# Draft Basic Assessment Report for the Proposed Piet Retief X22, Mpumalanga Province

**A Portion of Portion 100 of the farm Piet Retief Town and Townlands 149-HT**

**MDEDET Reference No: 17/2/3/GS-239**

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Part 2 of 4

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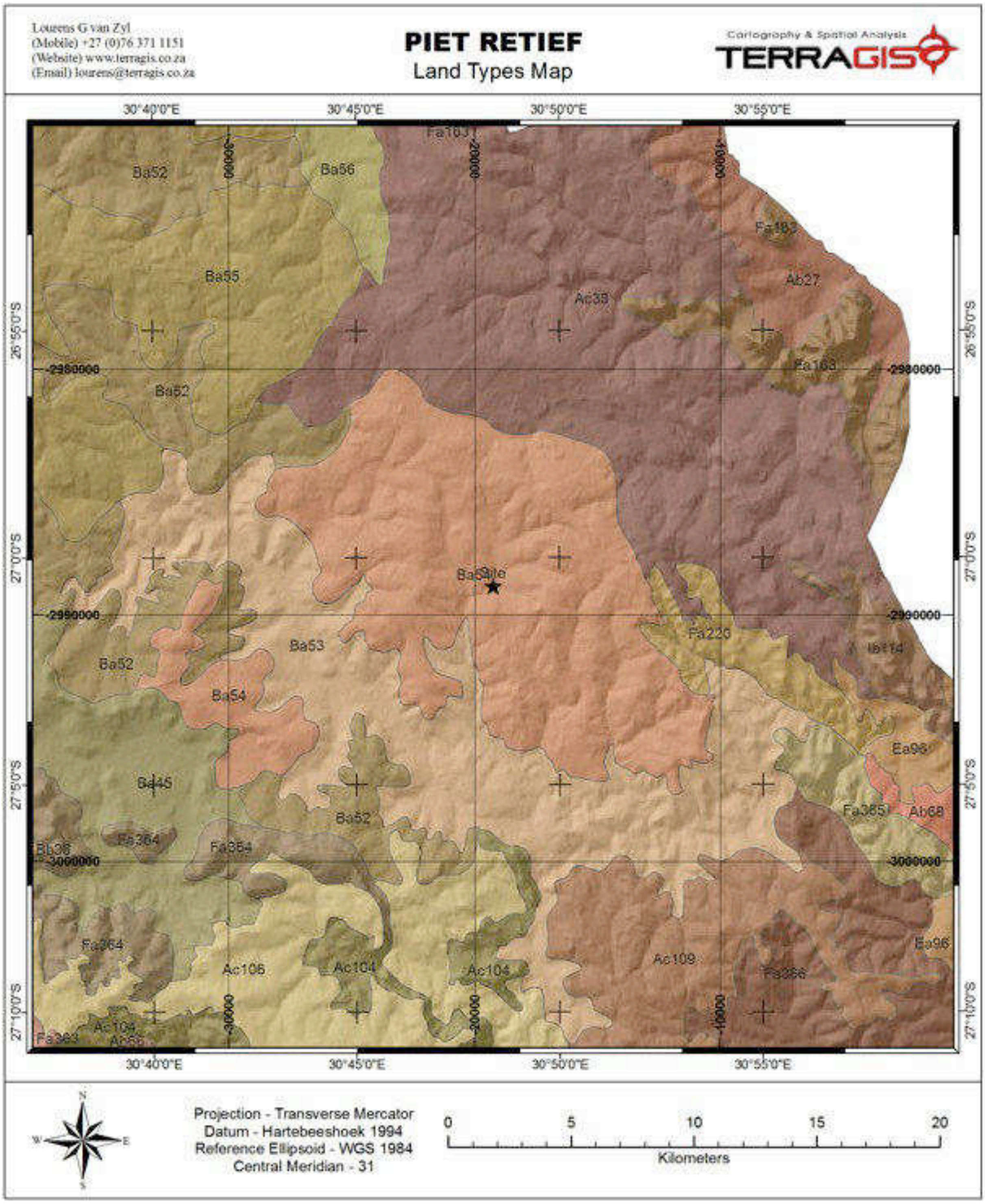


**Figure 2** Land type map of the survey site and surrounding area


**Figure 3** Contours of the survey area superimposed on an aerial photograph

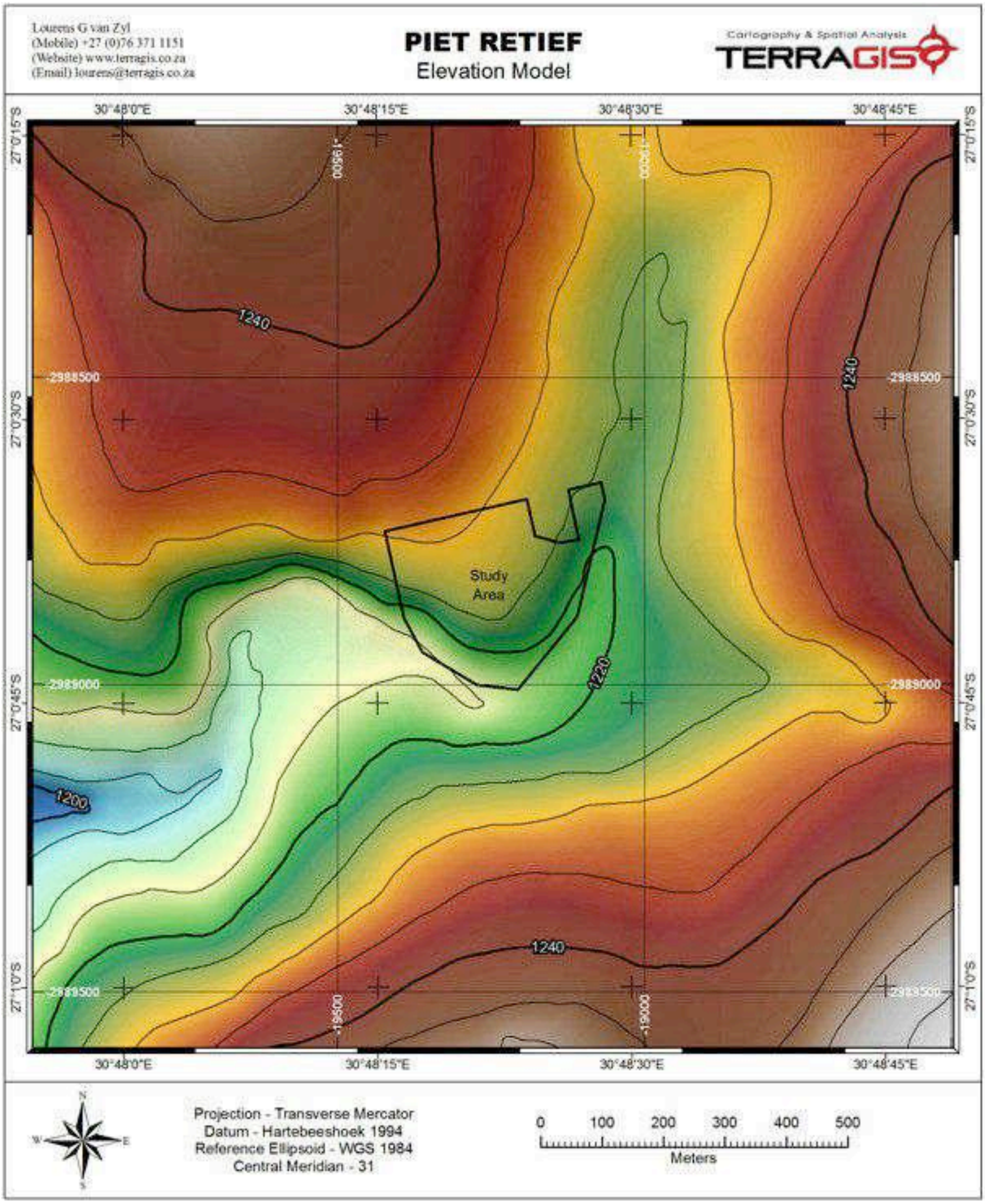


**Figure 4** DEM of the survey site

## 3. PROBLEM STATEMENT

The delineation of wetlands in areas with complex geological features, such as a mixture of igneous (mafic), sedimentary and metamorphic rock, is highly challenging. The difficulty arises from the fact that the different rock formations lead to the formation of entirely different soil profiles, with some of the rocks forming soils with more pronounced signs of hydromorphism even if hydrological processes are similar. The delineation exercise is often further hampered by various human activities that influence natural vegetation characteristics. This investigation will focus on the delineation of the wetland features based on landscape hydrological properties as well as soil hydromorphy and inferred hillslope processes in such a complex environment.

## 4. STATUTORY CONTEXT

The following is a brief summary of the statutory context of wetland delineation and assessment. Where necessary, additional comment is provided on problematic aspects or aspects that, according to this author, require specific emphasis.

### 4.1 WETLAND DEFINITION

Wetlands are defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

*"Land which is transitional between terrestrial and aquatic systems where the water table is usually at or near the surface, or the land is periodically covered with shallow water, and which land in normal circumstances supports or would support vegetation typically adapted to life in saturated soil."*

### 4.2 WATERCOURSE DEFINITION

"Catchment" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"…, in relation to a watercourse or watercourses or part of a watercourse, means the area from which any rainfall will drain into the watercourse or watercourses or part of a watercourse, through surface flow to a common point or common points;"

"Watercourse" is defined, in terms of the National Water Act (Act no 36 of 1998) (NWA), as:

"*(a)* a river or spring;
*(b)* a natural channel in which water flows regularly or intermittently;
*(c)* a wetland, lake or dam into which, or from which, water flows; and
*(d)* any collection of water which the Minister may, by notice in the *Gazette*, declare to be a water course,
and a reference to a watercourse includes, where relevant, its bed and banks;"

## 4.3 THE WETLAND DELINEATION GUIDELINES

In 2005 the Department of Water Affairs and Forestry published a manual entitled "A practical field procedure for identification and delineation of wetland and riparian areas" (DWAF, 2005). The "…manual describes field indicators and methods for determining whether an area is a wetland or riparian area, and for finding its boundaries." The definition of a wetland in the guidelines is that of the NWA and it states that wetlands must have one or more of the following attributes:

- "**Wetland (hydromorphic) soils** that display characteristics resulting from prolonged saturation"
- "The presence, at least occasionally, of **water loving plants (hydrophytes)**"
- "A **high water table** that results in saturation at or near the surface, leading to anaerobic conditions developing in the top 50cm of the soil."

The guidelines further list four indicators to be used for the finding of the outer edge of a wetland. These are:

- Terrain Unit Indicator. The terrain unit indicator does not only identify valley bottom wetlands but also wetlands on steep and mild slopes in crest, midslope and footslope positions.
- Soil Form Indicator. A number of soil forms (as defined by MacVicar et al., 1991) are listed as indicative of permanent, seasonal and temporary wetland zones.
- Soil Wetness Indicator. Certain soil colours and mottles are indicated as colours of wet soils. The guidelines stipulate that this is the primary indicator for wetland soils. (Refer to the guidelines for a detailed description of the colour indicators.) In essence, the reduction and removal of Fe in the form of "bleaching" and the accumulation of Fe in the form of mottles are the two main criteria for the identification of soils that are periodically or permanently wet.
- Vegetation Indicator. This is a key component of the definition of a wetland in the NWA. It often happens though that vegetation is disturbed and the guidelines therefore place greater emphasis on the soil form and soil wetness indicators as these are more permanent whereas vegetation communities are dynamic and react rapidly to external factors such as climate and human activities.

The main emphasis of the guidelines is therefore the use soils (soil form and wetness) as the criteria for the delineation of wetlands. The applicability of these guidelines in the context of the survey site will be discussed in further detail later in the report.

Due to numerous problems with the delineation of wetlands there are a plethora of courses being presented to teach wetland practitioners and laymen the required techniques. Most of the courses and practitioners focus on ecological or vegetation characteristics of landscapes and soil characteristics are often interpreted incorrectly due to a lacking soil science background of these practitioners. As such this author regularly presents, in conjunction with a colleague (Prof. Cornie van Huysteen) from the University of the Free Sate, a course on the aspects related to soil classification and wetland delineation.

## 4.4 THE RESOURCE DIRECTED MEASURES FOR PROTECTION OF WATER RESOURCES

The following are specific quotes from the different sections of the "Resource Directed Measures for Protection of Water Resources." as published by DWAF (1999).

### 4.4.1 The Resource Directed Measures for Protection of Water Resources: Volume 4: Wetland Ecosystems.

From the Introduction:

"This set of documents on Resource Directed Measures (RDM) for protection of water resources, issued in September 1999 in Version 1.0, presents the procedures to be followed in undertaking **preliminary determinations of the class, Reserve and resource quality objectives for water resources**, as specified in sections 14 and 17 of the South African National Water Act (Act 36 of 1998).

The development of procedures to determine RDM was initiated by the Department of Water Affairs and Forestry in July 1997. Phase 3 of this project will end in March 2000. Additional refinement and development of the procedures, and development of the full water resource classification system, will continue in Phase 4, until such time as the detailed procedures and full classification system are ready for publication in the Government Gazette.

It should be noted that until the final RDM procedures are published in the Gazette, and prescribed according to section 12 of the National Water Act, all determinations of RDM, whether at the rapid, the intermediate or the comprehensive level, will be considered to be preliminary determinations."

### 4.4.2 The Resource Directed Measures for Protection of Water Resources: Generic Section "A" for Specialist Manuals – Water Resource Protection Policy Implementation Process

"Step 3: Determine the reference conditions of each resource unit"

"What are reference conditions?"

"The determination of reference conditions is a very important aspect of the overall Reserve determination methodology. Reference conditions describe the natural unimpacted characteristics of a water resource. Reference conditions quantitatively describe the ecoregional type, specific to a particular water resource."

### 4.4.3 The Resource Directed Measures for Protection of Water Resources: Appendix W1 (Ecoregional Typing for Wetland Ecosystems)

Artificial modifiers are explained namely:

"Many wetlands are man-made, while others have been modified from a natural state to some degree by the activities of humans. Since the nature of these alterations often greatly influences the character of such habitats, the inclusion of modifying terms to accommodate human influence is important. In addition, many human modifications, such as dam walls and drainage ditches, are visible in aerial photographs and can be easily mapped. The following Artificial Modifiers are defined and can be used singly or in combination wherever they apply to wetlands:

*Farmed:* the soil surface has been physically altered for crop production, but hydrophytes will become re-established if farming is discontinued

*Artificial:* substrates placed by humans, using either natural materials such as dredge spoils or synthetic materials such as concrete. Jetties and breakwaters are examples of Non-vegetated Artificial habitats

*Excavated:* habitat lies within an excavated basin or channel

*Diked/Impounded:* created or modified by an artificial barrier which obstructs the inflow or outflow of water

*Partially Drained:* the water level has been artificially lowered, usually by means of ditches, but the area is still classified as wetland because soil moisture is sufficient to support hydrophytes."

### 4.4.4 The Resource Directed Measures for Protection of Water Resources: Appendix W4 IER (Floodplain Wetlands) Present Ecological Status (PES) Method

In Appendix W4 the methodology is provided for the determination of the present ecological status (PES) of a palustrine wetland.

The present ecological state (PES) of the wetland was determined according to the method described in "APPENDIX W4: IER (FLOODPLAIN WETLANDS) PRESENT ECOLOGICAL STATUS (PES) METHOD" of the "Resource Directed Measures for Protection of Water Resources. Volume 4: Wetland Ecosystems" as published by DWAF (1999). However, the PES methodology already forms an adaptation from the methodology to assess palustrine wetlands. Hillslope seepage wetlands have a range of different drivers and as such some modification of the criteria has been made by this author to accommodate the specific hydropedology drivers of hillslope seepage wetlands.

The criteria as described in Appendix 4 is provided below with the relevant modification or comment provided as well.

The summarised tasks in the PES methodology are (for detailed descriptions refer to the relevant documentation):

1. Conduct a literature review (review of available literature and maps) on the following:
   a. Determine types of development and land use (in the catchment in question).
   b. Gather hydrological data to determine the degree to which the flow regime has been modified (with the "virgin flow regime" as baseline). The emphasis is predominantly on surface hydrology and hydrology of surface water features as well as the land uses, such as agriculture and forestry, that lead to flow modifications. Important Note: The hydropedology of landscapes is not explicitly mentioned in the RDM documentation and this author will make a case for its consideration as probably the most important component of investigating headwater systems and seepage wetlands and areas.
   c. Assessment of the water quality as is documented in catchment study reports and water quality databases.
   d. Investigate erosion and sedimentation parameters that address aspects such as bank erosion and bed modification. Important Note: The emphasis in the RDM documentation is again on river and stream systems with little mention of erosion of headwater and seepage zone systems. Again a case will be made for the emphasis of such information generation.
   e. Description of exotic species (flora and fauna) in the specific catchment in question.
2. Conduct and aerial photographic assessment in terms of the parameters listed above.
3. Conduct a site visit and make use of local knowledge.
4. Assess the criteria and generate preliminary PES scores.
5. Generation of report.

**Table 1** presents the scoresheet with criteria for the assessment of habitat integrity of palustrine wetlands (as provided in the RDM documentation).

**Table 1 "Table W4-1: Scoresheet with criteria for assessing Habitat Integrity of Palustrine Wetlands (adapted from Kleynhans 1996)"**

| **Criteria and** attributes | **Relevance** | **Score** | **Confidence** |
|---|---|---|---|
| **Hydrologic** | | | |
| Flow modification | Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland. | | |
| Permanent Inundation | Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota. | | |
| **Water Quality** | | | |
| Water Quality Modification | From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland | | |
| Sediment load modification | Consequence of reduction due to entrapment by impoundments or increase due to land use | | |

| | | | |
|---|---|---|---|
| | practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats. | | |
| **Hydraulic/Geomorphic** | | | |
| Canalisation | Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage. | | |
| Topographic Alteration | Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns. | | |
| **Biota** | | | |
| Terrestrial Encroachment | Consequence of desiccation of wetland and encroachment of terrestrial plant speciesdue to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions. | | |
| Indigenous Vegetation Removal | Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion. | | |
| Invasive plant encroachment | Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading). | | |
| Alien fauna | Presence of alien fauna affecting faunal community structure. | | |
| Overutilisation of biota | Overgrazing, Over-fishing, etc | | |
| TOTAL<br>MEAN | | | |

Scoring guidelines per attribute:

natural, unmodified = 5; Largely natural = 4, Moderately modified = 3; largely modified = 2; seriously modified = 1; Critically modified = 0.

Relative confidence of score:

Very high confidence = 4; High confidence = 3; Moderate confidence = 2; Marginal/low confidence = 1.

Important Note: The present ecological state (PES) determination is, as discussed earlier in the report, based on criteria originally generated for palustrine and floodplain wetlands. Seepage wetlands very rarely have the same degree of saturation or free water and consequently often do not have permanent wetland zones. These wetlands are therefore often characterised by seasonal or temporary properties and as such a standard PES approach is flawed. The existing criteria is provided below as is a comment on the applicability as well as proposed improvements.

**Criteria**

Hydrological Criteria

- "Flow modification: Consequence of abstraction, regulation by impoundments or increased runoff from human settlements or agricultural land. Changes in flow regime (timing, duration, frequency), volumes, velocity which affect inundation of wetland habitats resulting in floristic changes or incorrect cues to biota. Abstraction of groundwater flows to the wetland." Comment: Although the description is wide it is very evident that seepage or hillslope wetlands do not become inundated but rather are fed by hillslope return flow processes. The main criterion should therefore be the surface and subsurface hydrological linkages expressed as a degree of alteration in terms of the surface, hydropedology and groundwater hydrology.
- "Permanent inundation: Consequence of impoundment resulting in destruction of natural wetland habitat and cues for wetland biota." Comment: Mostly not applicable to hillslope seepage wetlands.

Water Quality Criteria

- "Water quality modification: From point or diffuse sources. Measure directly by laboratory analysis or assessed indirectly from upstream agricultural activities, human settlements and industrial activities. Aggravated by volumetric decrease in flow delivered to the wetland." Comment: Water quality in this context applies generally but cognisance should be taken of seepage water quality that can be natural but significantly different to exposed water bodies. The main reason for this being the highly complex nature of many redox processes within the hillslope.
- "Sediment load modification: Consequence of reduction due to entrapment by impoundments or increase due to land use practices such as overgrazing. Cause of unnatural rates of erosion, accretion or infilling of wetlands and change in habitats." Comment: This is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences.

Hydraulic / Geomorphic Criteria

- "Canalisation: Results in desiccation or changes to inundation patterns of wetland and thus changes in habitats. River diversions or drainage." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.
- "Topographic Alteration: Consequence of infilling, ploughing, dykes, trampling, bridges, roads, railwaylines and other substrate disruptive activities which reduces or changes wetland habitat directly or through changes in inundation patterns." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

Biological Criteria

- "Terrestrial encroachment: Consequence of desiccation of wetland and encroachment of terrestrial plant species due to changes in hydrology or geomorphology. Change from wetland to terrestrial habitat and loss of wetland functions." Comment: Again this is a very relevant concept but on hillslopes should be linked to erosivity of the soils as well as the specific land use influences. This concept does however not address the influences on the hydropedology of the hillslope. These aspects shoud be elucidated and contextualised.

- "Indigenous vegetation removal: Direct destruction of habitat through farming activities, grazing or firewood collection affecting wildlife habitat and flow attenuation functions, organic matter inputs and increases potential for erosion."
- "Invasive plant encroachment: Affect habitat characteristics through changes in community structure and water quality changes (oxygen reduction and shading)."
- "Alien fauna: Presence of alien fauna affecting faunal community structure."
- "Overutilisation of biota: Overgrazing, Over-fishing, etc."

Scoring Guidelines
Scoring guidelines per attribute:
Natural, unmodified = 5
Largely natural = 4
Moderately modified = 3
Largely modified = 2
Seriously modified = 1
Critically modified = 0

Relative confidence of score:
Very high confidence = 4
High confidence = 3
Moderate confidence = 2
Marginal/low confidence = 1

### 4.4.5 The Resource Directed Measures for Protection of Water Resources: Appendix W5 IER (Floodplain Wetlands) Determining the Ecological Importance and Sensitivity (EIS) and the Ecological Management Class (EMC)

In Appendix W5 the methodology is provided for the determination of the ecological importance and sensitivity (EIS) and ecological management class (EMC) of floodplain wetlands.

"Ecological importance" of a water resource is an expression of its importance to the maintenance of ecological diversity and functioning on local and wider scales. "Ecological sensitivity" refers to the system's ability to resist disturbance and its capability to recover from disturbance once it has occurred. The Ecological Importance and sensitivity (EIS) provides a guideline for determination of the Ecological Management Class (EMC)." Please refer to the specific document for more detailed information.

The following primary determinants are listed as determining the EIS:

1. Rare and endangered species

2. Populations of unique species
3. Species / taxon richness
4. Diversity of habitat types or features
5. Migration route / breeding and feeding site for wetland species
6. Sensitivity to changes in the natural hydrological regime
7. Sensitivity to water quality changes
8. Flood storage, energy dissipation and particulate / element removal

The following modifying determinants are listed as determining the EIS:

1. Protected status
2. Ecological integrity

### 4.5 SUMMARY AND PROPOSED APPROACH

When working in environments where the landscape and land use changes are significant (such as urban and mining environments) it is important to answer the following critical questions regarding the assessment and management planning for wetlands:

1. What is the reference condition?
2. What is the difference between the reference condition and the current condition and how big is this difference from a hydrological driver perspective?
3. What are the hydrological drivers (as a function of geology, topography, rainfall and soils) and what are the relative contributions of these drivers to the functioning of the wetland system?
4. What is the intended or planned land use in the wetland as well as terrestrial area and how will these developments impact on the hydrology of the landscape and wetlands?
5. How can the intended land use be plied to secure the best possible hydrological functioning of the landscape in terms of storm water attenuation, erosion mitigation and water quality?

The key to the generation of adequate information lies in the approach that is to be followed. In the next section an explanation about and motivation in favour of will be provided for a hydropedology assessment approach. Due to the detailed nature of the information that can be generated through such an approach it is motivated that all wetland assessments be conducted with the requirements of criminal law in mind. The main reason for this is the fact that many well-meaning administrative exercises often yield not tangible results due to the gap in terms of information that is required should there be a compliance process followed.

**To Summarise:**

**During wetland assessments and delineations it is important to provide a perspective on assessment tools, the original or reference state of the wetland, the assessment process and outcome as well as the intended or possible state of the wetland and site post**

**development. Urban and mining developments are good examples of cases where surrounding developments and land use changes have significant effects on wetland integrity and water quality emanating from the site.**

# 5 CHALLENGES REGARDING WETLAND DELINEATION IN COMPLEX GEOLOGICAL ENVIRONMENTS

**Disclaimer:** The following section represents a discussion that I use as standard in describing the challenges regarding wetland delineation and management in complex geological environments. This implies that the section is verbatim the same as in other reports provided to clients and the authorities. Copyright is strictly reserved.

In order to discuss the procedures followed and the results of the wetland identification exercise it is necessary at the outset to provide some theoretical background on soil forming processes, soil wetness indicators, water movement in soils and topographical sequences of soil forms (catena).

## 5.1 PEDOGENESIS

Pedogenesis is the process of soil formation. Soil formation is a function of five (5) factors namely (Jenny, 1941(:

- Parent material;
- Climate;
- Topography;
- Living Organisms; and
- Time.

These factors interact to lead to a range of different soil forming processes that ultimately determine the specific soil formed in a specific location. Central to all soil forming processes is water and all the reactions (physical and chemical) associated with it. The physical processes include water movement onto, into, through and out of a soil unit. The movement can be vertically downwards, lateral or vertically upwards through capillary forces and evapotranspiration. The chemical processes are numerous and include dissolution, precipitation (of salts or other elements) and alteration through pH and reduction and oxidation (redox) changes. In many cases the reactions are promoted through the presence of organic material that is broken down through aerobic or anaerobic respiration by microorganisms. Both these processes alter the redox conditions of the soil and influence the oxidation state of elements such as Fe and Mn. Under reducing conditions Fe and Mn are reduced and become more mobile in the soil environment. Oxidizing conditions, in turn, lead to the precipitation of Fe and Mn and therefore lead to their immobilization. The dynamics of Fe and Mn in soil, their zones of depletion through mobilization and accumulation through precipitation, play an important role in the identification of the dominant water regime of a soil and could therefore be used to identify wetlands and wetland conditions.

## 5.2 WATER MOVEMENT IN THE SOIL PROFILE

In a specific soil profile, water can move upwards (through capillary movement), horizontally (owing to matric suction) and downwards under the influence of gravity.

The following needs to be highlighted in order to discuss water movement in soil:

- Capillary rise refers to the process where water rises from a deeper lying section of the soil profile to the soil surface or to a section closer to the soil surface. Soil pores can be regarded as miniature tubes. Water rises into these tubes owing to the adhesion (adsorption) of water molecules onto solid mineral surfaces and the surface tension of water.

  The height of the rise is inversely proportional to the radius of the soil pore and the density of the liquid (water). It is also directly proportional to the liquid's surface tension and the degree of its adhesive attraction. In a soil-water system the following simplified equation can be used to calculate this rise:

  $$\text{Height} = 0.15/\text{radius}$$

  Usually the eventual height of rise is greater in fine textured soil, but the rate of flow may be slower (Brady and Weil, 1999; Hillel, 1983).

- Matric potential or suction refers to the attraction of water to solid surfaces. Matric potential is operational in unsaturated soil above the water table while pressure potential refers to water in saturated soil or below the water table. Matric potential is always expressed as a negative value and pressure potential as a positive value.

  Matric potential influences soil moisture retention and soil water movement. Differences in the matric potential of adjoining zones of a soil results in the movement of water from the moist zone (high state of energy) to the dry zone (low state of energy) or from large pores to small pores.

  The maximum amount of water that a soil profile can hold before leaching occurs is called the field capacity of the soil. At a point of water saturation, a soil exhibits an energy state of 0 $J.kg^{-1}$. Field capacity usually falls within a range of -15 to -30 $J.kg^{-1}$ with fine textured soils storing larger amounts of water (Brady and Weil, 1999; Hillel, 1983).

- Gravity acts on water in the soil profile in the same way as it acts on any other body; it attracts towards earth's centre. The gravitational potential of soil water can be expressed as:

  $$\text{Gravitational potential} = \text{Gravity} \times \text{Height}$$

Following heavy rainfall, gravity plays an important part in the removal of excess water from the upper horizons of the soil profile and recharging groundwater sources below.

Excess water, or water subject to leaching, is the amount of water that falls between soil saturation (0 $J.kg^{-1}$) or oversaturation (> 0 $J.kg^{-1}$), in the case of heavy rainfall resulting in a pressure potential, and field capacity (-15 to -30 $J.kg^{-1}$). This amount of water differs according to soil type, structure and texture (Brady and Weil, 1999; Hillel, 1983).

- Under some conditions, at least part of the soil profile may be saturated with water, resulting in so-called saturated flow of water. The lower portions of poorly drained soils are often saturated, as are well-drained soils above stratified (layers differing in soil texture) or impermeable layers after rainfall.

  The quantity of water that flows through a saturated column of soil can be calculated using Darcy's law:

$$Q = Ksat.A.\Delta P/L$$

  Where Q represents the quantity of water per unit time, Ksat is the saturated hydraulic conductivity, A is the cross sectional area of the column through which the water flows, ΔP is the hydrostatic pressure difference from the top to the bottom of the column, and L is the length of the column.

  Saturated flow of water does not only occur downwards, but also horizontally and upwards. Horizontal and upward flows are not quite as rapid as downward flow. The latter is aided by gravity (Brady and Weil, 1999; Hillel, 1983).

- Mostly, water movement in soil is ascribed to the unsaturated flow of water. This is a much more complex scenario than water flow under saturated conditions. Under unsaturated conditions only the fine micropores are filled with water whereas the macropores are filled with air. The water content, and the force with which water molecules are held by soil surfaces, can also vary considerably. The latter makes it difficult to assess the rate and direction of water flow. The driving force behind unsaturated water flow is matric potential. Water movement will be from a moist to a drier zone (Brady and Weil, 1999; Hillel, 1983).

The following processes influence the amount of water to be leached from a soil profile:

- Infiltration is the process by which water enters the soil pores and becomes soil water. The rate at which water can enter the soil is termed infiltration tempo and is calculated as follows:

$$I = Q/A.t$$

  Where I represents infiltration tempo ($m.s^{-1}$), Q is the volume quantity of infiltrating water ($m^3$), A is the area of the soil surface exposed to infiltration ($m^2$), and t is time (s).

If the soil is quite dry when exposed to water, the macropores will be open to conduct water into the soil profile. Soils that exhibit a high 2:1 clay content (swelling-shrinking clays) will exhibit a high rate of infiltration initially. However, as infiltration proceeds, the macropores will become saturated and cracks, caused by dried out 2:1 clay, will swell and close, thus leading to a decline in infiltration (Brady and Weil, 1999; Hillel, 1983).

- Percolation is the process by which water moves downward in the soil profile. Saturated and unsaturated water flow is involved in the process of percolation, while the rate of percolation is determined by the hydraulic conductivity of the soil.

  During a rain storm, especially the down pouring of heavy rain, water movement near the soil surface mainly occurs in the form of saturated flow in response to gravity. A sharp boundary, referred to as the wetting front, usually appears between the wet soil and the underlying dry soil. At the wetting front, water is moving into the underlying soil in response to both matric and gravitational potential. During light rain, water movement at the soil surface may be ascribed to unsaturated flow (Brady and Weil, 1999; Hillel, 1983).

  The fact that water percolates through the soil profile by unsaturated flow has certain ramifications when an abrupt change in soil texture occurs (Brady and Weil, 1999; Hillel, 1983). A layer of course sand, underlying a fine textured soil, will impede downward movement of water. The macropores of the coarse textured sand offer less attraction to the water molecules than the macropores of the fine textured soil. When the unsaturated wetting front reaches the coarse sand, the matric potential is lower in the sand than in the overlying material. Water always moves from a higher to a lower state of energy. The water can, therefore, not move into the coarse textured sand. Eventually, the downward moving water will accumulate above the sand layer and nearly saturate the fine textured soil. Once this occurs, the water will be held so loosely that gravitational forces will be able to drag the water into the sand layer (Brady and Weil, 1999; Hillel, 1983).

  A coarse layer of sand in an otherwise fine textured soil profile will also inhibit the rise of water by capillary movement (Brady and Weil, 1999; Hillel, 1983).

Field observations and laboratory based analysis can aid in assessing the soil-water relations of an area. The South African soil classification system (Soil Classification Working Group, 1991.) comments on certain field observable characteristics that shed light on water movement in soil. The more important of these are:

- Soil horizons that show clear signs of leaching such as the E-horizon – an horizon where predominantly lateral water movement has led to the mobilisation and transport of sesquioxide minerals and the removal of clay material;
- Soil horizons that show clear signs of a fluctuating water table where Fe and Mn mottles, amongst other characteristics, indicate alternating conditions of reduction and oxidation (soft plinthic B-horizon);

- Soil horizons where grey colouration (Fe reduction and redox depletion), in an otherwise yellowish or reddish matrix, indicate saturated (or close to saturated) water flow for at least three months of the year (Unconsolidated/Unspecified material with signs of wetness);
- Soil horizons that are uniform in colouration and indicative of well-drained and aerated (oxidising) conditions (e.g. yellow brown apedal B-horizon).

### 5.3 WATER MOVEMENT IN THE LANDSCAPE

Water movement in a landscape is a combination of the different flow paths in the soils and geological materials. The movement of water in these materials is dominantly subject to gravity and as such it will follow the path of least resistance towards the lowest point. In the landscape there are a number of factors determining the paths along which this water moves. **Figure 5** provides a simplified schematic representation of an idealised landscape (in "profile curvature". The total precipitation (rainfall) on the landscape from the crest to the lowest part or valley bottom is taken as 100 %. Most geohydrologists agree that total recharge, the water that seeps into the underlying geological strata, is less than 4 % of total precipitation for most geological settings. Surface runoff varies considerably according to rainfall intensity and distribution, plant cover and soil characteristics but is taken as a realistic 6 % of total precipitation for our idealised landscape. The total for surface runoff and recharge is therefore calculated as 10 % of total precipitation. If evapotranspiration (from plants as well as the soil surface) is taken as a very high 30 % of total precipitation it leaves 60 % of the total that has to move through the soil and/or geological strata from higher lying to lower lying areas. In the event of an average rainfall of 750 mm per year it results in 450 mm per year having to move laterally through the soil and geological strata. In a landscape there is an accumulation of water down the slope as water from higher lying areas flow to lower lying areas.

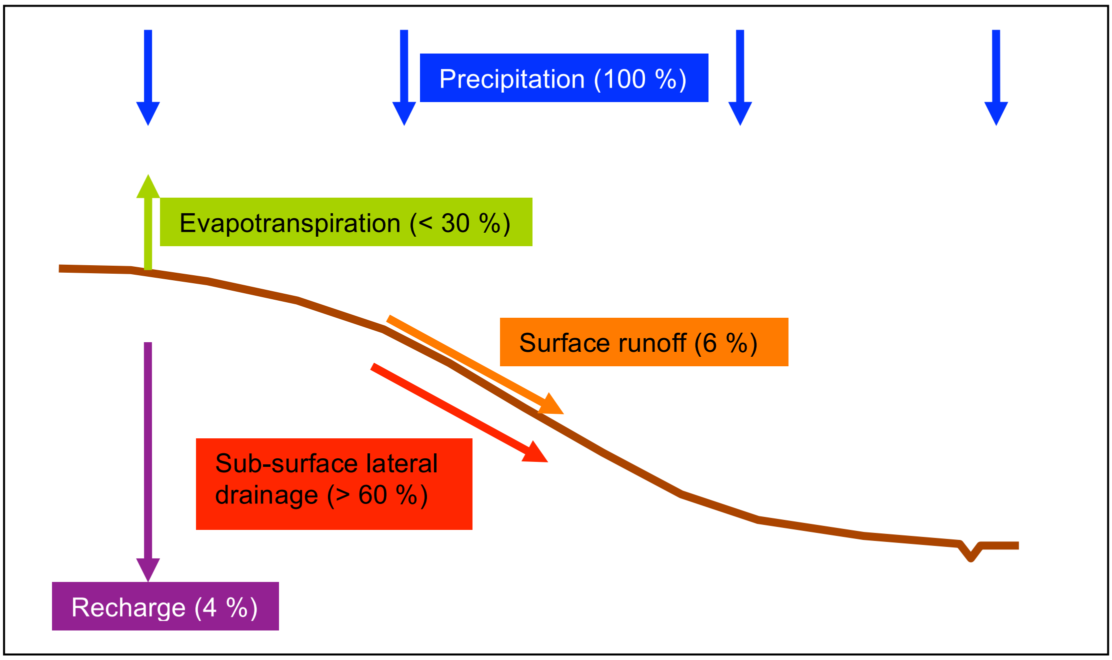


**Figure 5** Idealised landscape with assumed quantities of water moving through the landscape expressed as a percentage of total precipitation (100 %).

To illustrate: If the assumption is made that the area of interest is 100 m wide it follows that the first 100 m from the crest downwards has 4 500 $m^3$ (or 4 500 000 litres) of water moving laterally through the soil (100 m X 100 m X 0.45 m) per rain season. The next section of 100 m down the slope has its own 4 500 $m^3$ of water as well as the added 4 500 $m^3$ from the upslope section to contend with, therefore 9 000 $m^3$. The next section has 13 500 $m^3$ to contend with and the following one 18 000 $m^3$. It is therefore clear that, the longer the slope, the larger the volume of water that will move laterally through the soil profile.

Flow paths through soil and geological strata, referred to as "interflow" or "hillslope water", are very varied and often complex due to difficulty in measurement and identification. The difficulty in identification stems more from the challenges related to the physical determination of these in soil profile pits, soil auger samples and core drilling samples for geological strata. The identification of the morphological signs of water movement in permeable materials or along planes of weakness (cracks and seams) is a well-established science and the expression is mostly referred to as "redox morphology". In terms of the flow paths of water large variation exists but these can be grouped into a few simple categories. **Figure 6** provides a schematic representation of the different flow regimes that are usually encountered. The main types of water flow can be grouped as 1) recharge (vertically downwards) of groundwater; 2) lateral flow of water through the landscape along the hillslope (interflow or hillslope water); 3) return flow water that intercepts the soil/landscape surface; and 4) surface runoff. Significant variation exists with these flow paths and numerous combinations are often found. The main wetland types associated with the flow paths are: a) valley bottom wetlands (fed by groundwater, hillslope processes, surface runoff, and/or in-stream water); b) hillslope seepage wetlands (fed by interflow water and/or return flow water); and wetlands associated with surface runoff, ponding and surface ingress of water anywhere in the landscape.

Amongst other factors, the thickness of the soil profile at a specific point will influence the intensity of the physical and chemical reactions taking place in that soil. **Figure 7** illustrates the difference between a dominantly thick and a dominantly thin soil profile. If all factors are kept the same except for the soil profile thickness it can be assumed with confidence that the chemical and physical reactions associated with water in the landscape will be much more intense for the thin soil profile than for the thick soil profile. Stated differently: The volume of water moving through the soil per surface area of an imaginary plane perpendicular to the direction of water flow is much higher for the thin soil profile than for the thick soil profile. This aspect has a significant influence on the expression of redox morphology in different landscapes of varying soil/geology/climate composition.

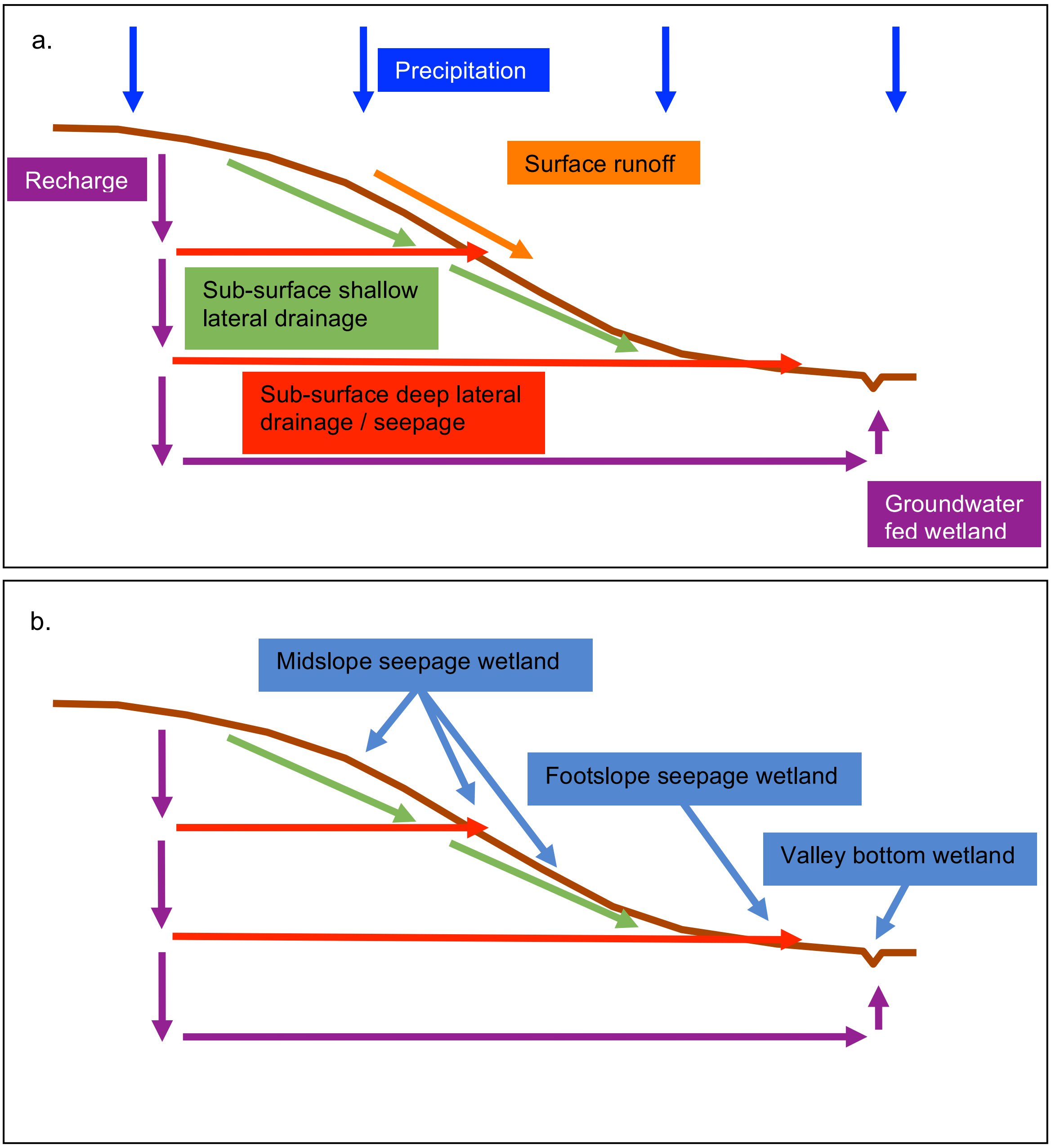


**Figure 6** Different flow paths of water through a landscape (a) and typical wetland types associated with the water regime (b)

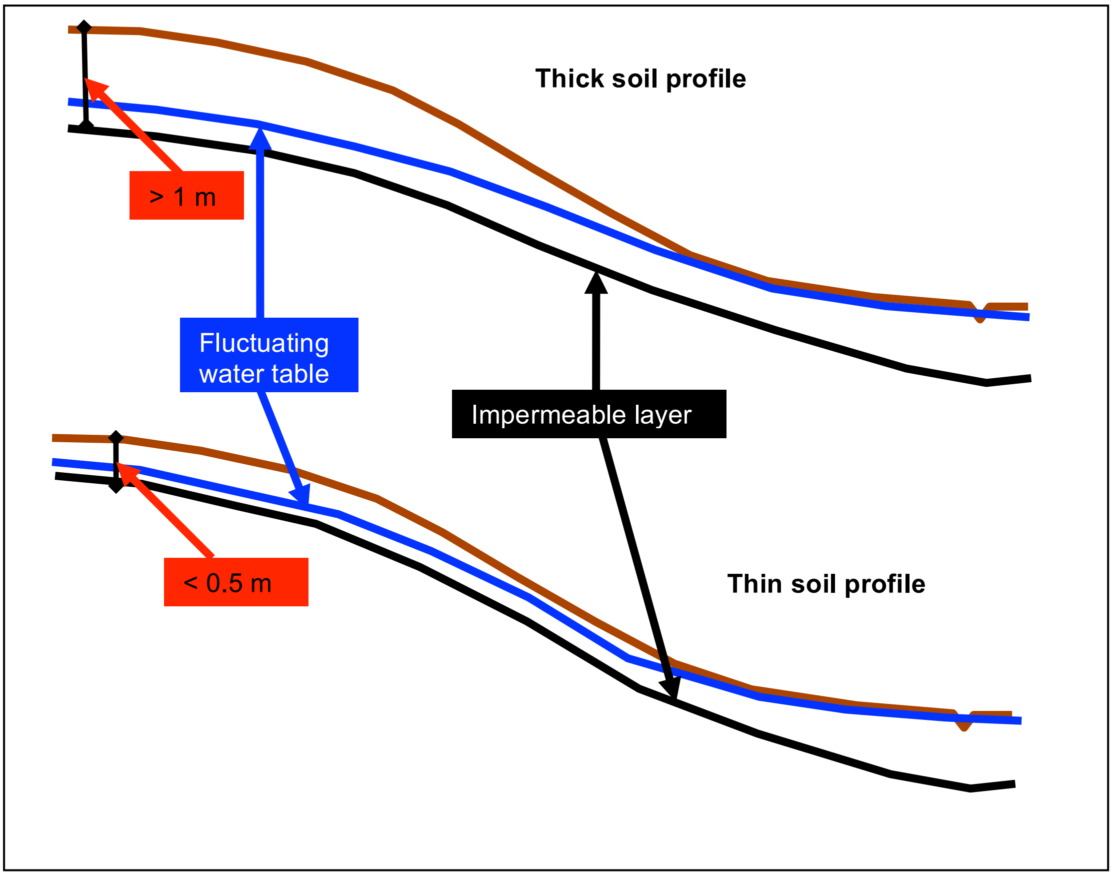


**Figure 7** The difference in water flow between a dominantly thick and dominantly thin soil profile.

### 5.4 THE CATENA CONCEPT

Here it is important to take note of the "catena" concept. This concept is one of a topographic sequence of soils in a homogenous geological setting where the water movement and presence in the soils determine the specific characteristics of the soils from the top to the bottom of the topography. **Figure 8** illustrates an idealised topographical sequence of soils in a catena for a quartz rich parent material. Soils at the top of the topographical sequence are typically red in colour (Hutton and Bainsvlei soil forms) and systematically grade to yellow further down the slope (Avalon soil form). As the volume of water that moves through the soil increases, typically in midslope areas, periodic saturated conditions are experienced and consequently Fe is reduced and removed in the laterally flowing water. In the event that the soils in the midslope positions are relatively sandy the resultant soil colour will be bleached or white due to the colour dominance of the sand quartz particles. The soils in these positions are typically of the Longlands and Kroonstad forms. Further down the slope there is an accumulation of clays and leaching products from higher lying soils and this leads to typical illuvial and clay rich horizons. Due to the regular presence of water the dominant conditions are anaerobic and reducing and the soils exhibit grey colours often with bright yellow and grey mottles (Katspruit soil form). In the event that there is a large depositional environment with prolonged saturation soils of the Champagne form may develop (typical peat land). Variations on this sequence (as is often found on the Mpumalanga Highveld) may include the presence of hard plinthic materials instead of soft plinthite with a consequent increase in the occurrence of bleached soil profiles. Extreme examples of such landscapes are discussed below.

