced in the sketch plan models are as per Table 4-6.

Table 4-14 Sketch plan model

No.	Nature of trip	Origin	Destination	Potential Impacted Routes	Potential Impacted Intersections	Comments
1	Movement of site personnel between construction camps and pipeline footprint	Construction Camps - evenly distributed alongside the pipeline	Project borrow pits, pipeline and structures footprint	High volumes on the following routes: R510, D175, D2701, D1925, D1675, D769 and D1649	High turning movement volumes at the following intersections: No. 5, No. 6, No. 7, No. 9, No. 10, No. 11, No. 15, No. 16, No. 17, No. 18 and No. 20	**Hazardous road conditions on D1925** – severe rutting and ponding during rainy season **School** located in the vicinity of Intersection No. 6 on Road D769 **Intersection No. 9** is on main road R510. A temporary right turn lane on the R510 northern approach should be considered.
2	Movement of construction labour (skilled and unskilled) from **local towns** to construction site	Thabazimbi (and Regorogile settlement)	Construction camps	High volumes on the following routes: R510, P16/2 and D1649	High turning movement volumes at the following intersections: No. 4 and No. 8	**Existing capacity issues** at Intersection No. 8 Vulnerable road users - high **pedestrian and informal trader** activity along R510 in the vicinity of Thabazimbi Town (between I/S No. 4 and 8.)
		Lephalale (and Marapong – most trips will be walking trips from here and Onverwacht)	Construction camps	High volumes on the following routes: R510, Nelson Mandela Dr. and D1675	High turning movement volumes at the following intersections: No. 18, No. 19 and No. 20	Increase in pedestrian crossings on Nelson Mandela Drive, in the vicinity of Marapong settlement and the project site.
		Vaalwater (along the R33)	Construction camps	R33/R517 and R510	Moderate increase in turning movement	

No.	Nature of trip	Origin	Destination	Potential Impacted Routes	Potential Impacted Intersections	Comments
					volumes at No. 14, No. 13, No. 12	
		Mmatladi	Construction camps	R518 and Nelson Mandela Dr.	Moderate increase in turning movement volumes at No. 18 and No. 19	
3	Movement of skilled labour and resources from **surrounding towns**	Lephalale, Thabazimbi, Mokopane, Modimolle, Rustenburg, Johannesburg/Pretoria	Construction Camps	Moderate increase in public transport demand and heavy vehicles on the following routes: R510, R518, R33, R517, R511, R516, and N1	Moderate increase in turning movement volumes at No. 1 No. 2, No. 3, No. 4, No. 8	Grass verge at the R510/R511 intersection (**No. 3**) needs to be kept short to maintain good sight distance at the intersection.
4	Transportation of fill material from borrow areas	**Borrow pits** BP51, BP14A, BP59A, BP13, BPJ, BP53, BP43, BP44, BP42, BP39A, BPH, BP38, BP41, BP33, BPG, BPF, BP28, BPE, BP35, BP30A, BPD, BP25, and BPB	Construction activity along pipeline footprint	D1649, D749, R510, D2701, D1925, D175, D1675 and D2649	High turning movement volumes at the following intersections: No. 5, No. 6, No. 7, No. 9, No. 10, No. 11, No. 15, No. 16, No. 17, No. 18 and No. 20	**Hazardous road conditions on D1925** – severe rutting and ponding during rainy season **School** located in the vicinity of Intersection No. 6 on Road D769 **Intersection No. 9** is on main road R510. A temporary right turn lane on the R510 northern approach should be considered. **Further damage to gravel roads** D1649, D1675 and D2649 likely due increased heavy vehicle trips.

No.	Nature of trip	Origin	Destination	Potential Impacted Routes	Potential Impacted Intersections	Comments
5	Transportation of spoil material to spoil sites	Construction activity along pipeline footprint	Spoil sites	D1649, D749, R510, D2701, D1925, D175, D1675 and D2649	Moderate increase in turning movement volumes the following intersections: No. 5, No. 6, No. 7, No. 9, No. 10, No. 11, No. 15, No. 16, No. 17, No. 18 and No. 20	**Intersection No. 9** is on main road R510. A temporary right turn lane on the R510 northern approach should be considered.
6	Delivery of construction materials commercial sources	Lephalale, Thabazimbi, Mokopane, Modimolle, Rustenburg, Johannesburg/Pretoria	Construction Camps	R510, R518, R33, R517, R511, R516 and N1	Moderate increase in turning movement volumes at No. 1 No. 2, No. 3, No. 4, No. 8	Grass verge at the R510/R511 intersection (**No. 3**) needs to be kept short to maintain good sight distance at the intersection at all times

4.7 Assessment of Traffic Impacts

The GBN-JV provided an impact rating scale with which to rate the existing and potential future impacts that were identified by the Specialists. This was done in accordance with Government Notice R.326, promulgated in terms of Section 24 of the NEMA and the criteria drawn from the Integrated Environmental Management (IEM) Guidelines Series, Guideline 5: Assessment of Alternatives and Impacts, published by the Department of Environmental Affairs (DEAT) (April 1998).

The residual risk is based on the following Table 4-15 provided to the team and used to assist the decision maker in determining the implications of the different residual risks:

Table 4-15 Residual Risk Category

		Residual risk				
Consequence	High	Moderate	High	High	Fatally flawed	
	Moderate – high	Low	Moderate	High	High	High
	Moderate	Low	Moderate	Moderate	Moderate	Moderate
	Moderate – low	Low	Low	Low	Low	Moderate
	Low	Low	Low	Low	Low	Low
		Highly unlikely	Unlikely but possible	Likely	Highly likely	Definite
	Likelihood					

The assignment of significance ratings has been undertaken based on past experience of the Specialist team as well as various site investigations.