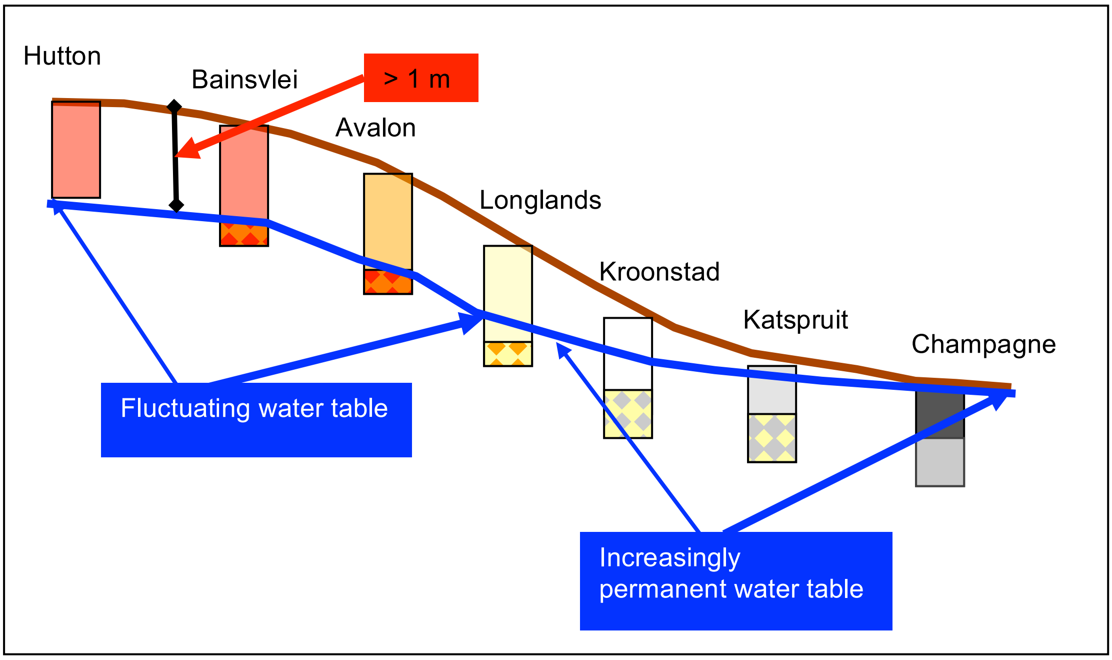


**Figure 8** Idealised catena on a quartz rich parent material.

### 5.5 THE BA54 LAND TYPE CATENA CHALLENGE

The **Ba54** land type description (Land Type Survey Staff, 1972 - 2006) indicates a range of soils within the landscape. For the specific survey area the geology has been reported to be granite in the western half with dolerite in the eastern section – all overlain by colluvial soil material (Geotechnical Report by Soilkraft cc – copy undated). Granite and dolerite differ in the characteristics of their weathering products with granite yielding sandier soils that exhibit bleaching and mottling more readily that the clayey soils derived from dolerite. The higher clay content soils also have lower water conductance and often have pH levels above 7 (refer to next section). Additionally, the colluvial material is often a mix of the residual rock material and therefore can have widely varying expression of hydromorphism – even at similar levels and durations of saturation.

### 5.6 REDOX MORPHOLOGY IN ALKALINE SOILS

Wetland delineation is a very challenging exercise in areas dominated by alkaline soils such as lime containing and/or vertic/melanic soils. This is mainly due to the almost complete absence of Fe-mottles in the soils that grade from the terrestrial to the wetland areas. There are a number of reasons that will be explained in more detail below.

In order to illustrate the stability and distribution of Fe minerals in soils the figure provided below (**Figure 9**) was copied from page 124 of a book entitled “Soil Chemistry” by Bohn, et al., (1990).

The essence is that when reduction and oxidation reactions of Fe (in this case) are considered in soils both the electron activity (driver of reducing conditions) and pH have to be considered as they are intimately linked and dependent on each other. Suffice to say that for redox and mineral stability purposes they are indicated on the same graph. From Figure 4.6 (**Figure 9**) it is clear that as the Eh decreases (increasing reducing conditions) the dominant Fe species in solution changes from $Fe^{3+}$ (insoluble and forming brightly coloured minerals) to $Fe^{2+}$ (soluble and essentially colourless). Once pH is included in the observation it is clear that distinct Fe minerals come into play. Applying the decreasing Eh values to Fe minerals at high pH it is clear that the dominant Fe mineral under oxidizing conditions is FeOOH (Goethite – predominantly yellow). As the conditions become more reducing the equilibrium shifts to $FeCO_3$ (Siderite – white) and thereafter to $FeS_2$ (Pyrite). Whereas goethite has a distinct colour in soil, siderite and pyrite are less conspicuous in small quantities. It follows therefore that Fe minerals are much less visible in high pH reduced soils than in oxidised soils. In addition, vertic and melanic soils are dark coloured and it is therefore also clear that this dark colour will mask the presence of the above mentioned Fe minerals.

Another factor related to pH is the degree of reduction that is required to reduce Fe from its oxidised to its reduced state. From the graph it is clear that there is a steep decreasing gradient as the pH of the soil increases. This implies that much more intensive reducing conditions are required for the same degree of Fe reduction when high pH conditions (as those experienced in vertic and melanic soils) are compared to low pH conditions.

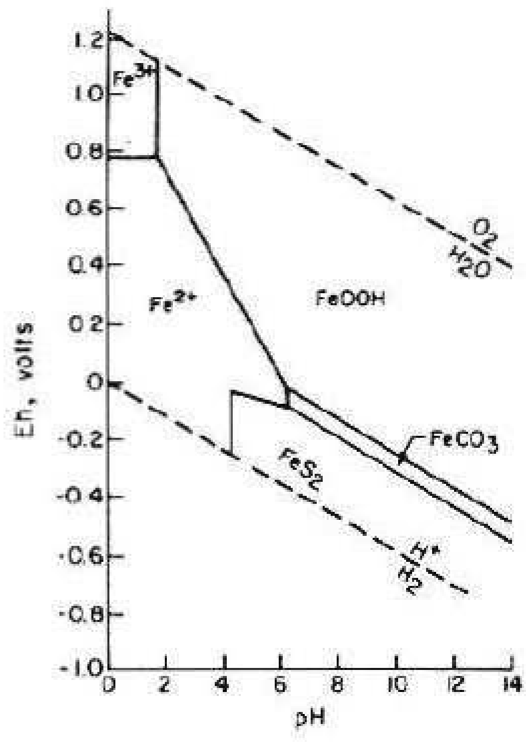


FIGURE 4.6. The *Eh*–pH diagram of various iron ions and compounds.

**Figure 9** Eh pH diagram as sourced from Bohn, et al., (1990) p124

The situation becomes even more complex as other intermediate Fe minerals (blue green rusts) come into play. The essence of the presence of blue-green rusts is that they are tints that occur extensively in poorly drained and poorly aerated soils such as G-horizons under vertic and/or melanic A-horizons. These minerals are not stable and often disappear within a few minutes of exposure to the atmosphere. They in all probability form some of the most important Fe phases in vertic soils but disappear rapidly. Before they disappear it is also evident that these minerals are visible against a grey matrix but poorly visible against a black or dark background.

In essence therefore, a number of factors, including degree of reduction, soil pH and dominant Fe minerals, conspire against the use of Fe indicators in vertic, melanic and lime containing soils for the delineation of wetlands. There is no quick solution to this problem and delineators should use as many other indicators of wetland conditions in such soils as they can.

**One word of caution**: The wetland delineation guidelines (DWAF, 2005) indicate the Rensburg and Willowbrook soil forms as occurring in the permanent wetland zone. This is somewhat erroneous. Although these can occur in permanent wetland zones their formation is dependent on distinct cycling between wet and dry seasons. The development of 2:1 clays (found in these soils) depends on the accumulation of weathering products and clays in lower lying landscape positions. These clays are, depending on a range of factors, either swelling or non-swelling and their formation requires a distinct time (seasonally) where evaporation exceeds precipitation, with consequent drying of the soil, to lead to a concentration of bases (Ca and Mg). These clay minerals (such as smectite) often express themselves in the form of distinct cracks in Vertic soils. From this discussion it follows that the Rensburg and Willowbrook soils could only have formed in conditions that resemble a **seasonal wetland**. Drainage lines on the site can, if dominated by Rensburg or Willowbrook soils, therefore not be classified as permanent wetlands unless there are other characteristics indicating conditions of permanent saturation.

### 5.7 IMPLICATIONS FOR WETLAND DELINEATION AND APPLICATION OF THE GUIDELINES

The main implication for the delineation of wetlands and the application of the guidelines is the fact that highly variable conditions occur in the specific land type. One set of indicators of hydromorphism cannot be used as many of the clayey soils do not exhibit mottling or grey colours. The opposite is true for the sandy soils where a very large proportion of them will indicate signs of Fe removal. But this, as explained earlier is a function of slightly acid pH and a low Fe reserve. A delineation exercise is therefore a complex process with a very distinct possibility of not elucidating the hydrological parameters need for the making of informed decision regarding the impact of the development on the wetland.

### 5.8 IMPLICATIONS FOR WETLAND CONSERVATION IN URBAN ENVIRONMENTS

Whether an area is designated a wetland or not loses some of its relevance once drastic influences on landscape hydrology are considered. If wetlands are merely the expression of water in a landscape due to proximity to the land surface (viz. the 50 cm mottle criterion in the delineation guidelines) it follows that potentially large proportions of the water moving in the landscape could fall outside of this sphere – as discussed in detail above. **Figures 10** and **11** provide schematic representations (as contrasted with **Figure 6**) of water dynamics in urban environments with distinct excavations and surface sealing activities respectively.

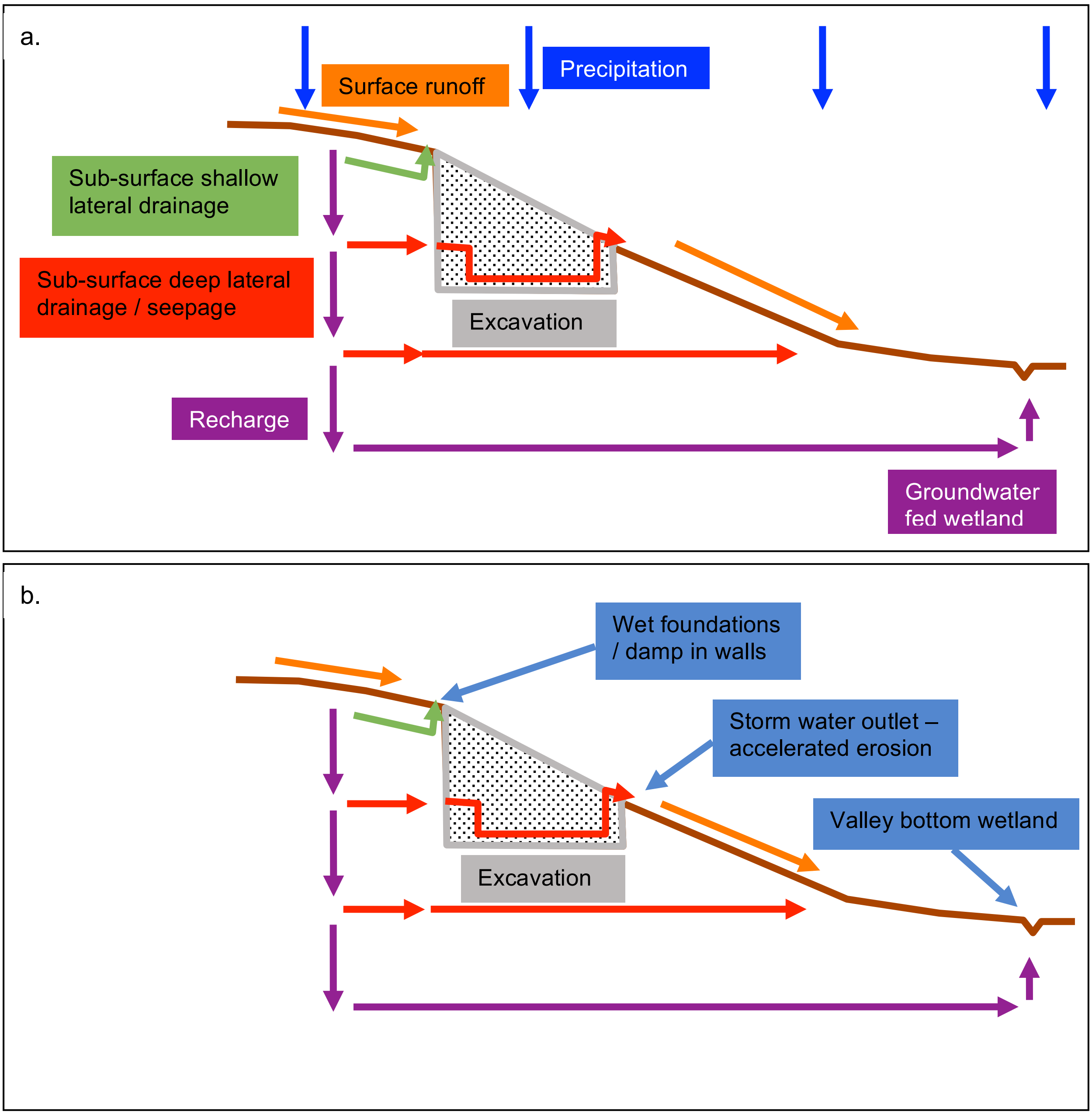


**Figure 10** Different flow paths of water through a landscape with an excavated foundation (a) and typical wetland types associated with the altered water regime (b)

Through the excavation of pits (**Figure 10**) for the construction of foundations for infrastructure or basements for buildings the shallow lateral flow paths in the landscape are severed. As discussed above these flow paths can account for up to 60 % of the volume of water entering the landscape in the form of precipitation. These severed flow paths often lead to the ponding of water upslope from the structure with a subsequent damp problem developing in buildings. Euphemistically we have coined the term “wet basement syndrome” (WBS) to describe the type of problem experienced extensively on certain landscapes. A different impact is experienced once the surface of the land is sealed through paving (roads and parking areas) and the construction of buildings (in this case the roof provides the seal) (**Figure 11**). In this case the recharge of water into the soil and weathered rock experienced naturally is altered to an accumulation and concentration of water on the surface with a subsequent rapid flowing downslope. The current approach is to channel this water into storm water structures and to release it in the nearest low-lying position in the landscape. These positions invariable correlate with drainage features and the result is accelerated erosion of such features due to a drastically altered peak flow regime.

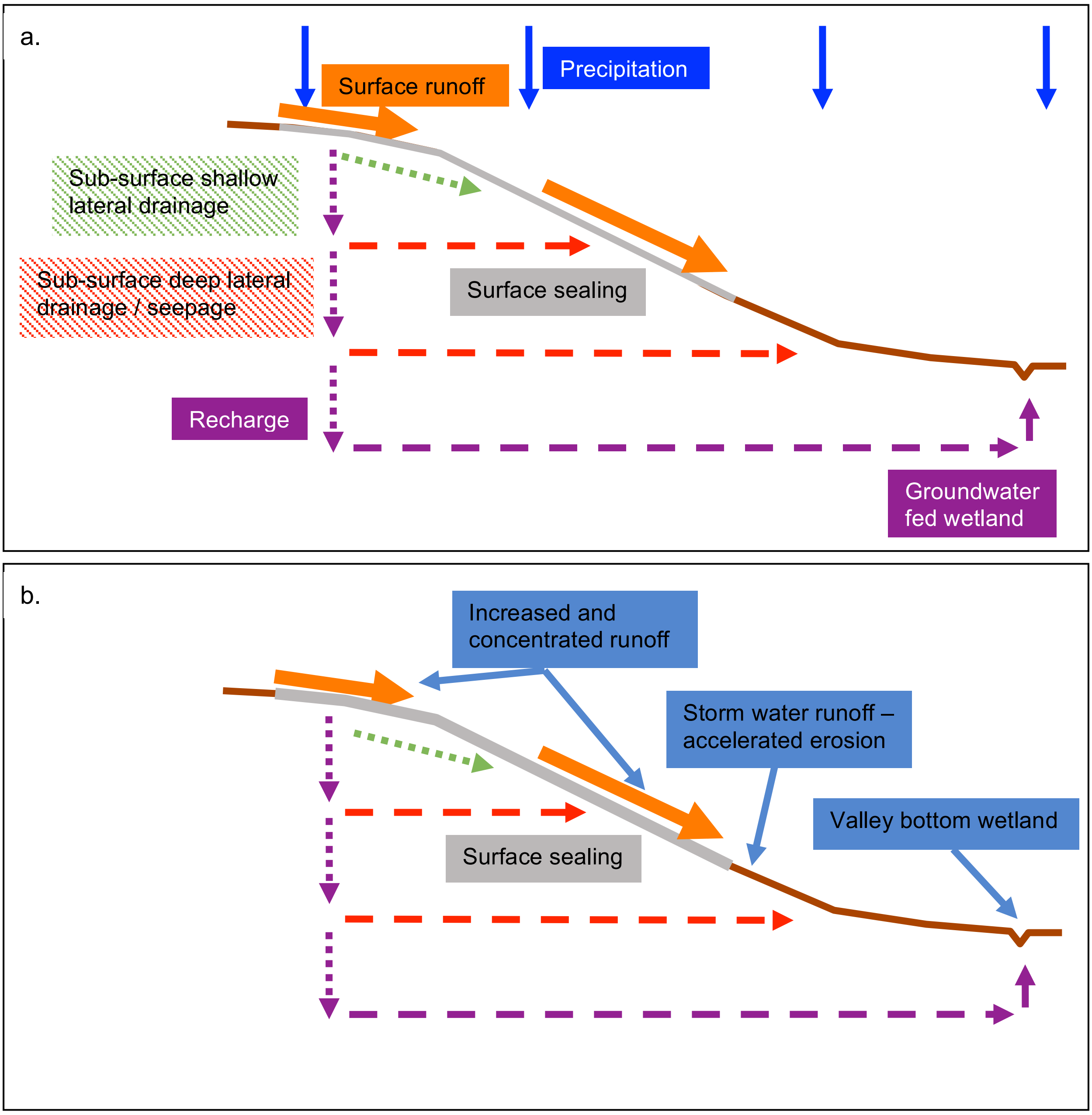


**Figure 11** Different flow paths of water through a landscape with surface sealing (buildings and paving) (a) and typical wetland types associated with the altered water regime (b)

The result of the above changes in landscape hydrology is the drastic alteration of flow dynamics and water volume spikes through wetlands. This leads to wetlands that become wetter and that experience vastly increased erosion pressures.

All the above aspects are complicated by variable geology in an area where the hydrological pathways could vary significantly. Later in the report specific reference will be made to the hydropedology of the site linked to the expected impacts of a pipeline development.

## 6. METHOD OF WETLAND INVESTIGATION AND DELINEATION

The wetlands on the site were investigated and assessed on the basis of the wetland indicators as described in the wetland delineation guidelines (DWAF, 2005).

### 6.1. AERIAL PHOTOGRAPH INTERPRETATION

An aerial photograph interpretation exercise was conducted through the use of Google Earth images and historical aerial photographs of the site. This data was used to obtain an indication of the extent of the wetlands on the site as well as to provide an indication of the artificial modifiers evident on the site and in the catchment.

### 6.2 TERRAIN UNIT INDICATOR

Detailed contours of the site (filtered to 2 m intervals for the purpose of map production) were used to provide an indication of drainage depressions and drainage lines. From this data the terrain unit indicator was deduced.

### 6.3 SOIL FORM AND SOIL WETNESS INDICATORS

The soil form and wetness indicators were assessed on the site through a dedicated soil survey within the context of the description of the Ba54 land type description as provided in sections 5.5 and 5.6. The site was traversed on foot and soils were augured and described where rock and rubble did not impede the soil auger. The areas covered by granite and dolerite were identified even though the colluvial material exhibited a large degree of variation.

Historical impacts were identified as the impacts on the soils are very distinct. Soil characteristics could therefore be used to provide a good indication of the historical impacts on the grounds of a forensic approach. In areas where soil impacts are limited the standard approach in terms of identification of soil form and soil wetness indicators was used.

### 6.4 VEGETATION INDICATOR

Due to the extent of the historical impacts as well as soil disturbances a dedicated vegetation survey for the purpose of wetland delineation was not conducted. Vegetation parameters were noted and these are addressed in the report where relevant.

### 6.5 ARTIFICIAL MODIFIERS

Artificial modifiers of the landscape and wetland area were identified during the different components of the investigation and are addressed in the context of the wetland delineation.

## 7. SITE SURVEY RESULTS AND DISCUSSION

### 7.1 AERIAL PHOTOGRAPH INTERPRETATION

#### 7.1.1 Potential Wetlands

From the aerial photograph interpretation that was based on several historical Google Earth images, the most likely wetland areas were identified. Apart from the drainage feature on the southern boundary of the site a few potential seepage wetland areas were identified. **Figure 12** indicates a partial coverage the satellite image and exhibits signatures that may be interpreted as seepage wetland areas. From the little information that is evident from the image these areas appear as if they may be the product of human activity. **Figures 13** to **16** indicate changes to 2013.


**Figure 12** Google Earth image (2003/10/02) indicating potential seepage areas (yellow arrows)

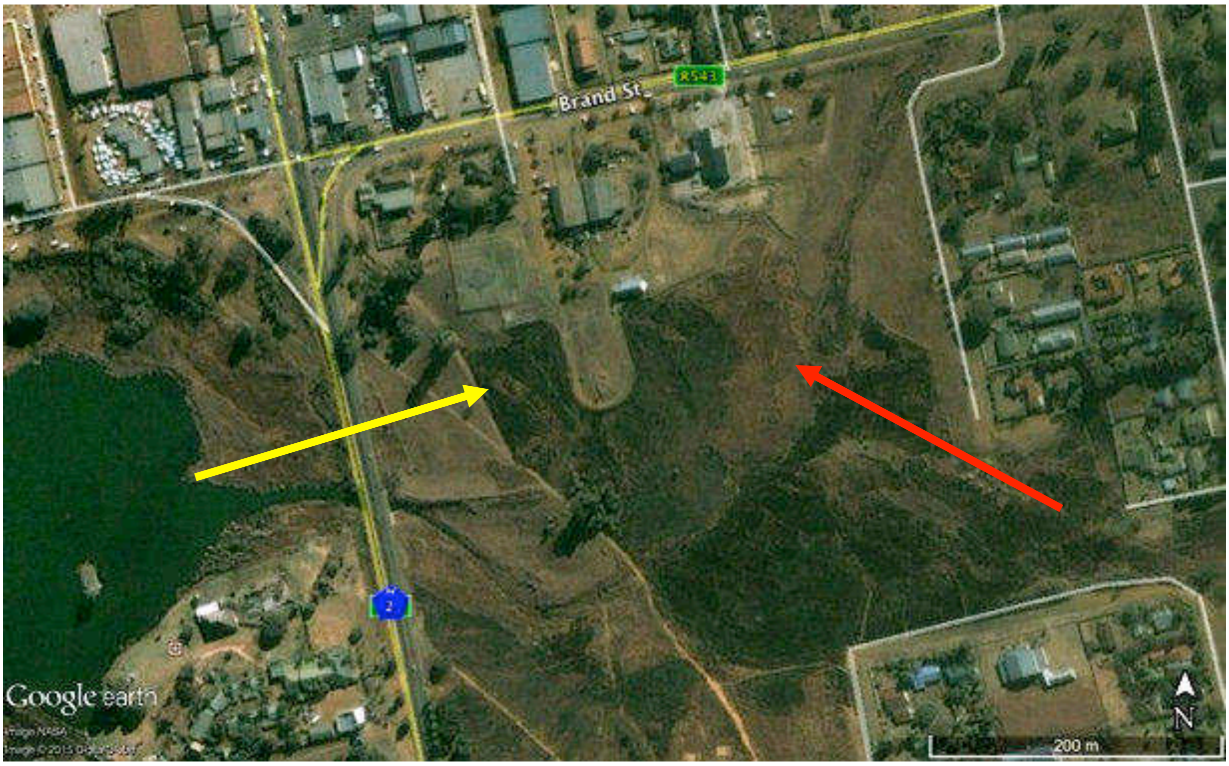


**Figure 13** Google Earth image (2010/06/18) with the potential seepage areas (yellow arrow) very evident as artificial modifiers and indicating a potential seepage wetland in the east (red arrow)


**Figure 14** Google Earth image (2011/07/20) with the potential seepage areas (yellow arrow) very evident as artificial modifiers and without signs of a potential seepage wetland in the east (red arrow)

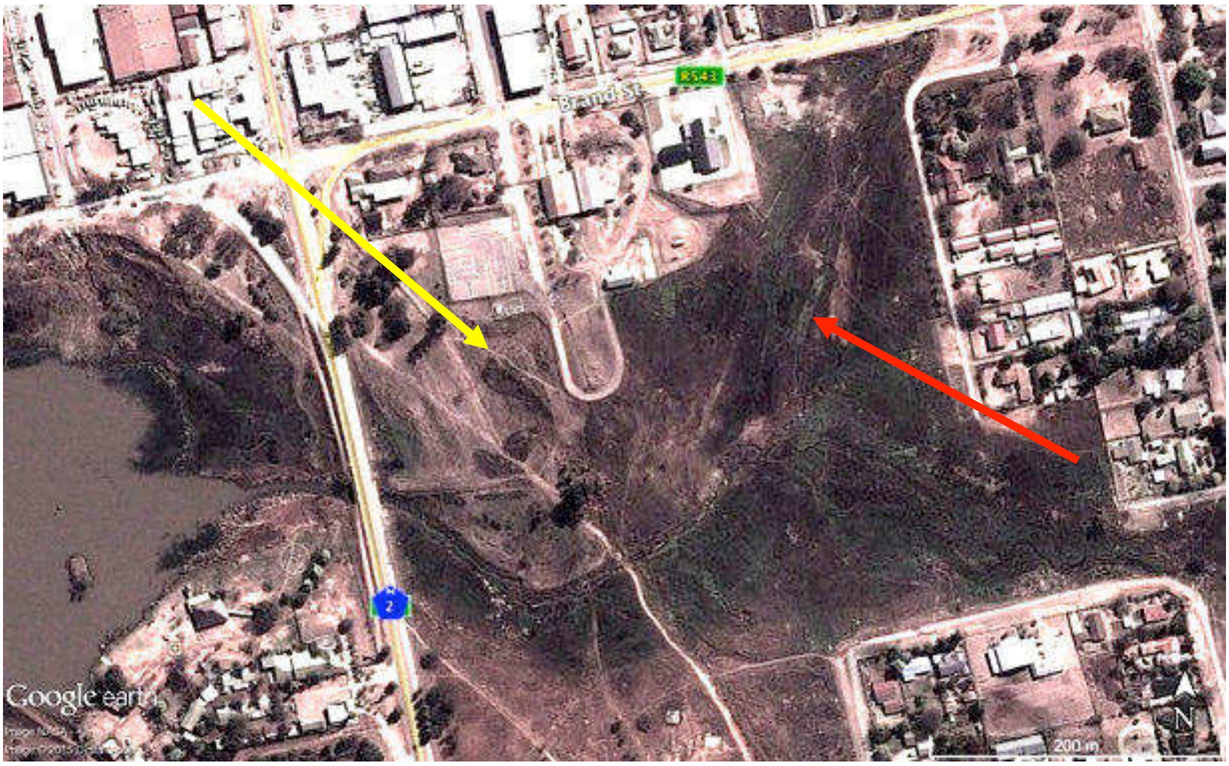


**Figure 15** Google Earth image (2012/09/09) with the potential seepage areas (yellow arrow) very evident as artificial modifiers and again indicating a potential seepage wetland in the east (red arrow)

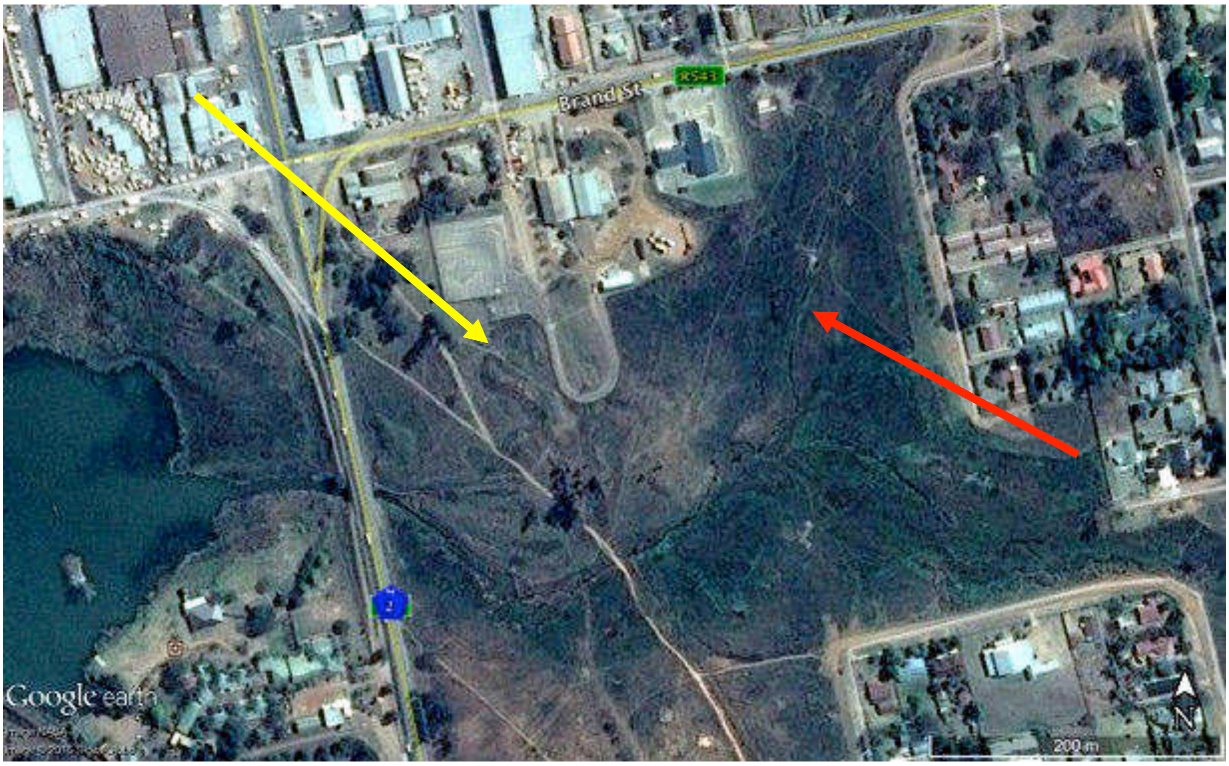


**Figure 16** Google Earth image (2013/08/26) with the potential seepage areas (yellow arrow) very evident as artificial modifiers and again indicating a potential seepage wetland in the east (red arrow)

From **Figures 13** to **16** seasonal changes are evident in the expression of the possible seepage wetland in the east. Also, the possible seepage wetland in the west from **Figure 12** is very evident to have been altered through human activities.

### 7.1.2 Historical Land Use Changes and Impacts

The details of the historical land use changes on the site cannot be gleaned from the Google Earth images as the impacts precede the first available image. However, it is very evident that changes on the site occurred since 2003 in the form of additional paving and storm water runoff. Changes are also apparent in the stream channel over the image period as the channel appears more eroded in the recent images.

## 7.2 TERRAIN UNIT INDICATOR

From the contour data a topographic wetness index (TWI) (**Figure 17**) was generated for the site. The TWI provides a very accurate indication of water flow paths and areas of water accumulation that are often correlated with wetlands. This is a function of the topography of the site and ties in with the dominant water flow regime in the soils and the landscape (refer to previous section where the concept of these flows was elucidated). Areas in blue indicate concentration of water in flow paths with lighter shades of blue indicating areas of regular water flows in the soils and on the surface of the wetland / terrestrial zone interface.

From the TWI (**Figure 17**) it is very evident that the entire site is situated on convex topography (both plan and profile curvature) and as such have no areas associated with concentrations of surface runoff. The stream channel to the south is the only confirmed area of concentrated water accumulation and flow. The delineation of the wetland is addressed later in the report.

## 7.3 SOIL FORM AND SOIL WETNESS INDICATORS (SITE SURVEY)

The site survey revealed widespread and significant alterations to the soils and land surface. As an indication of the extent of the alterations and influences **Figures 18** to **33** provide photographs along a half-moon shaped transect from the western edge to the eastern edge of the site upslope of the stream channel. The captions are self-explanatory.

The main findings along the transect is that the landscape has been altered significantly through historical and more recent human activities. These activities have in most case led to additional soil material and rock being deposited on the land surface or to distinct excavations for urban related infrastructure. The areas that have been altered either show denuded vegetation (due to hard-setting and increased surface runoff) on convex local slopes or accumulation water in depressions with associated increases in vigour of plants and colonisation of plants that prefer wetter soil conditions. These plans are, for the largest part of the site, not true indicators of original wetland conditions.

A small section of darker soil, associated with a wetter patch of land and dolerite rock, was found in the eastern section of the site (**Figures 29** and **30**). This corresponds to the "marshy" area described in the geotechnical report. Although this section is wet more regularly it is not possible to indicate whether this is a historical (pre-human settlement) wetland as the higher clay content of the soils (compared to the rest of the site) would lead to perching of surface water with rapid colonisation of wetland plants. This area is at the foot of storm water accumulation from the existing structures upslope.

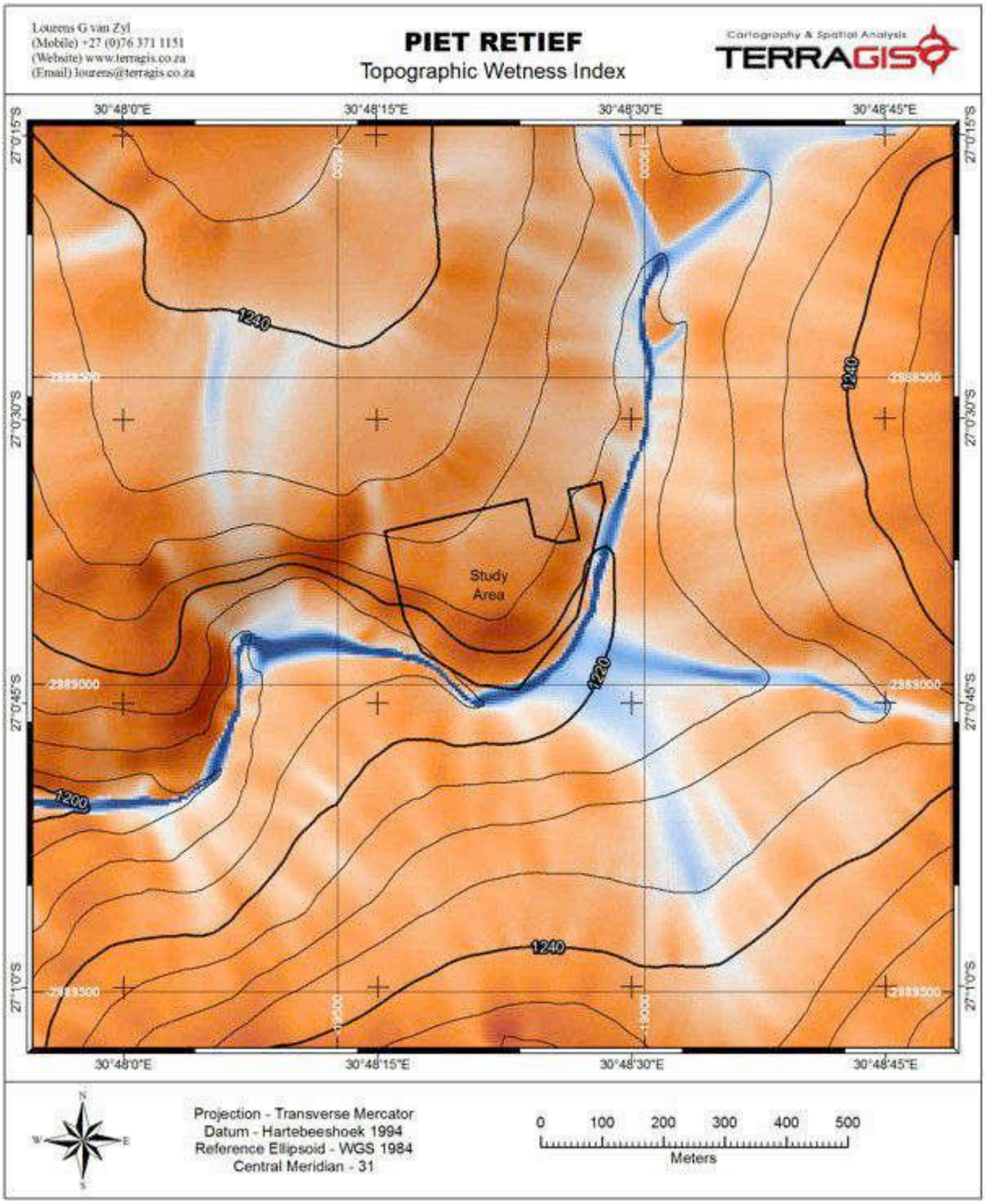


**Figure 17** Topographic wetness index (TWI) of the survey site

**Figure 18** Human impacts and altered landscape and vegetation on the western edge of the site

**Figure 19** Human impacts and altered landscape and vegetation on the western edge of the site

**Figure 20** Human impacts and altered landscape and vegetation on the western edge of the site – area erroneously identified during image interpretation as potential seepage wetland

**Figure 21** Human impacts and altered landscape and vegetation on the western edge of the site near the stream – note the presence of a pipeline as well as soil disturbances

**Figure 22** Human impacts in the form of a pipeline and historical earthworks on the southern boundary with the stream

**Figure 23** Foreign soil material and soil disturbances on the south western edge of the site

**Figure 24** Foreign soil material and soil disturbances on the south western edge of the site

**Figure 25** Vegetation alterations initially (but erroneously) identified as potential seepage areas (yellow arrow)

**Figure 26** Vegetation alterations to the south of the developments on the site

**Figure 27** Foreign soil material and soil disturbances on the southern sections of the site

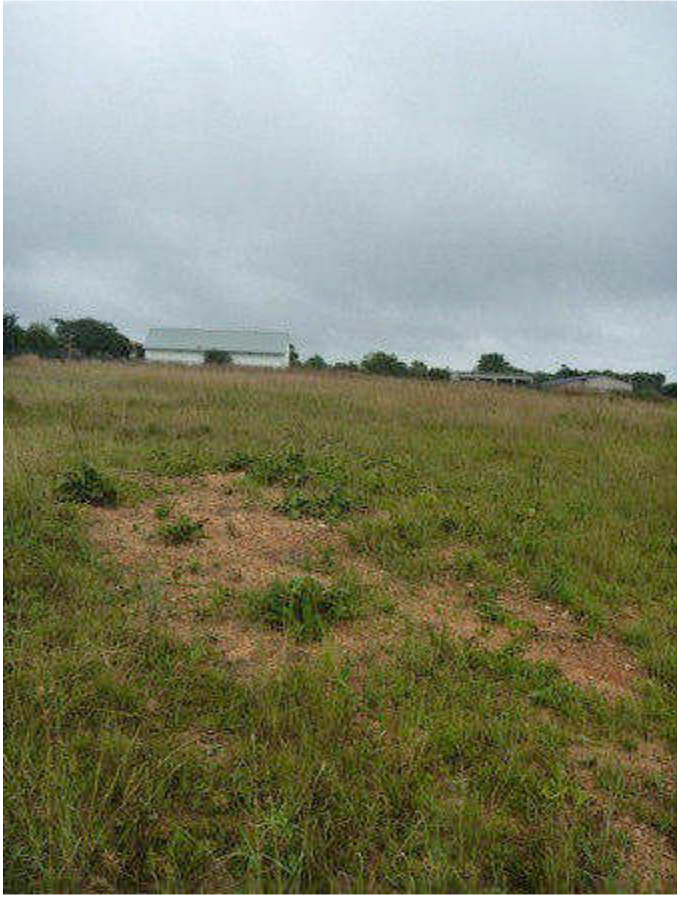

**Figure 28** Foreign soil material and soil disturbances on the southern sections of the site

**Figure 29** Vegetation alterations to the south of the developments on the site with evidence of regular surface wetness from plant species

**Figure 30** Vegetation alterations to the southeast of the developments on the site with evidence of regular surface wetness from plant species

**Figure 31** Vegetation and surface disturbances on the eastern section of the site

**Figure 32** Vegetation and surface disturbances on the eastern section of the site with widely occurring rubbish and rubble

**Figure 33** Altered stream channel (excavation and clearance)

The areas to the south and east of the drainage line exhibit large patches of potential seepage zones. Upon inspection these appeared to have some contribution of seepage water but the bulk of the water currently results from storm water runoff from paved areas upslope.

### 7.4 ARTIFICIAL MODIFIERS

The artificial modifiers have been discussed and elucidate in the previous sections.

## 8. WETLAND ASSESSMENT

### 8.1 PROPOSED DELINEATION AND BUFFER

From the investigation a wetland boundary, inclusive of storm water driven wetland areas, was determined **Figure 34**. It is difficult to assign a buffer to a wetland that has been impacted and that still receives significant contributions of water from storm water runoff from paved areas upslope. It is recommended that developments can encroach up to 30 from the drainage line and where the current developments are closer than that these areas should not be expanded. The above is proposed only in the event that adequate storm water planning and mitigation is conducted on site.

### 8.2 WETLAND CLASSIFICATION / TYPES

Based on the investigation two types of wetland areas are identified namely: 1) the areas associated with an impacted and eroded drainage feature and 2) a seepage/storm water outflow zone. As discussed earlier in the report it is not possible to indicate whether the latter zone is a natural seepage zone or a more recent development of storm water runoff increases and frequency.

### 8.3 WETLAND FUNCTIONALITY

The channelled valley bottom wetland / watercourse is fed predominantly from the catchment through overland flow with additions from storm water runoff from paved areas. The main contributor to the small impacted wetland patch on the site is storm water runoff from paved areas and structures upslope to the south. From the investigation it was not possible to identify any significant contributions of hillslope water or lateral flows to wetlands or the stream. This is a function of the convex slope of the site.

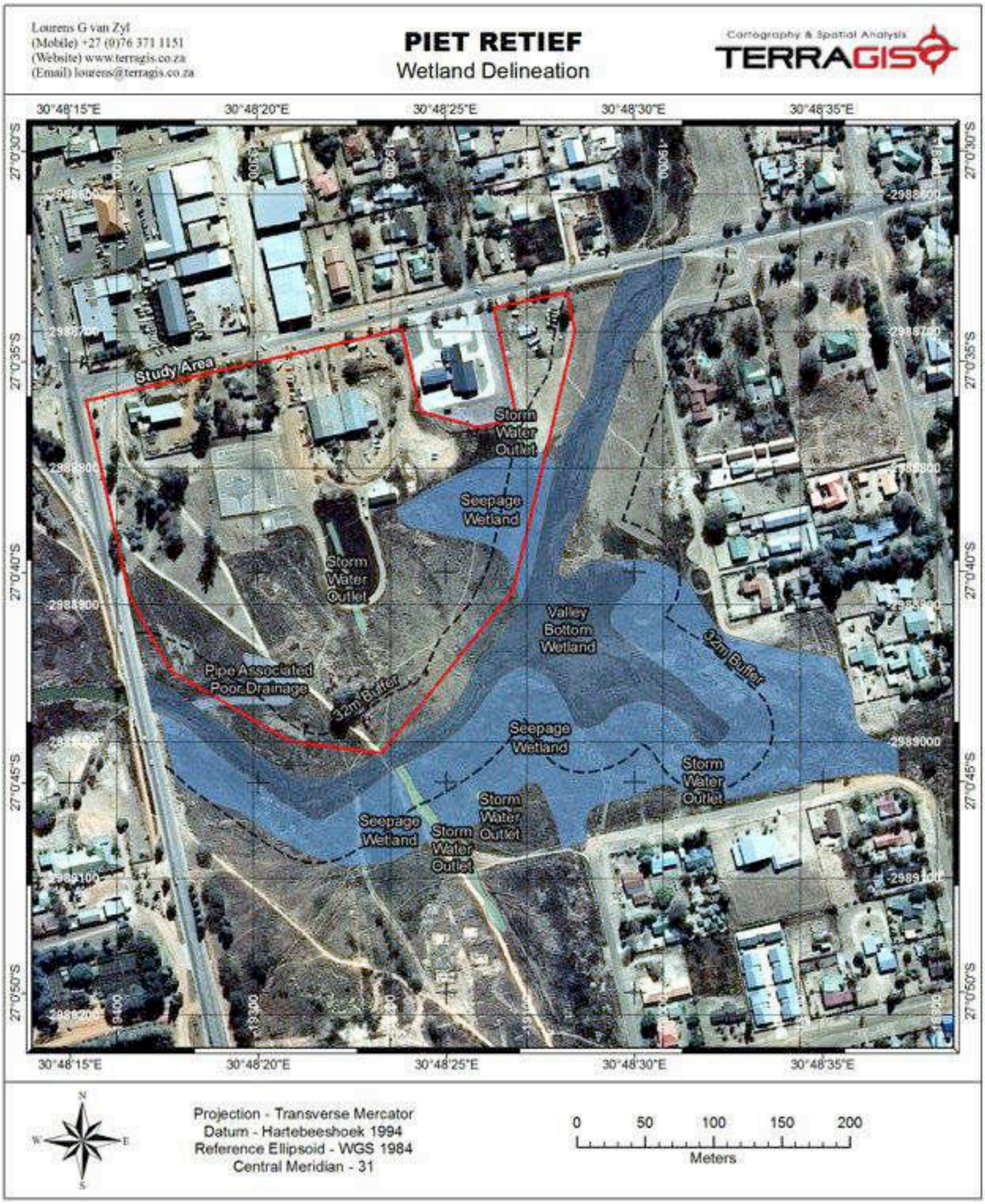


**Figure 27** Proposed delineation for the investigation site

### 8.4 PRESENT ECOLOGICAL STATUS (PES) DETERMINATION

Hydrological Criteria:

- Flow modification: Large modification due to urban infrastructure in the catchment with significant erosion in the channel and on the banks. Score 2, Confidence 4.
- Permanent inundation: Permanent inundation was not part of the reference state and cannot be included as a new aspect. Inundation does take place in areas but this is due to significant human impacts in the form of alteration and rubble dumping. Score 2, Confidence 4.

Water Quality Criteria

- Water quality modification: Score 1, Confidence 4
- Sediment load modification: Score 1, Confidence 4

Hydraulic / Geomorphic Criteria

- Canalisation: Score 2, Confidence 4
- Topographic Alteration: Score 1, Confidence 4

Biological Criteria

- Terrestrial encroachment: Score 1, Confidence 3
- Indigenous vegetation removal: Score 2 (for most of the site), Confidence 4
- Invasive plant encroachment: Score 1 (for most of the site), Confidence 4
- Alien fauna: Score 2, Confidence 3
- Overutilisation of biota: Score 1, Confidence 4

Score

PES category D-E

From the data generated as well as the extent of the identified alterations the conclusion is that the wetland systems on the site have a PES rating of an D to an E. The potential for improvement is small as the storm water and water quality aspects have to be addressed outside of the wetland areas within the respective catchments.

## 9. CONCLUSIONS AND RECOMMENDATIONS

The following conclusions are drawn from the investigation:

1. The entire site has undergone alterations in the form of varying intensity human activities.
2. The stream that forms the valley bottom section of the landscape is impacted in many areas through erosion and excavation. In addition, significant amounts of litter and invasive plants are evident throughout the channel.
3. A possible seepage wetland zone was identified at the foot of urban developments with storm water outflows. The specific soils found in this area indicate predominantly surface wetness and it is therefore concluded that the main contributor to wetland vegetation establishment is storm water emanating from the paved areas upslope.
4. The soils found in the small wetland area have high clay contents and this aspect precludes any significant volumes of water flowing laterally subsurface wise into the wetland. Dolerite intrusions in the general landscape often exhibit distinct weathering and zones of poor

drainage due to the localised effect of high clay content on water percolation, drainage and movement. From these aspects it is not possible to unequivocally assign the area as a seepage wetland. This area's possible recharge zone has been paved and it can therefore safely be assumed that the dominant hydrological functioning is one of surface water runoff from upslope areas during rainfall events.

5. During development of the site the construction activities should be limited to a distance of at least 30 m from the water course except if adequate storm water management and containments structures are constructed to minimise high energy flows into the stream channel.
6. The "seepage wetland" is situated immediately downslope of paved up sites and a buffer can therefore not be recommended. In this case the same recommendations as above regarding storm water management apply.

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# Appendix D3:

## Ecological Assessment

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[1]

# Bokamoso:

## Basic assessment Flora and Fauna Assessment

## Portion 17 of the farm Vlakfontein 522KR; Piet Retief, Mpumalanga Province, South Africa

By

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*Luke Verburgt*

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# 1 INTRODUCTION

Enviro-Insight CC was commissioned by Bokamoso to perform a basic assessment of fauna and flora for the proposed Portion of Portion 100 (Portion of Portion 1) of the farm Piet Retief Town and Townlands 149 HT; Mpumalanga Province, South Africa. This site falls entirely within the KaNgwane Montane Grassland regional vegetation unit (Figure 1; Mucina & Rutherford 2006). In addition, this vegetation type is the only vegetation unit in the immediately surrounding region. For the purposes of the study, any proposed developments should be compared against the new 2014 Environmental Impact Assessment Regulations, which drives much of the approach for this study.

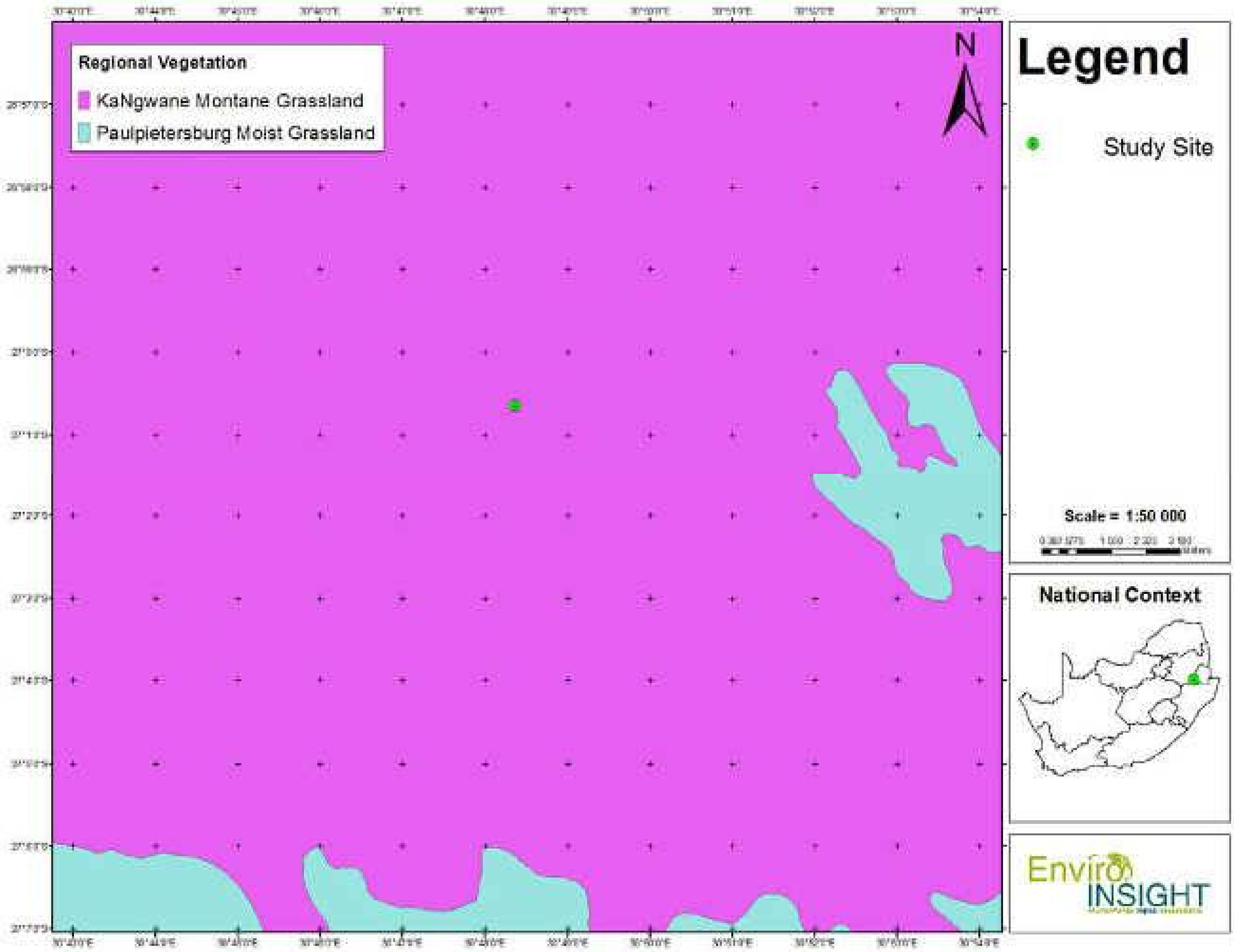


***Figure 1:*** *The study area in relation to the regional vegetation type*

# 2 METHODS

## 2.1 FIELD SURVEY

A field survey was performed in March 2015 by a specialist zoologist/ ecologist where the botanical and the faunal aspects of the survey area were evaluated. This represented a wet season survey. During the field survey, the proposed development site was covered on foot and a series of georeferenced photographs were taken of the habitat attributes that would serve to drive the results and conclusions. The field survey focused on a Basic Assessment level classification of the fauna, flora, habitats as well as the potential presence of Red Data species (also referred to as Red-Listed species), which are species of conservation concern in South African (either classified as threatened by the IUCN (2014), protected by NEMBA (2014) or indeed other legislations applicable provincially or nationally). An analysis of the diversity and ecological integrity of the habitats present on site was also performed as well as the presence of indigenous vegetation with an extent of more than 1 hectare.

## 2.2 DESKTOP SURVEY

### 2.2.1 Literature study

As mentioned above, much of the approach for this survey is based upon the National and Mpumalanga Requirements for Biodiversity Assessments. The level of this study does not warrant intensive sampling but rather serves to combine the aspects of the regional vegetation unit (obtained from Mucina and Rutherford 2006) with the field study in order to formulate a series of recommendations. Many of the potential avifaunal triggers were referenced by the Southern Africa Bird Atlas Project (SABAP 2) and Hockey *et al.* (2005). Mammal information was referenced by Skinner and Chimimba (2005) while reptiles and amphibians were referenced from Bates *et al.* (2014) and Du Preez and Carruthers (2009) respectively. It must be stated that evaluation of species of concern was considered only AFTER the field study which served to identify the potential for occurrence. Therefore, all species identified under the above mentioned references were not necessarily analysed in detail. Plants were identified using Van Oudtshoorn (2004) and Van Wyk & Van Wyk (1997). Species nomenclature follows the aforementioned references throughout this document. The applicability of the information obtained from the literature sources was evaluated for the study area and the subsequent recommendations are to be used by the client (Bokamoso) in order to drive the development process in accordance with the relevant legislation.

### 2.2.2 GIS

Ground truthing and the use of recent satellite imagery were used to assist in the characterisation of the study area. The Mpumalanga C-Plan (2014) was also used in conjunction with ground truthing in order to verify the status of the site, which is shown in Figure 3.

# 3 RESULTS

## 3.1 DESCRIPTION OF STUDY AREA

The specialist tracks as well as the location of the georeferenced photos are shown as Figure 2. The georeferenced photographs served to assist in both the site characterisation as well as the sensitivity analysis. Although some areas were not able to be covered fully (e.g. the north-west corner of the site), transparent fencing into disturbed areas provided more than enough clarity for accurate descriptions to be made.

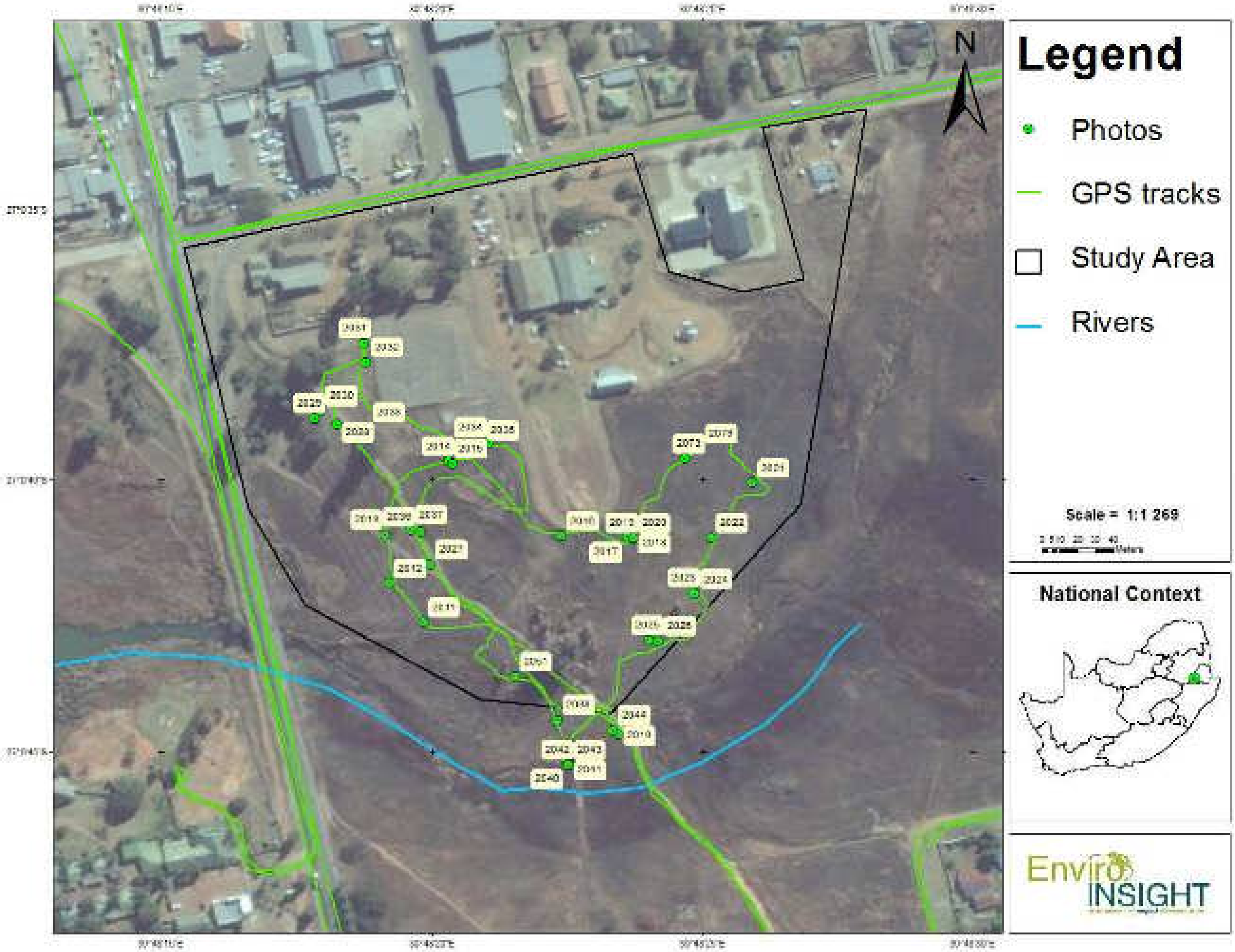


***Figure 2:*** *Specialist coverage and location of georeferenced photographs taken in the field*

The study area was classified as falling entirely within the Vulnerable KaNgwane Montane Grassland regional vegetation unit which is under threat due to the low levels of protection afforded to the unit. It was evident from the ground-truthing (georeferenced photos provided in the Appendix) that much of the study area is not ecologically intact and is poorly connected to similar ecologically intact vegetation. The potential for Red Listed species is discussed below. In addition, the Mpumalanga C-Plan (2014) has classified the area as having “no natural habitat remaining”.

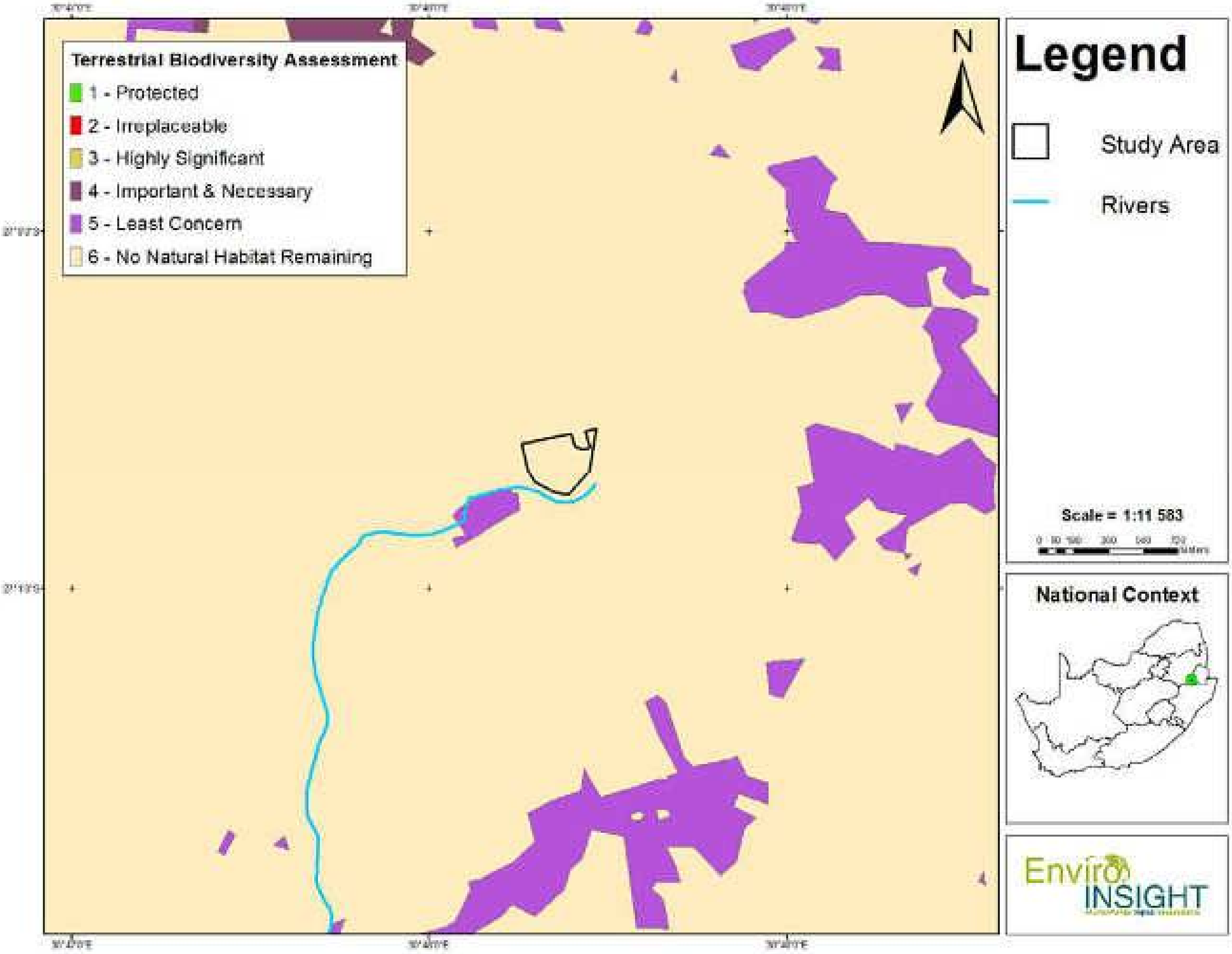


***Figure 3:*** *Mpumalanga (2014) C-Plan showing the conservation plan status of the project footprint*

Significant current impacts (shown photographically in Table 1) were recorded on site, most of which related directly to the current use of the development footprint.

The most significant identified impacts on site included:

- The high densities of alien invasive / indigenous invasive species including are prevalent;
- The physical manipulation (mowing) of the grassland system;
- Adjacent road networks (fragmentation, noise and traffic effects);
- Fence related habitat fragmentation;
- Residential related presence of feral predators (cats and dogs); and
- Human density effects.

Photographic evidence of the current impacts on the site is shown in Table 1.

***Table 1:*** *Examples of current impacts observed in the study area during the survey*

| | |
|---|---|
|  |  |
| Physical mowing of grassland | Alien invasive plant species |
|  |  |
| Fence effects | Human (road) effects |

The following section provides a description of each of the habitat types occurring within the study area.

### 3.2 HABITAT UNIT 1 – DISTURBED TRANSFORMED

This habitat type is characterised by building structures and development and is not considered o be ecologically functional in any way. Photographic evidence of this habitat type is shown as Figure 4.

***Figure 4:*** *Photographic example of the Disturbed Transformed*

## 3.3 HABITAT UNIT 2- DISTURBED VEGETATED HABITAT

This habitat type was by far the most prevalent within the study area and although it shows an abundance of indigenous vegetation, it is no longer considered to be ecologically functional in any way. The habitat is characterised in a number of ways, specifically;

- Previous disturbance with secondary grass regrowth
- Cultivated lawn
- Alien invasive species

Despite the slight variations within the habitat, it is entirely classified as non-sensitive and no Red-Listed species are expected to occur. Historically, the habitat type was most likely subjected to unsupervised grazing practices, human activities and physical manipulation of the floristic structure. In regards to actual classification, this is shown by both the undifferentiated or monospecific floristic structure and low diversity of species composition.

The grass cover throughout Disturbed Vegetated habitat was significant, although the representative species were indicative of disturbance. Dominant and sub-dominant species included *Melinis repens*, *Pennisetum clandestinum* (or other lawn grasses), *Aristida congesta* subsp. *barbicolis*, *Cynodon dactylon*, *Sporobolus africanus*, *Heteropogon contortus*, *Hyparrhenia hirta* and fragments of *Cymbopogon sp.* Most of the species fell within the "Increaser" classification as described by Van Outshoorn (2004) showing low grazing value and high previous levels of disturbance, although some pockets of *Themeda triandra* were present (Decreaser).

A photographic example of the Disturbed Vegetated Habitat Type is shown as Figure 5.

***Figure 5:*** *Photographic example of the Disturbed Vegetated Habitat Type*

## 3.4 HABITAT UNIT 3- STREAM AND STREAM BUFFER HABITAT TYPE

The Stream and Stream Buffer Habitat type mostly occurred outside of the project footprint, although the influence of the waterway and associated buffer on and within the study area warrants further discussion. In addition, it must be stated that formal wetland delineation was beyond the scope of this study which mostly sought to classify the flora fauna on a basic assessment level. The general classification of this habitat is required in order to subsequently relate its presence to potential Red-Listed faunal species.

Overall, this habitat type was divided into the following sub-categories:

- Flowing water (stream): This habitat appeared to flow from a north-easterly to south-westerly direction to the lowest point in the study area, terminating in what is now a large artificial permanent water body (see below). The stream habitat is considered to be in functional ecological condition, despite the evaluation from the C-Plan (Mpumalanga). Rock structure and good quality riparian vegetation persists throughout this habitat type.
- Stream buffer: This system consists of linear riparian vegetation buffering the open water streams draining into the large artificial wetland described below. The vegetation type shows intact vegetation which retains aspects of the previous ecological functionality of the system.
- Large artificial permanent wetland: This water body most likely was a functioning seasonal or semi-permanent wetland and through heavy excavation, has been converted into a permanent "dam like" water body. This habitat acts as a source for wetland birds and possibly aquatic mammals although it is considered to be of peripheral importance to the development as a whole.

A photographic example of the Stream/ Stream Buffer Habitat Type is shown as Figure 6.

**Note:** A formal wetland delineation has been carried out and further classiifcation was beyond the scope of this study, as per instructions.

## 3.5 FAUNAL SPECIES OF CONSERVATION CONCERN

Through the assessment of faunal characteristics of the site (habitat potential, evidence of the presence of faunal species etc.) as well as applying the basic assessment study performed in conjunction with the aforementioned faunal references, three faunal "trigger" species were identified and thus require further discussion. The species identified were based on a probability of occurrence (based on habitat potential and previous records) and are discussed below:

**Water Rat *Dasymys incomtus* (Near Threatened)**

The project footprint is intersected by a portion of intact stream drainage/stream buffer which shows a significant influence on the development area. Although water rats could be located within the site, the habitat observed is considered to be sub-optimal habitat for water rat (due to high levels of disturbance). It must be stated however that if the extension was to be developed without mitigation, the flow of the natural drainage line would be impeded significantly and riparian habitat could be eliminated. In light of this and by employing the precautionary principle (assuming that water rat is present in the area), it is concluded that simple mitigation measures could be employed by buffering the drainage line, so that free movement of animals can take place, thereby avoiding all direct impact and maintaining the existing integrity of the stream and stream buffer.

**Spotted-neck otter *Lutra maculicollis* (IUCN Near Threatened)**

It was apparent that some potentially suitable migratory/dispersal habitat persists on site, characterised by the linear stream and associated buffer. However, the area is mostly sub-optimal for spotted-neck otters which prefer deep, clear pools which support large populations of fish. The conclusion for the spotted-neck otter mirrors that of the water rat above which favours simple buffering rather than intensive studies on the presence of the species which may in fact prove inconclusive.

***Figure 6:*** *Photographic example of the Stream/ Stream Buffer Habitat Type*

**Striped Weasel *Poecilogale albinucha* (Data Deficient)**

Although this species is a grassland resident and is known from the region, the sheer level of disturbance would be highly unlikely to support a viable population of striped weasels.

### 3.6 FLORAL SPECIES OF CONCERN

Based on the vegetation analysis and the observations made during the survey it is evident that the area currently does not show sound ecological functionality and no Red-Listed plant species were observed and none are expected.

## 4 DISCUSSION AND RECOMMENDATIONS

The Discussion and Recommendation section will be driven by the legislative minimum requirements and the level of the study commissioned by the client (Basic Assessment). The section will also be broken down into the various components of Fauna, Flora and Habitats.

### 4.1 FAUNA

Due to the low habitat potential for the regional "trigger" species of conservation concern, the suggested recommendations are purely precautionary. The legislative buffering should be kept intact in order to not restrict the movement of red-listed aquatic mammals such as water rats and spotted neck otters.

### 4.2 FLORA

The primary recommendations regarding the floral assemblage relates to the buffering of the Stream/ Stream Buffer habitat as a way to maintain corridor movement of birds and aquatic faunal species. In addition, avifauna use this habitat as a corridor for movement between upstream wetland habitats and the large impoundments downstream. Finally, alien/ invasive species located within the project footprint should be subjected to the appropriate eradication program as stipulated by the recommendations of the ROD and any relevant legislation.

### 4.3 HABITAT

Although no significant ecological triggers were identified on a habitat level, the presence of stream/ stream buffer habitat within the study area does represent an elevated sensitivity for the Habitat Type. This is due to the possible occurrence of the above mentioned wetland associated faunal species. Figure 7 shows the final delineation of the study area with the identifiable Stream/ Stream Buffer area illustrated in blue, denoting the **only** area of high sensitivity. The habitat sensitivity is therefore illustrated as Figure 8. Once more it is imperative to mention that the majority of this habitat type has been subjected to formal wetland delineation and botanically, falls outside the scope of this study (as instructed by the client).

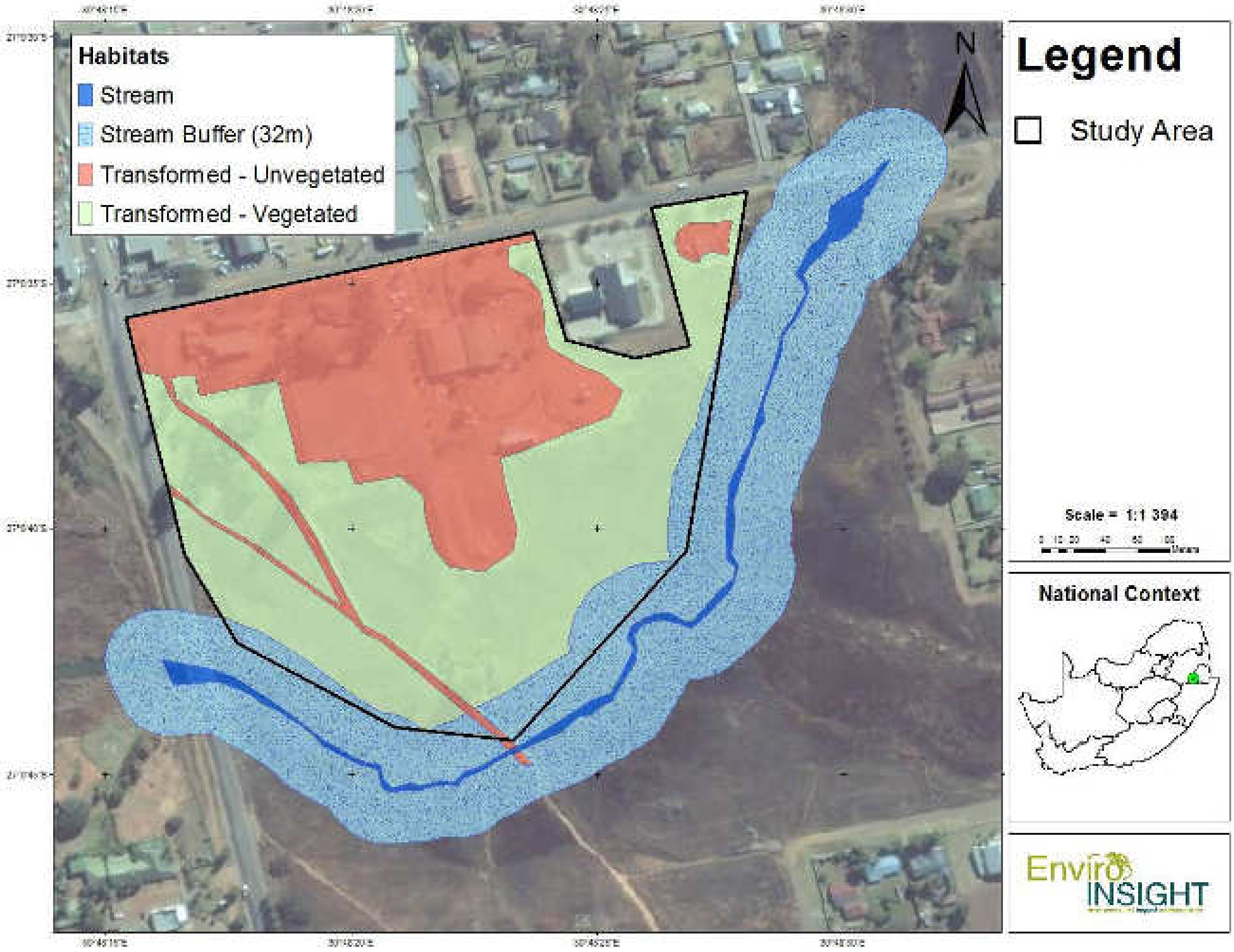


***Figure 7:*** *Final Habitat Delineation of the designated study area*

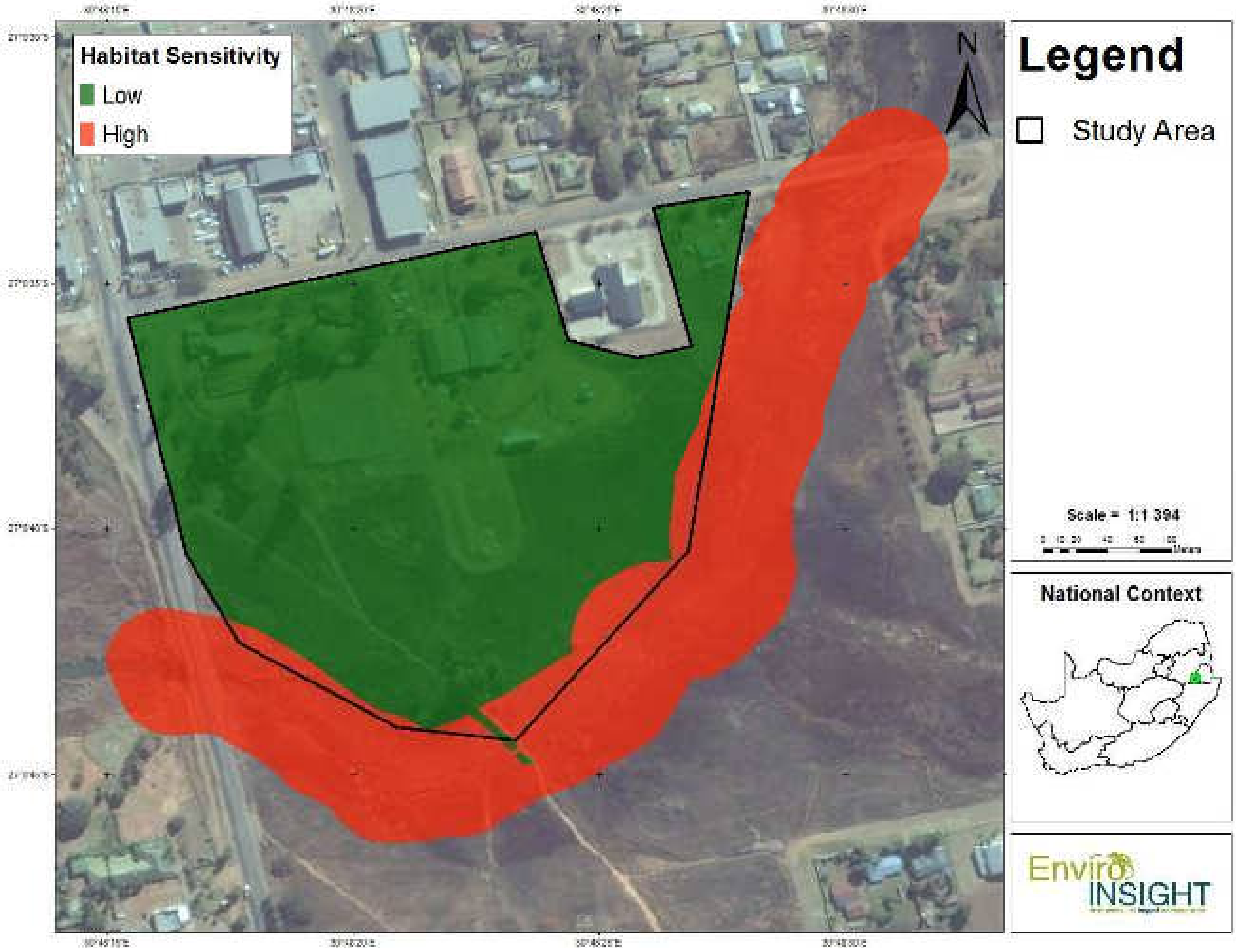


***Figure 8:*** *Final Habitat Sensitivity of the designated study area*

## 4.4 ASSESSMENT OF THE PRESENCE OF INDIGENOUS VEGETATION HABITAT IN ACCORDANCE WITH THE LEGISLATION

In accordance with the new legislation concerning the presence of 1 Ha or more of continuous indigenous vegetation, a summary based upon the findings of the basic assessment level study is listed below.

- The assessment identified 1 Ha or more of continuous indigenous vegetation within the study area which triggers this portion of the 2014 regulations;
- Primary climax grass swards were all but absent;
- The indigenous vegetation on site was highly manipulated and disturbed; and
- Overall and from a floristic point of view, none of the identified indigenous vegetation is considered to be highly sensitive. According to the NEMA Regulations, Indigenous vegetation is refers "to vegetation consisting of indigenous plant species occurring naturally in an area, regardless of the level of alien infestation and where the topsoil has not been lawfully disturbed during the preceding ten years". For the study area, disturbance is continuoius and on going.

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# 6 APPENDIX

***Appendix 1:*** *Georeferenced photographs taken during the fieldwork survey (shown in* ***Figure 2****)*

| | | | |
|---|---|---|---|
|  |  |  |  |
| 2059 | 2060 | 2061 | 2062 |
|  |  |  |  |
| 2063 | 2064 | 2065 | 2066 |
|  |  |  |  |
| 2067 | 2068 | 2069 | 2070 |

| | | | |
|---|---|---|---|
|  |  |  |  |
| 2071 | 2072 | 2073 | 2074 |
|  |  |  |  |
| 2075 | 2076 | 2077 | 2078 |
|  |  |  |  |
| 2080 | 2081 | 2082 | 2083 |
|  |  |  |  |
| 2084 | 2085 | 2086 | 2087 |
|  |  |  |  |
| 2088 | 2089 | 2090 | 2091 |

| | | | |
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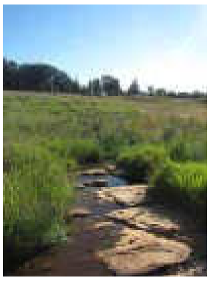
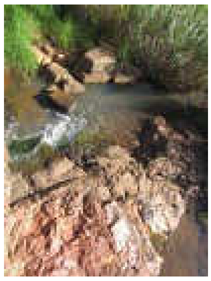
|  |  |  |  |
| 2092 | 2093 | 2094 | 2095 |
|  |  |  | |
| 2096 | 2097 | 2098 | |


Appendix D4:
Services Report

# ANAPROP PROPERTY MANAGEMENT

**PRELIMINARY SERVICES REPORT**
**CIVIL INFRASTRUCTURE**
**PIET RETIEF SHOPPING CENTRE**

# NOVEMBER 2013

**REPORT PREPARED FOR:** | **PROJECT No.:**
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Revision 01

# CONTENT

# 1. INTRODUCTION

Messrs Anaprop (PTY) Ltd requested Lekwa Consulting Engineers (Pty) Ltd to prepare a Preliminary Engineering Services Report on the proposed Bulk Civil infrastructure for the Piet Retief shopping centre development.

The object of the Piet Retief shopping centre development is to establish a number of new commercial units. These rental units will be placed outside the 1:100 year floodline.

The purpose of this report is to provide the preliminary planning and criteria to which the civil services will be designed and constructed, and provide a working document, on which the services agreements can be formalised for the final approval of building plans.

# 2. LOCATION

The site is referred to as a Portion of Portion 100 (a Portion of Portion 1) of the farm Piet Retief Town and Townlands 149-HT (to be known as Portion 126. The site is located on the corner of Brand Street and Kerk Street in the town of Piet Retief which is located within the Mkhondo Local Municipality area, which has jurisdiction within the Gert Sibande District Municipal area.

A locality map is attached as **Annexure 1**.

# 3. SITE DESCRIPTION

The site is situated on the west side of the N2 national road. This is an indication that the site is well suited for the proposed development of a shopping centre.

The site has a size of approximately *7,0254 Ha* but on this site a portion of the size 5 235 $m^2$ must be allocated for the town's local fire station. The proposed floor area will be approximately 39 000 $m^2$ and will be for retail/business purposes.

The site slopes from the eastern boundary to the western boundary.

# 4. CIVIL INFRASTRUCTURE

## 4.1 General

The Civil Infrastructure will be designed in accordance with the requirements of the:

- "Red Book" – Guidelines for the provision of Engineering Services and Amenities in Residents Township Developments"
- SABS 0400: National Building Regulations; and
- SABS 0252: Drainage and Water Supply

All contract documentation will be produced in accordance with the specification as set out in SABS 1200.

## 4.2 Geotechnical conditions

The Geotechnical considerations over the site have been dealt with in a separate report.

## 4.3 Hydraulic conditions

All commercial units will be developed above the 1:100 year floodline.

# 5. ACCESS AND ROAD WAYS

## 5.1 Design parameters

The design standards to be utilised in the design of streets in developments of this nature are those as set out in the "Red Book" – Guidelines for the provision of Engineering Services and Amenities in Residents Township Developments". All contract documentation will be produced in accordance with the specification as set out in SABS 1200. All streets will be designed above the 1: 10 year floodline level.

The access road ways are to be predominantly surfaced roads. Due to the type of development and the site conditions it is proposed that the design speed for all the traffic within the development to be 30 km/h. This reduces the allowable driving speed in the property thus reducing speed, along with creating safe environment for pedestrians.

It is intended that the design of the vertical alignment be flexible so that adjustments can be made to best suit the topography and any physical constraints found on site during the construction phase.

### 5.2 Access road

Access to the site will be from the Brand Street which intersects with the N2 national road or access can be obtained from the national road N2.

The access road way will be designed to have a crossfall and would have a permanent surface with the width of 6,0 m. The access road will have asphalt or paved surface determined by the material used in the parking area of the shopping centre.

The access road way will be designed for traffic comprising almost entirely passenger vehicles and light single axle heavy vehicles with a maximum loading of 9 tons per axle. The heaviest expected loading on the road network will be the construction traffic.

### 5.3 Residential roads

There will be no residential roads in this development site.

### 5.4 Existing roads

The only existing roads are those adjacent to the development site which will be used to gain access to the site. These are known as Brand Street and the national road N2 (Kerk Street).

## 6. STORMWATER DRAINAGE

### 6.1 Design parameters

The stormwater network of the development site must convey all surface stormwater run-off (both road and roof discharge) to the existing stormwater network serving the town of Piet Retief.

Due to the predisposition of the existing soils to erosion, it is imperative that effective stormwater erosion control measures be implemented both during and following construction of the civil infrastructure.

## 6.2 Road Stormwater

Stormwater on the parking area surface can be conveyed to open channels which can be covered by steel grids. These open channels can be built across the parking area to effectively catch all stormwater and these channels can be further used to convey the stormwater to the municipal stormwater network.

The stormwater can also be caught at collection points, and a network can be designed underneath the parking surface area to lead stormwater to the existing municipal stormwater networks.

These networks must be designed to create a controlled discharge into the existing municipal stormwater networks.

## 6.3 Roof Stormwater

All stormwater collected from roof runoff will be collected at a central point at each shop unit or drained into the design open channels. These structures can be constructed in such a manner as to lead the water into the municipal networks with a controlled discharge rate.

Efficient scour protection and filtration systems will be required at all discharge points to maintain the integrity of the water quality flow and control the erosion protection at these points.

## 6.4 Stormwater Attenuation

It is not anticipated that any stormwater attenuation will form part of the stormwater management of the proposed development.

# 7. WATER SUPPLY

Mkhondo Municipality is the Water Services Authority (WSA) and the Water Services Provider (WSP) for Piet Retief and is responsible for the provision of water services within its area of jurisdiction.

## 7.1 Existing services

An existing water connection is available and is currently being utilized by the present land occupiers.

The site is currently zoned as municipal and the existing rights allows for 75% coverage for Municipal purposes. As the property forms part of an existing township, the existing network would have been designed/sized for these existing rights. According to the “Red Book” the annual average water demand for Government and Municipal is the same as for Offices and Shops. It is therefore foreseen that the current water network and connection should have sufficient capacity.

### 7.2 Design parameters

The estimated water demand per office or shop unit as per “Red book” is 400 litres per day / 100m$^2$ of gross floor area. The instantaneous peak factor in the mains of the development is determined by converting the type of development to “equivalent erven” according to the design annual average demand. The accepted basis for design is: one equivalent erven (ee) has an annual average daily demand of 1 000 litres.

The peak factors will be calculated based on the final layout of the development. The peak factor is expected to be around 4.

The water demand for this development is therefore estimated at 156 kℓ per day.

## 8. SEWAGE DISPOSAL

Mkhondo municipality is the Water Services Authority (WSA) and the Water Services Provider (WSP) for Piet Retief and is responsible for the provision of water services within its area of jurisdiction.

### 8.1 Existing services

An existing sewer connection is available and is currently being utilized by the present land occupiers.

As stated previously the property forms part of an existing township and the existing connections would have been designed/sized for these existing rights. It is therefore foreseen that the current sewer network and connection should have sufficient capacity.

### 8.2 Design parameters

The estimated sewage outflow per unit of any sort as per “Red Book” standards is estimated as 80% of the water demand of that specific unit. In addition a 15% Stormwater infiltration rate will be allowed for.

A four meter wide Servitude line is proposed to be constructed to the south side of the development site, this proposed sever line runs across the site form the eastern side to the western side of the development site. The topography of the area will have to be considered during the design process and the viability of this option considered.

The sewer flow for this development is therefore estimated at 6,6 ℓ/s. An Ø110 mm sewer pipe installed at minimum 1:95 at 80% full flow will have sufficient capacity. The minimum pipe diameter should be determined taking this minimum requirement and the requirements of the National Building Regulations into consideration.

## 9. FIRE FIGHTING

All fire-fighting controls will be in accordance with the National Building Regulations as set out in the section for dealing with fire fighting and in accordance with “Red Book” standards

This proposed development will be considered as a High-risk area.

## 10. SOLID WASTE DISPOSAL

Mkhondo Municipality has a refuse removal service operating in the area. Mkhondo Municipality will be responsible for the removal and disposal of the solid waste generated by the proposed development.

## 11. ELECTRIC SUPPLY

An existing electrical connection is available and the final size of the connection will be determined by the type of facilities that will be accommodated in the centre.

At a later stage, when this information is available, will the size of the final connection be determined.

## 12. TELECOMMUNICATIONS

The supply of telecommunications will be the responsibility of Telkom and any upgrades required to deliver a service to the proposed development will be their responsibility.

The area of the proposed development is in a good mobile phone reception area.

## 13. CONCLUSION

The maintenance of all services on the property will be the responsibility of the land owners. The Mkhondo Municipality will have to agree to supply all services as discussed in this report.

All aspects of the design for both the bulk and internal services will generally be designed in accordance with the "Red Book" – Guidelines for Human Settlement planning and design and will be constructed in accordance with the requirements and specifications of SABS 1200.

As per the "Red Book" it is indicated that the water demand and sewerage flows for Retail/Business and Government/Municipal are the same. The development will be done with reduced floor area rights and therefore the water demand and sewerage flows will also reduce. As the existing water- and sewer networks would have been designed for the existing rights, it can be motivated that there will be sufficient capacity in the existing networks.

This report serves as preliminary planning for the civil infrastructure of proposed shopping centre development in Piet Retief and therefore some information and designs may change when the detail design commences.

Prior to the commencement of the detailed design stage the following information is required:

1. Specifications regarding the electric supply available to the development site currently must be discussed with representatives from Mkhondo Municipality and must be specified.

## 14. ANNEXURES

**Annexure 1: Locality map**

SOTIRALIS CONSULTING ENGINEERS (PTY) LTD
Consulting Civil and Structural Engineers

Ref: 3470 / 8.17 / 0076

31 March 2014

**Mkhondo Local Municipality**
Cnr. Market and De Wet Street
Piet Retief
2380

**Att:** Mr. Madubula Mabuza

**MALL@PIET RETIEF: SEWERAGE DRAINAGE**

Sotiralis Consulting Engineers (Pty) Ltd was appointed by Zarafusion (Pty) Ltd to administrate the design, monitoring and planning of the structural and civil engineering components for the proposed new Mall@Piet Retief shopping mall, situated on Portion 126 of Piet Retief town and Town lands 149HT.

As per the Guidelines for Human Settlement Planning and Design "RED BOOK" the estimated daily sewerage flow for the proposed new shopping mall development will be as follows:

| LAND USE | COVERAGE | DAILY SEWERAGE FLOW (AS PER THE "RED BOOK") | ESTIMATED EXPECTED SEWERAGE FLOW |
|---|---|---|---|
| Special for Business (7.0254ha) | 60% | 400 litres per day / 100m² of gross floor area | 168.61 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | **168.61 Kℓ/day** |

The current estimated daily sewerage flow, based on the existing land use rights of the property, can be summarized as follows (please refer to the attached document for a copy of the current, existing, land use rights of the property):

| LAND USE | COVERAGE | DAILY SEWERAGE FLOW (AS PER THE "RED BOOK") | ESTIMATED CURRENT SEWERAGE FLOW |
|---|---|---|---|
| Municipal (7.0254ha) | 75% | 400 litres per day / 100m² of gross floor area | 210.76 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | **210.76 Kℓ/day** |

As per the above it is evident that the estimated daily sewerage flow for the new proposed development will be less than the current allocated daily sewerage flow for the property as per the existing land use rights. We therefore foresee that the existing municipal outfall sewer pipeline and the existing municipal Sewerage Treatment Facility for the area should be sufficient to cater for sewerage flow from the proposed new development.

An existing municipal outfall sewer pipeline, of which the size is unknown at this stage, is located along the southern boundary of the proposed new development. According to the survey obtained from the site it seems that the capacity of this pipeline can be estimated as follows for different pipe sizes:

- 160mmØ Pipe : ± 20ℓ/s @ 80% Capacity
- 200mmØ Pipe : ± 60ℓ/s @ 80% Capacity
- 300mmØ Pipe : ± 128ℓ/s @ 80% Capacity

The sewerage network form the proposed new development will connect directly to this existing municipal outfall sewer pipeline.

***We herewith request confirmation that the Mkhondo Local Municipality is in agreement with the above and that the sewer drainage network of the new Mall@Piet Retief development can connect directly to the existing municipal outfall sewer pipeline south of the proposed new development.***

***Due to the urgent nature of the requested feedback as per above, confirmation needs to be obtained by latest closing of business coming Friday, 04 April 2014. If no feedback has been received by the said date, it will be assumed that the Mkhondo Local Municipality is in agreement with the above.***

You are welcome to contact us should you require any additional information.

Kind Regards

Kobus van Deventer
For and on behalf of
Sotiralis Consulting Engineers (Pty) Ltd

**MKHONDO** MUNICIPALITY MUNISIPALITEIT

Alle Korrespondensie moet gerig word aan DIE MUNISIPALE BESTUURDER

All Correspondence to be addressed to THE MUNICIPAL MANAGER

Navrae/Enquiries:
Bheki Bhengu

Verw./Ref.
Portion 100 (Ptn of Ptn 1) of Piet Retief Town and Townlands No. 149-HT

**DEPARTMENT OF CORPORATE SERVICES: TOWN PLANNING, HUMAN SETTLEMENTS AND BUILDING CONTROL**

**A. OWNER**

| | |
|---|---|
| NAME: | Mkhondo Municipality |

**B. DETAILS OF STAND**

| | |
|---|---|
| 1. STAND NUMBER: | Ptn 100 (Ptn of Ptn 1) of Piet Retief Town and Townlands No. 149-HT |
| 2. PHYSICAL LOCATION: | Brand Street |
| 3. TOWN: | Piet Retief |
| 4. SUBURB: | Piet Retief |
| 5. EXTENTION: | 0. |
| 6. AREA OF STAND: | 7, 0264 Hectares |

**C. DETAILS REGARDING DESTINATION AND CONDITIONS OF DEVELOPMENT OF ZONING**

| | |
|---|---|
| 1. CONSENT USE: | None |
| 2. ZONING: | Municipal |

**3. PRIMARY LAND USES:**

Municipal Purposes.

**4. SECONDARY LAND USE (with consent)**

Dwelling units, Residential buildings, Institutions, special uses, sports and recreation clubs

**5. PROHIBITED USE:**

Noxious industrial activities.

shopping centre

Check if it can be done by consent

6. PARKING REQUIREMENTS:

Adequate and paved parking, together with the necessary manoeuring area, shall be provided on the property for the Use Zones and uses to the satisfaction of the local authority.

| | |
|---|---|
| 7. FLOOR AREA RATIO (FAR): | Residential buildings 1,2 and other buildings 2,1 |
| 8. HEIGHT ZONE: | 0 |
| 9. COVERAGE: | Dwelling houses 50%, Residential buildings 40%, and Other buildings 75%. |
| 10. BUILDING LINES: | 5 metres along street boundaries and 2 metres on other boundaries. |

MR. BHEKI BHENGU
ADMIN CLERK TOWN PLANNING
MKHONDO MUNICIPALITY

15-11-2012
DATE

Ref: 3470 / 8.17 / 0077

31 March 2014

**Mkhondo Local Municipality**
Cnr. Market and De Wet Street
Piet Retief
2380

**Att:** Mr. Madubula Mabuza

**MALL@PIET RETIEF: SOLID WASTE REMOVAL**

Sotiralis Consulting Engineers (Pty) Ltd was appointed by Zarafusion (Pty) Ltd to administrate the design, monitoring and planning of the structural and civil engineering components for the proposed new Mall@Piet Retief shopping mall, situated on Portion 126 of Piet Retief town and Town lands 149HT.

Solid waste from the proposed new development will be collected on site and will be disposed of at the existing municipal landfill site.

***We herewith request confirmation that the Mkhondo Local Municipality is in agreement with the above and that the solid waste of the new Mall@Piet Retief can be disposed of into the existing municipal landfill site.***

***Due to the urgent nature of the requested feedback as per above, confirmation needs to be obtained by latest closing of business coming Friday, 04 April 2014. If no feedback has been received by the said date, it will be assumed that the Mkhondo Local Municipality is in agreement with the above.***

You are welcome to contact us should you require any additional information.

Kind Regards

Kobus van Deventer
For and on behalf of
Sotiralis Consulting Engineers (Pty) Ltd

SOTIRALIS CONSULTING ENGINEERS (PTY) LTD
Consulting Civil and Structural Engineers

Ref: 3470 / 8.17 / 0075

31 March 2014

**Mkhondo Local Municipality**
Cnr. Market and De Wet Street
Piet Retief
2380

**Att:** Mr. Madubula Mabuza

**MALL@PIET RETIEF: WATER SUPPLY**

Sotiralis Consulting Engineers (Pty) Ltd was appointed by Zarafusion (Pty) Ltd to administrate the design, monitoring and planning of the structural and civil engineering components for the proposed new Mall@Piet Retief shopping mall, situated on Portion 126 of Piet Retief town and Town lands 149HT.

As per the Guidelines for Human Settlement Planning and Design "RED BOOK" the estimated daily water demand for the proposed new shopping mall development will be as follows:

| LAND USE | COVERAGE | DAILY WATER DEMAND (AS PER THE "RED BOOK") | ESTIMATED EXPECTED WATER DEMEND |
|---|---|---|---|
| Special for Business (7.0254ha) | 60% | 400 litres per day / 100m² of gross floor area | 168.61 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | **168.61 Kℓ/day** |

The current estimated daily water demand, based on the existing land use rights of the property, can be summarized as follows (please refer to the attached document for a copy of the current, existing, land use rights of the property):

| LAND USE | COVERAGE | DAILY WATER DEMAND (AS PER THE "RED BOOK") | ESTIMATED CURRENT WATER DEMEND |
|---|---|---|---|
| Municipal (7.0254ha) | 75% | 400 litres per day / 100m² of gross floor area | 210.76 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | **210.76 Kℓ/day** |

As per the above it is evident that the estimated daily water demand for the new proposed development will be less than the current allocated daily water supply for the property as per the existing land use rights. We therefore foresee that the existing municipal bulk water supply to the area should be sufficient to supply the new proposed development with potable water.

The existing water supply point to the property will be utilized for the water connection to the new shopping centre and will be upgraded to a 160mmØ water connection and bulk water meter.

***We herewith request confirmation that the Mkhondo Local Municipality is in agreement with the above and that the water supply to the new Mall@Piet Retief development can be obtained from the existing municipal bulk water supply pipeline in the vicinity of the proposed new development.***

***Due to the urgent nature of the requested feedback as per above, confirmation needs to be obtained by latest closing of business coming Friday, 04 April 2014. If no feedback has been received by the said date, it will be assumed that the Mkhondo Local Municipality is in agreement with the above.***

You are welcome to contact us should you require any additional information.