It should be noted that the assessment is limited to the **public** road network and as such does not consider private property access issues.

During the construction phase there would be an increase in vehicle movement to and from the area of construction along the pipeline route. This increased vehicle movement is largely associated with the delivery of construction material, pipework and associated infrastructure and has the potential to impact on traffic using the existing road network in the area.

The increase in traffic could generate additional noise, dust and safety impacts for fauna, other road users and people living or working within close proximity to the roads used for accessing the construction site.

In addition to this, the increased volume of traffic along the transport route may increase the wear and tear on these roads and possibly lead to deterioration in road conditions.

There may also be some disruptions to traffic associated with the laying of sections of piping at road crossings. There are a total of four road crossings, including three minor gravel roads (D769, D175 and D1675) and a Provincial secondary road (R510). The level of use of the secondary and farm roads is low with a very low number of vehicle movements, significant traffic disruption may be expected on the R510.

The impact will occur over the medium-term construction period (6 years) and with the low level of use of the provincial and secondary roads and the limited disturbance of the road crossings the impact is assessed to have a MEDIUM significance. However, with implementation of mitigation measures this can be reduced to a LOW significance.

Traffic numbers would be significantly reduced during the operational phase with only a few vehicles expected for undertaking maintenance along access roads to the pipeline servitude and facilities.

Table 4-16 Traffic impact identification and mitigation measures

No.	Receptor/ Resource	Process/ Activity	Environmental Impact	Nature	Duration	Extent	Irreplaceable resources	Severity	Consequence = (Duration+ Extent+Irr) x Severity	Likelihood	Residual Risk	Significance	Confidence	Mitigation and Management Measures	Impact Monitoring	
															Monitoring	Time Frame for Monitoring
1.	Capacity on the road network	Additional vehicle trips generated by construction activity	• Congestion • Unsafe driving conditions on the road network • Frustration of local motorists due to increase in vehicle activity especially the presence of slow-moving construction vehicles	Negative Impact	Temporary (1)	Regional (4)	No (0)	High negative (-3)	Slightly detrimental (-15)	Definite (3)	Moderate	Moderate negative (-45)	High	Specific Measures to reduce / manage impacts: • Make available public transport such as a bus service to/from the construction camps for staff from surrounding settlements to reduce number of car and minibus taxi trips on the network • Lane capacity improvements to impacted intersections to reduce delays and overall journey time (in accordance with RAL and the local municipality specifications) • Conduct a warrant for a temporary signal at Intersection No. 8 (R510/P16/2) to reduce delays and improve safety by reducing the number of conflict points • Consider providing a temporary right turn lane on the R510 northern approach at Intersection No. 9 (R510 and Road A) to accommodate high right turn movement of trucks (heavily loaded trucks will require a longer gap in oncoming traffic, thus frustrating drivers behind them)	Monitoring of queue lengths at Intersection No. 8 to assess whether signal is required	Monthly monitoring during construction
2.	CO^2 Emissions	Additional vehicle trips generated by construction activity	• Increase in CO^2 emissions	Negative Impact	Temporary (1)	Regional (4)	Yes (1)	Moderate negative (-2)	Moderately detrimental (-12)	Definite (3)	Low	Low negative (-36)	High	Specific Measures to reduce / manage impacts: • Make available public transport such as a bus service to/from the construction camp sites for staff from surrounding settlements to reduce number of car and minibus taxi trips on the network and subsequent reduction in CO^2 emissions.		

No.	Receptor/ Resource	Process/ Activity	Environmental Impact	Nature	Duration	Extent	Irreplaceable resources	Severity	Consequence = (Duration+ Extent+Irr) x Severity	Likelihood	Residual Risk	Significance	Confidence	Mitigation and Management Measures	Impact Monitoring	
															Monitoring	Time Frame for Monitoring
3.	Vulnerable road users – VRU's (pedestrians, informal traders, learners and trolley pushers)	Additional vehicle trips generated by construction activity close to human settlements	• Hazardous road safety conditions and loss of life due to inattentive/reckl-ess driving	Negative Impact	Temporary (1)	Local (3)	Yes (1)	High negative (-3)	Sightly detrimental (-15)	Likely (2)	Low	Low negative (-30)	Medium	Specific Measures to reduce/manage impacts: • Reduce the speed limit for construction vehicles to 40 km/hr through town areas (on the R510 around Thabazimbi and Nelson Mandela Drive in Lephalale) • Install temporary rumble strips on sections of the above roads • Most areas are poorly lit making visibility of VRU's difficult during night-time conditions, restrict night shift work to remove construction traffic from the road during the night. Should the need for night shift work arise, ensure that areas close to human activity are well-lit • Conduct education and awareness training amongst site personnel with regard to safe driving practices • Contractor could assist with scholar patrol duty at the school on the D769 (Intersection No. 7) to ensure learners are crossing safely, install additional road signage warning of the presence of the school, vehicles to reduce speed to 20km/hr in the vicinity of the school	Monitoring of driver behaviour, speed profiles and crash statistics on the R510 and Nelson Mandela Drive	Monthly monitoring during construction
4.	General road users	Reduced lane widths during construction at pipe jack areas and the weir site adjacent R510	• Reduced road safety	Negative Impact	Temporary (1)	Site (2)	No (0)	Moderate Negative (-2)	Negligible (-6)	Likely (2)	Low	Very low negative (-12)	Medium	Develop a traffic accommodation plan which will include: • Implement road signage that alerts motorists of temporary lane direction • Use temporary barriers to demarcate sections of the road not accessible during construction	Monitor the implementation of measures and record road safety incidents	Daily monitoring during construction