Kind Regards

Kobus van Deventer
For and on behalf of
Sotiralis Consulting Engineers (Pty) Ltd

Tel: +27 12 991 0516
Fax: +27 12 991 0436

PO Box 1829
Faerie Glen
0043



info@sotiralis.co.za

MKHONDO MUNICIPALITY MUNISIPALITEIT

Alle Korrespondensie moet gerig word aan DIE MUNISIPALE BESTUURDER

All Correspondence to be addressed to THE MUNICIPAL MANAGER

Navrae/Enquiries:
Bheki Bhengu

Verw./Ref.
Portion 100 (Ptn of Ptn 1) of Piet Retief Town and Townlands No. 149-HT

DEPARTMENT OF CORPORATE SERVICES, TOWN PLANNING, HUMAN SETTLEMENTS AND BUILDING CONTROL

A. **OWNER**

NAME: Mkhondo Municipality

B. **DETAILS OF STAND**

1. STAND NUMBER: Ptn 100 (Ptn of Ptn 1) of Piet Retief Town and Townlands No. 149-HT
2. PHYSICAL LOCATION: Brand Street
3. TOWN: Piet Retief
4. SUBURB: Piet Retief
5. EXTENTION: 0.
6. AREA OF STAND: 7, 0254 Hectares

C. **DETAILS REGARDING DESTINATION AND CONDITIONS OF DEVELOPMENT OF ZONING**

1. CONSENT USE: None
2. ZONING: Municipal
3. PRIMARY LAND USES:

Municipal Purposes

4. SECONDARY LAND USE (with consent)

Dwelling units, Residential buildings, Institutions, special uses, sports and recreation clubs

Shopping centre

5. PROHIBITED USE:

Noxious industrial activities.

Check if it can be done by consent

(017) 826 8100 (017) 826 3129/8102 23 Piet Retief 2380

**6. PARKING REQUIREMENTS:**

Adequate and paved parking, together with the necessary manoeuring area, shall be provided on the property for the Use Zones and uses to the satisfaction of the local authority.

| | |
|---|---|
| **7. FLOOR AREA RATIO (FAR):** | Residential buildings 1,2 and other buildings 2,1 |
| **8. HEIGHT ZONE:** | 0 |
| **9. COVERAGE:** | Dwelling houses 50%, Residential buildings 40%, and Other buildings 75%. |
| **10. BUILDING LINES:** | 5 metres along street boundaries and 2 metres on other boundaries. |

**MR. BHEKI BHENGU**
**ADMIN CLERK TOWN PLANNING**
**MKHONDO MUNICIPALITY**

15-11-2012
**DATE**

SOTIRALIS CONSULTING ENGINEERS (PTY) LTD
Consulting Civil and Structural Engineers

Ref: 3470 / 8.17 / 0074

24 March 2014

**Mkhondo Local Municipality**
Cnr. Market and De Wet Street
Piet Retief
2380

**Att:** Mr. Madubula Mabuza

**MALL@PIET RETIEF: WATER DEMANDS AND SEWERAGE FLOWS**

Sotiralis Consulting Engineers (Pty) Ltd was appointed by Zarafusion (Pty) Ltd to administrate the design, monitoring and planning of the structural and civil engineering components for the proposed new Mall@Piet Retief shopping mall, situated on Portion 126 of Piet Retief town and Town lands 149HT, and the proposed new Municipal structures on a Portion of Portion 123 of Piet Retief Town and Town lands 149HT.

The purpose of this letter is to give an indication to the local council of the expected estimated sewerage flows and water demands of the proposed new developments on the above mentioned properties. An indication will also be given on the estimated existing water demands and sewerage flows based on the current land uses.

The following is a summary of the estimated existing water demands and sewerage flows based on the current land uses:

| PROPOSED DEVELOPMENT SITE | EXISTING LAND USE | EXISTING COVERAGE USES | DAILY WATER DEMAND & SEWERAGE FLOW | ESTIMATED EXISTING WATER DEMEND & SEWERAGE FLOW |
|---|---|---|---|---|
| **ESTIMATED EXISTING DAILY WATER DEMAND** | | | | |
| Mall site | Municipal (7.0254ha) | 75% | 400 litres per day / 100m² of gross floor area | 210.76 Kℓ/day |
| New Municipal Site | Public open Space | N/A | N/A | 0.00 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | | **210.76 Kℓ/day** |
| **ESTIMATED EXISTING DAILY SEWERAGE FLOWS** | | | | |
| Mall site | Municipal (7.0254ha) | 75% | 400 litres per day / 100m² of gross floor area | 210.76 Kℓ/day |
| New Municipal Site | Public open Space | N/A | N/A | 0.00 Kℓ/day |
| **TOTAL ESTIMATED DAILY SEWERAGE FLOWS** | | | | **210.76 Kℓ/day** |

An existing Municipal outfall sewer pipeline, of which the size is unknown at this stage, is located along the southern boundary of the proposed new development. According to the survey obtained from the site it seems that the capacity of this pipeline can be estimated as follows for different pipe sizes:

- 160mmØ Pipe : ± 20ℓ/s @ 80% Capacity
- 200mmØ Pipe : ± 60ℓ/s @ 80% Capacity
- 300mmØ Pipe : ± 128ℓ/s @ 80% Capacity

The following is a summary of the expected estimated water demands and sewerage flows for the proposed new developments:

| PROPOSED DEVELOPMENT SITE | NEW LAND USE | COVERAGE | DAILY WATER DEMAND & SEWERAGE FLOW | ESTIMATED EXPECTED WATER DEMEND & SEWERAGE FLOW |
|---|---|---|---|---|
| **ESTIMATED DAILY WATER DEMAND** | | | | |
| Mall site | Special for Business (7.0254ha) | 60% | 400 litres per day / 100m² of gross floor area | 168.61 Kℓ/day |
| New Municipal Site | Municipal | Building Area: ±588m² | 400 litres per day / 100m² of gross floor area | 2.35 Kℓ/day |
| **TOTAL ESTIMATED DAILY WATER DEMEND** | | | | **170.96 Kℓ/day** |
| **ESTIMATED DAILY SEWERAGE FLOWS** | | | | |
| Mall site | Special for Business (7.0254ha) | 60% | 400 litres per day / 100m² of gross floor area | 168.61 Kℓ/day |
| New Municipal Site | Municipal | Building Area: ±588m² | 400 litres per day / 100m² of gross floor area | 2.35 Kℓ/day |
| **TOTAL ESTIMATED DAILY SEWERAGE FLOWS** | | | | **170.96 Kℓ/day** |

All above calculations are based on the requirements as per the Guidelines for Human Settlement Planning and Design "RED BOOK".

You are welcome to contact us should you require any additional information.

Kind Regards

Kobus van Deventer
For and on behalf of
Sotiralis Consulting Engineers (Pty) Ltd

Tel: +27 12 991 0516
Fax: +27 12 991 0436

PO Box 1829
Faerie Glen
0043

MKHONDO MUNICIPALITY MUNISIPALITEIT

Alle Korrespondensie moet gerig word aan DIE MUNISIPALE BESTUURDER

All Correspondence to be addressed to THE MUNICIPAL MANAGER

Your Ref : 3470/8.17/0075, 0076and 0077

Your Ref : 16/2/4

Date : 09 April 2014

Sotiralis Consulting Engineers (Pty) Ltd

Faerie Glen

0043

Attention : Kobus Van Deventer

**RE: SERVICES AT MKHONDO LOCAL MUNICIPALITY: (1).WATER SUPPLY (2).SEWER CONNECTION AND (3).SOLID WASTE REMOVAL.**

The above subject together with your references cited above refers.

We write to confirm receipt of letters with the above cited references. The Municipality is not in a position to confirm the information contained in the letters you forwarded us at this stage.

The municipality, together with objectors, is conducting hearings for this project, we therefore cannot entertain queries about the project pending the outcome of the hearing. Further, we noted your assumption and or inference you are planning to draw.

The municipality, as already mentioned above, feels the need to expressly refute and or renounce, as we hereby do, itself from the assumption you drew and or about to draw regarding solid waste removal, sewer connection and water supply for the project.

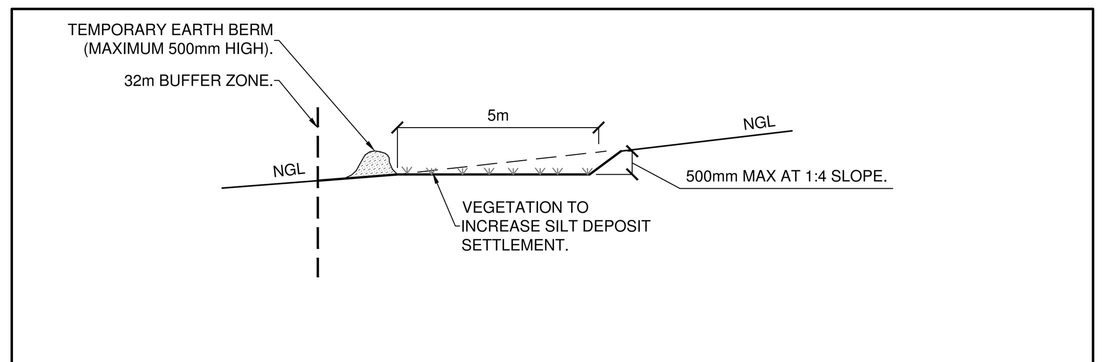
We trust the above is in order.

Yours faithfully

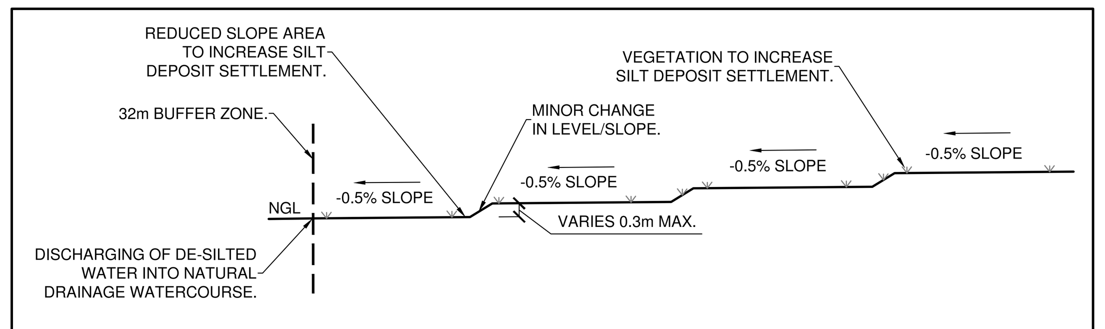
**A.N Mahlangu**

**Municipal Manager**


STORMWATER MANAGEMENT LAYOUT (CONSTRUCTION PHASE)
SCALE 1:500




TYPICAL CROSS SECTION THROUGH TEMPORARY DRAINAGE CHANNEL
NOT TO SCALE




TYPICAL LONGSECTION THROUGH TEMPORARY DRAINAGE CHANNEL
NOT TO SCALE

## NOTES:

1. ALL MATERIAL AND WORKMANSHIP MUST COMPLY WITH THE REQUIREMENTS OF THE LATEST RELEVANT SANS CODES.
2. ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE INDICATED.
3. DO NOT SCALE FROM THIS DRAWING.
4. ALL DIMENSIONS AND SETTING OUT POINTS MUST BE CHECKED AND APPROVED ON SITE BEFORE CONSTRUCTION COMMENCES.
5. FINAL POSITION OF EXISTING SERVICES TO BE CONFIRMED ON SITE BY CONTRACTOR.
6. ALL EXISTING SERVICES TO BE EXPOSED BY HAND EXCAVATION AND INVERT LEVELS TO BE PROVIDED TO THE ENGINEER IN WRITING BEFORE CONSTRUCTION COMMENCES.
7. ALL STORMWATER PIPES SHALL BE A MINIMUM 450mm DIAMETER INTERLOCKING JOINT CLASS 50D AND SHALL COMPLY WITH SANS 677, UNLESS OTHERWISE INDICATED.
8. CONCRETE PRECAST MANHOLES TO BE SEALED WATERTIGHT WITH EPOXY SEALER SUCH AS EPIDERMIX 344 OR PRO-STRUCT 687.
9. ENGINEER OR THE ENGINEER'S REPRESENTATIVE TO BE INVITED FOR INSPECTIONS ACCORDING TO SCE CIVIL ENGINEERING INSPECTION NOTIFICATION REQUIREMENTS.
10. CLEAN EXISTING STORMWATER INLETS AND REPAIR WHERE NECESSARY (IF APPLICABLE).
11. KERB INLET STRUCTURES (STEEL FRAME AND PRECAST COVERS), TO COMPLY WITH SCE STANDARD DRAWING SCE-SW001/002/003.
12. ALL STORMWATER JUNCTION BOX, MANHOLE AND COVER SLAB DETAILS TO COMPLY WITH SCE STANDARD DRAWING SCE-SW003/004/005/006/007.
13. ALL STORMWATER PIPE TRENCHES, BEDDING AND BACKFILLING TO COMPLY WITH SCE STANDARD DRAWING SCE-SW009.
14. MINIMUM FALL THROUGH ANY MANHOLE IS 80mm, UNLESS OTHERWISE INDICATED.
15. ALL STORMWATER PIPES TO BE LAID SOFFIT TO SOFFIT.
16. CONTRACTOR TO COMPLY WITH THE OCCUPATIONAL HEALTH AND SAFETY ACT (85 OF 1993), THE CONSTRUCTION REGULATIONS OF 2014 AND ALL RELEVANT REGULATIONS AS WELL AS THEIR AMENDMENTS.
17. CONTRACTOR TO IMMEDIATELY REPORT ANY DAMAGE TO EXISTING SERVICES IN WRITING TO THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
18. ON COMPLETION OF STORMWATER INSTALLATION, CONTRACTOR TO PROVIDE COMPLETE AS-BUILT INFORMATION TO THE ENGINEER.

## LEGEND:

| | |
|---|---|
| SW | PROPOSED STORMWATER LINE |
| EXSW | EXISTING STORMWATER LINE |
| MH | PROPOSED MANHOLE |
| EXMH | EXISTING MANHOLE |
| JB | PROPOSED JUNCTION BOX |
| EXJB | EXISTING JUNCTION BOX |
| JBMH | PROPOSED JUNCTION BOX WITH MANHOLE |
| EXJBMH | EXISTING JUNCTION BOX WITH MANHOLE |
| GI | PROPOSED GRID INLET |
| EXGI | EXISTING GRID INLET |
| LGI | PROPOSED LONG GRID INLET |
| EXLGI | EXISTING LONG GRID INLET |
| FI | PROPOSED FIELD INLET |
| EXFI | EXISTING FIELD INLET |
| KI | PROPOSED KERB INLET |
| EXKI (0/0/0) | EXISTING KERB INLET |
| | TRANSITION LENGTH UPSTREAM (US) |
| | CATCHPIT LENGTH (CP) |
| | TRANSITION LENGTH DOWNSTREAM (DS) |
| | FLOW DIRECTION OF STORMWATER |
| 2% | PERCENTAGE AND DIRECTION OF ROAD SLOPE |
| VAL | STORMWATER VALLEY LINE |
| SUB | STORMWATER SUBSOIL LINE |
| | ERF BOUNDARY |
| 100L | 1:100 YEAR FLOODLINE |
| | BENCHMARK |
| SWXXX | STORMWATER SETTING OUT POINT |
| | PROPOSED BUILDING |
| | VEGETATION |
| | EARTH BERM |

## REFERENCE DRAWINGS:

3470-BM-L01 BENCHMARK LAYOUT PLAN

ALL WORK TO SANS 1200

| NO | DATE | DESCRIPTION | DESIGN | DRAWN |
|---|---|---|---|---|
| A | 2014-11-14 | FOR INFORMATION | KVD | SC |

SOTIRALIS CONSULTING ENGINEERS (PTY) LTD
Consulting Civil And Structural Engineers
PO BOX 1829 FAERIE GLEN 0043 TELEPHONE (012) 991 0516
admin@sotiralis.co.za FACSIMILE (012) 991 0436

CLIENT:
ANAPROP PROPERTY MANAGEMENT

PROJECT:
MALL@PIET RETIEF
PORTION 126
PIET RETIEF

DRAWING TITLE:
STORMWATER MANAGEMENT LAYOUT PLAN (CONSTRUCTION PHASE)

| DATE: | SCALE: | DRAWN: |
|---|---|---|
| 2014-11-13 | AS SHOWN | S CHAMBERS |
| DESIGNED: | CHECKED: | REVISION NUMBER: |
| K VAN DEVENTER | S SOTIRALIS | A |

DRAWING NUMBER: 3470-SW-L02
FOR: INFORMATION


STORMWATER LAYOUT
SCALE 1:500

## NOTES:

1. ALL MATERIAL AND WORKMANSHIP MUST COMPLY WITH THE REQUIREMENTS OF THE LATEST RELEVANT SANS CODES.
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6. ALL EXISTING SERVICES TO BE EXPOSED BY HAND EXCAVATION AND INVERT LEVELS TO BE PROVIDED TO THE ENGINEER IN WRITING BEFORE CONSTRUCTION COMMENCES.
7. ALL STORMWATER PIPES SHALL BE A MINIMUM 450mm DIAMETER INTERLOCKING JOINT CLASS 50D AND SHALL COMPLY WITH SANS 677, UNLESS OTHERWISE INDICATED.
8. CONCRETE PRECAST MANHOLES TO BE SEALED WATERTIGHT WITH EPOXY SEALER SUCH AS EPIDERMIX 344 OR PRO-STRUCT 687.
9. ENGINEER OR THE ENGINEER'S REPRESENTATIVE TO BE INVITED FOR INSPECTIONS ACCORDING TO SCE CIVIL ENGINEERING INSPECTION NOTIFICATION REQUIREMENTS.
10. CLEAN EXISTING STORMWATER INLETS AND REPAIR WHERE NECESSARY (IF APPLICABLE).
11. KERB INLET STRUCTURES (STEEL FRAME AND PRECAST COVERS), TO COMPLY WITH SCE STANDARD DRAWING SCE-SW001/002/003.
12. ALL STORMWATER JUNCTION BOX, MANHOLE AND COVER SLAB DETAILS TO COMPLY WITH SCE STANDARD DRAWING SCE-SW003/004/005/006/007.
13. ALL STORMWATER PIPE TRENCHES, BEDDING AND BACKFILLING TO COMPLY WITH SCE STANDARD DRAWING SCE-SW009.
14. MINIMUM FALL THROUGH ANY MANHOLE IS 80mm, UNLESS OTHERWISE INDICATED.
15. ALL STORMWATER PIPES TO BE LAID SOFFIT TO SOFFIT.
16. CONTRACTOR TO COMPLY WITH THE OCCUPATIONAL HEALTH AND SAFETY ACT (85 OF 1993), THE CONSTRUCTION REGULATIONS OF 2014 AND ALL RELEVANT REGULATIONS AS WELL AS THEIR AMENDMENTS.
17. CONTRACTOR TO IMMEDIATELY REPORT ANY DAMAGE TO EXISTING SERVICES IN WRITING TO THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
18. ON COMPLETION OF STORMWATER INSTALLATION, CONTRACTOR TO PROVIDE COMPLETE AS-BUILT INFORMATION TO THE ENGINEER.

## LEGEND:

| | |
|---|---|
| SW | PROPOSED STORMWATER LINE |
| EXSW | EXISTING STORMWATER LINE |
| MH | PROPOSED MANHOLE |
| EXMH | EXISTING MANHOLE |
| JB | PROPOSED JUNCTION BOX |
| EXJB | EXISTING JUNCTION BOX |
| JBMH | PROPOSED JUNCTION BOX WITH MANHOLE |
| EXJBMH | EXISTING JUNCTION BOX WITH MANHOLE |
| GI | PROPOSED GRID INLET |
| EXGI | EXISTING GRID INLET |
| LGI | PROPOSED LONG GRID INLET |
| EXLGI | EXISTING LONG GRID INLET |
| FI | PROPOSED FIELD INLET |
| EXFI | EXISTING FIELD INLET |
| KI | PROPOSED KERB INLET |
| EXKI (0/0/0) | EXISTING KERB INLET |
| | TRANSITION LENGTH UPSTREAM (US) |
| | CATCHPIT LENGTH (CP) |
| | TRANSITION LENGTH DOWNSTREAM (DS) |
| | FLOW DIRECTION OF STORMWATER |
| 2% | PERCENTAGE AND DIRECTION OF ROAD SLOPE |
| VAL | STORMWATER VALLEY LINE |
| SUB | STORMWATER SUBSOIL LINE |
| | ERF BOUNDARY |
| 100L | 1:100 YEAR FLOODLINE |
| | BENCHMARK |
| SWXXX | STORMWATER SETTING OUT POINT |
| | PROPOSED BUILDING |

## REFERENCE DRAWINGS:

3470-BM-L01 BENCHMARK LAYOUT PLAN
3470-SW-LS01 STORMWATER LONGSECTIONS

ALL WORK TO SANS 1200

| NO | DATE | DESCRIPTION | DESIGN | DRAWN |
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| A | 2014-11-13 | FOR INFORMATION | KVD | SC |


SOTIRALIS CONSULTING ENGINEERS (PTY) LTD
Consulting Civil And Structural Engineers
PO BOX 1829 FAERIE GLEN 0043 TELEPHONE (012) 991 0516
admin@sotiralis.co.za FACSIMILE (012) 991 0436


CLIENT:
ANAPROP PROPERTY MANAGEMENT

PROJECT:
MALL@PIET RETIEF
PORTION 126
PIET RETIEF

DRAWING TITLE:
STORMWATER
LAYOUT PLAN

| DATE: | SCALE: | DRAWN: |
|---|---|---|
| 2014-11-07 | AS SHOWN | S CHAMBERS |
| DESIGNED: | CHECKED: | REVISION NUMBER: |
| K VAN DEVENTER | S SOTIRALIS | A |

DRAWING NUMBER: 3470-SW-L01
FOR: INFORMATION


## NOTES:

1. ALL MATERIAL AND WORKMANSHIP MUST COMPLY WITH THE REQUIREMENTS OF THE LATEST RELEVANT SANS CODES.
2. ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE INDICATED.
3. DO NOT SCALE FROM THIS DRAWING.
4. ALL SETTING OUT POINTS TO BE CHECKED AND CONFIRMED BEFORE ANY CONSTRUCTION COMMENCES. ANY DISCREPANCIES TO BE BROUGHT TO THE ENGINEER'S IMMEDIATE ATTENTION IN WRITING.
5. FINAL POSITION OF EXISTING SERVICES TO BE CONFIRMED ON SITE BY CONTRACTOR.
6. ALL EXISTING SERVICES TO BE EXPOSED BY HAND EXCAVATION AND INVERT LEVELS TO BE PROVIDED TO THE ENGINEER IN WRITING BEFORE CONSTRUCTION COMMENCES.
7. ALL SEWER PIPES SHALL BE A MINIMUM 110mm DIAMETER TWIN WALL UNPLASTICIZED POLYVINYL CHLORIDE (uPVC) CLASS 34 400kPa STIFFNESS AND SHALL COMPLY WITH SANS 1601, UNLESS OTHERWISE INDICATED.
8. CONCRETE PRECAST MANHOLES TO BE SEALED WATERTIGHT WITH EPOXY SEALER SUCH AS EPIDERMIX 344 OR PRO-STRUCT 687.
9. ENGINEER OR THE ENGINEER'S REPRESENTATIVE TO BE INVITED FOR INSPECTIONS ACCORDING TO SCE CIVIL ENGINEERING INSPECTION NOTIFICATION REQUIREMENTS.
10. ALL SEWER MANHOLES, MANHOLE COVERS AND MANHOLE FRAMES TO COMPLY WITH SCE STANDARD DRAWING SCE-SE001.
11. POSITION OF "CALAMITE" STEP IRONS OR SIMILAR APPROVED STEP IRONS IN ACCORDANCE WITH SCE STANDARD DRAWING SCE-SE001.
12. ALL SEWER PIPE TRENCHES AND BEDDING TO COMPLY WITH SCE STANDARD DRAWING SCE-SE002.
13. SEWER HOUSE CONNECTION DETAILS AND HOUSE CONNECTION MARKER BLOCKS TO COMPLY WITH SCE STANDARD DETAIL DRAWING SCE-SE003.
14. MINIMUM FALL THROUGH ANY MANHOLE IS 80mm, UNLESS OTHERWISE INDICATED.
15. SEWER PIPE LEVELS AT CONNECTIONS BETWEEN VARIOUS DIAMETER PIPES TO BE LAID INVERT TO INVERT.
16. ALL SEWERS TO BE AIR TESTED, ACCORDING TO THE SANS 1200, IN THE PRESENCE OF THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
17. CONTRACTOR TO COMPLY WITH THE OCCUPATIONAL HEALTH AND SAFETY ACT (85 OF 1993), THE CONSTRUCTION REGULATIONS OF 2014 AND ALL RELEVANT REGULATIONS AS WELL AS THEIR AMENDMENTS.
18. CONTRACTOR TO IMMEDIATELY REPORT ANY DAMAGE TO EXISTING SERVICES IN WRITING TO THE ENGINEER OR THE ENGINEER'S REPRESENTATIVE.
19. CONCRETE ANCHOR BLOCKS TO BE PROVIDED ON SEWERS WITH SLOPES OF 1:6 OR STEEPER TO ENGINEER'S DETAIL.
20. ON COMPLETION OF SEWER INSTALLATION, CONTRACTOR TO PROVIDE COMPLETE AS-BUILT INFORMATION TO THE ENGINEER.

## LEGEND:

| | |
|---|---|
| SEWER | PROPOSED SEWER LINE |
| EXSEWER | EXISTING SEWER LINE |
| MH | PROPOSED MANHOLE |
| EXMH | EXISTING MANHOLE |
| CE | PROPOSED CLEANING EYE |
| EXCE | EXISTING CLEANING EYE |
| LH | PROPOSED LAMP HOLE |
| EXLH | EXISTING LAMP HOLE |
| | ERF BOUNDARY |
| 100L | 1:100 YEAR FLOODLINE |
| | BENCHMARK |
| SEXXX | SEWER SETTING OUT POINT |
| | PROPOSED BUILDING |

## REFERENCE DRAWINGS:

3470-BM-L01 BENCHMARK LAYOUT PLAN
3470-SE-LS01 SEWER LONGSECTIONS

ALL WORK TO SANS 1200

| NO | DATE | DESCRIPTION | DESIGN | DRAWN |
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| A | 2014-11-13 | FOR INFORMATION | KVD | SC |

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CLIENT: ANAPROP PROPERTY MANAGEMENT

PROJECT: MALL@PIET RETIEF PORTION 126 PIET RETIEF

DRAWING TITLE: SEWER LAYOUT PLAN OPTION A

| DATE: | SCALE: | DRAWN: |
|---|---|---|
| 2014-11-07 | AS SHOWN | S CHAMBERS |
| DESIGNED: | CHECKED: | REVISION NUMBER: |
| K VAN DEVENTER | S SOTIRALIS | A |

DRAWING NUMBER: 3470-SE-L01
FOR: INFORMATION


SEWER LAYOUT
SCALE 1:500

## NOTES:

1. ALL MATERIAL AND WORKMANSHIP MUST COMPLY WITH THE REQUIREMENTS OF THE LATEST RELEVANT SANS CODES.
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3. DO NOT SCALE FROM THIS DRAWING.
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## LEGEND:

| | |
|---|---|
| SEWER | PROPOSED SEWER LINE |
| EXSEWER | EXISTING SEWER LINE |
| MH | PROPOSED MANHOLE |
| EXMH | EXISTING MANHOLE |
| CE | PROPOSED CLEANING EYE |
| EXCE | EXISTING CLEANING EYE |
| LH | PROPOSED LAMP HOLE |
| EXLH | EXISTING LAMP HOLE |
| | ERF BOUNDARY |
| 100L | 1:100 YEAR FLOODLINE |
| | BENCHMARK |
| SEXXX | SEWER SETTING OUT POINT |
| | PROPOSED BUILDING |

## REFERENCE DRAWINGS:

3470-BM-L01 BENCHMARK LAYOUT PLAN
3470-SE-LS01 SEWER LONGSECTIONS

ALL WORK TO SANS 1200

| NO | DATE | DESCRIPTION | DESIGN | DRAWN |
|---|---|---|---|---|
| A | 2014-11-13 | FOR INFORMATION | KVD | SC |

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CLIENT:
ANAPROP PROPERTY MANAGEMENT

PROJECT:
MALL@PIET RETIEF
PORTION 126
PIET RETIEF

DRAWING TITLE:
SEWER LAYOUT
PLAN OPTION B

| DATE: | SCALE: | DRAWN: |
|---|---|---|
| 2014-11-07 | AS SHOWN | S CHAMBERS |
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DRAWING NUMBER: 3470-SE-L02
FOR: INFORMATION

# Appendix D5:

## Traffic Impact Study

TECHWORLD
consulting ENGINEERS

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Cnr Glenmore & Glenwood Rd
Lynnwood Glen
South Africa

<< PO Box 12530
Hatfield
0028
South Africa

Traffic Engineering
Transportation Planning
Transport Economy
Project Management
Project Financing & Viability

# TRAFFIC IMPACT STUDY

## PIET RETIEF SHOPPING CENTRE

## MKHONDO MUNICIPALITY, MPUMALANGA

November 2013

# APPLICATION TO ROAD AUTHORITY

| | |
|---|---|
| OUR REFERENCE | REP01/TW646/01Nov13 |
| DATE | 01 November 2013 |
| AGENCY | Mkhondo Municipality |
| THE MANAGER | Municipal Manager |
| ADDRESS | PO Box 23, Piet Retief, 2380 |
| FOR ATTENTION | Mr Absalom N. Mahlangu |
| SUBJECT | TRAFFIC IMPACT STUDY FOR NEW PIET RETIEF SHOPPING CENTRE |

A new township is planned on Portion 126 (of Portion 100) of Piet Retief Town and Townlands 149-HT in the CBD of Piet Retief for commercial development ("Business 1") for a potential of 39,000 $m^2$ GLA that includes a shopping centre of maximum 25,000 $m^2$ GLA. The existing Municipal Buildings on the site will be relocated to a new site in Gerard Bohmer Road. Since the existing peak hour trip generation of the Municipal Buildings is negligible, the impact of the relocation was not addressed in this traffic impact study.

The primary access to the development is proposed from Brand Street opposite Kotze Street while a secondary access is proposed as a marginal access from Church Street (left-in and left-out).

No other large properties with existing undeveloped land use rights are known in the study area. An average to high traffic growth rate of 4.0% p.a. for the 5 year study period was assumed to account for growth in background traffic and any unknown latent land use rights.

The traffic impact study shows that the existing road network can accommodated the new development with relative ease. Mitigation measures are however required on the road network that provides access to the development and that borders the application site.

Improvements are recommended at the Church (N2) / Brand intersection (additional lanes and signalization), the Kotze / Brand intersection (additional lanes), the Church (N2) / Marginal Access intersection (additional lanes and widening to accommodate a physical curb median), and Church (N2) / Gerard Bohmer intersection (additional lanes and signalization).

The construction of taxi- / bus loading bays are also recommended along both sides of Church Street (N2) directly south of the intersection with Brand Street.

This comprehensive traffic impact study has determined the required mitigation measures for the township which are shown in *Figure 8: Required Road Improvements In Study Area.*

Your consideration and approval of this traffic impact study at your earliest convenience is hereby requested. Please do not hesitate to contact us (Pieter Kruger – 083 447 9961 / 012 348 0386) immediately for any discussions or enquiries.

Kind Regards

Pieter Kruger for TECHWORLD

# TABLE OF CONTENTS

# TABLE OF TABLES

# TABLE OF FIGURES



# TABLE OF APPENDICES

# TITLE PAGE OF REPORT

| | |
|---|---|
| TITLE OF REPORT | Traffic Impact Study: New Piet Retief Shopping Centre, Mkhondo Municipality, Mpumalanga Province. |
| DESCRIPTION | This traffic impact study evaluates the traffic impact of a new community shopping centre in Piet Retief |

| DATE | STATUS OF REPORT |
|---|---|
| November 2013 | Final Report |
| **CLIENTS** | **TOWN PLANNER** |
| SOUTHERN PALACE INVESTMENTS (Pty) Ltd<br>t/a Anaprop Property Management<br>Mr Yanni Anastasiadis<br>Tel: +2712 656 8957<br>Fax: +2712 656 8959 | NUPLAN DEVELOPMENT PLANNERS<br>Martin Strydom<br>Tel: +27 13 752 3422<br>Fax: +27 13 752 5795 |
| **PROJECT NUMBER** | **REPORT NUMBER** |
| TW646 | REP01/TW646/01Nov13 |
| **POSTAL ADDRESS** | **PHYSICAL ADDRESS** |
| PO Box 12530<br>Hatfield, 0028<br>Tel: (012) 998 3541<br>Fax: (012) 993 5506 | 78 Glenmore Street<br>C/O Glenmore & Glenwood Streets<br>Lynnwood Glen<br>Email: admin@techworld.co.za |
| **PROJECT TEAM** | **COPYRIGHT** |
| P Kruger, J Daling, MM Wilson | TECHWORLD |

| # 1 APPLICATION | ***Description of the application and property in terms of location, extent, current, and future usage*** | |
|---|---|---|
| **THE TYPE OF LAND USE APPLICATION IS THE FOLLOWING** | | |
| Type of Application | New township application for commercial development ("Business 1") in the CBD of Piet Retief for 39,000 $m^2$ GLA that includes a shopping centre of 25,000 $m^2$ GLA. | Refer to: *Figure 1: Locality Plan* |
| **THE LOCATION OF THE SITE IN TERMS OF THE PROPERTY DESCRIPTION IS THE FOLLOWING** | | |
| Portion | Portion 126 (of Portion 100) | Refer to: *Appendix A: Site Layout Plan* |
| Farm | Piet Retief Town and Townlands 149-HT | |
| **THE LOCATION OF THE SITE IN TERMS OF BORDERING AND/OR NEIGHBOURING ROADS ARE THE FOLLOWING** | | |
| Roads to the North | Brand Street (R543 East) | Directly bordering |
| Roads to the East | None | |
| Roads to the South | Gerard Bohmer Road | Not directly bordering |
| Roads to the West | Church Street (N2) | Directly bordering |
| **THE SIZE AND/OR EXTENT OF THE SITE IS THE FOLLOWING** | | |
| Extent of Total Property | ±6.50ha | |
| **THE EXISTING ZONING IS THE FOLLOWING** | | |
| Zoning | "Municipal" | |
| **THE EXISTING USAGE OF THE SITE IS THE FOLLOWING** | | |
| Usage | Municipal Buildings. The existing Municipal Buildings will be relocated to a new site in Gerard Bohmer Road near the Cemetery. | |

| THE REQUIRED ZONING AND EXTENT IS THE FOLLOWING | |
|---|---|
| Required Zoning<br>(*refer to the Township Application for details on the development controls*) | "Business 1" -<br>- FAR = 0.60<br>- Maximum Coverage = 80%<br>- Maximum Height = 3 storeys<br>- Parking = 2 bays / 100 m² GLA |
| | The allowable floor area is thus 39,011.4 m² of which the shopping centre will be limited to a maximum GLA of 25,000 m². The following development scenario was subsequently investigated from a traffic perspective:<br>Shopping Centre 25000 m²<br>Motor Dealerships 3500 m²<br>Offices 3500 m²<br>Mini Storage 3500 m²<br>Bulk Trade Centre 3500 m² |

| THE STUDY AREA AND TOWNSHIP LAYOUT IS SHOWN ON THE ATTACHED PLANS | | |
|---|---|---|
| Study Area | | Refer to:<br>*Figure 2: Study Area*<br>*Appendix A: Site Layout Plan* |

# 2 METHODOLOGY

***The approach and methodology followed in the execution of this study is described in this section***

| THE FOLLOWING GENERAL APPROACH AND METHODOLOGY WAS UTILIZED | |
|---|---|
| Guidelines | Guidelines contained in SA Manual for Traffic Impact Studies PR93/635,1995 |

| THE FOLLOWING TECHNICAL METHODOLOGY AND SOFTWARE WAS UTILIZED |
|---|

| | | |
|---|---|---|
| Traffic Impact Analysis Software | VISTRO 2.0 | Refer to: *Figure 3: Traffic Model (VISTRO)* |
| Capacity and Operational Analysis Software | Latest HCM2010 methodology | |
| **THE FOLLOWING CRITICAL PEAK HOURS WERE ANALYZED** | | |
| Critical Design Peak Hours | Weekday PM Peak Hour | |
| | Saturday AM Peak Hour | |
| **THE STUDY PERIOD FOR THE DEVELOPMENT IS THE FOLLOWING** | | |
| Base Year (Existing Situation) | 2013 | |
| Study Period | 5 years | |
| Horizon Year (Future Situation) | 2018 | 2013 plus 5 years |
| **THE FOLLOWING PLANNED ROAD NETWORK ALTERNATIVES WERE INVESTIGATED** | | |
| Network alternatives | None | |
| **THE FOLLOWING SCENARIOS WERE ANALYZED** | | |
| Scenario 1 | Existing 2013 peak hours. | Existing road network. |
| Scenario 2 | Expected 2018 peak hours with growth in background traffic. | Existing road network. |
| Scenario 3 | Expected 2018 peak hours with growth in background traffic and with full application. | Existing road network. |
| Scenario 4 | Expected 2018 peak hours with growth in background traffic and with full application. | Required mitigation measures to support application. |

| THE FOLLOWING TRAFFIC AND OTHER REPORTS WERE TAKEN INTO ACCOUNT | |
|---|---|
| Available reports | *Feasibility Study Update, Retail Development, Piet Retief Mpumalanga, October 2013, FERNRIDGE, October 2013* |

# 3 STUDY AREA AND NETWORK

***This section describes the identification of an appropriate study area, and the characteristics of the network included in the study area.***

## 3.1 LATENT DEVELOPMENT RIGHTS AND COMMITTED ROAD IMPROVEMENTS IN THE AREA

| THE FOLLOWING LATENT (EXISTING AND UNDEVELOPED) LAND USE RIGHTS EXIST IN THE STUDY AREA | | |
|---|---|---|
| Approved Land Use Rights | No other large properties with existing undeveloped land use rights (i.e. latent rights) are known in the study area. | Refer to: *Figure 1: Locality Plan* |
| Growth in Background Traffic | An average to high traffic growth rate of 4.0% p.a. for the 5 year study period was assumed to account for growth in background traffic and any unknown latent land use rights. | |

| THE FOLLOWING ROAD NETWORK IMPROVEMENTS ARE COMMITTED AND/OR PLANNED IN THE STUDY AREA | |
|---|---|
| Committed / Planned Road Improvements | None. |

## 3.2 STUDY AREA

**THE STUDY AREA WAS DETERMINED BASED ON THE FOLLOWING**

| | | |
|---|---|---|
| The Layout of The Current Road Network Influences the Required Study Area | Major roads such as Church (N2), Piet Retief (R543), and Brand (R543) will distribute traffic in north-south and east-west directions. | |
| The Expected Trip Distribution Influences the Required Study Area | The primary and secondary markets for the planned development were obtained from the Market Study by FERNRIDGE. | |
| The Extent of the Trip Generation Influences the Required Study Area | The expected primary (new) vehicle trip generation for the application is about 857 and 1612 vehicle trips during the Weekday PM and the Saturday AM peak hours, respectively. | |
| **THE FOLLOWING INTERSECTIONS WERE INCLUDED IN THE STUDY AREA (THE EXISTING TYPE OF TRAFFIC CONTROL IS ALSO INDICATED)** | | |
| Intersection 1 | Church (N2) / Theo Mocke | Two-way Stop |
| Intersection 2 | Church (N2) / Smit | Traffic Signals |
| Intersection 3 | Church (N2) / Piet Retief (R543)-Kruger | Traffic Signals |
| Intersection 4 | Church (N2) / Retief | Traffic Signals |
| Intersection 5 | Church (N2) / Brand (R543) | One-way Stop |
| Intersection 6 | Church (N2) / Gerard Bohmer | Two-way Stop |
| Intersection 7 | Kotze – Primary Access Piet Retief Mall / Brand (R543) | All-way Stop |
| Intersection 8 | Pretorius / Brand (R543) | One-way Stop |
| Intersection 9 | Von Brandis / Brand (R543) | All-way Stop |
| Intersection 10 | Church (N2) / Secondary Access Piet Retief Mall | Planned One-way Stop |
| **THE LAYOUT OF THE INTERSECTIONS IN THE STUDY AREA IS INDICATED SCHEMATICALLY ON THE ATTACHED FIGURE** | | |

| | | |
|---|---|---|
| Existing Road Network | | Refer to:<br>*Figure 4: Existing Road Network and Lane Layout* |

## 3.3 ROAD NETWORK DESCRIPTION

| | | |
|---|---|---|
| **ROAD NETWORK PLANNING IN AREA** | | |
| Road Network Planning | *None* | |
| **THE REGIONAL ACCESSIBILITY OF THE SITE IS PROVIDED BY THE FOLLOWING ROAD NETWORK** | | |
| N2 (Church Street), R543 West (Piet Retief Street), R543 East (Brand Street) | The N2 connects Piet Retief with Ermelo in the north and Pongola in the south, and also to Paulpietersburg in the south via the R33.<br>The R543 WEST connects Piet Retief with Wakkerstroom in the west, while the R543 EAST connects Piet Retief with Swaziland in the west.<br>The jurisdiction of SANRAL (by means of a national road declaration) starts / ends at Theo Mocke Street in the north and Kempville Street in the south. | Refer to:<br>*Figure 1: Locality Plan* |
| **THE LOCAL ACCESSIBILITY OF THE SITE IS PROVIDED BY THE FOLLOWING ROAD NETWORK** | | |
| Gerard Bohmer, Von Brandis, Pretorius, Kotze, Retief, Kruger, and Smit Streets | Traffic will also approach the development from the various residential areas along the following local streets; Gerard Bohmer, Von Brandis, Pretorius, Kotze, Retief, Kruger, and Smit Streets. | *Refer to:*<br>*Figure 1: Locality Plan*<br>*Figure 2: Study Area* |
| **THE ROAD NETWORK THAT SERVES THE DEVELOPMENT HAS THE FOLLOWING CHARACTERISTICS** | | |

| | | |
|---|---|---|
| N2 (Church Street), R543 West (Piet Retief Street), R543 East (Brand Street) | The N2 and R543 are classified as Class 2 Rural Distributors outside the Piet Retief urban area, but only comply with the design standards of Class 3 and Class 4 facilities in the urban area. These single carriageway roads are controlled with priority control as well as traffic signals at the high-volume intersections. | |
| Gerard Bohmer, Von Brandis, Pretorius, Kotze, Retief, Kruger, and Smit Streets | The functional classification of these streets are either Class 4 or Class 5 streets. | |

## 3.4 ACCESS

| ACCESS TO THE DEVELOPMENT WILL BE OBTAINED FROM THE FOLLOWING STREETS | | |
|---|---|---|
| Primary Access from Brand Street opposite Kotze Street | The primary access to the development is recommended from Brand Street opposite Kotze Street as the fourth approach of the Kotze / Brand Street T-junction approximately 150m from Church Street.<br><br>The expected trip distribution and assignment shows that 55% of the visitors are expected to use the primary access during the weekday PM peak hour and 62% during the Saturday AM peak hour.<br><br>Two inbound and two outbound lanes are required with a minimum throat length of about 35m. | Refer to:<br><br>*Figure 2: Study Area* |
| Secondary Access 2 from Church Street (N2) | A secondary access to the development is recommended from Church Street approximately 150m south of Brand Street (R543). This will basically extend the current block-pattern of the CBD – of 150m between cross-streets – with one block distance of 150m towards the south. | Refer to:<br><br>*Figure 2: Study Area* |

| | | |
|---|---|---|
| | This access will only be a marginal access – left-in and left-out – and a physical curb island must be provided to prohibit any right-turn movements from/to Church Street at the access.<br><br>The expected trip distribution and assignment shows that 45% of the visitors are expected to use the secondary access during the weekday PM peak hour and 38% during the Saturday AM peak hour.<br><br>Two inbound lanes and two outbound lanes are required with a minimum throat length of about 35m. | |
| **THE REQUIREMENTS FOR ACCESS CONTROL IS THE FOLLOWING:** | | |
| Access Control | Access control is not planned at this stage. | |

# 4 EXISTING TRAFFIC CHARACTERISTICS

***The existing traffic demand is described in this section.***

| | | |
|---|---|---|
| **TRAFFIC COUNTS WERE CONDUCTED DURING THE FOLLOWING PERIODS** | | |
| Weekday PM Peak Period | Friday 30/08/2013<br>Counting Period<br>12:00 to 18:00 | Peak Hour<br>16:00 to 17:00 |
| Saturday AM Peak Period | Saturday 31/08/2013<br>Counting Period<br>09:00 to 14:00 | Peak Hour<br>12:15 to 13:15 |
| **THE EXISTING TRAFFIC DEMAND IS SHOWN SCHEMATICALLY ON THE ATTACHED FIGURES** | | |

| | | |
|---|---|---|
| Peak Hour Traffic Demand | | Refer to:<br>*Figure 5: Weekday PM Peak Hour Traffic Demand*<br>*Figure 6: Saturday AM Peak Hour Traffic Demand* |
| **THE CURRENT TWO DIRECTIONAL PEAK HOUR FLOWS ON THE NETWORK ARE AS FOLLOWS (WEEK PM / SATURDAY AM)** | | |
| Church Street (N2) | South of Theo Mocke | ±900 / ±770 |
| | South of Piet Retief (R543) | ±1160 / ±950 |
| | South of Brand (R543) | ±1360 / ±1150 |
| | South of Gerard Bohmer | ±680 / ±430 |
| Piet Retief Street (R543) | West of Church Street (N2) | ±260 / ±240 |
| Brand Street (R543) | East of Church Street | ±220 / ±80 |
| | East of Von Brandis Street | ±370 / ±170 |
| Gerard Bohmer Street | West of Church Street | ±540 / ±880 |
| | East of Church Street | ±330 / ±220 |
| **THE CURRENT AVERAGE PHF'S FOR THE INTERSECTIONS IN THE STUDY AREA ARE AS FOLLOWS (WEEK PM / SAT AM)** | | |
| PHF'S | WEEK PM / SAT AM | 0.90 / 0.90 |

# 5 TRIP CHARACTERISTICS

***The expected trip characteristics of the development are described in this section in terms of trip generation, trip distribution, modal split, and trip assignment.***

## 5.1 TRIP GENERATION

**THE EXPECTED TRIP GENERATION WAS BASED ON THE FOLLOWING**

| | |
|---|---|
| Trip Generation | The trip generation was based on the South African Trip Generation Guidelines 2nd Edition RR92/228, 1995; enhanced with more recent information on trip generation.<br><br>A high utilization of public transportation and non-motorised transport trips is expected which is supported by the low parking requirement of only 2 bays per 100 m$^2$ GLA. The average trip generation rates for shopping centres in urban areas (in South Africa) were thus reduced with 30% for application in Piet Retief; namely to 3.95 and 6.84 trips / 100 m$^2$ GLA during the weekday afternoon (PM) and Saturday morning (AM) peak hours respectively.<br><br>Standard average trip rates were used for all the other auxiliary land uses on the site. |

**THE APPLICATION IS EXPECTED TO GENERATE THE FOLLOWING TOTAL NUMBER OF PEAK HOUR TRIPS (SPLIT GIVEN)**

| | | |
|---|---|---|
| TOTAL TRIPS | | Refer to:<br><br>*Table 1: Expected Trip Generation* |
| Weekday PM Peak Hour | 1203 (51% in / 49% out) | |
| Saturday AM Peak Hour | 1954 (50% in / 50% out) | |
| PRIMARY TRIPS | | |
| Weekday PM Peak Hour | 857 (52% in / 48% out) | |
| Saturday AM Peak Hour | 1612 (50% in / 50% out) | |
| BYPASS TRIPS | | |
| Weekday PM Peak Hour | 346 (50% in / 50% out) | |
| Saturday AM Peak Hour | 342 (50% in / 50% out) | |

| | | |
| --- | --- | --- |
| **IT IS EXPECTED THAT THE CURRENT APPLICATION WILL GENERATE THE FOLLOWING % BYPASS TRIPS DURING THE RESPECTIVE PEAK HOURS** | | |
| Bypass Trips | Bypass trips of 35% are expected during the weekday afternoon peak hour and 20% during the Saturday morning peak hour. The bypass trips were assumed to be attracted in proportion to the bypassing traffic; namely 85% from Church Street (N2) and 15% from Brand Street during the peak hours. | |
| **IT IS EXPECTED THAT THE CURRENT APPLICATION WILL GENERATE THE FOLLOWING MULTIPLE PURPOSE AND PUBLIC TRANSPORTATION TRIPS DURING THE RESPECTIVE PEAK HOURS** | | |
| Multiple Purpose and Public Transportation Trips | All the vehicle trips generated by the new land uses will not be new trips in the study area since some of these trips will be shared between land uses and will also be attracted from other land uses in the study area. A large utilization of public transportation is also expected given the target market of the shopping centre.<br>A reduction of 30% in the standard vehicle trip generation rates of only the shopping centre were however assumed for the analyses which is a conservative approach. | |
| **DETAIL ON THE EXPECTED TRIP GENERATION ARE SHOWN IN THE ATTACHED TABLE** | | |
| Trip Generation Table | | *Refer to:*<br>*Table 1: Expected Trip Generation* |

## 5.2 TRIP DISTRIBUTION

| | | |
| --- | --- | --- |
| **THE TRIP DISTRIBUTION WAS BASED ON THE FOLLOWING METHODOLOGY** | | |
| Method | Analogy Method | An assessment of the existing traffic flow pattern in the area was used as an adaptation of the Analogy Method |
| **THE FOLLOWING PRIMARY TRIP DISTRIBUTION (%) IS EXPECTED** | | |

| | | |
|---|---|---|
| Shopping Centre | Gerard Bohmer WEST | 10% |
| | Church (N2) SOUTH | 12% |
| | Gerard Bohmer EAST | 4% |
| | Von Brandis SOUTH | 6% |
| | Brand (R543 East) EAST | 10% |
| | Von Brandis NORTH | 7% |
| | Pretorius NORTH | 7% |
| | Kotze NORTH | 5% |
| | Retief EAST | 1% |
| | Kruger EAST | 1% |
| | Smit EAST | 2% |
| | Bodorp EAST | 2% |
| | Theo Mocke EAST | 2% |
| | Church (N2) NORTH | 8% |
| | Theo Mocke WEST | 1% |
| | Bodorp WEST | 4% |
| | Smit WEST | 4% |
| | Kruger WEST | 8% |
| | Retief WEST | 1% |
| | Brand / Zuidend WEST | 5% |
| **THE FOLLOWING DISTRIBUTION OF TRIPS BETWEEN THE VARIOUS MARKETS IS EXPECTED** | | |
| Trip Distribution | External | 32% |
| | North-Eastern Quadrant | 25% |
| | South-Eastern Quadrant | 10% |
| | North-Western Quadrant | 15% |
| | Western Suburbs | 18% |

**THE EXPECTED TRIP DISTRIBUTION IS SHOWN SCHEMATICALLY ON THE FOLLOWING FIGURE**

| | | |
|---|---|---|
| Trip Distribution | | Refer to: *Figure 7: Primary Trip Distribution* |

## 5.3 MODAL SPLIT

**THE FOLLOWING MODAL SPLIT FOR PUBLIC TRANSPORT USAGE IS EXPECTED**

| | |
|---|---|
| Modal Split | The average vehicle classification in the vicinity of the application site (i.e. centre of town) was 80% private light vehicles, 13% public transportation (bus and mini-bus taxi) vehicles, and 7% heavy commercial vehicles during the 6-hour survey period on a weekday afternoon. However in terms of modal split this translates into 43% private vehicle occupants, and 57% public transport passengers. |

**THE EXPECTED UTILIZATION OF PUBLIC TRANSPORT WARRANTS THE FOLLOWING ADJUSTMENTS**

| | |
|---|---|
| Adjustments for public transport | The expected vehicle trip generation rates for the shopping centre were reduced with 30% to make provision for the use of public transportation (which also includes an adjustment for multiple purpose trips, and the rural nature of the study area). |

## 5.4 TRIP ASSIGNMENT

**THE TRIP ASSIGNMENT WAS BASED ON THE FOLLOWING METHODOLOGY**

| | |
|---|---|
| Trip Assignment | Shortest travel time assignments taking into account the layout of the road network and the traffic control at key intersections. |

**THE ASSIGNED TRIPS FOR THE VARIOUS SCENARIOS ARE SHOWN SCHEMATICALLY IN THE FOLLOWING FIGURES**

| | | |
|---|---|---|
| Trip Assignment | | Refer to:<br>*Figure 5: Weekday PM Peak Hour Traffic Demand*<br>*Figure 6: Saturday AM Peak Hour Traffic Demand* |

# *6 CAPACITY AND OPERATIONAL ANALYSES*

***The capacity and operational analyses were subsequently done to determine the required road improvements for the various scenarios***

| THE FOLLOWING METHODOLOGY WAS UTILIZED | |
|---|---|
| Capacity and Operational Analyses | Methodology according to the 2010 Highway Capacity Manual (2010HCM) |

| THE MEUSURES OF PERFORMANCE (MOE'S) ACCORDING TO THE HCM WERE UTILIZED | |
|---|---|
| The best service levels are A which indicates free flow conditions while F indicates congestion and jammed conditions | Total (Control) delay in seconds |

**THE HCM2010 UTILIZES THE FOLLOWING LOS DELAY THRESHOLDS FOR SIGNALIZED AND UNSIGNALIZED INTERSECTIONS RESPECTIVELY**

| | SIGNALIZED | UNSIGNALIZED |
|---|---|---|
| The overall LOS and average delay are reported for the intersection except with priority control (stop on side road) where the critical side road LOS and delay is reported. | LOS A <10 | LOS A <10 |
| | LOS B >10 and <20 | LOS B >10 and <15 |
| | LOS C >20 and <35 | LOS C >15 and <25 |
| | LOS D >35 and <55 | LOS D >25 and <35 |
| | LOS E >55 and <80 | LOS E >35 and <50 |
| | LOS F >80 | LOS F >50 |

**THE RESULTS OF THE CAPACITY AND OPERATIONAL ANALYSES ARE SUMMARIZED IN THE FOLLOWING TABLES**

| | | |
|---|---|---|
| Detailed Results | | Refer to:<br>*Table 2: Weekday PM Peak Hour: Results of Capacity and Operational Analyses*<br>*Table 3: Saturday AM Peak Hour: Results of Capacity and Operational Analyses* |

**THE FOLLOWING RESULTS WERE OBTAINED FROM THE CAPACITY AND OPERATIONAL ANALYSES**

| | |
|---|---|
| Intersection 1<br>Church (N2) / Theo Mocke | This two-way stop controlled intersection is already operating close to saturation during the critical peak hours (LOS F / LOS E – Scenario 1). The growth in background traffic will result in very poor operating conditions in future (LOS F / LOS F – Scenario 2). This situation will be exacerbated by the application.<br>The construction of exclusive right-turn lanes on the southern (Church Street) and eastern approaches (Theo Mocke) in combination with the implementation of traffic signal control will ensure LOS B with the application in the design year (Scenario 4).<br>The required mitigation measures are however not the responsibility of the applicant given that this intersection is already saturated and it is located a long distance from the application site. |
| Intersection 2<br>Church (N2) / Smit | This traffic signal controlled intersection is expected to operate at good service levels (LOS C / LOS B) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 3).<br>No mitigation measures are required to support the application. |
| Intersection 3<br>Church (N2) / Piet Retief (R543) – Kruger | This traffic signal controlled intersection is expected to operate at good service levels (LOS C / LOS C) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 3).<br>No mitigation measures are required to support the application. |

| | |
|---|---|
| Intersection 4<br><br>Church (N2) / Retief | This traffic signal controlled intersection is expected to operate at good service levels (LOS D / LOS C) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 3).<br><br>No mitigation measures are required to support the application. |
| Intersection 5<br><br>Church (N2) / Brand (R543) | Long waiting times are already experienced at this one-way stop controlled intersection during the weekday PM peak hour (LOS F – Scenario1). This situation will deteriorate with the growth in background traffic and the application (Scenario 2 and Scenario 3).<br><br>The reconfiguration of this intersection through limited construction works, changes in lane designation, and the implementation of traffic signal control will ensure LOS C and LOS B with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 4).<br><br>These improvements are the responsibility of the applicant. |
| Intersection 6<br><br>Church (N2) / Gerard Bohmer | Long waiting times are already experienced at this two-way stop controlled intersection during the critical peak hours (LOS F – Scenario1). This situation will deteriorate with the growth in background traffic and the application (Scenario 2 and Scenario 3).<br><br>The reconfiguration of this intersection through the construction of additional lanes on all the approaches, changes in lane designation, and the implementation of traffic signal control will ensure LOS C and LOS B with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 4).<br><br>These improvements are the responsibility of the applicant. |
| Intersection 7<br><br>Kotze – Primary Access Piet Retief Mall / Brand (R543) | Traffic operations are expected to deteriorate at this all-way stop controlled intersection – which will also serve as the primary access to the application - with the growth in background traffic and the application.<br><br>The reconfiguration of this intersection through the construction of additional lanes on all the approaches, and changes in lane designation, will ensure LOS B with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 4). All-way stop control (AWSC) will however suffice.<br><br>These improvements are the responsibility of the applicant. |

| | |
|---|---|
| Intersection 8<br>Pretorius / Brand (R543) | This two-way stop controlled intersection is expected to operate at good service levels (LOS C) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 3).<br>No mitigation measures are required to support the application. |
| Intersection 9<br>Von Brandis / Brand (R543) | This all-way stop controlled intersection is expected to operate at good service levels (LOS C and LOS B) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 3).<br>No mitigation measures are required to support the application. |
| Intersection 10<br>Church (N2) / Secondary Access Piet Retief Mall | This proposed new one-way stop controlled intersection is expected to operate at reasonable service levels (LOS D) with the application during the weekday PM and Saturday AM peak hours in the design year (Scenario 4).<br>The improvements are the responsibility of the applicant. |

# *7 ROAD IMPROVEMENTS AND MITIGATION MEASURES*

***All the required road improvements on the road network, the subsequent apportionment of cost, and the required road improvements by the developer is discussed in this section.***

## 7.1 REQUIRED ROAD IMPROVEMENTS BY APPLICANT TO SUPPORT THE APPLICATION

| THE FOLLOWING ROAD IMPROVEMENTS BY THE APPLICANT ARE REQUIRED TO SUPPORT THE APPLICATION | | |
|---|---|---|
| Intersection 5<br>Church (N2) / Brand (R543) | The reconfiguration of this intersection through limited construction works, changes in lane designation, and the implementation of traffic signal control is required. | Refer to:<br>*Figure 8: Required Road Improvements In Study Area* |

| | | |
|---|---|---|
| | | *Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall* |
| Intersection 6<br><br>Church (N2) / Gerard Bohmer | The reconfiguration of this intersection through the construction of additional lanes on all the approaches, changes in lane designation, and the implementation of traffic signal control is required. | Refer to:<br><br>*Figure 8: Required Road Improvements In Study Area*<br><br>*Appendix D: Proposed Road Improvements at the Church (N2) / Gerard Bohmer Intersection to Support the Piet Retief Mall* |
| Intersection 7<br><br>Kotze – Primary Access Piet Retief Mall / Brand (R543) | The reconfiguration of this intersection through the construction of additional lanes on all the approaches, and changes in lane designation is required. All-way stop control (AWSC) will however suffice. | Refer to:<br><br>*Figure 8: Required Road Improvements In Study Area*<br><br>*Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall* |
| Intersection 10<br><br>Church (N2) / Secondary Access Piet Retief Mall | The construction of a left-turn deceleration lane of 45m / 45m (lane / taper) and a 2.5m wide physical median is required to prohibit any right-turn movements at this access. | Refer to:<br><br>*Figure 8: Required Road Improvements In Study Area*<br><br>*Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall* |

## 7.2 REQUIRED ROAD RESERVE REQUIREMENTS BY THE APPLICANT TO SUPPORT THE APPLICATION

**THE FOLLOWING LAND MUST BE PROVIDED BY THE APPLICANT TO SUPPORT THE APPLICATION**

| | | |
|---|---|---|
| Brand Street (R543) and Church Street (N2) | The applicant must provide the necessary land for the required widening of road reserves. | Refer to:<br>*Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall* |

# *8 PUBLIC TRANSPORT AND PEDESTRIANS REQUIREMENTS*

***This section describes requirements in terms of facilities for public transport and pedestrians (non-motorised forms of transport).***

## 8.1 PUBLIC TRANSPORT BACKGROUND

**THE FOLLOWING ASSESSMENT IS REQUIRED**

In terms of the National Land Transport Transition Act, Act 22 of 2000 (Section 29), it is also required to carry out a public transport assessment for all new developments. The assessment need to address aspects such as the number of new employment opportunities that will be created for public transport users, the expected travelling pattern of these users, as well as the impact it may have on the existing public transport network.

**THE ESTIMATED DEMAND FOR PUBLIC TRANSPORT USERS ARE THE FOLLOWING**

| | | |
|---|---|---|
| Full Application | In the absence of better information in this regard, the number of public transport users is estimated at about 2 per 100 $m^2$ GLA for the commercial bulk which translates to about 780 persons during the peak hours. | The expected public transport users can be transported with about 65 mini-bus taxi's in the peak hour (assuming an average occupancy of 12 persons). |

| | | |
|---|---|---|
| | | This is a conservative estimate since some of the public transport users will make use of bus transport. |
| **THE FOLLOWING PUBLIC TRANSPORT FACILITIES ARE RECOMMENDED** | | |
| The objectives of the National Transport Policy (published by the Department of Transport in September 1996) are to limit walking distances for public transport users to less than 1 km in urban areas. | | |
| Construction of Taxi- / Bus Loading Zones | The construction of taxi- / bus loading zones are recommended on both sides of the Church Street (N2) south of the intersection with Brand Street (R543).<br>This position is recommended to enable pedestrians to cross Church Street (N2) at the signalized intersection with Brand Street. | Refer to:<br>*Figure 8: Required Road Improvements In Study Area*<br>*Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall* |

## 8.2 PEDESTRIAN AND NMT FACILITIES

| | |
|---|---|
| **THE FOLLOWING PEDESTRIAN AND NMT FACILITIES ARE REQUIRED** | |
| Pedestrian Sidewalks | To improve road safety and to separate vehicle and pedestrian traffic a 1.5m wide paved sidewalk must be provided along Brand Street (R543) and Church Street (N2) that borders the application site.<br>Particular attention must be given to the movement of pedestrians between the taxi- / bus loading zone and the Shopping Centre. |

# *9 PARKING REQUIREMENTS*

***This section describes the parking requirements of the site based on the relevant town planning scheme conditions***

| | |
|---|---|
| **THE FOLLOWING NUMBER OF PARKING BAYS WILL BE PROVIDED ON THE SITE** | |
| Parking Supply according to the Town Planning Scheme | The normal Town Planning Scheme requirements of two (2) parking bays per 100m$^2$ GLA will apply to the application site. |

# 10 SITE DEVELOPMENT PLAN (SDP) ISSUES

***Internal circulation and parking issues which are important for the site development plan (SDP) are discussed in this section.***

| | |
|---|---|
| **A SITE DEVELOPMENT PLAN (SDP) IS AVAILABLE FOR THE DEVELOPMENT** | |
| SDP | Only Concept |
| **TRAFFIC ENGINEERING INPUT WILL BE PROVIDED FOR THE FINAL SDP** | |
| Traffic engineering input | Affirmative |

# 11 CONCLUSIONS AND RECOMMENDATIONS

***This section contains the conclusions and recommendations of the report.***

## 11.1 CONCLUSIONS

| | |
|---|---|
| **THE FOLLOWING IS CONCLUDED** | |
| Application | New township application for commercial development (“Business 1”) in the CBD of Piet Retief for 39,000 $m^2$ GLA that includes a shopping centre of 25,000 $m^2$ GLA. |
| Latent Rights and Growth in Background Traffic | No other large properties with existing undeveloped land use rights (i.e. latent rights) are known in the study area.<br>An average to high traffic growth rate of 4.0% p.a. for the 5-year study period was assumed to account for growth in background traffic and any unknown latent land use rights. |
| ACCESS ARRANGEMENTS | |
| Primary Access from Brand Street opposite Kotze Street | The primary access to the development is recommended from Brand Street opposite Kotze Street as the fourth approach of the Kotze / Brand Street T-junction approximately 150m from Church Street. |

| | | |
|---|---|---|
| | The expected trip distribution and assignment shows that 55% of the visitors are expected to use the primary access during the weekday PM peak hour and 62% during the Saturday AM peak hour.<br><br>Two inbound and two outbound lanes are required with a minimum throat length of about 35m. | |
| Secondary Access 2 from Church Street (N2) | A secondary access to the development is recommended from Church Street approximately 150m south of Brand Street (R543). This will basically extend the current block-pattern of the CBD – of 150m between cross-streets – with one block distance of 150m towards the south.<br><br>This access will only be a marginal access – left-in and left-out – and a physical curb island must be provided to prohibit any right-turn movements from/to Church Street at the access.<br><br>The expected trip distribution and assignment shows that 45% of the visitors are expected to use the secondary access during the weekday PM peak hour and 38% during the Saturday AM peak hour.<br><br>Two inbound lanes and two outbound lanes are required with a minimum throat length of about 35m. | |
| Expected Trip Generation | <u>TOTAL TRIPS</u> | |
| | Weekday PM Peak Hour | 1203 (51% in / 49% out) |
| | Saturday AM Peak Hour | 1954 (50% in / 50% out) |
| | <u>PRIMARY TRIPS</u> | |
| | Weekday PM Peak Hour | 857 (52% in / 48% out) |
| | Saturday AM Peak Hour | 1612 (50% in / 50% out) |
| | <u>BYPASS TRIPS</u> | |
| | Weekday PM Peak Hour | 346 (50% in / 50% out) |
| | Saturday AM Peak Hour | 342 (50% in / 50% out) |
| REQUIRED ROAD IMPROVEMENTS TO SUPPORT THE APPLICATION | | |
| Intersection 5<br><br>Church (N2) / Brand (R543) | The reconfiguration of this intersection through limited construction works, changes in lane designation, and the implementation of traffic signal control is required. | |

| | |
|---|---|
| Intersection 6<br><br>Church (N2) / Gerard Bohmer | The reconfiguration of this intersection through the construction of additional lanes on all the approaches, changes in lane designation, and the implementation of traffic signal control is required. |
| Intersection 7<br><br>Kotze – Primary Access Piet Retief Mall / Brand (R543) | The reconfiguration of this intersection through the construction of additional lanes on all the approaches, and changes in lane designation is required. All-way stop control (AWSC) will however suffice. |
| Intersection 10<br><br>Church (N2) / Secondary Access Piet Retief Mall | The construction of a left-turn deceleration lane of 45m / 45m (lane / taper) and a 2.5m wide physical median is required to prohibit any right-turn movements at this access. |
| REQUIRED ROAD RESERVE FROM APPLICATION SITE | |
| Brand Street (R543) and Church Street (N2) | The applicant must provide the necessary land for the required widening of road reserves. |
| PUBLIC TRANSPORTATION AND NMT REQUIREMENTS | |
| Public Transport Facilities | The construction of taxi- / bus loading zones are recommended on both sides of the Church Street (N2) south of the intersection with Brand Street (R543).<br><br>This position is recommended to enable pedestrians to cross Church Street (N2) at the signalized intersection with Brand Street. |
| Pedestrian and NMT facilities | To improve road safety and to separate vehicle and pedestrian traffic a 1.5m wide paved sidewalk must be provided along Brand Street (R543) and Church Street (N2) that borders the application site.<br><br>Particular attention must be given to the movement of pedestrians between the taxi- / bus loading zone and the Shopping Centre. |
| Parking Supply according to the Town Planning Scheme | The normal Town Planning Scheme requirements of two (2) parking bays per $100m^2$ GLA will apply to the application site. |

## 11.2 RECOMMENDATIONS

| **THE FOLLOWING IS RECOMMENDED** | |
|---|---|
| Requirements | It is recommended that the application be approved from a traffic engineering point of view subject to the required mitigation measures shown in *Figure 8, Appendix C, and Appendix D*. |

# TABLES

TECHWORLD consulting ENGINEERS

| Table 1: Expected Trip Generation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM | LAND USE | EXTENT | UNITS | WEEKDAY PM PEAK HOUR | | | | SATURDAY AM PEAK HOUR | | | |
| | | | | TRIP RATE | TOTAL TRIPS | IN | OUT | TRIP RATE | TOTAL TRIPS | IN | OUT |
| 1 | Retail | 25000 | $m^2$ GLA | 3.95 | 988 | 50% | 50% | 6.84 | 1711 | 50% | 50% |
| 2 | Motor Dealerships | 3500 | $m^2$ GLA | 2.30 | 81 | 50% | 50% | 2.20 | 77 | 45% | 55% |
| 3 | Offices | 3500 | $m^2$ GLA | 2.10 | 74 | 80% | 20% | 0.45 | 16 | 55% | 45% |
| 4 | Mini Storage | 3500 | $m^2$ GLA | 0.25 | 9 | 50% | 50% | 0.40 | 14 | 50% | 50% |
| 5 | Bulk Trade Centre | 3500 | $m^2$ GLA | 1.50 | 53 | 40% | 60% | 3.90 | 137 | 50% | 50% |
| | | 39000 | $m^2$ GLA | | 1203 | | | | 1954 | | |
| | | | | | | | | | | | |
| A | Primary Trips | | | 71% | 857 | 446 | 412 | 82% | 1612 | 803 | 809 |
| B | Bypass Trips | | | 29% | 346 | 173 | 173 | 18% | 342 | 171 | 171 |
| C | Total Trips | | | 100% | 1203 | 618 | 585 | 100% | 1954 | 974 | 980 |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

# TABLES

| Table 1: Expected Trip Generation | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| ITEM | LAND USE | EXTENT | UNITS | WEEKDAY PM PEAK HOUR | | | | SATURDAY AM PEAK HOUR | | | |
| | | | | TRIP RATE | TOTAL TRIPS | IN | OUT | TRIP RATE | TOTAL TRIPS | IN | OUT |
| Church Street (N2) | Primary Trips | | | 28% | 243 | 137 | 106 | 28% | 456 | 246 | 210 |
| | Bypass Trips | | | 85% | 294 | 147 | 147 | 85% | 290 | 145 | 145 |
| | Total Trips | | | 45% | 537 | 284 | 253 | 38% | 746 | 391 | 355 |
| Brand Street (R543) | Primary Trips | | | 72% | 614 | 310 | 304 | 72% | 1152 | 554 | 598 |
| | Bypass Trips | | | 15% | 52 | 26 | 26 | 15% | 52 | 26 | 26 |
| | Total Trips | | | 55% | 666 | 336 | 330 | 62% | 1204 | 580 | 624 |

# TABLES

*Table 2: Weekday PM Peak Hour: Results of Capacity and Operational Analyses*

| INTERSECTION | (MOE) | 1 | 2 | 3 | 4 |
|---|---|---|---|---|---|
| | **Measure of Effectiveness** | **Existing Situation** | **With Background Growth** | **With Application** | **With Application**<br>**With Mitigation** |
| | | **2013** | **2018** | **2018** | **2018** |
| Intersection 1<br>Church (N2) / Theo Mocke | Traffic Control | TWSC | TWSC | TWSC | TSC |
| | Worse Movement | SWBR | SWBR | SWBR | - |
| | V/C | 0.234 | 0.780 | 1.344 | 0.531 |
| | Delay | 75.1 | 468.4 | 871.8 | 15.90 |
| | LOS | F | F | F | B |
| Intersection 2<br>Church (N2) / Smit | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.527 | 0.674 | 0.831 | |
| | Delay | 16.4 | 19.2 | 27.1 | |
| | LOS | B | B | C | |
| Intersection 3<br>Church (N2) / Piet Retief (R543) - Kruger | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.581 | 0.707 | 0.832 | |
| | Delay | 17.3 | 19.2 | 25.5 | |
| | LOS | B | B | C | |
| Intersection 4<br>Church (N2) / Retief | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.584 | 0.714 | 0.796 | |
| | Delay | 20.1 | 27.6 | 36.1 | |
| | LOS | C | C | D | |
| Intersection 5<br>Church (N2) / Brand (R543) | Traffic Control | OWSC | OWSC | OWSC | TSC |
| | Worse Movement | WBR | WBT | WBR | - |
| | V/C | 0.195 | 0.949 | 12.490 | 0.582 |
| | Delay | 67.0 | 236.4 | 5710.0 | 26.42 |
| | LOS | F | F | F | C |

# TABLES

<table>
<tr><th colspan="6">Table 2: Weekday PM Peak Hour: Results of Capacity and Operational Analyses</th></tr>
<tr><th rowspan="4">INTERSECTION</th><th>(MOE)</th><th>1</th><th>2</th><th>3</th><th>4</th></tr>
<tr><th rowspan="3">Measure of Effectiveness</th><th rowspan="2">Existing Situation</th><th rowspan="2">With Background Growth</th><th rowspan="2">With Application</th><th>With Application</th></tr>
<tr><th>With Mitigation</th></tr>
<tr><th>2013</th><th>2018</th><th>2018</th><th>2018</th></tr>
<tr><td rowspan="5">Intersection 6<br><br>Church (N2) / Gerard Bohmer</td><td>Traffic Control</td><td>TWSC</td><td>TWSC</td><td>TWSC</td><td>TSC</td></tr>
<tr><td>Worse Movement</td><td>WBR</td><td>EBT</td><td>EBT</td><td>-</td></tr>
<tr><td>V/C</td><td>7.467</td><td>2.024</td><td>4.547</td><td>0.708</td></tr>
<tr><td>Delay</td><td>3447.7</td><td>10000.0</td><td>10000.0</td><td>24.88</td></tr>
<tr><td>LOS</td><td>F</td><td>F</td><td>F</td><td>C</td></tr>
<tr><td rowspan="5">Intersection 7<br><br>Kotze – Primary Access Piet Retief Mall / Brand (R543)</td><td>Traffic Control</td><td>AWSC</td><td>AWSC</td><td>AWSC</td><td>AWSC</td></tr>
<tr><td>Worse Movement</td><td>SBR</td><td>SBR</td><td>NBL</td><td>EBR</td></tr>
<tr><td>V/C</td><td>-</td><td>-</td><td>-</td><td>-</td></tr>
<tr><td>Delay</td><td>8.0</td><td>8.3</td><td>15.9</td><td>12.52</td></tr>
<tr><td>LOS</td><td>A</td><td>A</td><td>C</td><td>B</td></tr>
<tr><td rowspan="5">Intersection 8<br><br>Pretorius / Brand (R543)</td><td>Traffic Control</td><td>TWSC</td><td>TWSC</td><td>TWSC</td><td></td></tr>
<tr><td>Worse Movement</td><td>NBR</td><td>NBR</td><td>NBR</td><td></td></tr>
<tr><td>V/C</td><td>0.000</td><td>0.000</td><td>0.000</td><td></td></tr>
<tr><td>Delay</td><td>11.7</td><td>12.7</td><td>16.5</td><td></td></tr>
<tr><td>LOS</td><td>B</td><td>B</td><td>C</td><td></td></tr>
<tr><td rowspan="5">Intersection 9<br><br>Von Brandis / Brand (R543)</td><td>Traffic Control</td><td>AWSC</td><td>AWSC</td><td>AWSC</td><td></td></tr>
<tr><td>Worse Movement</td><td>EBT</td><td>EBT</td><td>EBT</td><td></td></tr>
<tr><td>V/C</td><td>-</td><td>-</td><td>-</td><td></td></tr>
<tr><td>Delay</td><td>10.1</td><td>11.9</td><td>17.1</td><td></td></tr>
<tr><td>LOS</td><td>B</td><td>B</td><td>C</td><td></td></tr>
<tr><td rowspan="5">Intersection 10<br><br>Church (N2) / Secondary Access Piet Retief Mall</td><td>Traffic Control</td><td>NA</td><td>NA</td><td>NA</td><td>OWSC</td></tr>
<tr><td>Worse Movement</td><td>NA</td><td>NA</td><td>NA</td><td>WBL</td></tr>
<tr><td>V/C</td><td>NA</td><td>NA</td><td>NA</td><td>0.687</td></tr>
<tr><td>Delay</td><td>NA</td><td>NA</td><td>NA</td><td>31.0</td></tr>
<tr><td>LOS</td><td>NA</td><td>NA</td><td>NA</td><td>D</td></tr>
</table>

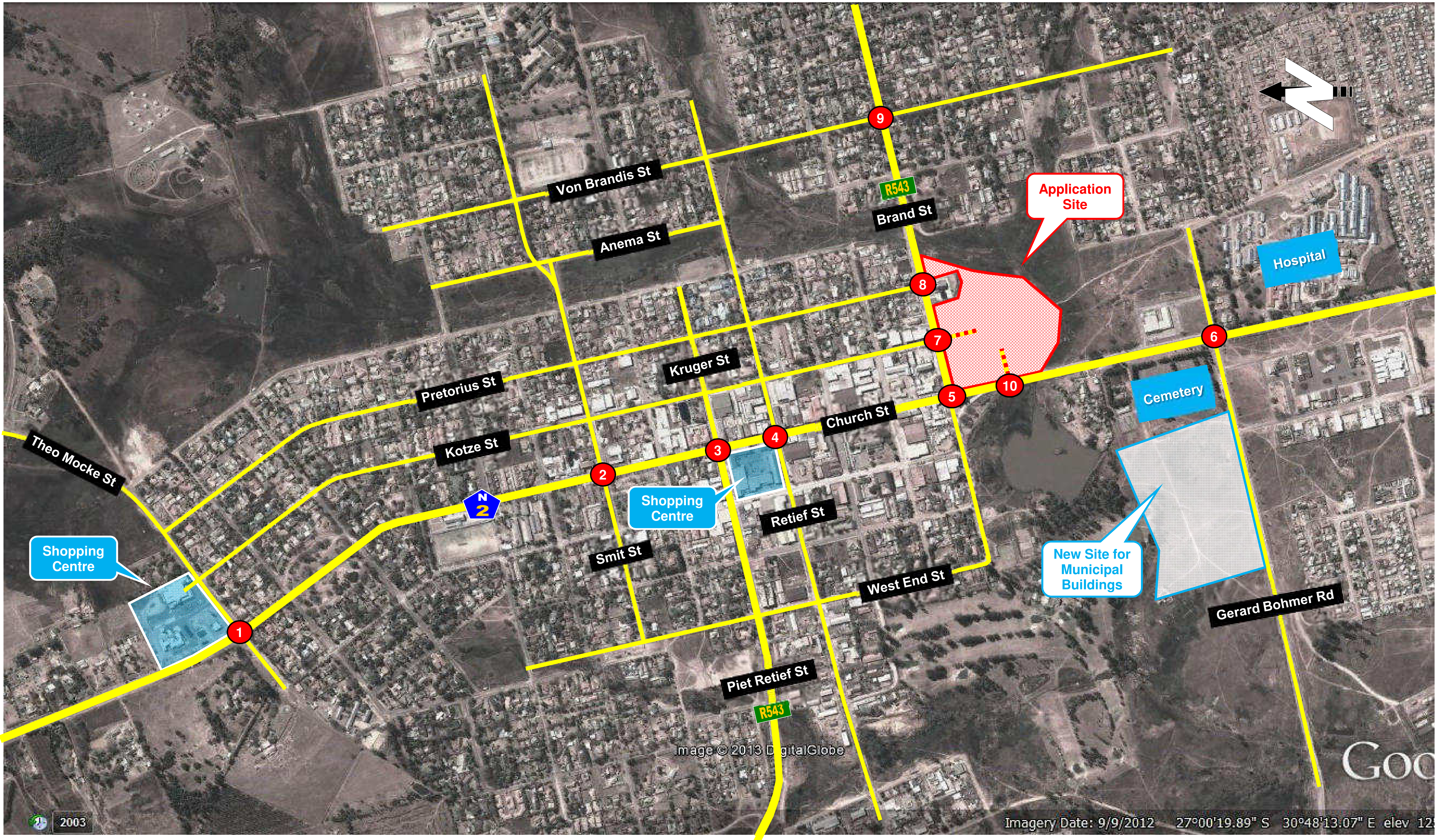
# TABLES

| Table 3: Saturday AM Peak Hour: Results of Capacity and Operational Analyses | | | | | |
|---|---|---|---|---|---|
| **INTERSECTION** | **(MOE)** | **1** | **2** | **3** | **4** |
| | **Measure of Effectiveness** | **Existing Situation** | **With Background Growth** | **With Application** | **With Application<br>With Mitigation** |
| | | **2013** | **2018** | **2018** | **2018** |
| Intersection 1<br><br>Church (N2) / Theo Mocke | Traffic Control | TWSC | TWSC | TWSC | TSC |
| | Worse Movement | NEBR | SWBR | NEBR | |
| | V/C | 0.011 | 0.143 | 0.638 | 0.573 |
| | Delay | 47.8 | 131.7 | 416.1 | 16.37 |
| | LOS | E | F | F | B |
| Intersection 2<br><br>Church (N2) / Smit | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.458 | 0.562 | 0.678 | |
| | Delay | 14.1 | 16.0 | 18.3 | |
| | LOS | B | B | B | |
| Intersection 3<br><br>Church (N2) / Piet Retief (R543) - Kruger | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.479 | 0.591 | 0.856 | |
| | Delay | 15.0 | 16.4 | 26.6 | |
| | LOS | B | B | C | |
| Intersection 4<br><br>Church (N2) / Retief | Traffic Control | TSC | TSC | TSC | |
| | V/C | 0.464 | 0.567 | 0.750 | |
| | Delay | 16.4 | 18.3 | 26.3 | |
| | LOS | B | B | C | |
| Intersection 5<br><br>Church (N2) / Brand (R543) | Traffic Control | OWSC | OWSC | OWSC | TSC |
| | Worse Movement | WBR | WBR | WBR | |
| | V/C | 0.019 | 0.040 | 15.776 | 0.522 |
| | Delay | 28.7 | 43.0 | 7028.6 | 13.67 |
| | LOS | D | E | F | B |

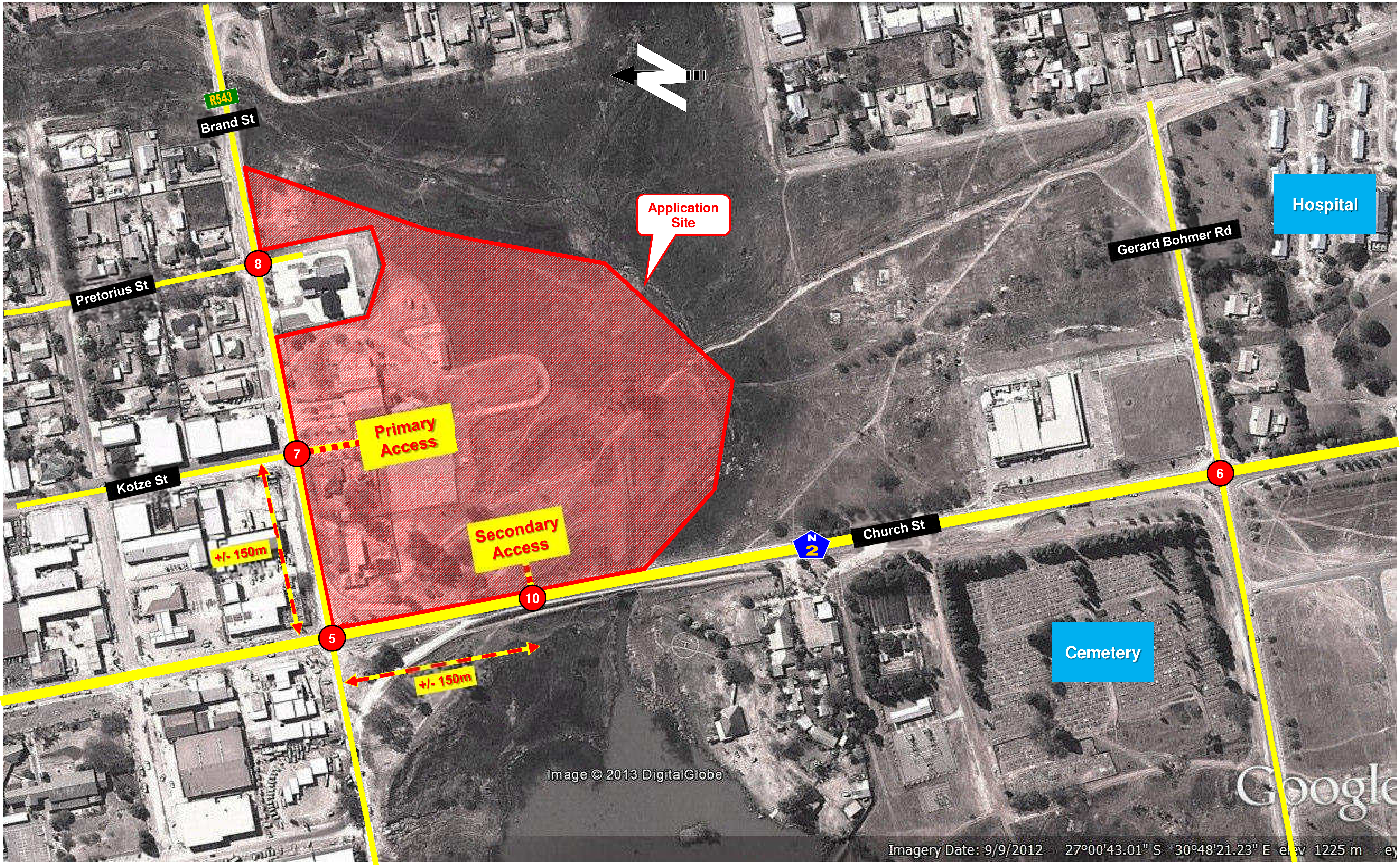
| Table 3: Saturday AM Peak Hour: Results of Capacity and Operational Analyses | | | | | |
|---|---|---|---|---|---|
| **INTERSECTION** | **(MOE)** | **1** | **2** | **3** | **4** |
| | **Measure of Effectiveness** | **Existing Situation** | **With Background Growth** | **With Application** | **With Application / With Mitigation** |
| | | **2013** | **2018** | **2018** | **2018** |
| Intersection 6<br><br>Church (N2) / Gerard Bohmer | Traffic Control | TWSC | TWSC | TWSC | TSC |
| | Worse Movement | WBR | EBT | EBT | |
| | V/C | 3.624 | 1.641 | 7.428 | 0.973 |
| | Delay | 1779.6 | 10000.0 | 10000.0 | 16.88 |
| | LOS | F | F | F | B |
| Intersection 7<br><br>Kotze – Primary Access Piet Retief Mall / Brand (R543) | Traffic Control | AWSC | AWSC | AWSC | AWSC |
| | Worse Movement | SBR | SBR | NBL | |
| | V/C | - | - | - | - |
| | Delay | 7.3 | 7.5 | 86.5 | 13.33 |
| | LOS | A | A | F | B |
| Intersection 8<br><br>Pretorius / Brand (R543) | Traffic Control | TWSC | TWSC | TWSC | |
| | Worse Movement | SBT | SBT | SBR | |
| | V/C | 0.000 | 0.000 | 0.328 | |
| | Delay | 11.3 | 12.0 | 23.3 | |
| | LOS | B | B | C | |
| Intersection 9<br><br>Von Brandis / Brand (R543) | Traffic Control | AWSC | AWSC | AWSC | |
| | Worse Movement | NBT | NBT | EBT | |
| | V/C | - | - | - | |
| | Delay | 8.1 | 8.5 | 11.3 | |
| | LOS | A | A | B | |
| Intersection 10<br><br>Church (N2) / Secondary Access Piet Retief Mall | Traffic Control | NA | NA | NA | OWSC |
| | Worse Movement | NA | NA | NA | NBT |
| | V/C | NA | NA | NA | 0.937 |
| | Delay | NA | NA | NA | 43.7 |
| | LOS | NA | NA | NA | D |

# FIGURES

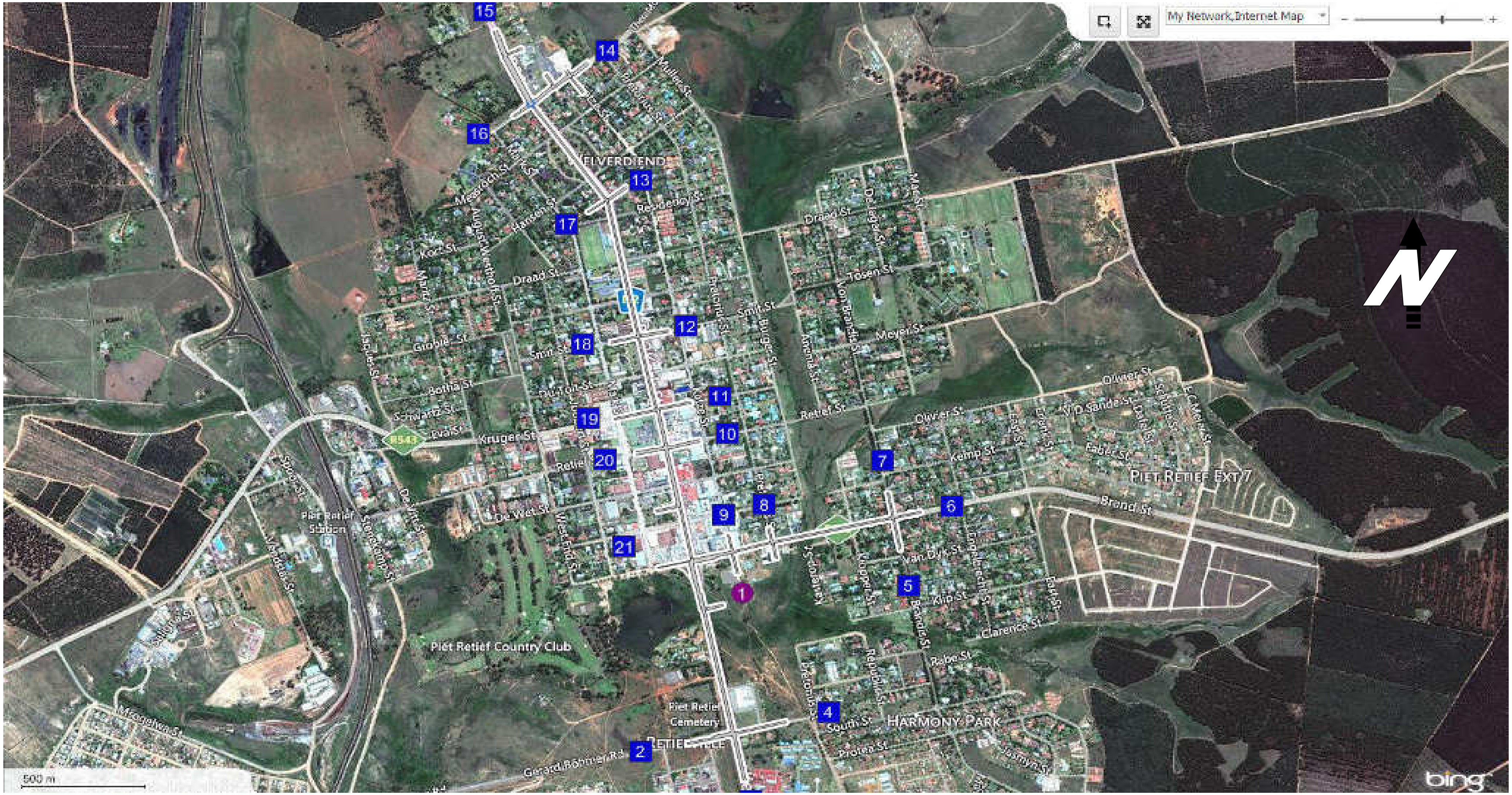
| FIGURES |
| --- |
| *Figure 1: Locality Plan*<br>*Figure 2: Study Area*<br>*Figure 3: Traffic Model (VISTRO)*<br>*Figure 4: Existing Road Network and Lane Layout*<br>*Figure 5: Weekday PM Peak Hour Traffic Demand*<br>*Figure 6: Saturday AM Peak Hour Traffic Demand*<br>*Figure 7: Primary Trip Distribution*<br>*Figure 8: Required Road Improvements In Study Area* |



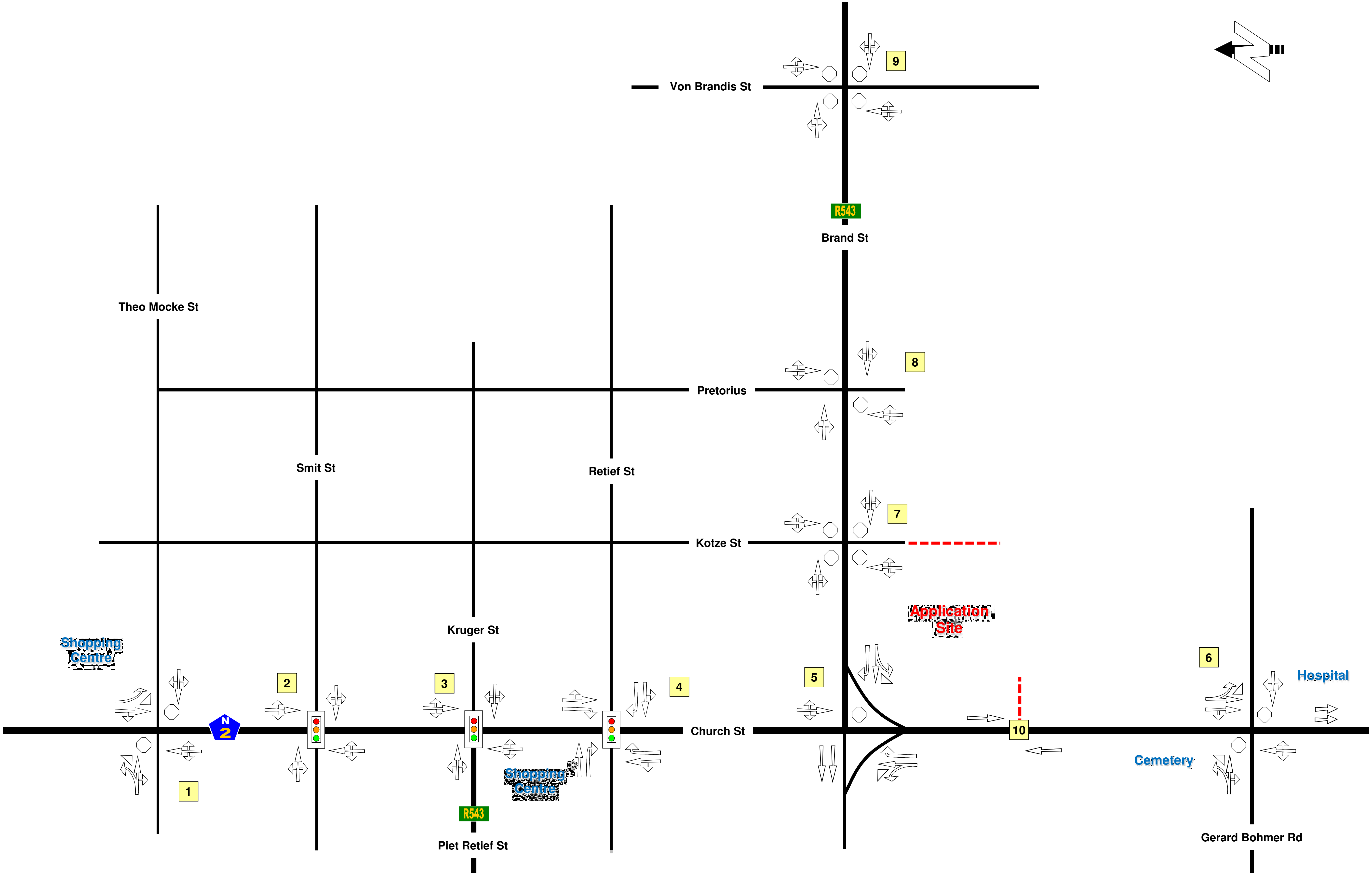

| MALL@PIET RETIEF | Locality Plan | FIGURE 1 |
|---|---|---|



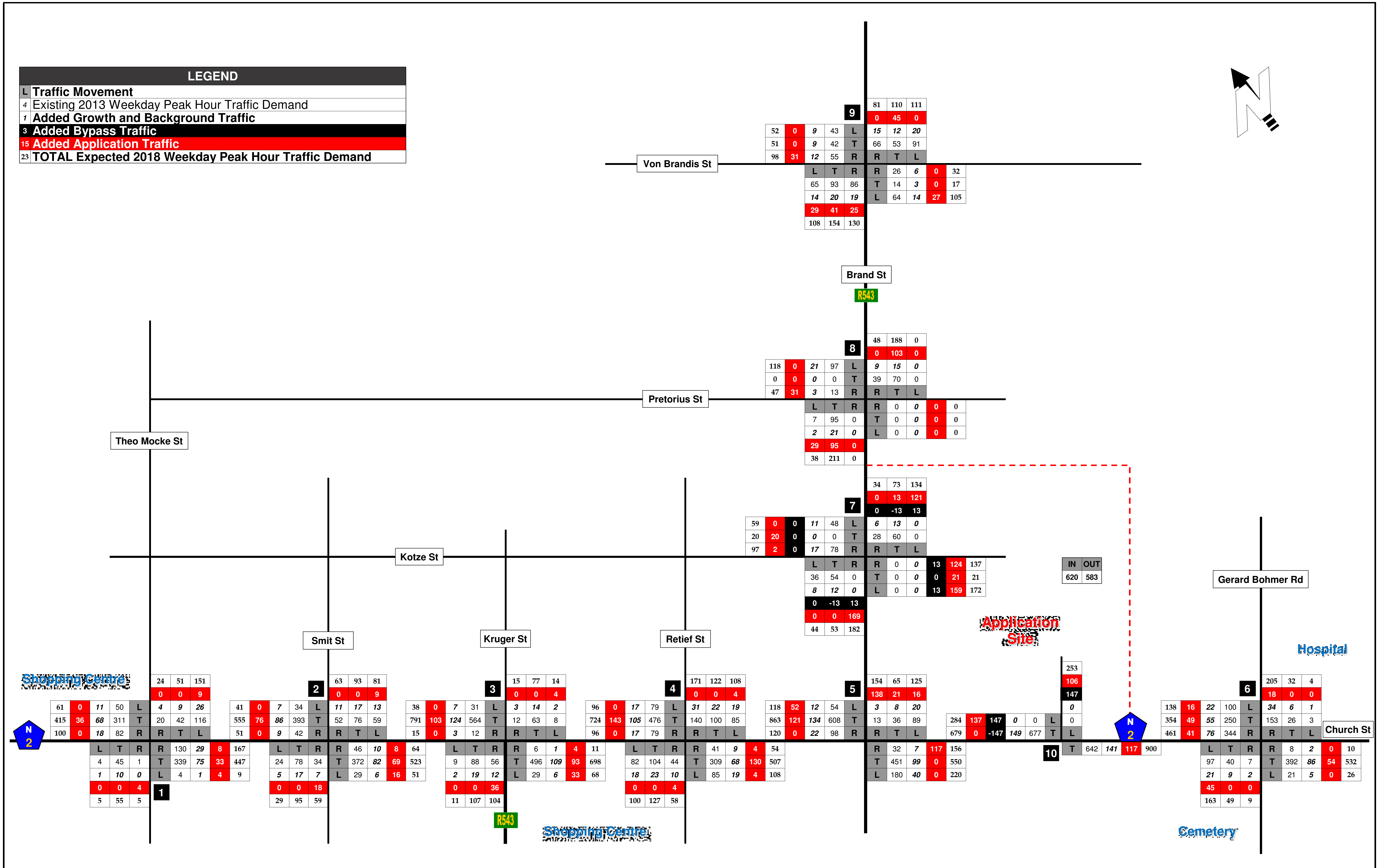

| | | | |
|---|---|---|---|
| | MALL@PIET RETIEF | Study Area | FIGURE 2 |




| | | | |
|---|---|---|---|
| | MALL@PIET RETIEF | Traffic Model (VISTRO) | FIGURE 3 |




| MALL@PIET RETIEF | Existing Road Network and Lane Layout | FIGURE 4 |
|---|---|---|