No.	Receptor/ Resource	Process/ Activity	Environmental Impact	Nature	Duration	Extent	Irreplaceable resources	Severity	Consequence = (Duration+ Extent+Irr) x Severity	Likelihood	Residual Risk	Significance	Confidence	Mitigation and Management Measures	Impact Monitoring	
															Monitoring	Time Frame for Monitoring
5.	• Pavement Condition	Increase in heavy vehicle volumes during construction	• Deterioration in pavement quality (increase in potholes) resulting in unsafe driving conditions	Negative Impact	Temporary (1)	Regional (4)	No (0)	Moderate Negative (-2)	Slightly detrimental (-10)	Definite (3)	Moderate	Low negative (-30)	High	• Trucks should not be overloaded, and wheel/axle loading should be in accordance with legislation (TMH 3)	• Monitoring of truck loading for compliance • Monitoring of road condition (more detail provided under Road Assessment sections)	Monthly compliance monitoring during construction
6.	• Dust Generation	Increase in vehicle volumes along gravel district roads	• Dust inhalation by staff walking to work and other VRU's living close to construction activity	Negative Impact	Temporary (1)	Local (3)	No (0)	Low negative (-1)	Negligible (-4)	Definite (3)	Low	Very low negative (-12)	High	• Dust suppression using a water truck on gravel roads close to human settlements/activity	• Monitoring of dust levels • Reducing the speed limit to lower the amount of dust generated by moving vehicles. • Adding a gravel layer to the road.	Fortnightly monitoring during construction (frequency depending on weather conditions)

No.	Receptor/ Resource	Process/ Activity	Environmental Impact	Nature	Duration	Extent	Irreplaceable resources	Severity	Consequence = (Duration+ Extent+Irr) x Severity	Likelihood	Residual Risk	Significance	Confidence	Mitigation and Management Measures	Impact Monitoring	
															Monitoring	Time Frame for Monitoring
7.	• Noise generation by heavy vehicles and constructio n activity	Construction activity	• Noise Pollution to nearby residential areas within earshot	Negative Impact	Temporary (1)	Local (3)	No (0)	Low negative (-1)	Negligible (-4)	Definite (3)	Low	Very low – negative (-12)	High	• Limited settlements in the vicinity of the construction activity although night shift that would generate significant noise should be avoided	• Monitoring of noise levels • Notify persons likely to be affected. • Work within normal work hours as far as possible	Monthly compliance monitoring during construction
8.	• Disturbance to Fauna and Flora	Removal of vegetation and trees at construction sites	• Fragmentatio n of habitat for native fauna and flora	Negative Impact	Short term (2)	Regional (4)	Yes (1)	Moderate Negative (-2)	Moderately detrimental (-14)	Definite (3)	Moderate	Moderate Negative (-42)	High	• Limit vegetation clearing to what is necessary for pipeline infrastructure construction • Revegetation of disturbed areas with native trees, shrubs and herbaceous plants	None.	None.

4.7.1 Mitigation Risk Measures

The following mitigation measures are recommended to avoid possible construction-related traffic issues that might otherwise occur on the roads under consideration in this report.

1. Transport of project workforce

(a) This item relates to the transport of the workforce associated with the project. To mitigate the risk of any related accidents or incidents the following measures are suggested:

(i) **Vehicles, including buses, taxis etc**

- Staff may arrive at the various site offices in their own vehicles but transport on site should only be in approved vehicles
- All vehicles used on site must have prior approval by client, and a current roadworthy certificate from an approved Roadworthy Testing Centre, valid for a period of 12 months from the date of issue and renewable annually during the contract period
- All site vehicles should be clearly identifiable and must have highly visible branding as specified in the contract to identify approved vehicles. No vehicles should be allowed on site without client certification and a disciplinary process needs to be put in place for any transgressions that might occur, with possible dismissals, if necessary, although this is usually seen as a last resort
- Vehicles used for transport of the workforce should be fitted with restraining devices and canopies to ensure the safety and protection of the workforce
- All staff must wear full PPE whether that they might work in an office or not, comprising as a minimum, hard hat, eye goggles, reflective safety jacket (not vest), steel toecap boots, necessary ear protection (if needed) and bare arm protection (long sleeve vest or other arm protection).
- All drivers must have appropriate valid driver's licenses.

(ii) **Speed limits**

- For the sections of surfaced R- and D- Roads to be utilised extensively for the project, consideration should be given to approach the relevant road authority with the suggestion that lower speed limits be posted, not exceeding 100 km/h
- In the case of the unsurfaced roads, the approach should be similar, with a speed limit of 60 km/h being posted

(iii) **Medicals and induction**

- All staff should have an OHS Act Medical Certificate to be renewed annually
- There must be generic induction for all persons to be employed on site, in the appropriate languages so that everyone understands HIRAC training
- There must also be site specific induction carried out to ensure that the workforce understands its responsibility regarding safe transportation around the site
- All site personnel should be breathalysed daily

(iv) **Safety meetings**

- These must take place on a regular basis but with no fewer than one per month

(v) **Consequences**

- In terms of Table 4-16 above, simply by implementing the above measures, the chance of an accident taking place is considered low and highly unlikely.

2. Haulage of construction materials and other supplies

(a) This item relates to the transport of large quantities of suitable pipe bedding, backfill materials and other supplies required for the project. This material will be procured from several borrow pits, quarries as well as other suppliers.
The following mitigation measures are suggested:

(i) Trucks and other haulage vehicles

- Similar safety and identification measures as earlier mentioned should be followed for haulage vehicles
- In addition, haulage vehicles should meet minimum criteria in terms of quality of vehicle and capacity
- At each borrow pit or quarry site as well as at other locations where construction vehicles are present, there should be traffic control measures including amongst other things, stop / go boards used strictly in accordance with the South African Road Traffic Signs Manual to control the movement of vehicles
- Where appropriate, flagmen may be utilised to control the movement of vehicles in and out of the borrow pit and quarry sites, but this should be reviewed daily as it may become necessary to use the stop / go boards instead

(ii) Speed limits

- Due consideration and approach should be given to the maximum speed limits as previously outlined
- Contractors should give an undertaking, before any contract is awarded, not to give incentives to the drivers which might encourage speeding between loading and offloading sites.