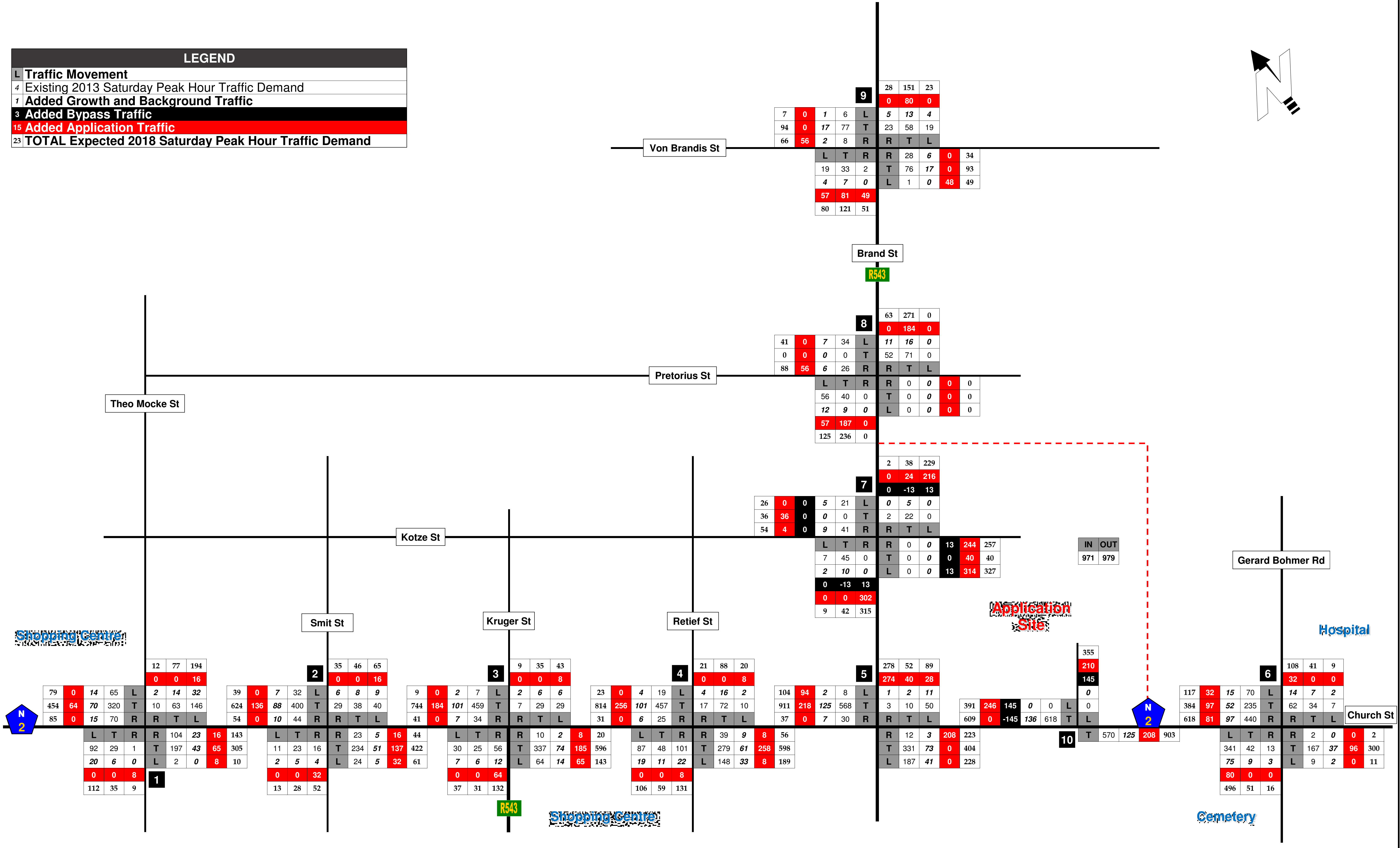



MALL@PIET RETIEF

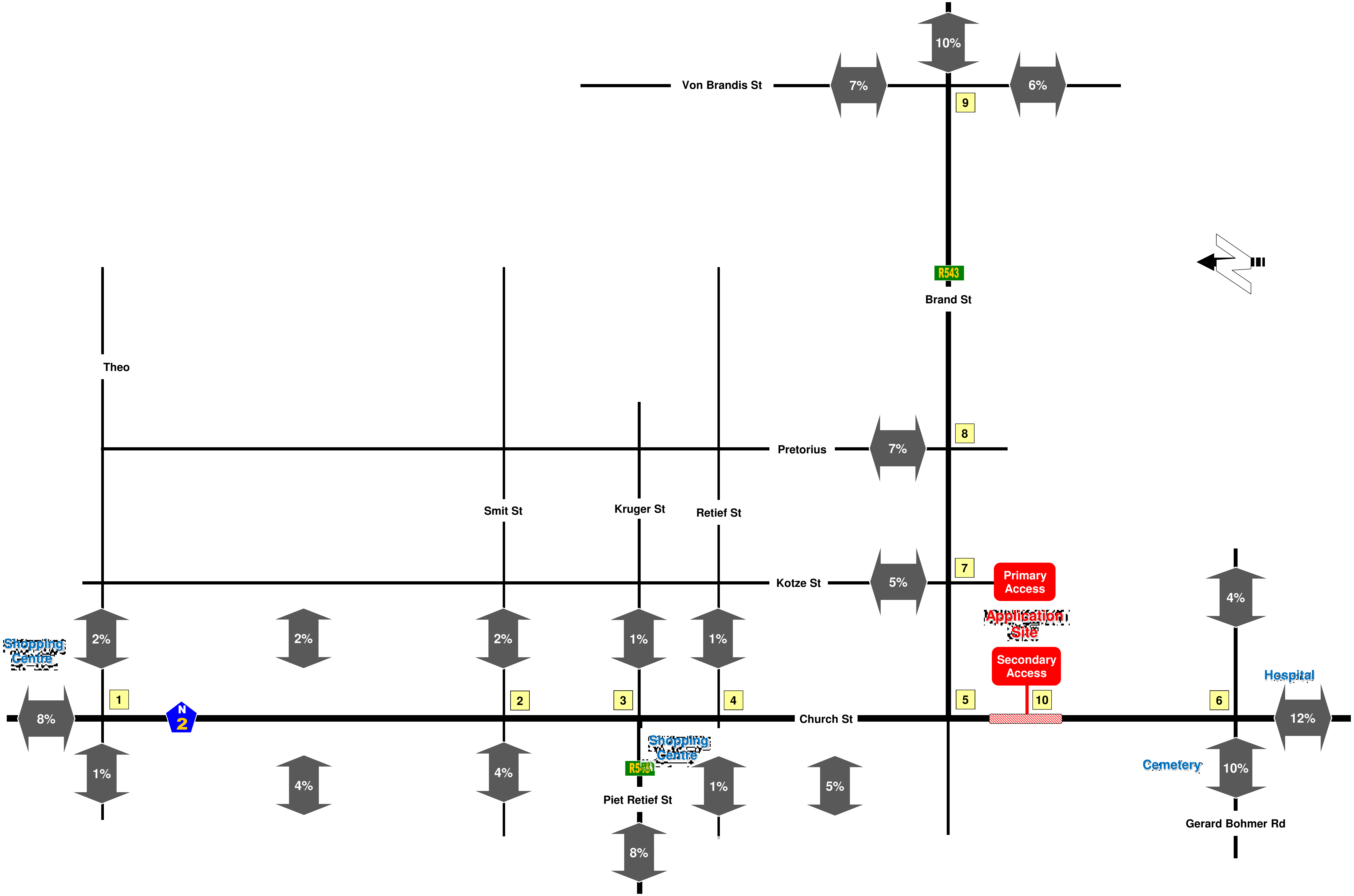
Weekday PM Peak Hour Traffic Demand

FIGURE 5

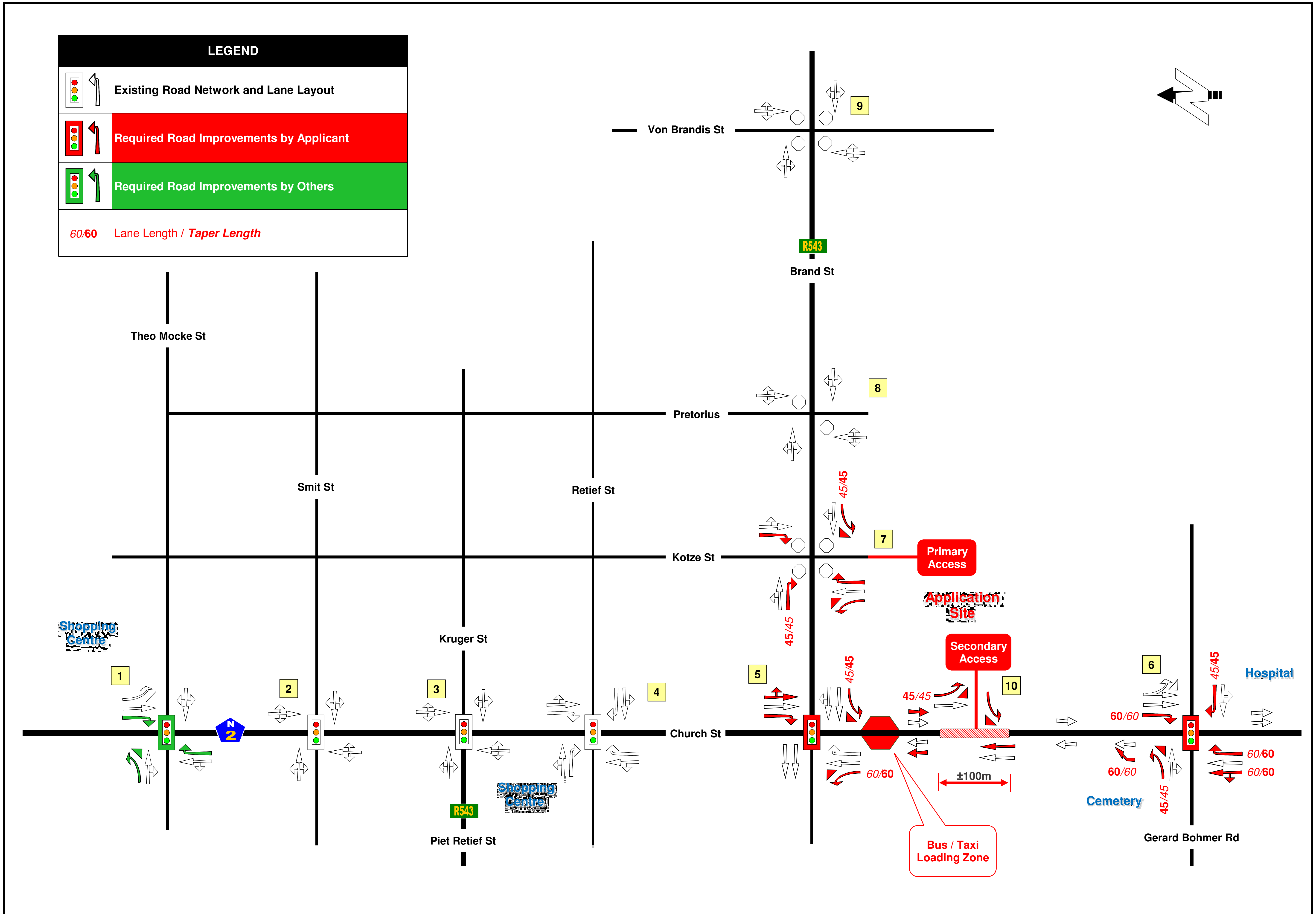
| LEGEND | |
|---|---|
| L | Traffic Movement |
| 4 | Existing 2013 Saturday Peak Hour Traffic Demand |
| 1 | Added Growth and Background Traffic |
| 3 | Added Bypass Traffic |
| 15 | Added Application Traffic |
| 23 | TOTAL Expected 2018 Saturday Peak Hour Traffic Demand |




| | | | |
|---|---|---|---|
| TECHWORLD | MALL@PIET RETIEF | Saturday AM Peak Hour Traffic Demand | FIGURE 6 |




| | | | |
|---|---|---|---|
| | MALL@PIET RETIEF | Primary Trip Distribution | FIGURE 7 |




| | | |
|---|---|---|
| MALL@PIET RETIEF | Required Road Improvements in Study Area | FIGURE 8 |

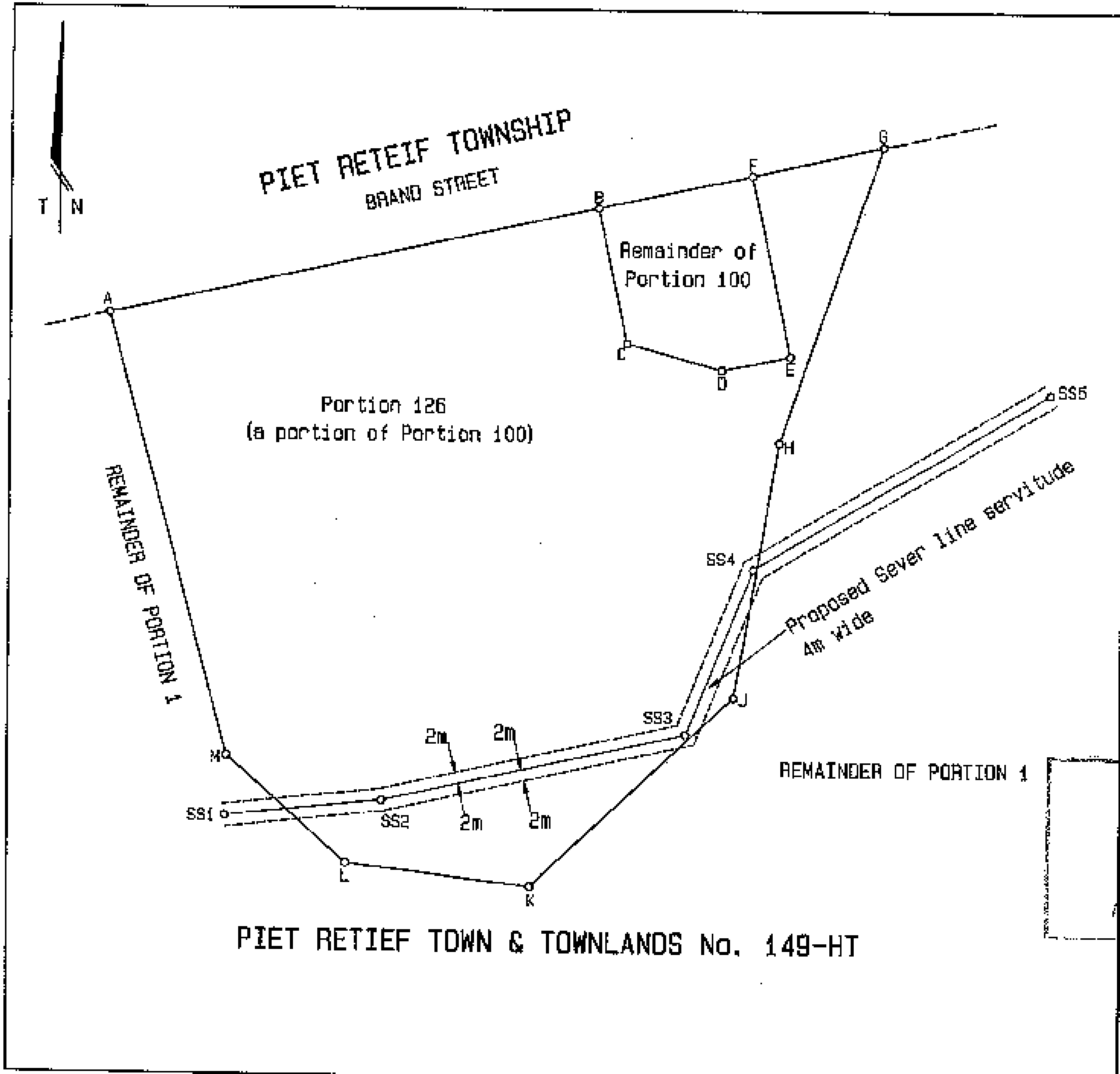
# APPENDICES

| APPENDICES |
| --- |
| *Appendix A: Site Layout Plan: Portion 126*<br><br>*Appendix B: Concept SDP Mall@Piet Retief*<br><br>*Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall*<br><br>*Appendix D: Proposed Road Improvements at the Church (N2) / Gerard Bohmer Intersection to Support the Piet Retief Mall*<br><br>*Appendix E: Traffic Counts* |
| |

APPENDICES

TECHWORLD
consulting ENGINEERS

## Appendix A: Site Layout Plan




**SKETCH PLAN**
in terms Ordinance 20/1986

Subdivision of Portion 126
(a portion of Portion 100)
of the farm
Piet Retief Town & Townlands No. 149-HT
Province of Mpumalanga

**REED & PARTNERS/VENNOTE**

PROFESSIONAL LAND SURVEYORS
PROFESSIONELE LANDMETERS

OWNER / EIENAAR : P. REED & GENOTE INC. REG NO. 94/08178/21

Joubertstr. 100
PO Box/Posbus 132
ERMELO , 2350

Tel. : (017) 8112348
Fax. : (017) 8187841
e-mail : rperm@nagawsb.co.za

Layout / Sketch plan approved in terms of Section 18 of Ordinance 20/1986.

MKHONDO MUNICIPALITY
2013 -06- 27
MUNICIPALITY
DATE X. POSBUS 23
PIET RETIEF 2380

MUNICIPAL MANAGER

Date June 2013
Scale 1: 500

J. VAN WYK (PLS 0875)

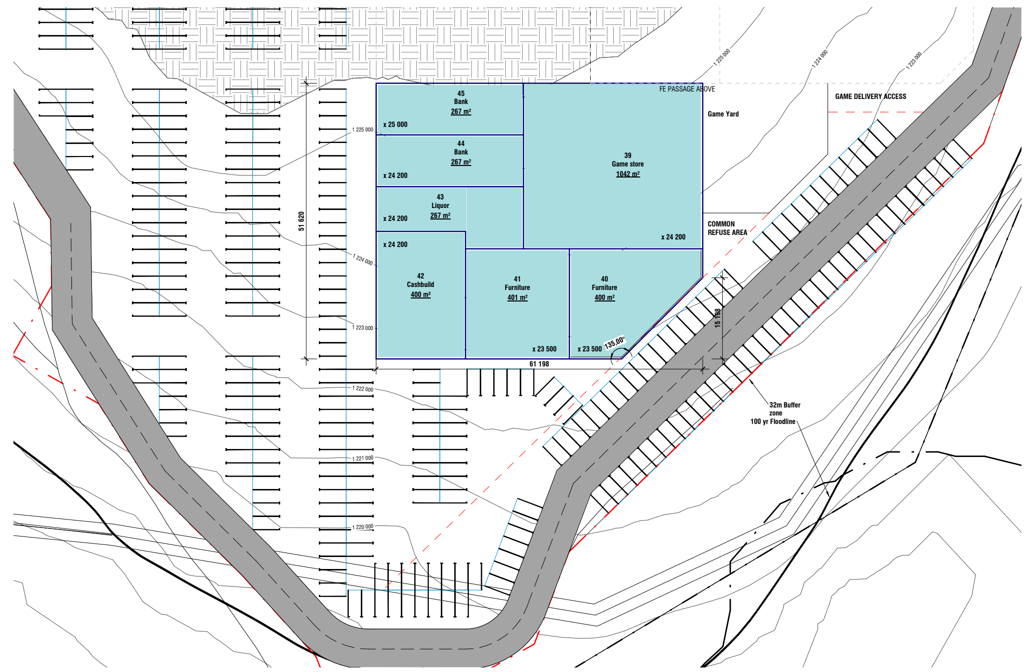
| REFERENCE NO. | VERWYSINGS NO. | DRWG NO. | TEK NO. |
|---|---|---|---|
| C:\DAT\DAT2013\P268-10\PTN126SP.drw | | | 1 |

# APPENDICES

## Appendix B: Concept SDP Mall@Piet Retief


## 00 Ground Floor (Option D)

SCALE: 1 : 500




## -01 Level (Option D)

SCALE: 1 : 500

| Area Schedule (Rentable Option D) | | | | |
|---|---|---|---|---|
| **Area** | **Level** | **Name** | **Number** | **Area Retail Type** |
| 1042 m² | -01 Level (Option D) | Game store | 39 | Tenant |
| 400 m² | -01 Level (Option D) | Furniture | 40 | Tenant |
| 401 m² | -01 Level (Option D) | Furniture | 41 | Tenant |
| 400 m² | -01 Level (Option D) | Cashbuild | 42 | Tenant |
| 267 m² | -01 Level (Option D) | Liquor | 43 | Tenant |
| 267 m² | -01 Level (Option D) | Bank | 44 | Tenant |
| 267 m² | -01 Level (Option D) | Bank | 45 | Tenant |
| 3044 m² | | | | |
| 3044 m² ← TOTAL GLA LEVEL -01 | | | | |
| 924 m² | 00 Ground Floor (Option D) | Area | 27 | Future Extension |
| 924 m² | | | | |
| 2504 m² | 00 Ground Floor (Option D) | Edgars | 1 | Tenant |
| 3201 m² | 00 Ground Floor (Option D) | Spar and Pharmacy | 2 | Tenant |
| 100 m² | 00 Ground Floor (Option D) | Dodo's | 4 | Tenant |
| 704 m² | 00 Ground Floor (Option D) | Mr Price | 5 | Tenant |
| 284 m² | 00 Ground Floor (Option D) | Exact | 7 | Tenant |
| 323 m² | 00 Ground Floor (Option D) | Cape Union Mart | 8 | Tenant |
| 280 m² | 00 Ground Floor (Option D) | Pep Home | 15 | Tenant |
| 406 m² | 00 Ground Floor (Option D) | Shops | 17 | Tenant |
| 450 m² | 00 Ground Floor (Option D) | Identity | 9 | Tenant |
| 3201 m² | 00 Ground Floor (Option D) | Shoprite | 10 | Tenant |
| 1606 m² | 00 Ground Floor (Option D) | Truworths | 24 | Tenant |
| 3001 m² | 00 Ground Floor (Option D) | Game | 28 | Tenant |
| 250 m² | 00 Ground Floor (Option D) | Tops | 46 | Tenant |
| 150 m² | 00 Ground Floor (Option D) | Shopr Liquor | 47 | Tenant |
| 450 m² | 00 Ground Floor (Option D) | Pep | 48 | Tenant |
| 40 m² | 00 Ground Floor (Option D) | Pep cell | 49 | Tenant |
| 290 m² | 00 Ground Floor (Option D) | Dunns | 50 | Tenant |
| 515 m² | 00 Ground Floor (Option D) | Ackermans | 51 | Tenant |
| 50 m² | 00 Ground Floor (Option D) | Am Swiss | 52 | Tenant |
| 734 m² | 00 Ground Floor (Option D) | Clicks | 53 | Tenant |
| 180 m² | 00 Ground Floor (Option D) | John Craig | 54 | Tenant |
| 224 m² | 00 Ground Floor (Option D) | Shoe City | 55 | Tenant |
| 170 m² | 00 Ground Floor (Option D) | Sheet Street | 56 | Tenant |
| 45 m² | 00 Ground Floor (Option D) | Shop | 57 | Tenant |
| 72 m² | 00 Ground Floor (Option D) | Drimac | 58 | Tenant |
| 402 m² | 00 Ground Floor (Option D) | Foschini | 59 | Tenant |
| 65 m² | 00 Ground Floor (Option D) | Area | 60 | Tenant |
| 180 m² | 00 Ground Floor (Option D) | Hungry lion | 61 | Tenant |
| 220 m² | 00 Ground Floor (Option D) | Totalsports | 62 | Tenant |
| 180 m² | 00 Ground Floor (Option D) | Sport Scene | 63 | Tenant |
| 139 m² | 00 Ground Floor (Option D) | Shop | 64 | Tenant |
| 115 m² | 00 Ground Floor (Option D) | Shop | 65 | Tenant |
| 101 m² | 00 Ground Floor (Option D) | Shop | 66 | Tenant |
| 32 m² | 00 Ground Floor (Option D) | Shop | 67 | Tenant |
| 30 m² | 00 Ground Floor (Option D) | Shop | 68 | Tenant |
| 403 m² | 00 Ground Floor (Option D) | CB STORES | 69 | Tenant |
| 273 m² | 00 Ground Floor (Option D) | Shop | 70 | Tenant |
| 52 m² | 00 Ground Floor (Option D) | Shop | 71 | Tenant |
| 406 m² | 00 Ground Floor (Option D) | Shop | 72 | Tenant |
| 138 m² | 00 Ground Floor (Option D) | Food | 73 | Tenant |
| 127 m² | 00 Ground Floor (Option D) | Food | 74 | Tenant |
| 77 m² | 00 Ground Floor (Option D) | Food | 75 | Tenant |
| 44 m² | 00 Ground Floor (Option D) | Food | 76 | Tenant |
| 22215 m² | | | | |
| 23139 m² ← TOTAL GLA GROUND FLOOR LEVEL | | | | |
| 26183 m² ← TOTAL GLA BOTH LEVELS | | | | |

## PARKING CALCULATION - RETAIL

Gross Rentable Area = 26192 m²

Assignable Area (80% of Gross Rentable Area) = 20954 m²

| Total Parking Bays Required | | Less Taxi Credits | Bays in Hand |
|---|---|---|---|
| Parking @ 6 Bays per 100m² = | 1257,216 Bays | 1057,216 Bays | -528,216 Bays |
| Parking @ 5 Bays per 100m² = | 1047,68 Bays | 847,68 Bays | -318,68 Bays |
| Parking @ 4 Bays per 100m² = | 838,144 Bays | 638,144 Bays | -109,144 Bays |
| Total Taxi Bays Provided = | **25 Bays** | | |
| Parking Bay Credits at 8 Bays per Taxi = | 200 Bays | | |
| Total Parking Bays Provided = | **529 Bays** (Includes Tenant Parking Area) | | |

## Parking Schedule

SCALE: 1 : 100

ACTUAL PARKING RATIO IS 3.48/100 (X/100=729/20954 )

PARAGON GROUP
PARAGON ARCHITECTS
PARAGON INTERFACE
HUB ARCHITECTS
PARAGON ARQUITETURA

# PARAGON ARCHITECTS

# Mall@Piet Retief

FOR

Anaprop Property Management

Portion 126, Piet Retief Town & Townlands 149HT, Mpumalanga

## Design Option D

SCALE: As indicated

| PROJECT | STAGE / SERIES / SIZE | REVISION |
|---|---|---|
| PAX_138 | D001-07-A0 | C |

INFO | COUNCIL | TENDER | CONSTRUCTION

DATE: 2013.08.12 DRAWN BY: MB

ACTS OF PARLIAMENT
All Contractors shall ensure that, before any work is put in hand, they comply with all the necessary Acts of Parliament of the Republic of South Africa.

C:\Revit files\131021_PAX138_mel DESIGN OPTION D.rvt

2013/10/22 03:47:12 PM

# APPENDICES

TECHWORLD
consulting ENGINEERS

## Appendix C: Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall


SUNBIRD PARK
Cnr. Delfi & Sunbird Ave
Garsfontein Ext 15
TEL:012 - 998 3541
FAX:012 - 9935506
TECHWORLD
E-MAIL: admin@techworld.co.za

**MALL@PIET RETIEF**

**Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall**

**APPENDIX C**

# APPENDICES

TECHWORLD
consulting ENGINEERS

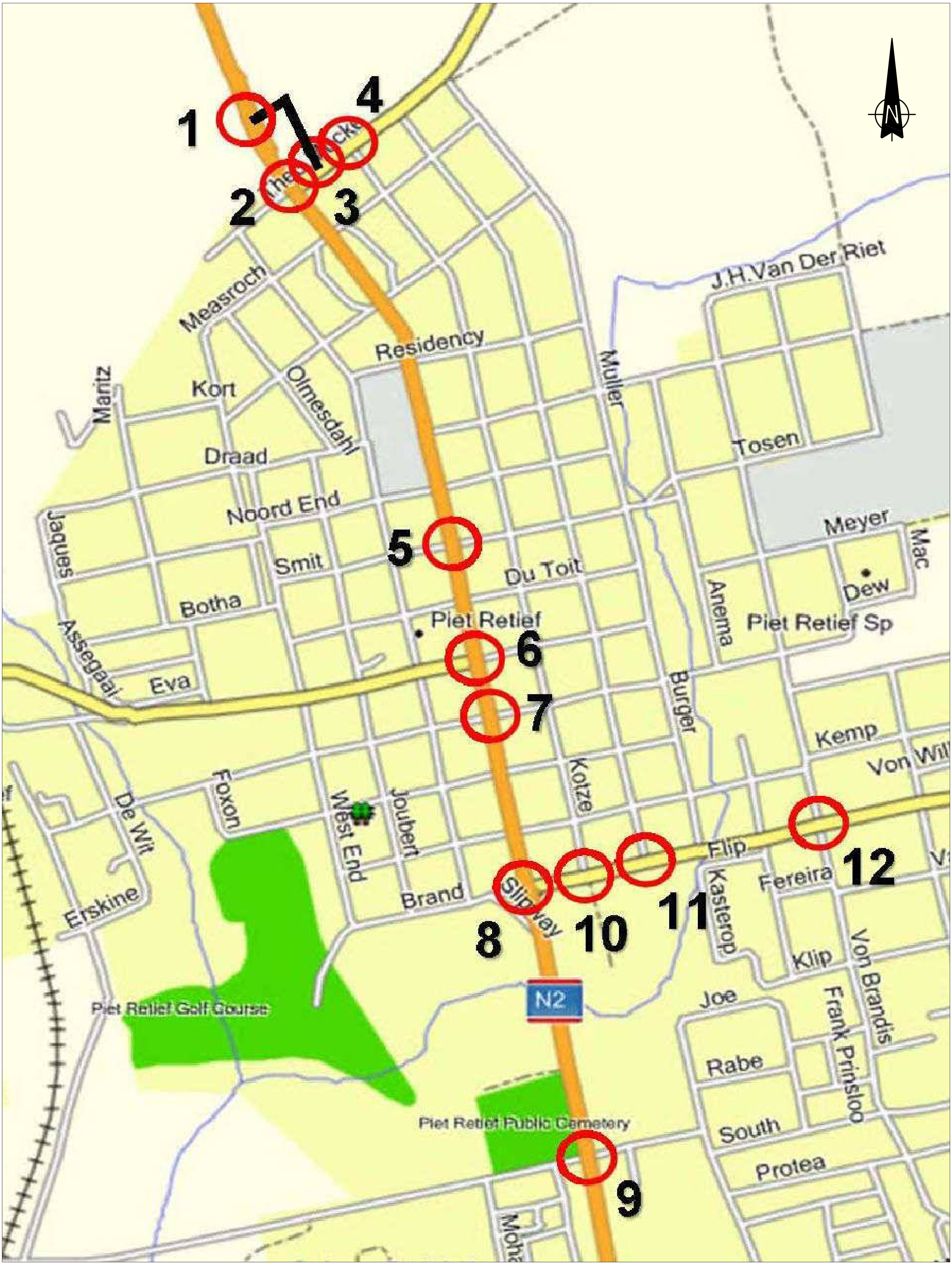
## Appendix D: Proposed Road Improvements at the Church (N2) / Gerard Bohmer Intersection to Support the Piet Retief Mall


| | | | |
|---|---|---|---|
| SUNBIRD PARK<br>Cnr. Delfi & Sunbird Ave<br>Garsfontein Ext 15<br>TEL:012 - 998 3541<br>FAX:012 - 9935506<br>TECHWORLD<br>E-MAIL: admin@techworld.co.za | **MALL@PIET RETIEF** | **Proposed Road Improvements at the Church (N2) / Gerard Bohmer Intersection to Support the Piet Retief Mall** | **APPENDIX D** |

APPENDICES

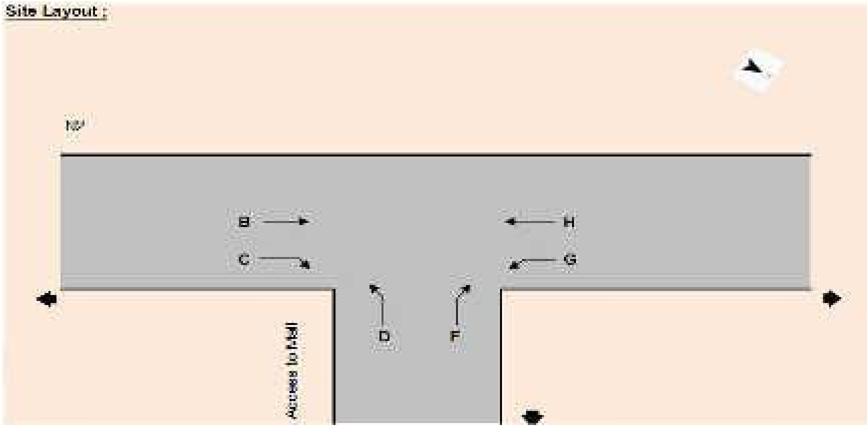
TECHWORLD consulting ENGINEERS

## Appendix E: Traffic Counts

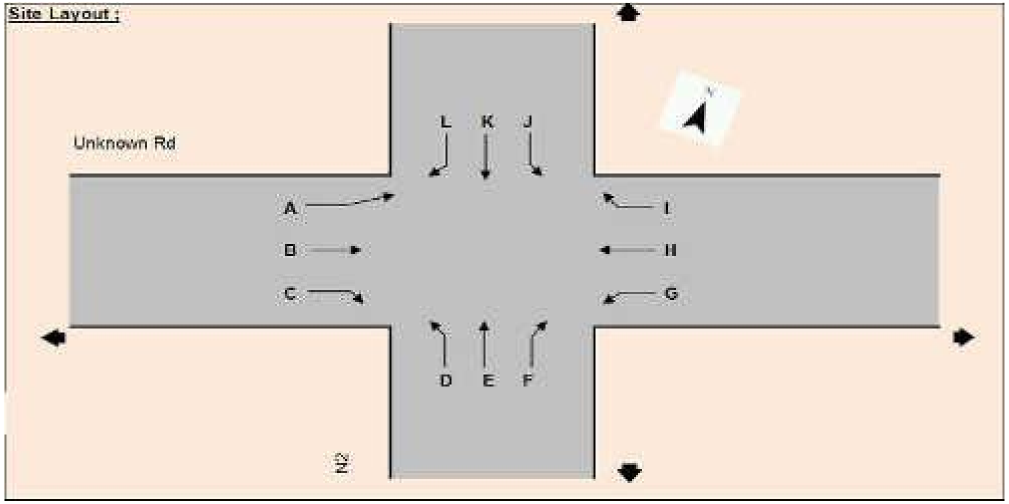



| PROJECT: | FIGURE: | Nr. |
| --- | --- | --- |
| PIET RETIEF TRAFFIC SURVEY | TRAFFIC SURVEY LOCATIONS | FIGURE 01 |

Trafsol

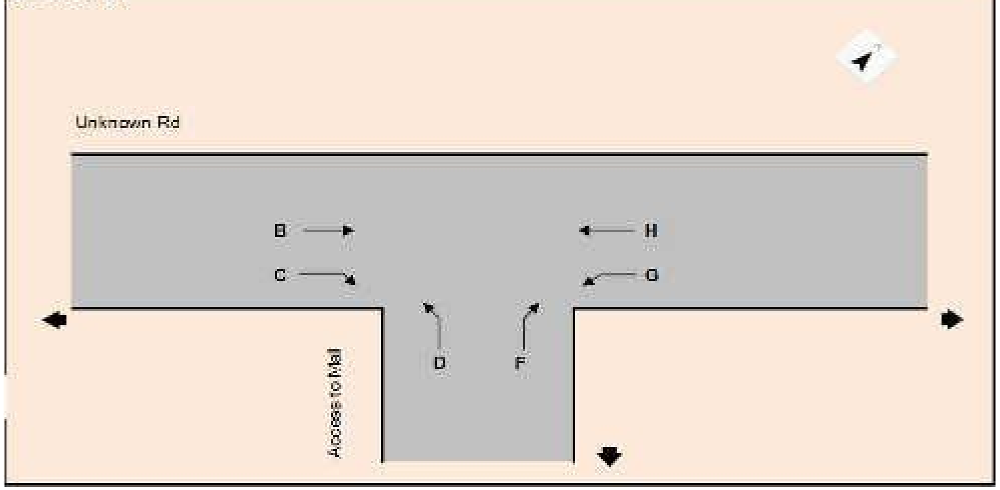



| Time Period | | TOTAL VEHICLES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | End | H | G | F | D | C | B | Total |
| 12:00 | 12:15 | 71 | 16 | 28 | 25 | 38 | 29 | **207** |
| 12:15 | 12:30 | 101 | 5 | 10 | 8 | 16 | 56 | **196** |
| 12:30 | 12:45 | 78 | 12 | 21 | 17 | 16 | 53 | **197** |
| 12:45 | 13:00 | 66 | 17 | 24 | 21 | 25 | 59 | **212** |
| 13:00 | 13:15 | 172 | 13 | 23 | 14 | 28 | 132 | **382** |
| 13:15 | 13:30 | 97 | 5 | 9 | 7 | 8 | 113 | **239** |
| *13:30* | *13:45* | *90* | *10* | *11* | *8* | *16* | *90* | ***225*** |
| *13:45* | *14:00* | *97* | *8* | *24* | *15* | *32* | *80* | ***256*** |
| *14:00* | *14:15* | *126* | *17* | *28* | *16* | *31* | *92* | ***310*** |
| *14:15* | *14:30* | *95* | *28* | *17* | *20* | *36* | *61* | ***257*** |
| 14:30 | 14:45 | 92 | 22 | 28 | 22 | 27 | 85 | **276** |
| 14:45 | 15:00 | 84 | 12 | 28 | 19 | 38 | 78 | **259** |
| 15:00 | 15:15 | 105 | 20 | 29 | 17 | 27 | 70 | **268** |
| 15:15 | 15:30 | 108 | 8 | 19 | 17 | 21 | 85 | **258** |
| 15:30 | 15:45 | 73 | 10 | 30 | 20 | 35 | 52 | **220** |
| 15:45 | 16:00 | 60 | 17 | 24 | 16 | 21 | 39 | **177** |
| 16:00 | 16:15 | 82 | 20 | 31 | 17 | 24 | 55 | **229** |
| 16:15 | 16:30 | 129 | 16 | 20 | 16 | 33 | 69 | **283** |
| 16:30 | 16:45 | 80 | 23 | 38 | 19 | 24 | 71 | **255** |
| 16:45 | 17:00 | 92 | 13 | 27 | 17 | 36 | 64 | **249** |
| 17:00 | 17:15 | 98 | 14 | 30 | 16 | 34 | 79 | **271** |
| 17:15 | 17:30 | 94 | 16 | 28 | 17 | 31 | 51 | **237** |
| 17:30 | 17:45 | 47 | 18 | 31 | 19 | 37 | 68 | **220** |
| 17:45 | 18:00 | 76 | 23 | 29 | 9 | 24 | 31 | **192** |
| **TOTAL** | | **2213** | **363** | **587** | **392** | **658** | **1662** | **5875** |

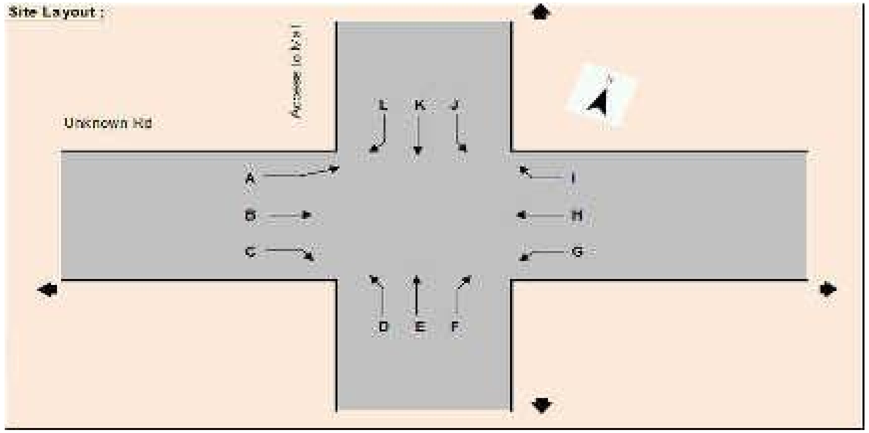



| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **L** | **K** | **J** | **I** | **H** | **G** | **F** | **E** | **D** | **C** | **B** | **A** | **Total** |
| 12:00 | 12:15 | 17 | 70 | 0 | 3 | 21 | 26 | 23 | 43 | 1 | 0 | 14 | 0 | **218** |
| 12:15 | 12:30 | 13 | 80 | 0 | 5 | 11 | 23 | 27 | 50 | 0 | 0 | 16 | 0 | **225** |
| 12:30 | 12:45 | 17 | 66 | 0 | 5 | 21 | 24 | 26 | 38 | 1 | 2 | 10 | 1 | **211** |
| 12:45 | 13:00 | 9 | 64 | 0 | 3 | 15 | 20 | 25 | 54 | 0 | 1 | 16 | 0 | **207** |
| 13:00 | 13:15 | 26 | 140 | 0 | 6 | 20 | 38 | 48 | 99 | 0 | 1 | 13 | 6 | **397** |
| 13:15 | 13:30 | 17 | 74 | 0 | 7 | 12 | 31 | 35 | 79 | 0 | 0 | 8 | 3 | **266** |
| *13:30* | *13:45* | *15* | *70* | *0* | *4* | *12* | *30* | *32* | *72* | *0* | *0* | *6* | *2* | ***243*** |
| *13:45* | *14:00* | *20* | *79* | *0* | *4* | *9* | *22* | *30* | *76* | *0* | *0* | *13* | *1* | ***254*** |
| *14:00* | *14:15* | *25* | *103* | *0* | *8* | *10* | *24* | *23* | *78* | *1* | *0* | *18* | *1* | ***291*** |
| *14:15* | *14:30* | *24* | *76* | *1* | *9* | *9* | *19* | *34* | *61* | *0* | *1* | *14* | *1* | ***249*** |
| 14:30 | 14:45 | 18 | 80 | 0 | 6 | 16 | 25 | 20 | 59 | 1 | 0 | 12 | 2 | **239** |
| 14:45 | 15:00 | 22 | 72 | 0 | 6 | 6 | 23 | 33 | 74 | 0 | 0 | 13 | 4 | **253** |
| 15:00 | 15:15 | 22 | 87 | 0 | 6 | 10 | 22 | 23 | 63 | 0 | 0 | 7 | 0 | **240** |
| 15:15 | 15:30 | 21 | 92 | 0 | 2 | 8 | 30 | 35 | 72 | 0 | 1 | 18 | 1 | **280** |
| 15:30 | 15:45 | 14 | 62 | 0 | 6 | 6 | 23 | 34 | 53 | 0 | 0 | 9 | 2 | **209** |
| 15:45 | 16:00 | 8 | 51 | 0 | 4 | 7 | 26 | 27 | 49 | 0 | 0 | 7 | 0 | **179** |
| 16:00 | 16:15 | 17 | 71 | 0 | 3 | 9 | 30 | 32 | 59 | 0 | 0 | 11 | 1 | **233** |
| 16:15 | 16:30 | 28 | 102 | 0 | 4 | 13 | 40 | 34 | 69 | 1 | 0 | 9 | 2 | **302** |
| 16:30 | 16:45 | 16 | 66 | 0 | 7 | 4 | 23 | 33 | 54 | 1 | 1 | 17 | 1 | **223** |
| 16:45 | 17:00 | 21 | 72 | 0 | 6 | 16 | 23 | 31 | 57 | 2 | 0 | 8 | 0 | **236** |
| 17:00 | 17:15 | 13 | 80 | 0 | 7 | 11 | 29 | 36 | 70 | 0 | 0 | 14 | 1 | **261** |
| 17:15 | 17:30 | 21 | 71 | 0 | 9 | 7 | 27 | 39 | 48 | 0 | 4 | 12 | 2 | **240** |
| 17:30 | 17:45 | 5 | 52 | 0 | 7 | 13 | 27 | 31 | 67 | 0 | 0 | 12 | 1 | **215** |
| 17:45 | 18:00 | 12 | 56 | 0 | 7 | 6 | 34 | 17 | 38 | 1 | 1 | 9 | 0 | **181** |
| **TOTAL** | | **421** | **1836** | **1** | **134** | **272** | **639** | **728** | **1482** | **9** | **12** | **286** | **32** | **5852** |

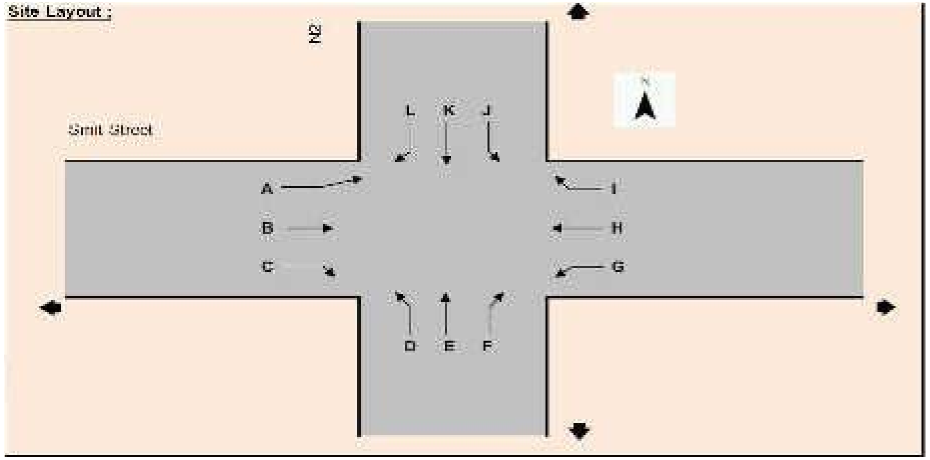
Site Layout :