(iii) Medicals and induction

- Medicals and induction is similar to the previously mentioned, but in addition, random drug testing of haulage drivers is also recommended.

(iv) Safety meetings

- Toolbox talks should be held daily where all the drivers should sign their attendance and have input into all the risks associated with the haulage to be carried out on that day.

(v) Consequences

- In terms of Table 4-16 above, simply by implementing the above measures, the chance of an accident taking place is considered low and unlikely.

5 CONCLUSIONS

5.1 Road Assessment

VCI results demonstrate that the **surfaced roads** are currently in a fair-to-good condition, and the DCP results confirm that the surfaced roads can be considered structurally sound. The surfaced roads were also investigated for riding quality (IRI) and rut depth. The results indicated that apart from Road R510-2 and Road R516-1, more than 80% of each road has an IRI index of less than 3.5. (72.67% of Road R510-2 recorded an IRI index of less than 3.5 whilst Road R516-1 recorded 61.94% for the same).

The South African Pavement Engineering Manual (Figure 24) shows that the expected IRI range for older surfaced roads is between 2.2 and 7.5 and generally all the surfaced roads are within this acceptable range.

As per the surfaced roads, the **gravel roads** are also found to be structurally sound, however it needs to be borne in mind that in many instances the in-situ subgrade layer is in fact serving as a wearing course layer. Therefore, when reference is made to the gravel roads being structurally sound, it refers more to the subgrade layer and the layers below. Further to this, with reference to the visual assessment and the DCP results, indications are that the quality of the current subgrade material is acceptable. In summary, the VCI results demonstrate that the gravel roads are in a poor-to-fair condition.

Roads D769, D2701, D175, and D1925 were each tested for layer thickness and were all found to be well below the minimum required thickness of 200 mm and in some instances the gravel roads had virtually no wearing course layer. The little (if any) wearing course layer was mostly found to consist of loose, sandy material which in some instances needs to be modified and re-graded with a good quality wearing course material.

It is evident from the visual assessment of the gravel roads that the profile of the roads is inadequate for the drainage of stormwater from the roads, that neither the gravel roads nor their drainage culverts have been adequately maintained and, in most cases show little to no signs of maintenance. Generally, culverts are silted, blocked and totally ineffective. In addition, in many instances, culverts have limited or no cover, with evidence of much damage to the culvert barrels. The lack of cover to the culverts may have resulted from subgrade layers and wearing course material being displaced over time. In some instances, the lack of cover may even be from grading over the years.

5.2 Traffic Assessment

The results of the baseline traffic assessment indicate that during the construction phase the district roads providing access to the construction activities will experience increased heavy vehicle volumes over the duration of the construction due to the **movement of personnel and construction materials** whilst the provincial roads allowing for inter-regional movements will experience increased heavy vehicle volumes attributed to the delivery of imported materials to site. The **increased heavy vehicle trips** have potential to impact on the traffic using the road network and may increase the wear and tear on these roads and possibly lead to deterioration in road conditions.

Trips generated from the transportation of abnormal loads have been considered negligible compared to the number of heavy vehicle trips as they will occur less frequently and are typically generated due to abnormal sizes of materials and not necessarily the weight of the material.

Furthermore, the labour force will cause an **increase in public transport trips** and the increased traffic volumes on the road network could generate noise, dust and road safety impacts for other road users and those working or living in close proximity to the project site. It is anticipated that local labours will originate from surrounding residential settlements in Thabazimbi, Lephalale, Vaalwater, Marapong and Onverwacht.

The traffic count survey data indicates that intersections such as R516/R101 and R511/r510 tend to process higher traffic volumes in excess of 12000 vehicles over a 12-hour period, whilst the gravel road intersections serving predominantly agricultural movements such as D1649/D769 and D1925/D175 process much smaller volumes less than 500 vehicles over a 12-hour period.

The capacity evaluation of critical intersections indicate that most intersection operate well within the acceptable conditions at Level of Service A or B, except for the intersection of R510/P16/2, where consideration should be made for possibly temporarily signalising the intersection for the duration of the project, as the intersection is currently already under significant traffic strain and the addition of heavy construction vehicles is likely to have a further negative impact on the traffic.

During the operational phase of the project, the generated trips will reduce significantly with only a few vehicles expected for the purpose of maintaining the pipeline infrastructure.

The overall impact of the project on traffic and the associated road network is assessed to be **MEDIUM** and may be reduced to LOW with the implementation of mitigation measures. Traffic calculations and impact assessment should be refined for critical road infrastructure elements if more accurate construction information in future suggests that certain impacts may have been underestimated.

6 RECOMMENDATIONS

6.1 Surfaced Roads

The R-Roads, namely R510-2, R510-3, R511-3 and R516-1 are well maintained and in good condition with no additional work required. All drainage culverts including inlet and outlet structures and side drains are also in good order and require no additional work.

The D-Roads, on the other hand, namely D1649, D2701, D1675 and D2649 are not well maintained, and although the roads drive reasonably well, significant restorative action is required, which may include some or all of the following:

- Repairs to road edge breaks
- Sealing of surface cracks with a modified sealant
- Painting of new road markings and replacement of signage where necessary
- Installation of centre line road studs
- Grass cutting and bush clearing between the edge of road and boundary fences as well as in the vicinity of kilometre markers
- Reinstatement of headwalls and wingwalls and the unblocking of pipe culverts
- Provision of inlet and outlet channels and stone pitching where necessary to negate erosion
- Reinstatement and grading of gravel shoulders

Apart from the above actions, consideration should be given to the resurfacing of Roads D1649 and D2649 as both these sections of road, although driving well at present, exhibit extensive cracking which may lead to failure especially considering the increased number of construction vehicles which will be traversing these roads.