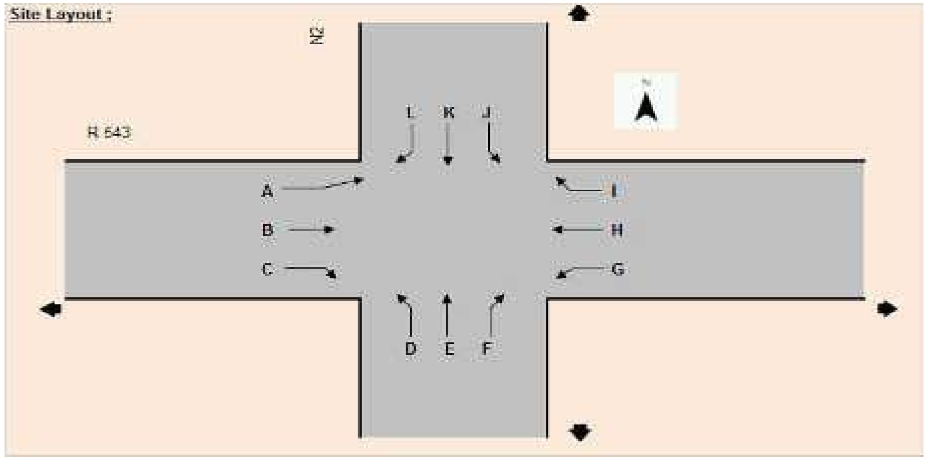

| Time Period | | TOTAL VEHICLES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | End | H | G | F | D | C | B | Total |
| 12:00 | 12:15 | 36 | 10 | 15 | 12 | 0 | 35 | **108** |
| 12:15 | 12:30 | 33 | 26 | 8 | 13 | 11 | 31 | **122** |
| 12:30 | 12:45 | 21 | 27 | 19 | 25 | 6 | 31 | **129** |
| 12:45 | 13:00 | 25 | 30 | 19 | 26 | 12 | 19 | **131** |
| 13:00 | 13:15 | 27 | 34 | 17 | 18 | 14 | 47 | **157** |
| 13:15 | 13:30 | 34 | 22 | 23 | 13 | 12 | 27 | **131** |
| *13:30* | *13:45* | *30* | *16* | *16* | *15* | *14* | *30* | ***121*** |
| *13:45* | *14:00* | *37* | *13* | *9* | *13* | *12* | *26* | ***110*** |
| *14:00* | *14:15* | *34* | *20* | *18* | *17* | *20* | *24* | ***133*** |
| *14:15* | *14:30* | *29* | *12* | *18* | *19* | *17* | *19* | ***114*** |
| 14:30 | 14:45 | 27 | 11 | 21 | 20 | 12 | 26 | **117** |
| 14:45 | 15:00 | 17 | 38 | 14 | 17 | 15 | 21 | **122** |
| 15:00 | 15:15 | 30 | 13 | 18 | 15 | 14 | 20 | **110** |
| 15:15 | 15:30 | 34 | 31 | 13 | 26 | 16 | 27 | **147** |
| 15:30 | 15:45 | 23 | 37 | 14 | 11 | 10 | 21 | **116** |
| 15:45 | 16:00 | 27 | 24 | 18 | 14 | 12 | 19 | **114** |
| 16:00 | 16:15 | 18 | 36 | 17 | 28 | 14 | 25 | **138** |
| 16:15 | 16:30 | 28 | 30 | 25 | 16 | 14 | 32 | **145** |
| 16:30 | 16:45 | 29 | 38 | 18 | 26 | 13 | 16 | **140** |
| 16:45 | 17:00 | 30 | 25 | 23 | 28 | 14 | 22 | **142** |
| 17:00 | 17:15 | 34 | 37 | 22 | 29 | 10 | 25 | **157** |
| 17:15 | 17:30 | 30 | 40 | 23 | 21 | 17 | 20 | **151** |
| 17:30 | 17:45 | 22 | 30 | 27 | 20 | 20 | 20 | **139** |
| 17:45 | 18:00 | 21 | 22 | 22 | 18 | 16 | 25 | **124** |
| **TOTAL** | | **676** | **622** | **437** | **460** | **315** | **608** | **3118** |



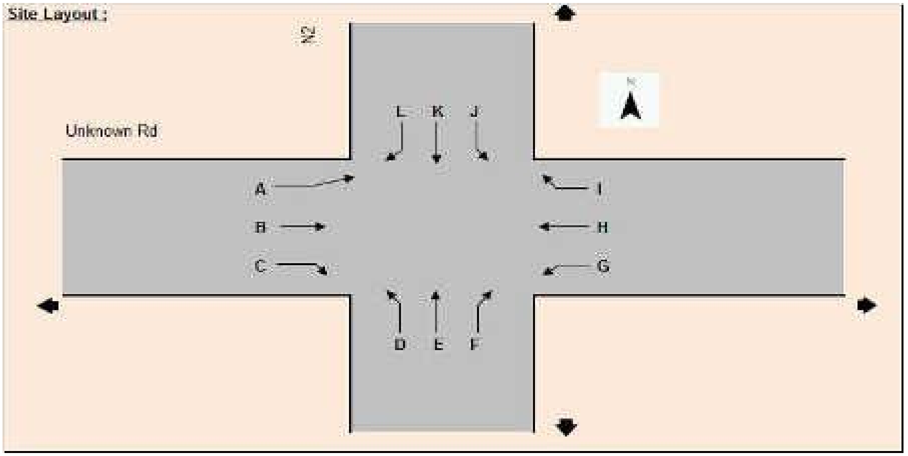

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | L | K | J | I | H | G | F | E | D | C | B | A | Total |
| 12:00 | 12:15 | 9 | 16 | 18 | 9 | 20 | 12 | 5 | 13 | 6 | 7 | 37 | 4 | **156** |
| 12:15 | 12:30 | 18 | 14 | 27 | 22 | 20 | 13 | 3 | 21 | 4 | 13 | 28 | 5 | **188** |
| 12:30 | 12:45 | 29 | 25 | 30 | 22 | 4 | 16 | 1 | 18 | 4 | 5 | 40 | 1 | **195** |
| 12:45 | 13:00 | 16 | 20 | 32 | 18 | 7 | 15 | 6 | 21 | 8 | 11 | 39 | 1 | **194** |
| 13:00 | 13:15 | 18 | 21 | 20 | 18 | 33 | 21 | 4 | 13 | 10 | 18 | 43 | 4 | **223** |
| 13:15 | 13:30 | 16 | 16 | 22 | 31 | 17 | 19 | 1 | 18 | 6 | 12 | 26 | 9 | **193** |
| *13:30* | *13:45* | *14* | *18* | *28* | *32* | *23* | *17* | *1* | *13* | *7* | *12* | *24* | *4* | ***193*** |
| *13:45* | *14:00* | *10* | *18* | *30* | *40* | *23* | *19* | *2* | *11* | *5* | *13* | *39* | *4* | ***214*** |
| *14:00* | *14:15* | *16* | *23* | *32* | *34* | *14* | *20* | *1* | *18* | *14* | *17* | *20* | *4* | ***213*** |
| *14:15* | *14:30* | *16* | *23* | *35* | *33* | *14* | *14* | *0* | *17* | *6* | *22* | *30* | *8* | ***218*** |
| 14:30 | 14:45 | 15 | 16 | 20 | 41 | 10 | 24 | 0 | 16 | 13 | 25 | 27 | 5 | **212** |
| 14:45 | 15:00 | 12 | 17 | 32 | 27 | 12 | 16 | 1 | 13 | 12 | 14 | 15 | 5 | **176** |
| 15:00 | 15:15 | 12 | 15 | 23 | 21 | 10 | 21 | 2 | 18 | 12 | 13 | 23 | 9 | **179** |
| 15:15 | 15:30 | 22 | 18 | 14 | 15 | 10 | 29 | 5 | 20 | 11 | 18 | 33 | 9 | **204** |
| 15:30 | 15:45 | 11 | 20 | 36 | 36 | 10 | 19 | 5 | 24 | 10 | 19 | 10 | 5 | **205** |
| 15:45 | 16:00 | 12 | 16 | 21 | 40 | 10 | 29 | 2 | 20 | 9 | 17 | 17 | 7 | **200** |
| 16:00 | 16:15 | 18 | 23 | 57 | 47 | 12 | 25 | 2 | 21 | 9 | 13 | 27 | 6 | **260** |
| 16:15 | 16:30 | 27 | 21 | 26 | 41 | 13 | 24 | 4 | 24 | 6 | 12 | 19 | 13 | **230** |
| 16:30 | 16:45 | 15 | 22 | 50 | 60 | 7 | 24 | 4 | 21 | 7 | 20 | 31 | 4 | **265** |
| 16:45 | 17:00 | 21 | 24 | 33 | 35 | 7 | 22 | 2 | 26 | 8 | 25 | 26 | 7 | **236** |
| 17:00 | 17:15 | 21 | 28 | 40 | 30 | 10 | 23 | 5 | 27 | 4 | 25 | 32 | 6 | **251** |
| 17:15 | 17:30 | 20 | 23 | 23 | 30 | 9 | 29 | 3 | 22 | 8 | 18 | 28 | 5 | **218** |
| 17:30 | 17:45 | 22 | 20 | 22 | 25 | 7 | 30 | 7 | 22 | 11 | 30 | 4 | 8 | **208** |
| 17:45 | 18:00 | 25 | 25 | 18 | 32 | 9 | 23 | 6 | 17 | 7 | 6 | 27 | 6 | **201** |
| **TOTAL** | | **415** | **482** | **689** | **739** | **311** | **504** | **72** | **454** | **197** | **385** | **645** | **139** | **5032** |



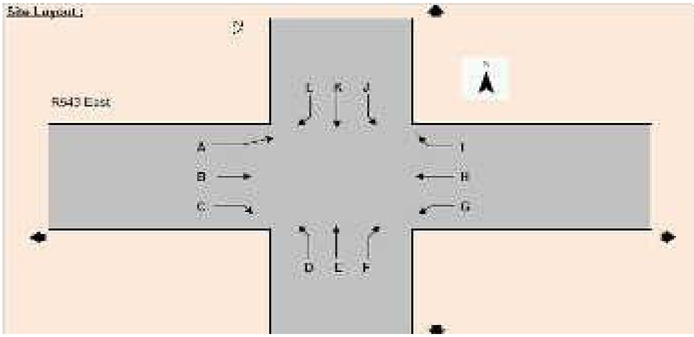

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | L | K | J | I | H | G | F | E | D | C | B | A | Total |
| 12:00 | 12:15 | 10 | 80 | 8 | 6 | 17 | 9 | 9 | 58 | 3 | 9 | 19 | 4 | **232** |
| 12:15 | 12:30 | 11 | 93 | 5 | 9 | 23 | 8 | 10 | 67 | 4 | 8 | 15 | 4 | **257** |
| 12:30 | 12:45 | 13 | 85 | 5 | 7 | 23 | 9 | 6 | 70 | 7 | 7 | 24 | 3 | **259** |
| 12:45 | 13:00 | 10 | 81 | 8 | 5 | 18 | 11 | 4 | 62 | 6 | 8 | 33 | 3 | **249** |
| 13:00 | 13:15 | 11 | 94 | 13 | 10 | 28 | 9 | 13 | 59 | 4 | 10 | 22 | 8 | **281** |
| 13:15 | 13:30 | 5 | 90 | 5 | 10 | 27 | 9 | 8 | 66 | 15 | 6 | 18 | 4 | **263** |
| *13:30* | *13:45* | *13* | *133* | *19* | *14* | *33* | *9* | *12* | *67* | *4* | *8* | *23* | *3* | ***338*** |
| *13:45* | *14:00* | *12* | *80* | *5* | *14* | *16* | *10* | *15* | *67* | *6* | *10* | *20* | *6* | ***261*** |
| *14:00* | *14:15* | *12* | *115* | *8* | *7* | *15* | *7* | *4* | *80* | *10* | *10* | *21* | *4* | ***293*** |
| *14:15* | *14:30* | *6* | *99* | *6* | *12* | *19* | *11* | *13* | *80* | *10* | *6* | *18* | *3* | ***283*** |
| 14:30 | 14:45 | 6 | 97 | 5 | 12 | 22 | 11 | 10 | 85 | 13 | 11 | 23 | 6 | **301** |
| 14:45 | 15:00 | 9 | 84 | 19 | 11 | 23 | 13 | 8 | 100 | 4 | 7 | 17 | 3 | **298** |
| 15:00 | 15:15 | 13 | 102 | 19 | 13 | 22 | 14 | 12 | 91 | 6 | 7 | 23 | 4 | **326** |
| 15:15 | 15:30 | 12 | 83 | 16 | 14 | 19 | 9 | 16 | 100 | 9 | 9 | 29 | 6 | **322** |
| 15:30 | 15:45 | 13 | 80 | 17 | 11 | 23 | 11 | 8 | 92 | 12 | 9 | 21 | 5 | **302** |
| 15:45 | 16:00 | 10 | 111 | 14 | 10 | 24 | 18 | 15 | 92 | 10 | 6 | 16 | 6 | **332** |
| 16:00 | 16:15 | 9 | 94 | 10 | 8 | 20 | 19 | 13 | 95 | 8 | 9 | 15 | 7 | **307** |
| 16:15 | 16:30 | 9 | 100 | 8 | 13 | 18 | 13 | 11 | 92 | 6 | 9 | 19 | 3 | **301** |
| 16:30 | 16:45 | 11 | 104 | 6 | 17 | 17 | 17 | 11 | 99 | 6 | 10 | 20 | 6 | **324** |
| 16:45 | 17:00 | 13 | 95 | 10 | 14 | 21 | 10 | 11 | 86 | 9 | 6 | 24 | 8 | **307** |
| 17:00 | 17:15 | 12 | 93 | 11 | 14 | 23 | 9 | 10 | 87 | 8 | 5 | 18 | 9 | **299** |
| 17:15 | 17:30 | 12 | 77 | 5 | 8 | 24 | 19 | 10 | 78 | 5 | 9 | 29 | 6 | **282** |
| 17:30 | 17:45 | 6 | 85 | 5 | 13 | 20 | 19 | 12 | 83 | 8 | 7 | 25 | 5 | **288** |
| 17:45 | 18:00 | 12 | 83 | 8 | 14 | 20 | 16 | 11 | 102 | 10 | 5 | 19 | 3 | **303** |
| **TOTAL** | | **250** | **2238** | **235** | **266** | **515** | **290** | **252** | **1958** | **183** | **191** | **511** | **119** | **7008** |



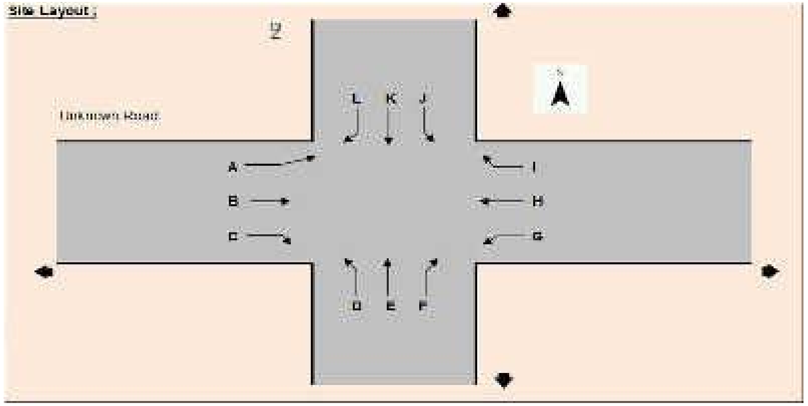

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **L** | **K** | **J** | **I** | **H** | **G** | **F** | **E** | **D** | **C** | **B** | **A** | **Total** |
| 12:00 | 12:15 | 1 | 119 | 5 | 1 | 13 | 1 | 3 | 103 | 8 | 6 | 14 | 1 | **275** |
| 12:15 | 12:30 | 3 | 115 | 2 | 4 | 6 | 1 | 2 | 98 | 5 | 7 | 27 | 2 | **272** |
| 12:30 | 12:45 | 4 | 126 | 2 | 2 | 12 | 1 | 1 | 96 | 18 | 5 | 22 | 2 | **291** |
| 12:45 | 13:00 | 2 | 112 | 5 | 3 | 24 | 3 | 2 | 107 | 10 | 5 | 24 | 6 | **303** |
| 13:00 | 13:15 | 1 | 112 | 7 | 4 | 14 | 0 | 3 | 93 | 12 | 13 | 22 | 2 | **283** |
| 13:15 | 13:30 | 3 | 120 | 3 | 2 | 11 | 4 | 0 | 110 | 8 | 10 | 19 | 0 | **290** |
| *13:30* | *13:45* | *1* | *115* | *11* | *5* | *16* | *4* | *5* | *131* | *10* | *10* | *30* | *2* | ***340*** |
| *13:45* | *14:00* | *2* | *141* | *3* | *7* | *30* | *2* | *2* | *92* | *14* | *12* | *18* | *2* | ***325*** |
| *14:00* | *14:15* | *4* | *97* | *7* | *2* | *19* | *5* | *1* | *130* | *19* | *17* | *20* | *3* | ***324*** |
| *14:15* | *14:30* | *1* | *94* | *6* | *6* | *13* | *3* | *3* | *146* | *8* | *23* | *18* | *1* | ***322*** |
| 14:30 | 14:45 | 1 | 118 | 8 | 5 | 18 | 1 | 2 | 121 | 18 | 12 | 26 | 2 | **332** |
| 14:45 | 15:00 | 2 | 117 | 6 | 2 | 16 | 0 | 6 | 134 | 11 | 8 | 16 | 1 | **319** |
| 15:00 | 15:15 | 4 | 129 | 5 | 3 | 18 | 0 | 2 | 110 | 7 | 12 | 22 | 3 | **315** |
| 15:15 | 15:30 | 2 | 118 | 5 | 2 | 12 | 2 | 1 | 126 | 8 | 11 | 37 | 2 | **326** |
| 15:30 | 15:45 | 2 | 133 | 5 | 8 | 9 | 4 | 1 | 116 | 13 | 16 | 29 | 3 | **339** |
| 15:45 | 16:00 | 2 | 117 | 2 | 3 | 15 | 2 | 3 | 130 | 7 | 13 | 25 | 4 | **323** |
| 16:00 | 16:15 | 3 | 134 | 6 | 2 | 13 | 3 | 1 | 133 | 6 | 14 | 21 | 2 | **338** |
| 16:15 | 16:30 | 3 | 149 | 7 | 1 | 14 | 3 | 1 | 117 | 9 | 17 | 21 | 1 | **343** |
| 16:30 | 16:45 | 3 | 150 | 10 | 5 | 20 | 0 | 3 | 121 | 8 | 10 | 23 | 4 | **357** |
| 16:45 | 17:00 | 3 | 131 | 8 | 4 | 16 | 2 | 1 | 125 | 6 | 15 | 23 | 2 | **336** |
| 17:00 | 17:15 | 1 | 112 | 7 | 7 | 15 | 2 | 1 | 111 | 10 | 20 | 35 | 4 | **325** |
| 17:15 | 17:30 | 2 | 117 | 5 | 3 | 13 | 4 | 2 | 123 | 7 | 11 | 39 | 1 | **327** |
| 17:30 | 17:45 | 2 | 108 | 3 | 1 | 18 | 0 | 1 | 133 | 3 | 14 | 20 | 1 | **304** |
| 17:45 | 18:00 | 1 | 127 | 2 | 2 | 9 | 4 | 1 | 127 | 5 | 13 | 27 | 0 | **318** |
| **TOTAL** | | **53** | **2911** | **130** | **84** | **364** | **51** | **48** | **2833** | **230** | **294** | **578** | **51** | **7627** |



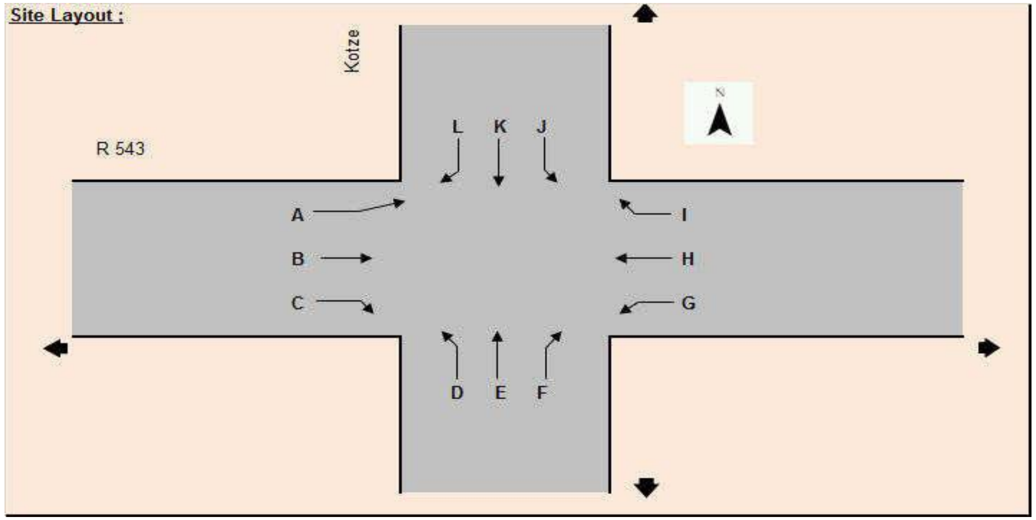

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **L** | **K** | **J** | **I** | **H** | **G** | **F** | **E** | **D** | **C** | **B** | **A** | **Total** |
| 12:00 | 12:15 | 14 | 109 | 12 | 33 | 25 | 20 | 4 | 68 | 23 | 4 | 18 | 12 | **342** |
| 12:15 | 12:30 | 13 | 107 | 13 | 32 | 29 | 18 | 6 | 61 | 23 | 5 | 18 | 12 | **337** |
| 12:30 | 12:45 | 15 | 111 | 16 | 35 | 28 | 20 | 6 | 67 | 22 | 5 | 18 | 13 | **356** |
| 12:45 | 13:00 | 21 | 93 | 10 | 29 | 26 | 28 | 8 | 78 | 26 | 7 | 34 | 12 | **372** |
| 13:00 | 13:15 | 20 | 99 | 11 | 27 | 35 | 23 | 5 | 70 | 29 | 10 | 41 | 11 | **381** |
| 13:15 | 13:30 | 20 | 101 | 15 | 23 | 33 | 24 | 16 | 80 | 33 | 6 | 45 | 15 | **411** |
| *13:30* | *13:45* | *19* | *99* | *15* | *35* | *37* | *15* | *9* | *84* | *25* | *8* | *20* | *27* | ***393*** |
| *13:45* | *14:00* | *25* | *118* | *16* | *34* | *69* | *20* | *21* | *45* | *29* | *6* | *39* | *29* | ***451*** |
| *14:00* | *14:15* | *24* | *86* | *16* | *30* | *19* | *28* | *13* | *102* | *24* | *10* | *25* | *18* | ***395*** |
| *14:15* | *14:30* | *23* | *90* | *16* | *33* | *14* | *26* | *11* | *102* | *23* | *10* | *25* | *22* | ***395*** |
| 14:30 | 14:45 | 21 | 102 | 16 | 36 | 25 | 29 | 16 | 84 | 38 | 12 | 33 | 22 | **434** |
| 14:45 | 15:00 | 19 | 93 | 14 | 31 | 27 | 15 | 3 | 97 | 35 | 10 | 38 | 22 | **404** |
| 15:00 | 15:15 | 27 | 101 | 19 | 44 | 18 | 21 | 9 | 67 | 36 | 9 | 27 | 8 | **386** |
| 15:15 | 15:30 | 11 | 113 | 19 | 34 | 25 | 34 | 10 | 90 | 22 | 10 | 17 | 11 | **396** |
| 15:30 | 15:45 | 24 | 116 | 13 | 32 | 23 | 20 | 15 | 82 | 28 | 13 | 38 | 18 | **422** |
| 15:45 | 16:00 | 14 | 114 | 11 | 45 | 28 | 23 | 14 | 80 | 30 | 9 | 17 | 15 | **400** |
| 16:00 | 16:15 | 26 | 117 | 9 | 38 | 21 | 15 | 17 | 82 | 27 | 14 | 20 | 20 | **406** |
| 16:15 | 16:30 | 20 | 121 | 28 | 26 | 24 | 23 | 12 | 81 | 16 | 6 | 38 | 20 | **415** |
| 16:30 | 16:45 | 17 | 122 | 23 | 36 | 34 | 25 | 7 | 75 | 22 | 14 | 22 | 21 | **418** |
| 16:45 | 17:00 | 16 | 116 | 19 | 40 | 21 | 22 | 5 | 71 | 20 | 10 | 24 | 21 | **385** |
| 17:00 | 17:15 | 8 | 112 | 9 | 35 | 27 | 20 | 9 | 72 | 32 | 12 | 29 | 16 | **381** |
| 17:15 | 17:30 | 11 | 107 | 17 | 41 | 23 | 18 | 7 | 78 | 12 | 14 | 18 | 14 | **360** |
| 17:30 | 17:45 | 10 | 99 | 13 | 29 | 21 | 11 | 10 | 93 | 16 | 13 | 15 | 16 | **346** |
| 17:45 | 18:00 | 12 | 126 | 13 | 38 | 14 | 12 | 6 | 84 | 20 | 5 | 17 | 11 | **358** |
| **TOTAL** | | **430** | **2572** | **363** | **816** | **646** | **510** | **239** | **1893** | **611** | **222** | **636** | **406** | **9344** |




| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **L** | **K** | **J** | **I** | **H** | **G** | **F** | **E** | **D** | **C** | **B** | **A** | **Total** |
| 12:00 | 12:15 | 17 | 116 | 10 | 4 | 6 | 21 | 5 | 107 | 49 | 0 | 0 | 0 | **335** |
| 12:15 | 12:30 | 19 | 129 | 18 | 3 | 2 | 19 | 10 | 112 | 36 | 0 | 0 | 0 | **348** |
| 12:30 | 12:45 | 17 | 128 | 14 | 1 | 4 | 18 | 10 | 114 | 41 | 0 | 0 | 0 | **347** |
| 12:45 | 13:00 | 16 | 131 | 16 | 3 | 2 | 19 | 5 | 107 | 55 | 0 | 0 | 0 | **354** |
| 13:00 | 13:15 | 18 | 135 | 13 | 5 | 5 | 16 | 12 | 110 | 40 | 0 | 0 | 0 | **354** |
| 13:15 | 13:30 | 22 | 132 | 18 | 4 | 4 | 15 | 11 | 130 | 54 | 0 | 0 | 0 | **390** |
| *13:30* | *13:45* | *21* | *150* | *19* | *5* | *3* | *20* | *8* | *129* | *37* | *0* | *0* | *0* | ***392*** |
| *13:45* | *14:00* | *22* | *144* | *14* | *3* | *10* | *27* | *8* | *112* | *30* | *0* | *0* | *0* | ***370*** |
| *14:00* | *14:15* | *19* | *137* | *15* | *3* | *6* | *20* | *7* | *130* | *26* | *0* | *0* | *0* | ***363*** |
| *14:15* | *14:30* | *18* | *139* | *7* | *2* | *9* | *24* | *8* | *132* | *27* | *0* | *0* | *0* | ***366*** |
| 14:30 | 14:45 | 16 | 128 | 10 | 2 | 4 | 19 | 6 | 127 | 48 | 0 | 0 | 0 | **360** |
| 14:45 | 15:00 | 28 | 135 | 12 | 2 | 6 | 21 | 4 | 128 | 44 | 0 | 0 | 0 | **380** |
| 15:00 | 15:15 | 23 | 150 | 9 | 3 | 6 | 23 | 6 | 119 | 44 | 0 | 0 | 0 | **383** |
| 15:15 | 15:30 | 21 | 160 | 9 | 4 | 6 | 19 | 4 | 119 | 49 | 0 | 0 | 0 | **391** |
| 15:30 | 15:45 | 23 | 147 | 10 | 5 | 3 | 19 | 2 | 134 | 47 | 0 | 0 | 0 | **390** |
| 15:45 | 16:00 | 23 | 147 | 8 | 6 | 3 | 21 | 5 | 126 | 51 | 0 | 0 | 0 | **390** |
| 16:00 | 16:15 | 24 | 159 | 6 | 4 | 2 | 15 | 5 | 126 | 47 | 0 | 0 | 0 | **388** |
| 16:15 | 16:30 | 28 | 161 | 7 | 3 | 3 | 17 | 1 | 113 | 35 | 0 | 0 | 0 | **368** |
| 16:30 | 16:45 | 25 | 157 | 14 | 1 | 7 | 19 | 3 | 98 | 50 | 0 | 0 | 0 | **374** |
| 16:45 | 17:00 | 21 | 131 | 7 | 5 | 4 | 18 | 3 | 114 | 48 | 0 | 0 | 0 | **351** |
| 17:00 | 17:15 | 18 | 146 | 12 | 5 | 5 | 20 | 7 | 102 | 56 | 0 | 0 | 0 | **371** |
| 17:15 | 17:30 | 19 | 151 | 13 | 6 | 3 | 15 | 5 | 101 | 51 | 0 | 0 | 0 | **364** |
| 17:30 | 17:45 | 20 | 159 | 16 | 3 | 6 | 15 | 11 | 104 | 48 | 0 | 0 | 0 | **382** |
| 17:45 | 18:00 | 17 | 148 | 12 | 5 | 3 | 17 | 5 | 118 | 45 | 0 | 0 | 0 | **370** |
| **TOTAL** | | **495** | **3420** | **289** | **87** | **112** | **457** | **151** | **2812** | **1058** | **0** | **0** | **0** | **8881** |

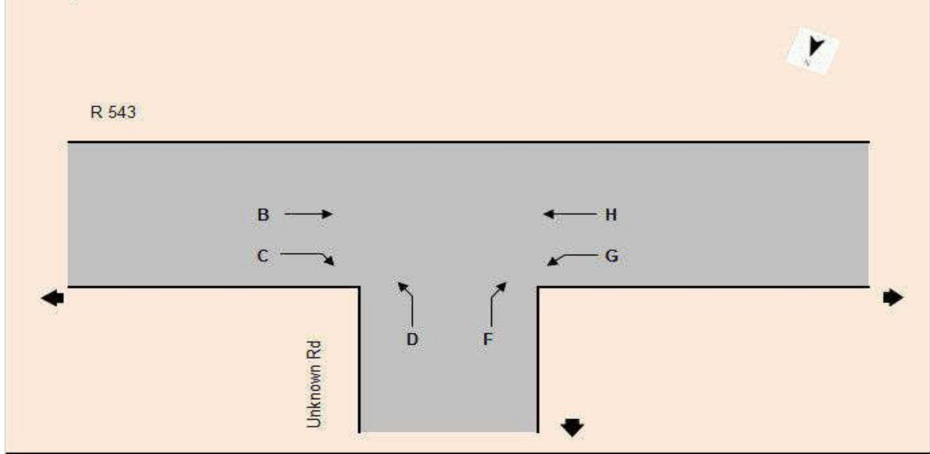



| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | L | K | J | I | H | G | F | E | D | C | B | A | Total |
| 12:00 | 12:15 | 58 | 41 | 15 | 22 | 6 | 1 | 0 | 59 | 6 | 1 | 8 | 2 | **219** |
| 12:15 | 12:30 | 68 | 42 | 14 | 22 | 7 | 5 | 1 | 78 | 5 | 3 | 7 | 7 | **259** |
| 12:30 | 12:45 | 72 | 34 | 16 | 27 | 5 | 3 | 2 | 85 | 2 | 1 | 8 | 10 | **265** |
| 12:45 | 13:00 | 75 | 38 | 18 | 24 | 8 | 2 | 5 | 93 | 14 | 3 | 4 | 12 | **296** |
| 13:00 | 13:15 | 80 | 44 | 22 | 24 | 6 | 4 | 6 | 93 | 5 | 1 | 2 | 16 | **303** |
| 13:15 | 13:30 | 73 | 41 | 20 | 22 | 4 | 5 | 3 | 102 | 6 | 2 | 3 | 13 | **294** |
| *13:30* | *13:45* | *76* | *52* | *18* | *33* | *6* | *2* | *2* | *103* | *9* | *3* | *10* | *14* | ***328*** |
| *13:45* | *14:00* | *76* | *50* | *21* | *30* | *8* | *3* | *5* | *100* | *5* | *3* | *2* | *18* | ***321*** |
| *14:00* | *14:15* | *61* | *42* | *23* | *34* | *6* | *3* | *4* | *101* | *4* | *3* | *10* | *14* | ***305*** |
| *14:15* | *14:30* | *95* | *70* | *23* | *32* | *6* | *3* | *5* | *96* | *17* | *6* | *7* | *12* | ***372*** |
| 14:30 | 14:45 | 84 | 68 | 29 | 21 | 17 | 6 | 3 | 73 | 7 | 4 | 13 | 16 | **341** |
| 14:45 | 15:00 | 101 | 82 | 22 | 19 | 8 | 2 | 2 | 94 | 2 | 3 | 11 | 10 | **356** |
| 15:00 | 15:15 | 101 | 84 | 22 | 27 | 10 | 5 | 2 | 59 | 2 | 1 | 8 | 15 | **336** |
| 15:15 | 15:30 | 90 | 62 | 23 | 13 | 8 | 2 | 4 | 70 | 2 | 4 | 9 | 9 | **296** |
| 15:30 | 15:45 | 90 | 64 | 39 | 13 | 11 | 1 | 2 | 59 | 5 | 2 | 9 | 14 | **309** |
| 15:45 | 16:00 | 92 | 66 | 16 | 24 | 9 | 4 | 1 | 55 | 4 | 0 | 8 | 14 | **293** |
| 16:00 | 16:15 | 112 | 93 | 17 | 20 | 4 | 0 | 3 | 42 | 4 | 1 | 14 | 5 | **315** |
| 16:15 | 16:30 | 111 | 79 | 32 | 13 | 9 | 2 | 0 | 54 | 7 | 4 | 10 | 12 | **333** |
| 16:30 | 16:45 | 57 | 38 | 19 | 6 | 7 | 0 | 3 | 19 | 1 | 0 | 6 | 7 | **163** |
| 16:45 | 17:00 | 64 | 40 | 32 | 13 | 6 | 1 | 2 | 18 | 9 | 2 | 10 | 9 | **206** |
| 17:00 | 17:15 | 62 | 42 | 30 | 16 | 2 | 1 | 1 | 33 | 8 | 4 | 10 | 4 | **213** |
| 17:15 | 17:30 | 58 | 39 | 30 | 16 | 5 | 0 | 0 | 33 | 5 | 1 | 6 | 11 | **204** |
| 17:30 | 17:45 | 54 | 32 | 27 | 8 | 6 | 0 | 0 | 45 | 5 | 4 | 5 | 5 | **191** |
| 17:45 | 18:00 | 34 | 34 | 20 | 10 | 3 | 0 | 0 | 40 | 1 | 2 | 6 | 6 | **156** |
| **TOTAL** | | **1844** | **1277** | **548** | **489** | **167** | **55** | **56** | **1604** | **135** | **58** | **186** | **255** | **6674** |

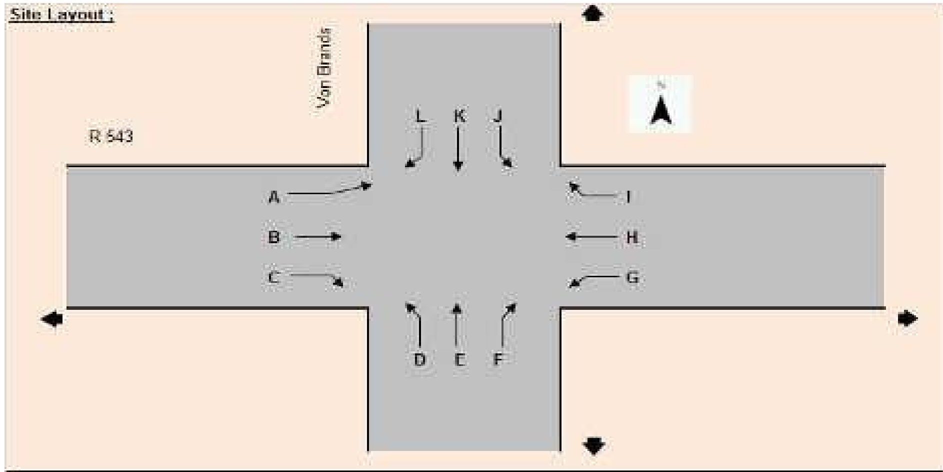



| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | L | K | J | I | H | G | F | E | D | C | B | A | Total |
| 12:00 | 12:15 | 9 | 0 | 2 | 5 | 13 | 0 | 0 | 0 | 0 | 0 | 6 | 7 | **42** |
| 12:15 | 12:30 | 10 | 0 | 3 | 7 | 14 | 0 | 0 | 0 | 0 | 0 | 14 | 14 | **62** |
| 12:30 | 12:45 | 12 | 0 | 5 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 10 | 11 | **48** |
| 12:45 | 13:00 | 13 | 0 | 4 | 4 | 7 | 0 | 0 | 0 | 0 | 0 | 9 | 12 | **49** |
| 13:00 | 13:15 | 13 | 0 | 2 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 10 | 9 | **43** |
| 13:15 | 13:30 | 14 | 0 | 6 | 9 | 3 | 0 | 0 | 0 | 0 | 0 | 12 | 11 | **55** |
| *13:30* | *13:45* | *19* | *0* | *6* | *8* | *7* | *0* | *0* | *0* | *0* | *0* | *7* | *14* | ***61*** |
| *13:45* | *14:00* | *15* | *0* | *7* | *7* | *17* | *0* | *0* | *0* | *0* | *0* | *7* | *13* | ***66*** |
| *14:00* | *14:15* | *23* | *0* | *3* | *7* | *2* | *0* | *0* | *0* | *0* | *0* | *10* | *16* | ***61*** |
| *14:15* | *14:30* | *13* | *0* | *8* | *5* | *20* | *0* | *0* | *0* | *0* | *0* | *14* | *15* | ***75*** |
| 14:30 | 14:45 | 14 | 0 | 7 | 4 | 8 | 0 | 0 | 0 | 0 | 0 | 6 | 12 | **51** |
| 14:45 | 15:00 | 9 | 0 | 5 | 7 | 15 | 0 | 0 | 0 | 0 | 0 | 7 | 13 | **56** |
| 15:00 | 15:15 | 16 | 0 | 7 | 8 | 16 | 0 | 0 | 0 | 0 | 0 | 5 | 14 | **66** |
| 15:15 | 15:30 | 17 | 0 | 6 | 10 | 7 | 0 | 0 | 0 | 0 | 0 | 4 | 9 | **53** |
| 15:30 | 15:45 | 16 | 0 | 6 | 6 | 6 | 0 | 0 | 0 | 0 | 0 | 3 | 15 | **52** |
| 15:45 | 16:00 | 17 | 0 | 3 | 9 | 6 | 0 | 0 | 0 | 0 | 0 | 4 | 12 | **51** |
| 16:00 | 16:15 | 15 | 0 | 5 | 5 | 3 | 0 | 0 | 0 | 0 | 0 | 3 | 9 | **40** |
| 16:15 | 16:30 | 18 | 0 | 5 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 2 | 11 | **47** |
| 16:30 | 16:45 | 17 | 0 | 5 | 8 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 3 | **41** |
| 16:45 | 17:00 | 16 | 0 | 4 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 13 | **47** |
| 17:00 | 17:15 | 20 | 0 | 6 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 5 | 9 | **49** |
| 17:15 | 17:30 | 16 | 0 | 5 | 9 | 3 | 0 | 0 | 0 | 0 | 0 | 6 | 12 | **51** |
| 17:30 | 17:45 | 13 | 0 | 4 | 8 | 6 | 0 | 0 | 0 | 0 | 0 | 11 | 11 | **53** |
| 17:45 | 18:00 | 15 | 0 | 7 | 6 | 4 | 0 | 0 | 0 | 0 | 0 | 7 | 13 | **52** |
| **TOTAL** | | **360** | **0** | **121** | **166** | **175** | **0** | **0** | **0** | **0** | **0** | **171** | **278** | **1271** |

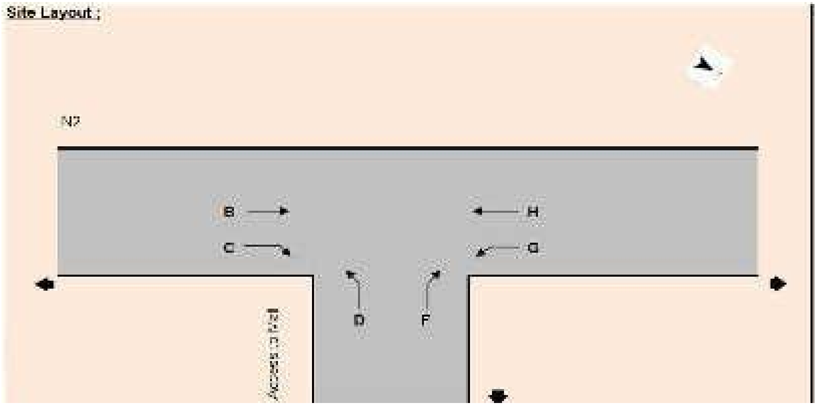
Site Layout :



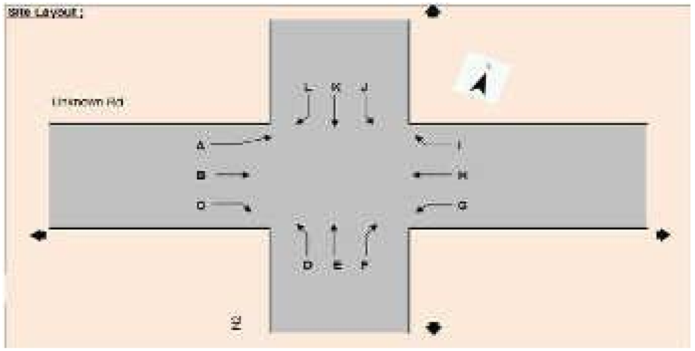

| | | TOTAL VEHICLES | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **H** | **G** | **F** | **D** | **C** | **B** | **Total** |
| 12:00 | 12:15 | 10 | 2 | 2 | 23 | 6 | 16 | **59** |
| 12:15 | 12:30 | 15 | 2 | 3 | 22 | 6 | 18 | **66** |
| 12:30 | 12:45 | 10 | 4 | 6 | 24 | 10 | 6 | **60** |
| 12:45 | 13:00 | 17 | 3 | 2 | 27 | 9 | 10 | **68** |
| 13:00 | 13:15 | 11 | 5 | 3 | 27 | 5 | 5 | **56** |
| 13:15 | 13:30 | 12 | 2 | 5 | 22 | 4 | 12 | **57** |
| *13:30* | *13:45* | *17* | *2* | *6* | *19* | *5* | *11* | ***60*** |
| *13:45* | *14:00* | *16* | *2* | *2* | *23* | *5* | *23* | ***71*** |
| *14:00* | *14:15* | *15* | *3* | *3* | *22* | *8* | *5* | ***56*** |
| *14:15* | *14:30* | *15* | *2* | *6* | *26* | *7* | *19* | ***75*** |
| 14:30 | 14:45 | 17 | 4 | 5 | 22 | 8 | 6 | **62** |
| 14:45 | 15:00 | 17 | 1 | 4 | 23 | 2 | 17 | **64** |
| 15:00 | 15:15 | 15 | 2 | 4 | 23 | 7 | 20 | **71** |
| 15:15 | 15:30 | 15 | 5 | 3 | 23 | 7 | 15 | **68** |
| 15:30 | 15:45 | 13 | 2 | 6 | 26 | 6 | 5 | **58** |
| 15:45 | 16:00 | 14 | 2 | 5 | 23 | 10 | 11 | **65** |
| 16:00 | 16:15 | 13 | 2 | 2 | 24 | 9 | 6 | **56** |
| 16:15 | 16:30 | 13 | 2 | 3 | 25 | 4 | 9 | **56** |
| 16:30 | 16:45 | 15 | 1 | 2 | 23 | 2 | 10 | **53** |
| 16:45 | 17:00 | 14 | 2 | 6 | 25 | 4 | 5 | **56** |
| 17:00 | 17:15 | 15 | 3 | 7 | 25 | 6 | 1 | **57** |
| 17:15 | 17:30 | 16 | 4 | 5 | 26 | 10 | 8 | **69** |
| 17:30 | 17:45 | 16 | 2 | 2 | 31 | 2 | 12 | **65** |
| 17:45 | 18:00 | 17 | 2 | 5 | 29 | 2 | 6 | **61** |
| **TOTAL** | | **348** | **61** | **97** | **583** | **144** | **256** | **1489** |




| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **L** | **K** | **J** | **I** | **H** | **G** | **F** | **E** | **D** | **C** | **B** | **A** | **Total** |
| 12:00 | 12:15 | 3 | 1 | 1 | 12 | 11 | 16 | 1 | 0 | 10 | 19 | 15 | 6 | **95** |
| 12:15 | 12:30 | 2 | 3 | 4 | 17 | 11 | 21 | 4 | 1 | 10 | 22 | 11 | 5 | **111** |
| 12:30 | 12:45 | 11 | 5 | 9 | 25 | 10 | 15 | 5 | 1 | 8 | 24 | 15 | 8 | **136** |
| 12:45 | 13:00 | 6 | 1 | 6 | 14 | 14 | 13 | 8 | 4 | 12 | 16 | 15 | 19 | **128** |
| 13:00 | 13:15 | 5 | 4 | 11 | 11 | 12 | 15 | 3 | 3 | 7 | 19 | 14 | 9 | **113** |
| 13:15 | 13:30 | 8 | 6 | 14 | 21 | 16 | 13 | 6 | 5 | 10 | 24 | 12 | 17 | **152** |
| *13:30* | *13:45* | *9* | *12* | *16* | *26* | *10* | *16* | *6* | *2* | *7* | *17* | *11* | *15* | ***147*** |
| *13:45* | *14:00* | *9* | *11* | *18* | *21* | *9* | *13* | *5* | *3* | *10* | *18* | *13* | *15* | ***145*** |
| *14:00* | *14:15* | *12* | *10* | *12* | *27* | *9* | *12* | *7* | *4* | *8* | *16* | *20* | *16* | ***153*** |
| *14:15* | *14:30* | *1* | *11* | *4* | *16* | *16* | *16* | *9* | *5* | *6* | *15* | *19* | *12* | ***130*** |
| 14:30 | 14:45 | 5 | 10 | 11 | 25 | 12 | 20 | 3 | 5 | 7 | 25 | 25 | 11 | **159** |
| 14:45 | 15:00 | 8 | 11 | 15 | 17 | 15 | 12 | 10 | 4 | 11 | 19 | 30 | 10 | **162** |
| 15:00 | 15:15 | 9 | 14 | 10 | 15 | 11 | 23 | 9 | 2 | 8 | 27 | 18 | 14 | **160** |
| 15:15 | 15:30 | 10 | 15 | 9 | 23 | 10 | 14 | 6 | 7 | 11 | 25 | 16 | 15 | **161** |
| 15:30 | 15:45 | 13 | 12 | 15 | 23 | 10 | 12 | 5 | 6 | 9 | 21 | 19 | 19 | **164** |
| 15:45 | 16:00 | 9 | 15 | 16 | 13 | 11 | 9 | 7 | 4 | 8 | 20 | 15 | 19 | **146** |
| 16:00 | 16:15 | 5 | 14 | 11 | 24 | 14 | 19 | 5 | 3 | 14 | 28 | 24 | 21 | **182** |
| 16:15 | 16:30 | 15 | 13 | 8 | 16 | 15 | 27 | 10 | 4 | 16 | 17 | 22 | 20 | **183** |
| 16:30 | 16:45 | 17 | 9 | 13 | 14 | 13 | 26 | 2 | 6 | 17 | 13 | 22 | 16 | **168** |
| 16:45 | 17:00 | 18 | 6 | 11 | 12 | 11 | 19 | 9 | 1 | 17 | 28 | 25 | 8 | **165** |
| 17:00 | 17:15 | 12 | 5 | 9 | 28 | 10 | 26 | 6 | 6 | 15 | 26 | 29 | 25 | **197** |
| 17:15 | 17:30 | 14 | 4 | 11 | 11 | 18 | 23 | 5 | 2 | 12 | 24 | 14 | 17 | **155** |
| 17:30 | 17:45 | 13 | 11 | 9 | 11 | 13 | 17 | 9 | 3 | 9 | 16 | 20 | 15 | **146** |
| 17:45 | 18:00 | 10 | 9 | 11 | 13 | 16 | 23 | 11 | 1 | 10 | 19 | 14 | 7 | **144** |
| **TOTAL** | | **224** | **212** | **254** | **435** | **297** | **420** | **151** | **82** | **252** | **498** | **438** | **339** | **3602** |

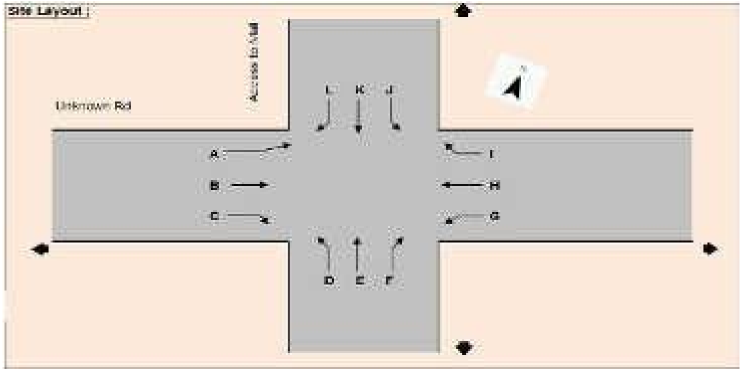



| Time Period | | Total vehicles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | End | B | C | D | F | G | H | Total |
| 09:00 | 09:15 | 20 | 11 | 23 | 18 | 16 | 25 | **113** |
| 09:15 | 09:30 | 26 | 15 | 15 | 16 | 6 | 17 | **95** |
| 09:30 | 09:45 | 14 | 35 | 20 | 12 | 21 | 15 | **117** |
| 09:45 | 10:00 | 15 | 34 | 11 | 17 | 10 | 45 | **132** |
| 10:00 | 10:15 | 17 | 30 | 18 | 10 | 11 | 45 | **131** |
| 10:15 | 10:30 | 35 | 25 | 15 | 13 | 10 | 61 | **159** |
| *10:30* | *10:45* | *69* | *20* | *12* | *17* | *8* | *59* | ***185*** |
| *10:45* | *11:00* | *41* | *19* | *10* | *16* | *7* | *95* | ***188*** |
| *11:00* | *11:15* | *62* | *33* | *24* | *33* | *8* | *66* | ***226*** |
| *11:15* | *11:30* | *50* | *23* | *12* | *12* | *8* | *60* | ***165*** |
| 11:30 | 11:45 | 63 | 18 | 16 | 17 | 6 | 104 | **224** |
| 11:45 | 12:00 | 49 | 24 | 17 | 19 | 19 | 93 | **221** |
| 12:00 | 12:15 | 50 | 20 | 24 | 15 | 8 | 64 | **181** |
| 12:15 | 12:30 | 54 | 25 | 11 | 21 | 16 | 73 | **200** |
| 12:30 | 12:45 | 59 | 20 | 13 | 22 | 10 | 128 | **252** |
| 12:45 | 13:00 | 52 | 19 | 12 | 18 | 7 | 101 | **209** |
| 13:00 | 13:15 | 49 | 10 | 5 | 7 | 7 | 74 | **152** |
| 13:15 | 13:30 | 58 | 11 | 6 | 8 | 7 | 76 | **166** |
| 13:30 | 13:45 | 36 | 11 | 11 | 15 | 9 | 71 | **153** |
| 13:45 | 14:00 | 61 | 8 | 15 | 20 | 8 | 60 | **172** |
| **TOTAL** | | **880** | **411** | **290** | **326** | **202** | **1332** | **3441** |