In the case of Road D1675 which is severely cracked over its entire length of approximately 13 km, consideration should be given, as a minimum, to carrying out extensive crack sealing and if this proves to be ineffective then in-situ recycling of its pavement layers followed by resurfacing should be considered.

It should be noted that any remedial action carried out to the above-mentioned D-Roads should be planned in coordination with RAL, the responsible road authority.

6.2 Gravel Roads

The most common issues relating to the gravel roads include the lack of maintenance, road profile/shape for effective drainage, the varying thickness of the wearing course or its absence and damage to the existing pipe culverts due to the lack of cover. In dealing with these issues, the following actions are to be considered:

- Improve the profile/shape of gravel roads by adding gravel layers (including a wearing course layer layer) thereby elevating the gravel roads to improve riding quality, road drainage as well as providing adequate cover to pipe culverts
- Replacement of damage pipe culverts and where necessary extending culverts to beyond the road profile
- Unblocking and cleaning of culverts and providing drainage channels for effective drainage
- Providing headwalls and wingwalls to culverts and installing the necessary warning signage
- Grass cutting and bush clearing between the edge of the road and road reserve fences to enable regular maintenance of inlet and outlets to culverts and drainage channels
- Due to the varying thickness of the wearing course layer of the gravel roads, ensuring a wearing course layer of 200 mm minimum in thickness for all gravel roads and maintaining this layer thickness for the duration of the construction period. At no stage should the wearing course layer be allowed to reduce to less than 150 mm thick
- Regular maintenance of the gravel roads for the duration of the construction period which could with ease be achieved by involving local communities

Further to the above, within the gravel roads there are sections of road which may require total reconstruction, e.g. Road D175 (currently a sand track), Road D1925 (currently a sand track with absolutely no defined shape) and Gravel Road 2, km 1.8 to km 2.8 (an extremely rocky section of road).

Gravel Roads 2, 3 and 4 are essentially non-public farm access and service roads. These roads are narrow in places and may need widening to facilitate the safe passing of construction vehicles. In addition, these roads have very limited drainage and may require a combination of pipe culverts and diagonal gravel mounds to facilitate improved drainage. In the case of Gravel Road 4 which is a service road running parallel to an existing railway line it is essential that drainage be provided across this road at regular intervals which would then also accommodate drainage from the railway line.

With respect to the roads, it is anticipated that most challenges from local communities may relate to the gravel roads where any perceived deterioration to their condition will be regarded as construction related. It is therefore considered essential that effort be devoted to improving and maintaining the condition of the gravel roads.

6.3 Traffic Management

The following traffic mitigation measures are recommended to reduce impact on traffic operations, roads and the surrounding environment:

- Reduce the speed limit for construction vehicles to 40 km/hr through town areas (on the R510 around Thabazimbi and Nelson Mandela Drive in Lephalale).
- Provision of a temporary right turn lane on the R510 northern approach at Intersection No. 9 (R510 and Road A) to accommodate high right turn movement of trucks (heavily loaded trucks will require a longer gap in oncoming traffic, thus frustrating drivers behind them which may trigger reckless driver behaviour).
- Conduct a warrant for a temporary signal at Intersection No. 8 (R510/P16/2) to reduce delays and improve safety by reducing the number of conflict points.
- Provision of public transport services such as a bus service to/from the construction camps for staff from surrounding settlements to reduce number of car and minibus taxi trips on the network. This will reduce number of car and minibus taxi trips on the network and subsequent reduction in CO_2 emissions.
- Conduct education and awareness training amongst site personnel regarding safe driving practices.

- Restriction of night shift work to remove construction traffic from the road during the night. Should the need for night shift work arise, ensure that areas close to human activity are well-lit
- Implementation of traffic calming measures and pedestrian facilities in the vicinity of Kesarona Primary School located along road D769 as the will be higher than usual volumes of heavy construction vehicles on this road which may comprise safety for school learners that walk or cycle to the school.
    - Install speed bumps in the vicinity of the school
    - Install additional road signage warning of scholar activity
    - Provide pedestrian crossing facilities
    - Reduce speed limit to 20km/h in the vicinity of the school
    - Assist with scholar patrol duty to ensure learners cross the roads safely

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GBN JOINT VENTURE

MOKOLO AND CROCODILE RIVER (WEST) WATER AUGMENTATION PROJECT PHASE 2 (MCWAP-2)

ROADS AND TRAFFIC BASELINE ASSESSMENT REPORT

TRAFFIC MANAGEMENT PLAN

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1 INTRODUCTION

1.1 Scope of this Document

This Traffic Management Plan (TMP) is an overarching document covering proposals to be adopted for accommodation of traffic and the management of construction transport/traffic during construction work on the Mokolo Crocodile Water Augmentation Phase 2 located in Limpopo Province.

The purpose of the TMP is to ensure the safety of employees, contractors, the public, pedestrians and traffic by undertaking the following:

- Provide, maintain and update an effective TMP.
- Ensure traffic is accommodated for optimal flow and safety during construction.
- Maintain satisfactory property access.
- Minimise traffic delays.
- Minimise disruption to businesses.
- Minimise disturbance to the environment.

The overall objectives of the plan are to ensure that optimal and safe flow of traffic is maintained during construction, and to reduce road accidents during all the phases of the project and to minimize personal exposure and property damage. The TMP is a living document and must be continually updated during construction to reflect new developments on the project.

It should be noted that the appointed Contractor(s) for the construction contracts associated with the project will be required to submit a traffic accommodation plan, considering the contents of this TMP, to the responsible Engineer for approval.

This document should be read in conjunction with the MCWAP-2 Roads and Traffic Assessment Report and the South African Road Safety Manual.

2 TRAFFIC ACTIVITIES

2.1 Construction Activities

The MCWAP-2 related vehicle trips will be made to/from and between the following locations of construction activity:

- The Vlieëpoort Abstraction Works in the Crocodile River (West) on the farm Mooivallei, south-west of Thabazimbi with an abstraction capacity of 125 million m3/a. The Vlieëpoort Abstraction Works includes a diversion weir in the Crocodile River (West), boulder trap, gravel trap and various sand traps. The diversion weir includes a flow measuring section.
- A low-lift pump station at the Vlieëpoort Abstraction Works with an installed capacity of 75 million m3/a that will transfer water via two low-lift rising mains (1000 mm diameter each), approximately 5.9 km long, to the sedimentation works and a 650 mega litre (Ml) balancing reservoir.
- A high-lift pump station with an installed capacity of 75 million m3/a at the balancing reservoir will pump water over approximately 27 km through a 1400 mm diameter pipe, to a small break pressure tank.
- From the break pressure tank water will gravitate through a 1400 mm diameter pipe to the 90 Ml break pressure reservoir.

- From the break pressure reservoir, water will gravitate over approximately 82.09 km to Off-Take C (future users). The gravity pipeline comprises 33 km of 1600 mm diameter pipe, 30.5 km of 1500 mm diameter pipe and 18.59 km of 1400 mm diameter pipe.
- From Off-Take C water will gravitate through a 12.9 km of 1100 mm diameter pipeline to Off-Take B (Medupi Power Station).
- From Off-Take B water will gravitate through a 6.3 km of 900 mm diameter pipeline to Off-Take A (Matimba Power Station, Exarro, Grootgeluk and Thabametsi).
- Ancillary works that will comprise an Operational Control Centre, offices, housing and workshops.

2.2 Traffic Sketch Plan Model

A sketch plan model of traffic movements attributed to the construction of the project is provided in Table 1 below. The model is based on an assessment of the most viable routes between possible origins and destinations during construction and indicate roads that are likely to be impacted.

Table 1: Sketch Plan Model

No.	Nature of trip	Origin	Destination	Potential Impacted Routes
1	Movement of site personnel between construction camps and pipeline footprint	Construction Camps - evenly distributed alongside the pipeline	Project borrow pits, pipeline and structures footprint	High volumes on the following routes: R510, D175, D2701, D1925, D1675, D769 and D1649
2	Movement of construction labour (skilled and unskilled) from **local towns** to construction site	Thabazimbi (and Regorogile settlement)	Construction camps	High volumes on the following routes: R510, P16/2 and D1649
		Lephalale (and Marapong – most trips will be walking trips from here and Onverwacht)	Construction camps	High volumes on the following routes: R510, Nelson Mandela Dr. and D1675
		Vaalwater (along the R33)	Construction camps	R33/R517 and R510
		Mmatladi	Construction camps	R518 and Nelson Mandela Dr.
3	Movement of skilled labour and resources from **surrounding towns**	Lephalale, Thabazimbi, Mokopane, Modimolle, Rustenburg, Johannesburg/Pretoria	Construction Camps	Moderate increase in public transport demand and heavy vehicles on the following routes: R510, R518, R33, R517, R511, R516, and N1

No.	Nature of trip	Origin	Destination	Potential Impacted Routes
4	Transportation of fill material from borrow areas	**Borrow pits** BP51, BP14A, BP59A, BP13, BPJ, BP53, BP43, BP44, BP42, BP39A, BPH, BP38, BP41, BP33, BPG, BPF, BP28, BPE, BP35, BP30A, BPD, BP25, and BPB	Construction activity along pipeline footprint	D1649, D749, R510, D2701, D1925, D175, D1675 and D2649
5	Transportation of spoil material to spoil sites	Construction activity along pipeline footprint	Spoil sites	D1649, D749, R510, D2701, D1925, D175, D1675 and D2649
6	Delivery of construction materials commercial sources	Lephalale, Thabazimbi, Mokopane, Modimolle, Rustenburg, Johannesburg/Pretoria	Construction Camps	R510, R518, R33, R517, R511, R516 and N1

3 RISKS & MITIGATION

3.1 Traffic Impacts

A detailed assessment of traffic related impacts of the projects was undertaken, and they can be summarised as follows:

- Traffic congestion
- Unsafe driving conditions on the road network
- Frustration of local motorists due to increase in vehicle activity especially the presence of slow-
- Increase in CO_2 emissions
- Hazardous road safety conditions and loss of life due to inattentive/reckless driving
- Deterioration in pavement quality resulting in unsafe driving conditions
- Dust inhalation by staff walking to work and other VRU's living close to construction activity
- Noise Pollution to nearby residential areas within earshot

3.2 Traffic Management Recommendations

The following project specific traffic mitigation measures are recommended to reduce impact on traffic operations, roads and the surrounding environment:

- Reduce the speed limit for construction vehicles to 40 km/hr through town areas (on the R510 around Thabazimbi and Nelson Mandela Drive in Lephalale).
- Provision of a temporary right turn lane on the R510 northern approach at Intersection No. 9 (R510 and Road A) to accommodate high right turn movement of trucks (heavily loaded trucks will require a longer gap in oncoming traffic, thus frustrating drivers behind them which may trigger reckless driver behaviour).
- Conduct a warrant for a temporary signal at Intersection No. 8 (R510/P16/2) to reduce delays and improve safety by reducing the number of conflict points.

- Provision of public transport services such as a bus service to/from the construction camps for staff from surrounding settlements to reduce number of car and minibus taxi trips on the network. This will reduce number of car and minibus taxi trips on the network and subsequent reduction in CO_2 emissions.
- Conduct education and awareness training amongst site personnel regarding safe driving practices.
- Restriction of night shift work to remove construction traffic from the road during the night. Should the need for night shift work arise, ensure that areas close to human activity are well-lit
- Implementation of traffic calming measures and pedestrian facilities in the vicinity of Kesarona Primary School located along road D769 as the will be higher than usual volumes of heavy construction vehicles on this road which may comprise safety for school learners that walk or cycle to the school.
    - Install speed bumps in the vicinity of the school.
    - Install additional road signage warning of scholar activity.

    Provide pedestrian crossing facilities.

    Reduce speed limit to 20km/h in the vicinity of the school.

    Assist with scholar patrol duty to ensure learners cross the roads safely

3.3 Risk Mitigation Measures

The following risk mitigation measures are recommended to avoid possible construction-related traffic issues that might otherwise occur on the roads under consideration in this report.

3.3.1 Transport of project workforce

This item relates to the transport of the workforce associated with the project. To mitigate the risk of any related accidents or incidents the following measures are suggested:

a) Vehicles, including buses, taxis etc

- Staff may arrive at the various site offices in their own vehicles but transport on site should only be in approved vehicles
- All vehicles used on site must have prior approval by client, and a current roadworthy certificate from an approved Roadworthy Testing Centre, valid for a period of 12 months from the date of issue and renewable annually during the contract period
- All site vehicles should be clearly identifiable and must have highly visible branding as specified in the contract to identify approved vehicles. No vehicles should be allowed on site without client certification and a disciplinary process needs to be put in place for any transgressions that might occur, with possible dismissals, if necessary, although this is usually seen as a last resort
- Vehicles used for transport of the workforce should be fitted with restraining devices and canopies to ensure the safety and protection of the workforce
- All staff must wear full PPE whether that they might work in an office or not, comprising as a minimum, hard hat, eye goggles, reflective safety jacket (not vest), steel toecap boots, necessary ear protection (if needed) and bare arm protection (long sleeve vest or other arm protection).
- All drivers must have appropriate valid driver's licenses.

b) Speed limits

- For the sections of surfaced R- and D- Roads to be utilised extensively for the project, consideration should be given to approach the relevant road authority with the suggestion that lower speed limits be posted, not exceeding 100 km/h
- In the case of the unsurfaced roads, the approach should be similar, with a speed limit of 60 km/h being posted

c) Medicals and induction

- All staff should have an OHS Act Medical Certificate to be renewed annually
- There must be generic induction for all persons to be employed on site, in the appropriate languages so that everyone understands HIRAC training
- There must also be site specific induction carried out to ensure that the workforce understands its responsibility regarding safe transportation around the site
- All site personnel should be breathalysed daily

d) Safety meetings

- These must take place on a regular basis but with no fewer than one per month

3.3.2 Haulage of construction materials and other supplies

This item relates to the transport of large quantities of suitable pipe bedding, backfill materials and other supplies required for the project. This material will be procured from several borrow pits, quarries as well as other suppliers.

The following mitigation measures are suggested:

a) Trucks and other haulage vehicles

- Similar safety and identification measures as earlier mentioned should be followed for haulage vehicles
- In addition, haulage vehicles should meet minimum criteria in terms of quality of vehicle and capacity
- At each borrow pit or quarry site as well as at other locations where construction vehicles are present, there should be traffic control measures including amongst other things, stop / go boards used strictly in accordance with the South African Road Traffic Signs Manual to control the movement of vehicles
- Where appropriate, flagmen may be utilised to control the movement of vehicles in and out of the borrow pit and quarry sites, but this should be reviewed daily as it may become necessary to use the stop / go boards instead

b) Speed limits

- Due consideration and approach should be given to the maximum speed limits as previously outlined
- Contractors should give an undertaking, before any contract is awarded, not to give incentives to the drivers which might encourage speeding between loading and offloading sites.

c) Medicals and induction

- Medicals and induction are similar to the previously mentioned, but in addition, random drug testing of haulage drivers is also recommended.

d) Safety meetings

- Toolbox talks should be held daily where all the drivers should sign their attendance and have input into all the risks associated with the haulage to be carried out on that day.

4 TRAFFIC MANAGEMENT

4.1 Accommodation of Traffic

The appointed Contractor(s) is to submit a detailed Traffic Accommodation Plan to the Engineer for approval. The traffic accommodation specifications shall be strictly in accordance with the South African Road Traffic Signs Manual Volume 2, Chapter 13 and in accordance with the relevant specifications of the project documents.

The Contractor must ensure that provision is made for access by emergency vehicles, where required.

The Contractor must ensure that provision is made for the management and required signage for temporary closure and/or deviations of any formal pedestrian access affected by the works.

The Traffic Accommodation Plan must, as a minimum, adhere to the principles described below to ensure efficient and safe site operations.

4.1.1 Principles for Works affecting Public Roads

a) Warning Area

An area of the construction site which is utilised to alert motorists of any impending temporary conditions that will require particular care other than what would normally be expected.

When the construction site is on or directly adjacent to a road, a stepped reduction in speed will inevitably be required within this area. This stepped reduction should occur in 20 km/hr decrements and at reasonable intervals (minimum 200 metres) until the speed for which the traffic control is designed is indicated. This final speed limit should be repeated at least once within the area of the traffic accommodation as good practice.

The length of the advance warning area should relate directly to measured approach speeds, and a reasonable distance must be allowed for speed reduction. In situations of high traffic volumes, a generous length will be required as more time is needed to take in the sign message and to react accordingly. The advance warning area will become longer in the event of a combination of higher approach speeds and high traffic volumes.

b) Transition Area

This is the area in which the motorist is required to take an action.

This area of the construction site can be defined as where there is a shift of position on the roadway without a reduction in the number of lanes (diversion) such as the merge of two lanes into one (lane drop) or entering a detour that is separate from the construction works.

The transition area must be clearly demarcated using delineator plates and should confirm to the layout, if any, depicted on the guidance signs preceding it. The length of a transition area will depend on the approach speed of traffic and the amount of shift in alignment involved by the transition.

c) Stabilising Area

The purpose of a stabilising area is to allow traffic flow to stabilise after negotiating a transition area, and before reaching another change of condition. In the instance of where more than one transition area is required to achieve the final traffic configuration, the signing of subsequent transitions should be located within the stabilising area(s). The stabilising area is normally defined by delineator plates.

d) Buffer Zone

The buffer zone is normally located between a transition area and the actual work area. In a situation involving more than one transition area, the buffer zone will occur after the transition area closest to the work area.

The principal function of a buffer zone is to separate traffic from the workers at the site in the interests of worker safety. The provision of a longitudinal buffer zone, together with a lateral buffer zone, should be considered as fundamental to effective worker safety.

e) Work Area

The work area can be adequately defined by delineators in less complex conditions. However, where there is a risk to traffic or workers for vehicles entering the work area, temporary barriers of a standard sufficient to prevent vehicle penetration should be put in place. If traffic is located well away from the work area, then little action is required along the length of the work area other than to protect the workers and construction vehicles.

f) Termination Area

This area involves the return of traffic to normal flow conditions. For simple cases, a relatively short taper or delineator signs will suffice. In more complex situations, a reverse crossover may be required. This should follow the same principles given for such conditions at the commencement of the construction works.

4.1.2 Roles & Responsibilities

It is the responsibility of the Contractor (for the duration of the construction phase) and TCTA (for the duration of the operational phase) to ensure the following:

- o All equipment and/or materials transported to or from Site shall be appropriately secured to, or contained in, vehicles.
- o No construction vehicles shall be loaded more than its manufacturer-specified weight bearing capacity.
- o All vehicles used during the Project shall have the appropriate load-bearing capacity for the materials and/or equipment intended to be transported.
- o Drivers are appropriately skilled and trained.

5 EVALUATION & MONITORING

5.1.1 Monitoring

The following guidelines are to be followed for completing daily/weekly checks as part of the traffic management.

a) Daily

- Construction vehicles:
  - o Check tyres visually.
  - o Ensure that all lights as operating correctly. It is an offence to drive if vehicle lights are not functioning properly.
  - o Ensure that the vehicle has sufficient fuel.
  - o Clean the windscreen, all windows, mirrors, headlamps and all other light lenses.
- Check the engine oil level daily and before setting out on a long journey.

- Road Safety
    - Check positions and visibility of temporary road signs as per the traffic accommodation plan
    - Record any road safety incident

b) Weekly

- Check and correct the tyre pressure and tread wear including the spare wheel. Keep to the pressures recommended in the manufacturer's handbook.
- Check the battery. Keep the terminals clean and ensure that all connections are secure.
- Check the radiator water - anti-freeze mixture level weekly and/or before setting out on a long journey.
- Top up the windscreen washer reservoir at least once a week. Check the action of the windscreen wipers and the condition of the wiper blades at the same time.
- Check the clutch fluid and brake fluid reservoirs (where fitted).
- General Service and Maintenance
    - Preventative maintenance through inspection and regular servicing can reduce the defect rate and help improve reliability. It is, therefore, important that all vehicles are properly maintained.
    - Vehicles must be serviced in line with the manufacturer's recommendations. These are outlined in the service book, which accompanies each vehicle.

c) Monthly

- Road safety incidents in the vicinity of construction activity

d) Seat Belts

- The wearing of seat belts is compulsory and is the responsibility of the driver.
- Drivers
    - All escort and light vehicle drivers must meet the national driving requirements and hold a valid driving license for the type and class of vehicle being driven or operated.
    - The heavy-duty drivers must meet the national driving requirements and hold a valid driving license for the heavy-duty vehicles being driven or operated.
    - Each driver is responsible for the condition of their own vehicle (fines/penalties and bans will be administered internally).
    - Drivers must meet the minimum national driving standards and any additional project or site requirements must be followed and adhered to.

5.1.2 Incident Reporting

The aim of reporting and investigating incidents is to determine the cause and prevent reoccurrence.

It is the responsibility of all employees and contractors to report accidents, incidents and near misses at any place of work to their immediate Site Manager/Supervisor or Foreman. It is then the duty of that Manager/Supervisor or Foreman to ensure that appropriate entries are made in the Accident Book and, at the earliest opportunity, to inform the construction manager of the incident and, where applicable, the client's representative.

It is the responsibility of the construction manager to initially investigate incidents or delegate the responsibility for such investigation to another competent person. If the incident is major or there is a fatality, then the Department of Employment and Labour shall also be involved.

2 CONCLUSION

The implementation schedule of this traffic management plan will be determined in accordance with the project's construction and operation schedules.

This Plan shall be reviewed periodically during the lifetime of the Project to facilitate on going and effective management of traffic. After each review the revision date and revision number (indicated at the bottom left corner of this Plan) shall be updated accordingly.

Construction phase review

The TMP shall be reviewed 2 months after the commencement of construction by the Project Managers. Thereafter the Plan shall be reviewed every quarter of a year during the construction period unless there is an accident, in which case the Plan shall be reviewed by the Project Managers immediately after the accident and appropriate corrective measures are incorporated into this Plan to avoid similar accidents in the future.

Operational phase review

During the operational phase, the Plan shall be reviewed annually by the Project Manager unless there is an accident, in which case the Plan shall be reviewed immediately after the accident and appropriate corrective measures are incorporated into this Plan to avoid similar accidents in the future.