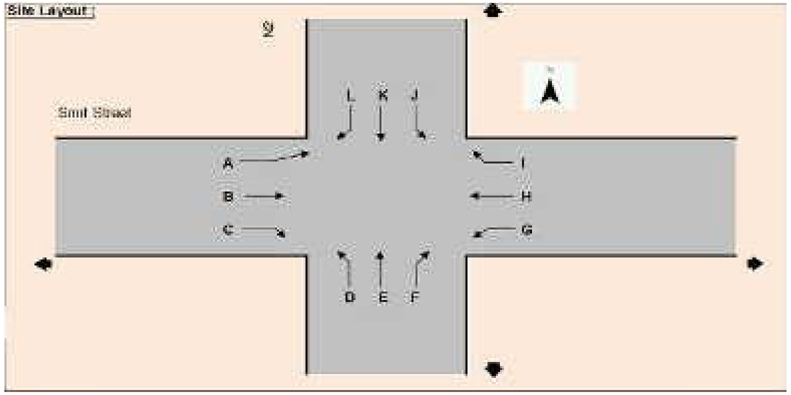



| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | C | D | E | F | G | H | I | J | K | L | Total |
| 09:00 | 09:15 | 13 | 2 | 3 | 1 | 11 | 11 | 4 | 2 | 1 | 23 | 26 | 2 | 99 |
| 09:15 | 09:30 | 15 | 9 | 1 | 2 | 17 | 7 | 12 | 2 | 3 | 13 | 16 | 4 | 101 |
| 09:30 | 09:45 | 11 | 6 | 4 | 1 | 30 | 13 | 7 | 5 | 5 | 13 | 21 | 2 | 118 |
| 09:45 | 10:00 | 13 | 4 | 5 | 0 | 36 | 21 | 5 | 3 | 2 | 6 | 41 | 4 | 140 |
| 10:00 | 10:15 | 14 | 3 | 2 | 4 | 30 | 21 | 12 | 4 | 1 | 9 | 43 | 5 | 148 |
| 10:15 | 10:30 | 16 | 8 | 4 | 2 | 33 | 25 | 19 | 12 | 1 | 3 | 61 | 2 | 186 |
| 10:30 | 10:45 | 26 | 13 | 0 | 1 | 75 | 14 | 22 | 7 | 1 | 6 | 63 | 7 | 235 |
| 10:45 | 11:00 | 18 | 4 | 1 | 1 | 47 | 20 | 20 | 4 | 1 | 15 | 83 | 8 | 222 |
| 11:00 | 11:15 | 24 | 10 | 0 | 1 | 61 | 19 | 23 | 4 | 6 | 13 | 65 | 19 | 245 |
| 11:15 | 11:30 | 23 | 10 | 0 | 0 | 50 | 30 | 17 | 5 | 6 | 9 | 51 | 10 | 211 |
| 11:30 | 11:45 | 28 | 42 | 0 | 0 | 61 | 29 | 13 | 5 | 7 | 46 | 67 | 13 | 311 |
| 11:45 | 12:00 | 30 | 17 | 0 | 1 | 43 | 37 | 18 | 7 | 3 | 8 | 77 | 21 | 262 |
| 12:00 | 12:15 | 25 | 12 | 1 | 0 | 49 | 21 | 22 | 10 | 7 | 16 | 61 | 15 | 239 |
| 12:15 | 12:30 | 27 | 10 | 0 | 1 | 48 | 21 | 22 | 6 | 3 | 10 | 59 | 17 | 224 |
| 12:30 | 12:45 | 23 | 8 | 0 | 0 | 63 | 26 | 71 | 21 | 4 | 27 | 117 | 27 | 387 |
| 12:45 | 13:00 | 25 | 5 | 0 | 0 | 37 | 32 | 50 | 18 | 3 | 17 | 81 | 21 | 289 |
| 13:00 | 13:15 | 17 | 6 | 0 | 1 | 49 | 25 | 3 | 18 | 0 | 11 | 63 | 5 | 198 |
| 13:15 | 13:30 | 18 | 9 | 1 | 1 | 48 | 20 | 21 | 14 | 1 | 16 | 71 | 3 | 223 |
| 13:30 | 13:45 | 23 | 7 | 0 | 0 | 12 | 26 | 16 | 4 | 1 | 12 | 69 | 3 | 173 |
| 13:45 | 14:00 | 22 | 5 | 1 | 0 | 63 | 27 | 25 | 10 | 2 | 13 | 65 | 4 | 237 |
| TOTAL | | 411 | 190 | 23 | 17 | 863 | 445 | 402 | 161 | 58 | 286 | 1200 | 192 | 4248 |

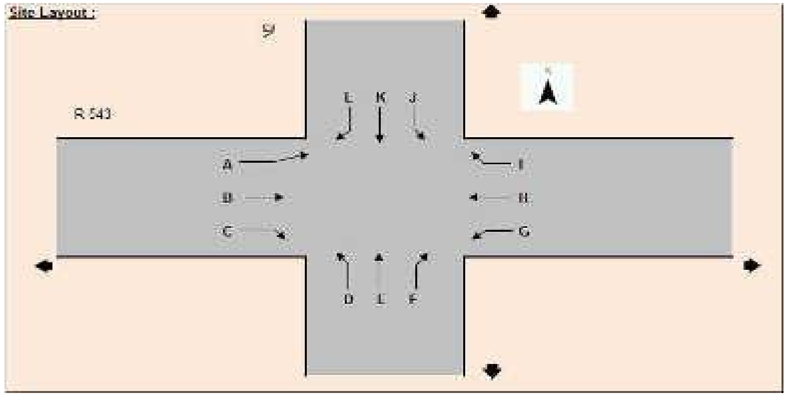
| Time Period | | Total vehicles | | | | | | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Start | End | B | C | D | F | G | H | Total |
| 09:00 | 09:15 | 5 | 2 | 6 | 1 | 1 | 5 | **20** |
| 09:15 | 09:30 | 8 | 10 | 4 | 2 | 2 | 8 | **34** |
| 09:30 | 09:45 | 11 | 14 | 10 | 2 | 0 | 7 | **44** |
| 09:45 | 10:00 | 10 | 12 | 14 | 2 | 1 | 15 | **54** |
| 10:00 | 10:15 | 13 | 13 | 9 | 7 | 3 | 13 | **58** |
| 10:15 | 10:30 | 19 | 16 | 16 | 2 | 3 | 14 | **70** |
| *10:30* | *10:45* | *18* | *12* | *18* | *4* | *2* | *16* | ***70*** |
| *10:45* | *11:00* | *13* | *14* | *17* | *4* | *4* | *15* | ***67*** |
| *11:00* | *11:15* | *15* | *15* | *11* | *2* | *0* | *27* | ***70*** |
| *11:15* | *11:30* | *22* | *11* | *10* | *16* | *4* | *16* | ***79*** |
| 11:30 | 11:45 | 9 | 25 | 10 | 7 | 3 | 6 | **60** |
| 11:45 | 12:00 | 7 | 12 | 10 | 7 | 3 | 18 | **57** |
| 12:00 | 12:15 | 10 | 12 | 19 | 2 | 6 | 20 | **69** |
| 12:15 | 12:30 | 2 | 10 | 25 | 12 | 2 | 15 | **66** |
| 12:30 | 12:45 | 11 | 1 | 62 | 0 | 2 | 15 | **91** |
| 12:45 | 13:00 | 15 | 7 | 30 | 6 | 6 | 25 | **89** |
| 13:00 | 13:15 | 5 | 11 | 15 | 3 | 11 | 6 | **51** |
| 13:15 | 13:30 | 10 | 12 | 5 | 3 | 3 | 6 | **39** |
| 13:30 | 13:45 | 3 | 3 | 10 | 5 | 0 | 12 | **33** |
| 13:45 | 14:00 | 20 | 20 | 25 | 5 | 3 | 20 | **93** |
| **TOTAL** | | **226** | **232** | **326** | **92** | **59** | **279** | **1214** |



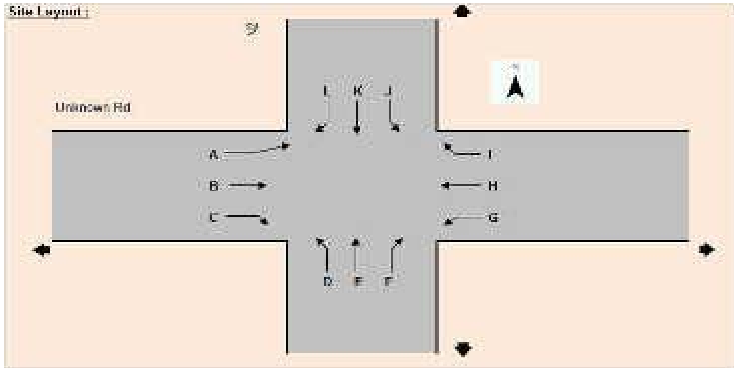

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | C | D | E | F | G | H | I | J | K | L | Total |
| 09:00 | 09:15 | 7 | 9 | 16 | 9 | 6 | 5 | 5 | 28 | 11 | 6 | 11 | 7 | **120** |
| 09:15 | 09:30 | 11 | 5 | 10 | 5 | 6 | 4 | 8 | 13 | 8 | 7 | 8 | 4 | **89** |
| 09:30 | 09:45 | 7 | 9 | 11 | 4 | 3 | 0 | 2 | 17 | 7 | 10 | 6 | 8 | **84** |
| 09:45 | 10:00 | 2 | 7 | 9 | 4 | 8 | 1 | 1 | 13 | 9 | 4 | 9 | 8 | **75** |
| 10:00 | 10:15 | 11 | 7 | 10 | 5 | 6 | 1 | 3 | 7 | 8 | 11 | 16 | 7 | **92** |
| 10:15 | 10:30 | 2 | 12 | 9 | 5 | 3 | 1 | 3 | 16 | 12 | 7 | 11 | 17 | **98** |
| *10:30* | *10:45* | *5* | *15* | *9* | *9* | *4* | *1* | *2* | *15* | *7* | *5* | *12* | *3* | ***87*** |
| *10:45* | *11:00* | *5* | *11* | *14* | *8* | *9* | *5* | *1* | *15* | *8* | *7* | *17* | *12* | ***112*** |
| *11:00* | *11:15* | *8* | *6* | *19* | *11* | *7* | *0* | *1* | *8* | *9* | *9* | *15* | *10* | ***103*** |
| *11:15* | *11:30* | *10* | *8* | *10* | *1* | *11* | *2* | *0* | *16* | *10* | *9* | *11* | *5* | ***93*** |
| 11:30 | 11:45 | 11 | 14 | 11 | 9 | 14 | 3 | 5 | 7 | 6 | 6 | 10 | 5 | **101** |
| 11:45 | 12:00 | 61 | 6 | 13 | 11 | 2 | 1 | 1 | 11 | 9 | 8 | 13 | 14 | **150** |
| 12:00 | 12:15 | 12 | 12 | 14 | 8 | 5 | 6 | 2 | 12 | 4 | 3 | 10 | 7 | **95** |
| 12:15 | 12:30 | 6 | 13 | 13 | 8 | 6 | 1 | 3 | 16 | 13 | 8 | 10 | 11 | **108** |
| 12:30 | 12:45 | 7 | 13 | 11 | 5 | 11 | 0 | 3 | 10 | 4 | 3 | 9 | 7 | **83** |
| 12:45 | 13:00 | 5 | 14 | 13 | 7 | 7 | 1 | 1 | 11 | 7 | 5 | 8 | 10 | **89** |
| 13:00 | 13:15 | 5 | 11 | 4 | 5 | 11 | 1 | 3 | 49 | 0 | 4 | 3 | 5 | **101** |
| 13:15 | 13:30 | 5 | 18 | 11 | 1 | 6 | 3 | 2 | 10 | 11 | 7 | 14 | 11 | **99** |
| 13:30 | 13:45 | 7 | 18 | 20 | 16 | 8 | 0 | 1 | 10 | 9 | 5 | 9 | 7 | **110** |
| 13:45 | 14:00 | 15 | 36 | 12 | 17 | 0 | 0 | 0 | 4 | 6 | 2 | 7 | 2 | **101** |
| **TOTAL** | | **202** | **244** | **239** | **148** | **133** | **36** | **47** | **288** | **158** | **126** | **209** | **160** | **1990** |



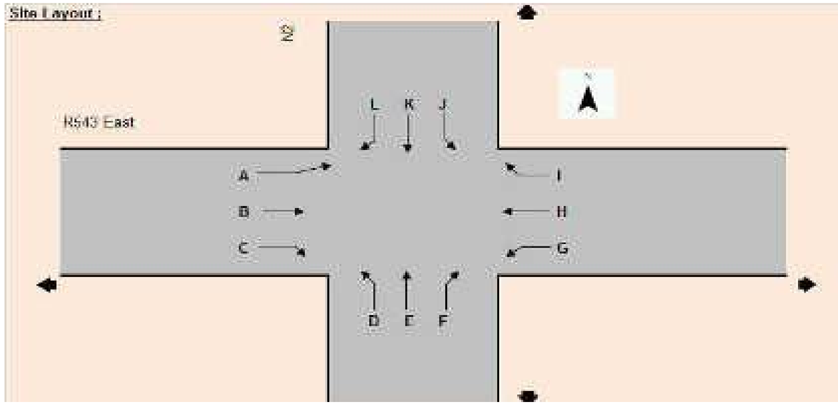

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | C | D | E | F | G | H | I | J | K | L | Total |
| 09:00 | 09:15 | 2 | 4 | 2 | 4 | 28 | 5 | 7 | 4 | 2 | 2 | 57 | 1 | **118** |
| 09:15 | 09:30 | 5 | 7 | 2 | 2 | 43 | 6 | 5 | 5 | 4 | 7 | 51 | 1 | **138** |
| 09:30 | 09:45 | 4 | 8 | 2 | 0 | 40 | 4 | 10 | 4 | 2 | 5 | 64 | 5 | **148** |
| 09:45 | 10:00 | 5 | 8 | 2 | 2 | 33 | 3 | 4 | 3 | 4 | 7 | 80 | 2 | **153** |
| 10:00 | 10:15 | 2 | 10 | 1 | 0 | 57 | 5 | 13 | 5 | 5 | 10 | 89 | 1 | **198** |
| 10:15 | 10:30 | 5 | 7 | 3 | 5 | 55 | 7 | 12 | 6 | 6 | 15 | 96 | 5 | **222** |
| *10:30* | *10:45* | *2* | *9* | *3* | *6* | *86* | *8* | *17* | *9* | *5* | *6* | *97* | *2* | ***250*** |
| *10:45* | *11:00* | *2* | *4* | *5* | *1* | *58* | *6* | *11* | *9* | *12* | *3* | *100* | *1* | ***212*** |
| *11:00* | *11:15* | *5* | *10* | *2* | *4* | *76* | *6* | *10* | *13* | *11* | *7* | *103* | *5* | ***252*** |
| *11:15* | *11:30* | *3* | *7* | *2* | *6* | *73* | *8* | *8* | *14* | *9* | *7* | *87* | *6* | ***230*** |
| 11:30 | 11:45 | 3 | 11 | 2 | 7 | 76 | 10 | 10 | 8 | 5 | 9 | 96 | 1 | **238** |
| 11:45 | 12:00 | 2 | 11 | 3 | 5 | 65 | 2 | 10 | 8 | 6 | 11 | 82 | 6 | **211** |
| 12:00 | 12:15 | 4 | 11 | 5 | 5 | 77 | 4 | 10 | 8 | 8 | 9 | 78 | 6 | **225** |
| 12:15 | 12:30 | 5 | 5 | 6 | 8 | 57 | 4 | 7 | 10 | 6 | 6 | 78 | 7 | **199** |
| 12:30 | 12:45 | 1 | 8 | 5 | 7 | 60 | 8 | 13 | 11 | 6 | 12 | 110 | 12 | **253** |
| 12:45 | 13:00 | 2 | 8 | 1 | 5 | 56 | 4 | 13 | 9 | 9 | 9 | 104 | 19 | **239** |
| 13:00 | 13:15 | 3 | 2 | 4 | 4 | 61 | 7 | 7 | 8 | 8 | 5 | 108 | 6 | **223** |
| 13:15 | 13:30 | 1 | 2 | 4 | 3 | 70 | 9 | 5 | 3 | 14 | 7 | 82 | 3 | **203** |
| 13:30 | 13:45 | 2 | 6 | 4 | 2 | 84 | 6 | 7 | 5 | 17 | 11 | 82 | 3 | **229** |
| 13:45 | 14:00 | 2 | 4 | 3 | 2 | 74 | 11 | 9 | 2 | 3 | 6 | 85 | 4 | **205** |
| **TOTAL** | | **60** | **142** | **61** | **78** | **1229** | **123** | **188** | **144** | **142** | **154** | **1729** | **96** | **4146** |



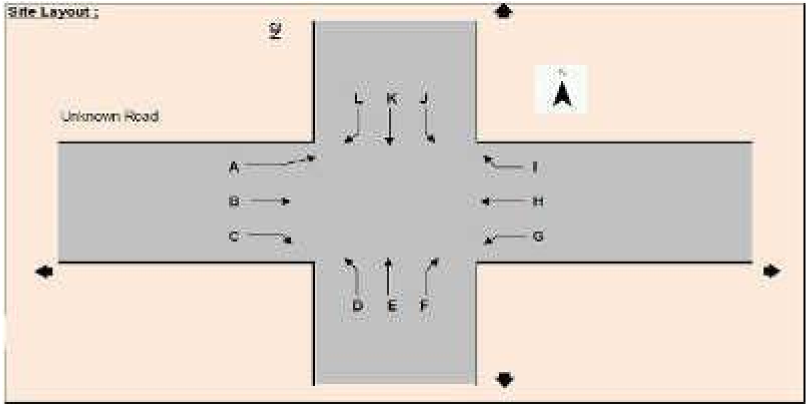

| Time Period | | Total vehicles | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **Total** |
| 09:00 | 09:15 | 4 | 4 | 5 | 6 | 40 | 4 | 1 | 2 | 1 | 1 | 46 | 2 | **116** |
| 09:15 | 09:30 | 6 | 2 | 7 | 3 | 31 | 1 | 5 | 2 | 2 | 0 | 62 | 3 | **124** |
| 09:30 | 09:45 | 5 | 4 | 14 | 2 | 58 | 3 | 1 | 3 | 1 | 2 | 91 | 5 | **189** |
| 09:45 | 10:00 | 3 | 2 | 9 | 3 | 50 | 2 | 2 | 2 | 1 | 1 | 75 | 3 | **153** |
| 10:00 | 10:15 | 8 | 4 | 14 | 8 | 64 | 3 | 2 | 5 | 1 | 2 | 98 | 2 | **211** |
| 10:15 | 10:30 | 8 | 3 | 15 | 9 | 72 | 3 | 5 | 5 | 2 | 4 | 104 | 7 | **237** |
| *10:30* | *10:45* | *9* | *8* | *15* | *12* | *85* | *5* | *2* | *5* | *3* | *5* | *104* | *4* | ***257*** |
| *10:45* | *11:00* | *9* | *6* | *11* | *16* | *65* | *5* | *2* | *3* | *1* | *2* | *111* | *12* | ***243*** |
| *11:00* | *11:15* | *14* | *6* | *12* | *18* | *62* | *4* | *4* | *4* | *1* | *1* | *111* | *8* | ***245*** |
| *11:15* | *11:30* | *11* | *7* | *22* | *22* | *102* | *5* | *6* | *7* | *4* | *3* | *86* | *14* | ***289*** |
| 11:30 | 11:45 | 11 | 4 | 26 | 17 | 86 | 3 | 3 | 6 | 3 | 5 | 105 | 9 | **278** |
| 11:45 | 12:00 | 9 | 10 | 13 | 17 | 84 | 1 | 6 | 6 | 3 | 3 | 112 | 10 | **274** |
| 12:00 | 12:15 | 10 | 9 | 15 | 22 | 74 | 6 | 5 | 8 | 1 | 3 | 103 | 9 | **265** |
| 12:15 | 12:30 | 9 | 7 | 16 | 17 | 89 | 3 | 9 | 2 | 2 | 2 | 85 | 8 | **249** |
| 12:30 | 12:45 | 9 | 6 | 16 | 13 | 83 | 1 | 5 | 10 | 1 | 1 | 115 | 9 | **269** |
| 12:45 | 13:00 | 6 | 5 | 12 | 16 | 84 | 2 | 4 | 9 | 2 | 2 | 127 | 8 | **277** |
| 13:00 | 13:15 | 6 | 7 | 12 | 18 | 81 | 4 | 11 | 8 | 2 | 2 | 132 | 9 | **292** |
| 13:15 | 13:30 | 10 | 5 | 10 | 6 | 81 | 3 | 2 | 6 | 2 | 4 | 102 | 7 | **238** |
| 13:30 | 13:45 | 8 | 6 | 10 | 14 | 101 | 4 | 3 | 1 | 2 | 2 | 92 | 9 | **252** |
| 13:45 | 14:00 | 8 | 4 | 18 | 14 | 102 | 1 | 4 | 0 | 3 | 1 | 90 | 7 | **252** |
| **TOTAL** | | **163** | **109** | **272** | **253** | **1494** | **63** | **82** | **94** | **38** | **46** | **1951** | **145** | **4710** |



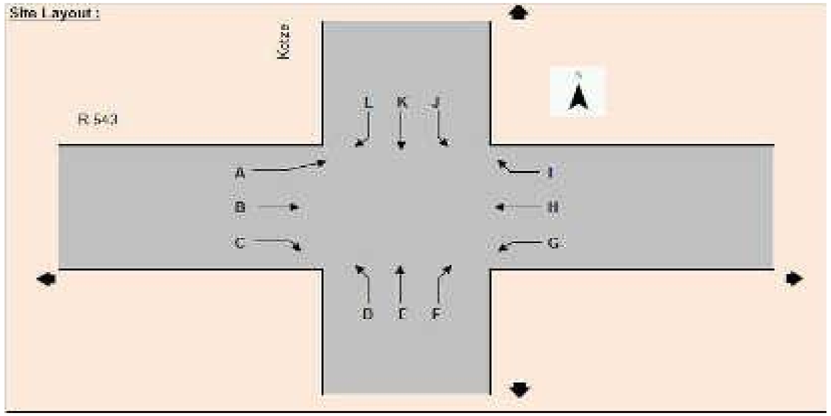

| **Time Period** | | **Total vehicles** | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **Total** |
| 09:00 | 09:15 | 2 | 9 | 0 | 15 | 34 | 6 | 2 | 5 | 1 | 1 | 38 | 1 | **114** |
| 09:15 | 09:30 | 5 | 11 | 0 | 12 | 54 | 6 | 1 | 14 | 1 | 1 | 64 | 2 | **171** |
| 09:30 | 09:45 | 4 | 4 | 0 | 17 | 61 | 8 | 1 | 10 | 2 | 0 | 72 | 2 | **181** |
| 09:45 | 10:00 | 8 | 10 | 0 | 18 | 53 | 18 | 1 | 18 | 4 | 0 | 66 | 4 | **200** |
| 10:00 | 10:15 | 4 | 14 | 5 | 28 | 50 | 10 | 3 | 21 | 2 | 2 | 60 | 2 | **201** |
| 10:15 | 10:30 | 2 | 27 | 12 | 14 | 64 | 9 | 3 | 20 | 8 | 4 | 95 | 2 | **260** |
| *10:30* | *10:45* | *8* | *15* | *17* | *14* | *70* | *34* | *5* | *11* | *8* | *3* | *97* | *5* | ***287*** |
| *10:45* | *11:00* | *9* | *12* | *14* | *15* | *74* | *25* | *3* | *14* | *3* | *6* | *97* | *3* | ***275*** |
| *11:00* | *11:15* | *2* | *11* | *16* | *35* | *81* | *5* | *3* | *27* | *2* | *3* | *95* | *11* | ***291*** |
| *11:15* | *11:30* | *17* | *16* | *12* | *17* | *74* | *4* | *8* | *9* | *5* | *1* | *96* | *5* | ***264*** |
| 11:30 | 11:45 | 5 | 15 | 5 | 14 | 65 | 1 | 3 | 8 | 4 | 2 | 93 | 2 | **217** |
| 11:45 | 12:00 | 22 | 16 | 23 | 29 | 67 | 13 | 8 | 18 | 10 | 6 | 76 | 7 | **295** |
| 12:00 | 12:15 | 20 | 18 | 22 | 6 | 60 | 8 | 6 | 27 | 4 | 4 | 64 | 7 | **246** |
| 12:15 | 12:30 | 30 | 12 | 34 | 48 | 70 | 17 | 2 | 39 | 6 | 3 | 87 | 7 | **355** |
| 12:30 | 12:45 | 22 | 12 | 26 | 32 | 71 | 8 | 3 | 18 | 3 | 9 | 76 | 7 | **287** |
| 12:45 | 13:00 | 17 | 13 | 23 | 29 | 35 | 8 | 1 | 8 | 4 | 2 | 94 | 3 | **237** |
| 13:00 | 13:15 | 18 | 11 | 18 | 39 | 53 | 6 | 4 | 7 | 4 | 5 | 100 | 8 | **273** |
| 13:15 | 13:30 | 27 | 23 | 31 | 4 | 66 | 17 | 3 | 17 | 1 | 7 | 98 | 3 | **297** |
| 13:30 | 13:45 | 24 | 4 | 35 | 30 | 79 | 5 | 1 | 10 | 5 | 7 | 90 | 3 | **293** |
| 13:45 | 14:00 | 25 | 16 | 42 | 63 | 39 | 9 | 4 | 23 | 6 | 4 | 94 | 8 | **333** |
| **TOTAL** | | **271** | **269** | **335** | **479** | **1220** | **217** | **65** | **324** | **83** | **70** | **1652** | **92** | **5077** |



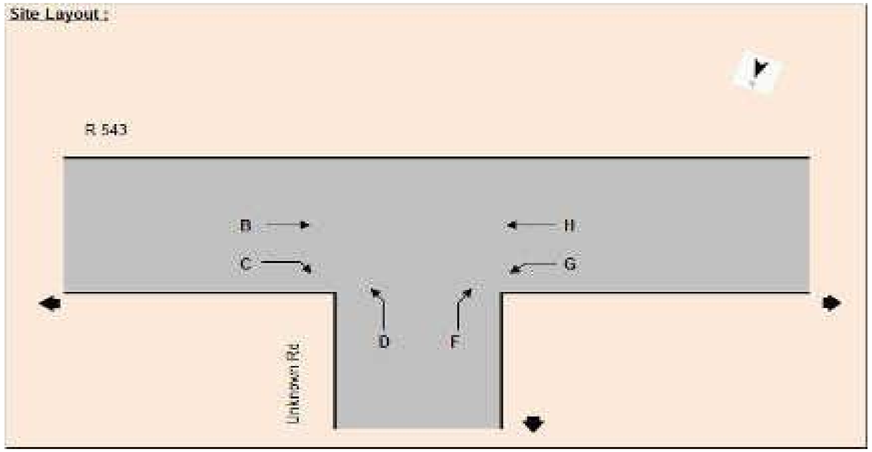

| Time Period | | TOTAL VEHICLES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | C | D | E | F | G | H | I | J | K | L | Total |
| 09:00 | 09:15 | 0 | 0 | 0 | 19 | 52 | 2 | 5 | 2 | 1 | 0 | 79 | 5 | **165** |
| 09:15 | 09:30 | 0 | 0 | 0 | 26 | 69 | 7 | 10 | 4 | 0 | 0 | 108 | 7 | **231** |
| 09:30 | 09:45 | 0 | 0 | 0 | 30 | 76 | 4 | 15 | 3 | 0 | 1 | 105 | 5 | **239** |
| 09:45 | 10:00 | 0 | 0 | 0 | 27 | 100 | 6 | 10 | 3 | 1 | 0 | 128 | 11 | **286** |
| 10:00 | 10:15 | 0 | 0 | 0 | 32 | 91 | 7 | 16 | 1 | 0 | 0 | 125 | 11 | **283** |
| 10:15 | 10:30 | 0 | 0 | 0 | 20 | 70 | 8 | 18 | 2 | 0 | 0 | 139 | 14 | **271** |
| *10:30* | *10:45* | *0* | *0* | *0* | *35* | *92* | *7* | *23* | *4* | *3* | *4* | *150* | *15* | ***333*** |
| *10:45* | *11:00* | *0* | *0* | *0* | *31* | *104* | *5* | *21* | *3* | *0* | *3* | *133* | *16* | ***316*** |
| *11:00* | *11:15* | *0* | *0* | *0* | *38* | *118* | *7* | *26* | *7* | *0* | *2* | *144* | *11* | ***353*** |
| *11:15* | *11:30* | *0* | *0* | *0* | *43* | *89* | *30* | *7* | *2* | *4* | *4* | *125* | *13* | ***317*** |
| 11:30 | 11:45 | 0 | 0 | 0 | 46 | 111 | 7 | 15 | 3 | 3 | 4 | 154 | 10 | **353** |
| 11:45 | 12:00 | 0 | 0 | 0 | 50 | 82 | 32 | 11 | 0 | 0 | 4 | 110 | 2 | **291** |
| 12:00 | 12:15 | 0 | 0 | 0 | 37 | 90 | 2 | 11 | 1 | 2 | 3 | 155 | 11 | **312** |
| 12:15 | 12:30 | 0 | 0 | 0 | 46 | 91 | 4 | 9 | 5 | 1 | 4 | 135 | 12 | **307** |
| 12:30 | 12:45 | 0 | 0 | 0 | 46 | 87 | 1 | 2 | 1 | 1 | 1 | 119 | 3 | **261** |
| 12:45 | 13:00 | 0 | 0 | 1 | 45 | 78 | 4 | 23 | 3 | 1 | 2 | 155 | 7 | **319** |
| 13:00 | 13:15 | 0 | 0 | 0 | 50 | 75 | 3 | 16 | 1 | 0 | 1 | 159 | 8 | **313** |
| 13:15 | 13:30 | 0 | 0 | 0 | 39 | 117 | 5 | 15 | 1 | 3 | 3 | 94 | 5 | **282** |
| 13:30 | 13:45 | 0 | 0 | 0 | 37 | 81 | 2 | 6 | 0 | 2 | 3 | 108 | 9 | **248** |
| 13:45 | 14:00 | 0 | 0 | 0 | 41 | 102 | 8 | 9 | 1 | 0 | 3 | 132 | 9 | **305** |
| **TOTAL** | | **0** | **0** | **1** | **738** | **1775** | **151** | **268** | **47** | **22** | **42** | **2557** | **184** | **5785** |



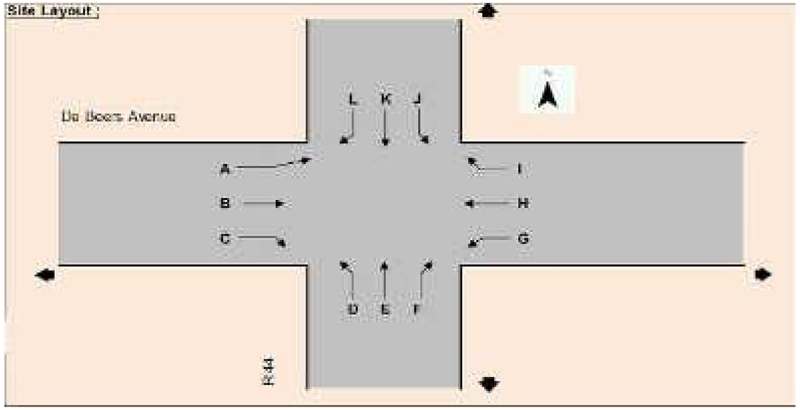

| Time Period | | TOTAL VEHICLES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Start** | **End** | **A** | **B** | **C** | **D** | **E** | **F** | **G** | **H** | **I** | **J** | **K** | **L** | **Total** |
| 09:00 | 09:15 | 33 | 2 | 1 | 1 | 6 | 1 | 1 | 0 | 3 | 7 | 23 | 25 | **103** |
| 09:15 | 09:30 | 61 | 2 | 0 | 0 | 10 | 0 | 0 | 2 | 5 | 7 | 36 | 41 | **164** |
| 09:30 | 09:45 | 53 | 8 | 1 | 2 | 14 | 1 | 2 | 1 | 11 | 7 | 59 | 56 | **215** |
| 09:45 | 10:00 | 47 | 2 | 2 | 1 | 21 | 0 | 1 | 11 | 9 | 11 | 43 | 46 | **194** |
| 10:00 | 10:15 | 67 | 4 | 1 | 1 | 5 | 1 | 1 | 5 | 21 | 9 | 45 | 60 | **220** |
| 10:15 | 10:30 | 83 | 1 | 0 | 1 | 11 | 0 | 0 | 12 | 21 | 10 | 57 | 57 | **253** |
| *10:30* | *10:45* | *88* | *2* | *2* | *3* | *23* | *0* | *1* | *10* | *21* | *11* | *74* | *76* | ***311*** |
| *10:45* | *11:00* | *70* | *6* | *1* | *3* | *28* | *0* | *2* | *1* | *22* | *11* | *62* | *66* | ***272*** |
| *11:00* | *11:15* | *63* | *3* | *0* | *3* | *32* | *2* | *1* | *5* | *20* | *13* | *74* | *69* | ***285*** |
| *11:15* | *11:30* | *128* | *5* | *2* | *3* | *27* | *1* | *1* | *8* | *14* | *16* | *61* | *91* | ***357*** |
| 11:30 | 11:45 | 76 | 8 | 2 | 8 | 33 | 0 | 2 | 14 | 14 | 10 | 76 | 73 | **316** |
| 11:45 | 12:00 | 108 | 13 | 5 | 4 | 64 | 0 | 1 | 9 | 22 | 11 | 61 | 65 | **363** |
| 12:00 | 12:15 | 71 | 4 | 3 | 3 | 61 | 0 | 2 | 10 | 17 | 15 | 67 | 84 | **337** |
| 12:15 | 12:30 | 76 | 11 | 5 | 1 | 57 | 1 | 1 | 7 | 20 | 14 | 59 | 92 | **344** |
| 12:30 | 12:45 | 100 | 13 | 2 | 2 | 47 | 0 | 1 | 9 | 16 | 13 | 66 | 83 | **352** |
| 12:45 | 13:00 | 94 | 6 | 3 | 6 | 32 | 1 | 3 | 11 | 12 | 21 | 48 | 142 | **379** |
| 13:00 | 13:15 | 71 | 12 | 3 | 0 | 31 | 0 | 2 | 7 | 14 | 22 | 62 | 123 | **347** |
| 13:15 | 13:30 | 73 | 10 | 6 | 4 | 27 | 2 | 3 | 13 | 15 | 20 | 84 | 98 | **355** |
| 13:30 | 13:45 | 73 | 6 | 1 | 2 | 47 | 3 | 3 | 8 | 20 | 13 | 68 | 89 | **333** |
| 13:45 | 14:00 | 75 | 9 | 2 | 5 | 48 | 1 | 1 | 3 | 8 | 7 | 67 | 88 | **314** |
| **TOTAL** | | **1510** | **127** | **42** | **53** | **624** | **14** | **29** | **146** | **305** | **248** | **1192** | **1524** | **5814** |




| Time Period | | Total vehicles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | H | I | J | L | Total |
| 09:00 | 09:15 | 1 | 11 | 2 | 0 | 1 | 2 | **17** |
| 09:15 | 09:30 | 1 | 12 | 2 | 1 | 2 | 3 | **21** |
| 09:30 | 09:45 | 1 | 15 | 7 | 0 | 0 | 5 | **28** |
| 09:45 | 10:00 | 1 | 12 | 6 | 0 | 1 | 6 | **26** |
| 10:00 | 10:15 | 2 | 11 | 12 | 0 | 1 | 6 | **32** |
| 10:15 | 10:30 | 1 | 14 | 11 | 0 | 2 | 7 | **35** |
| *10:30* | *10:45* | *3* | *13* | *12* | *3* | *9* | *8* | ***48*** |
| *10:45* | *11:00* | *1* | *11* | *10* | *9* | *4* | *20* | ***55*** |
| *11:00* | *11:15* | *2* | *12* | *11* | *2* | *2* | *9* | ***38*** |
| *11:15* | *11:30* | *10* | *11* | *7* | *7* | *5* | *10* | ***50*** |
| 11:30 | 11:45 | 3 | 10 | 12 | 2 | 4 | 35 | **66** |
| 11:45 | 12:00 | 2 | 13 | 2 | 0 | 3 | 1 | **21** |
| 12:00 | 12:15 | 3 | 12 | 13 | 0 | 5 | 7 | **40** |
| 12:15 | 12:30 | 1 | 11 | 5 | 1 | 4 | 8 | **30** |
| 12:30 | 12:45 | 4 | 10 | 1 | 1 | 7 | 20 | **43** |
| 12:45 | 13:00 | 0 | 9 | 11 | 0 | 4 | 8 | **32** |
| 13:00 | 13:15 | 2 | 15 | 5 | 0 | 6 | 5 | **33** |
| 13:15 | 13:30 | 1 | 6 | 3 | 0 | 4 | 7 | **21** |
| 13:30 | 13:45 | 1 | 11 | 2 | 0 | 2 | 5 | **21** |
| 13:45 | 14:00 | 2 | 10 | 4 | 0 | 1 | 1 | **18** |
| **TOTAL** | | **42** | **229** | **138** | **26** | **67** | **173** | **675** |




| Time Period | | Total vehicles | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Start | End | G | H | F | B | C | D | Total |
| 09:00 | 09:15 | 6 | 10 | 7 | 11 | 7 | 4 | **45** |
| 09:15 | 09:30 | 8 | 18 | 9 | 8 | 5 | 3 | **51** |
| 09:30 | 09:45 | 8 | 6 | 9 | 11 | 6 | 6 | **46** |
| 09:45 | 10:00 | 4 | 13 | 6 | 7 | 5 | 3 | **38** |
| 10:00 | 10:15 | 6 | 18 | 4 | 10 | 8 | 1 | **47** |
| 10:15 | 10:30 | 11 | 12 | 3 | 10 | 11 | 6 | **53** |
| *10:30* | *10:45* | *6* | *11* | *4* | *18* | *7* | *5* | ***51*** |
| *10:45* | *11:00* | *9* | *12* | *5* | *15* | *5* | *5* | ***51*** |
| *11:00* | *11:15* | *7* | *16* | *7* | *15* | *4* | *8* | ***57*** |
| *11:15* | *11:30* | *6* | *7* | *5* | *14* | *5* | *3* | ***40*** |
| 11:30 | 11:45 | 6 | 12 | 5 | 8 | 10 | 5 | **46** |
| 11:45 | 12:00 | 8 | 11 | 7 | 8 | 12 | 6 | **52** |
| 12:00 | 12:15 | 16 | 11 | 2 | 10 | 10 | 15 | **64** |
| 12:15 | 12:30 | 13 | 6 | 5 | 10 | 10 | 9 | **53** |
| 12:30 | 12:45 | 15 | 5 | 9 | 19 | 13 | 9 | **70** |
| 12:45 | 13:00 | 19 | 19 | 6 | 17 | 19 | 8 | **88** |
| 13:00 | 13:15 | 9 | 10 | 6 | 25 | 10 | 8 | **68** |
| 13:15 | 13:30 | 24 | 12 | 8 | 15 | 8 | 8 | **75** |
| 13:30 | 13:45 | 21 | 9 | 9 | 9 | 8 | 7 | **63** |
| 13:45 | 14:00 | 12 | 11 | 5 | 14 | 9 | 8 | **59** |
| **TOTAL** | | **214** | **229** | **121** | **254** | **172** | **127** | **1117** |




| Time Period | | TOTAL VEHICLES | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Start | End | A | B | C | D | E | F | G | H | I | J | K | L | Total |
| 09:00 | 09:15 | 8 | 10 | 1 | 1 | 19 | 6 | 8 | 14 | 2 | 3 | 16 | 5 | **93** |
| 09:15 | 09:30 | 7 | 7 | 0 | 2 | 28 | 8 | 10 | 12 | 1 | 1 | 33 | 2 | **111** |
| 09:30 | 09:45 | 2 | 8 | 2 | 0 | 2 | 6 | 3 | 9 | 1 | 0 | 0 | 3 | **36** |
| 09:45 | 10:00 | 4 | 3 | 1 | 0 | 20 | 5 | 5 | 16 | 3 | 0 | 19 | 4 | **80** |
| 10:00 | 10:15 | 3 | 15 | 0 | 2 | 17 | 12 | 4 | 18 | 4 | 0 | 33 | 4 | **112** |
| 10:15 | 10:30 | 3 | 10 | 0 | 1 | 23 | 11 | 4 | 19 | 5 | 1 | 30 | 3 | **110** |
| *10:30* | *10:45* | *2* | *4* | *5* | *0* | *9* | *3* | *3* | *14* | *7* | *1* | *21* | *3* | ***72*** |
| *10:45* | *11:00* | *5* | *10* | *0* | *1* | *26* | *11* | *5* | *23* | *9* | *3* | *38* | *1* | ***132*** |
| *11:00* | *11:15* | *0* | *6* | *1* | *0* | *18* | *4* | *3* | *2* | *4* | *0* | *17* | *4* | ***59*** |
| *11:15* | *11:30* | *8* | *8* | *1* | *0* | *22* | *10* | *1* | *18* | *3* | *0* | *19* | *2* | ***92*** |
| 11:30 | 11:45 | 8 | 13 | 1 | 1 | 21 | 0 | 2 | 8 | 3 | 0 | 1 | 2 | **60** |
| 11:45 | 12:00 | 5 | 14 | 2 | 0 | 26 | 6 | 6 | 6 | 5 | 1 | 24 | 2 | **97** |
| 12:00 | 12:15 | 2 | 5 | 1 | 1 | 7 | 5 | 3 | 10 | 1 | 2 | 17 | 2 | **56** |
| 12:15 | 12:30 | 7 | 11 | 0 | 0 | 18 | 5 | 5 | 8 | 8 | 3 | 12 | 2 | **79** |
| 12:30 | 12:45 | 3 | 12 | 1 | 0 | 12 | 11 | 6 | 7 | 5 | 3 | 24 | 0 | **84** |
| 12:45 | 13:00 | 6 | 4 | 1 | 1 | 26 | 7 | 3 | 20 | 6 | 0 | 19 | 1 | **94** |
| 13:00 | 13:15 | 3 | 6 | 0 | 0 | 20 | 5 | 5 | 23 | 4 | 0 | 22 | 5 | **93** |
| 13:15 | 13:30 | 3 | 3 | 0 | 0 | 16 | 7 | 1 | 13 | 5 | 0 | 12 | 1 | **61** |
| 13:30 | 13:45 | 2 | 5 | 0 | 2 | 6 | 2 | 1 | 11 | 1 | 1 | 6 | 1 | **38** |
| 13:45 | 14:00 | 5 | 10 | 0 | 3 | 34 | 8 | 3 | 14 | 2 | 2 | 19 | 4 | **104** |
| **TOTAL** | | **86** | **164** | **17** | **15** | **370** | **132** | **81** | **265** | **79** | **21** | **382** | **51** | **1663** |



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**MALL@PIET RETIEF**

**Proposed Road Improvements at the Accesses & Church (N2) / Brand (R543) Intersection to Support the Piet Retief Mall**

**APPENDIX C**


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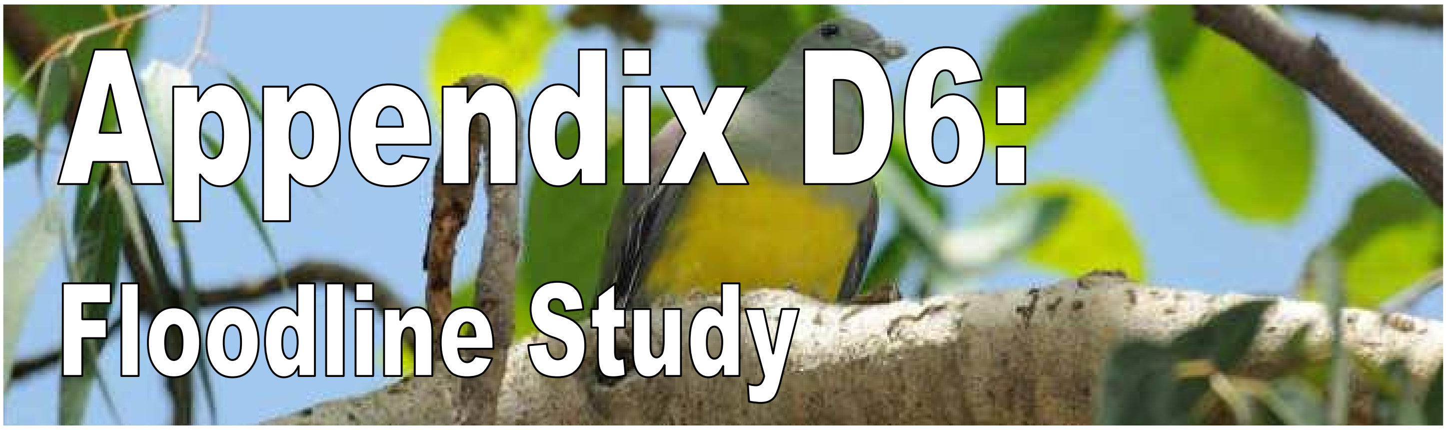
**APPENDIX C**


Appendix D6:
Floodline Study

Anaprop Property Management

# PROJECT:
## Development of Portions 100 & 123
## PIET RETIEF TOWN
## *(Townland 149 HT)*

## Report on the Delineation of the 1:100 Year Floodlines

**Report No PB/13/286/PIET-FL1**
**August 2013**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# DELINEATION OF THE 1:100 YEAR FLOODLINES FOR DEVELOPMENT OF PORTIONS 100 & 123 – PIET RETIEF TOWN

## CONTENTS

## LIST OF ABBREVIATIONS

| | |
|---|---|
| APP | Approved professional person |
| DWA | Department of Water Affairs |
| EPP | Emergency preparedness plan |
| FSL | Full supply level |
| HRU | Hydrological Research Unit |
| K | Regional coefficient |
| MAP | Mean annual precipitation |
| MAR | Mean annual run-off |
| MSL | Mean sea level |
| NOC | Non-overspill crest |
| NWA | National Water Act, Act 36 of 1998 |
| OMM | Operation and maintenance manual |
| PMF | Probable maximum flood |
| PMP | Probable maximum precipitation |
| RDD | Recommended design discharge |
| RDF | Recommended design flood |
| RI | Recurrence interval |
| RL | Reduced level |
| RMF | Regional maximum flood |
| SANCOLD | South African Committee on Large Dams |
| SCS | Soil Conservation Service |
| SED | Safety evaluation discharge |
| SEF | Safety evaluation flood |

# DELINEATION OF THE 1:100 YEAR FLOODLINES FOR DEVELOPMENT OF PORTIONS 100 & 123 – PIET RETIEF TOWN

## SECTION 1: INTRODUCTION

A floodline analysis was required to determine the position of the 1 in 100 year floodlines for the developments to take place on portions 100 and 123 in the town of Piet Retief in the Mpumalanga Province. Both sites are situated near the Klipmesselspruit (Townland 149 HT).

The analysis starts at approximately latitude **27° 00' 31,1"** and longitude **30° 48' 32,4"** (Cross-section RS100) and ends at latitude **27° 00' 50.8"** and longitude **30° 47' 54,4"** (Cross-section RS85) – WGS84.

The specific area which was analyzed during this investigation will be affected by accumulated flood waters in the Klipmesselspruit and associate tributaries.

The determination / analysis of the post-development 1:100 year floodlines were carried out by PG Consulting Engineers on behalf of Lekwa Consulting Engineers & Project Managers.

## SECTION 2: HYDROLOGY AND SUMMARY OF FLOW DIMENSIONS

### a) Methods used for Calculations

Methods that were used to calculate the different run-off peaks with variance in return periods are summarised below (a deterministic method with two different implementations were used and compared against an empirical method). The empirical method was furthermore utilized to calculate the RMF peaks.

a) Rational method - Implementation 1: Based on the regional DDF-equations representing the HRU 1/78 DDF-relationships ("Op ter Noort & Stephenson" - 1982)

b) Rational method - Implementation 2: Based on DWA's implementation

c) Empirical Method (TR137) – Regional maximum floods based on "Francou-Rodier" K-values ("Kovacs" - 1988) - Commonly used by DWAF for catchments >10km²

*NB! It was specifically decided on the above mentioned rational implementations as they provide for the incorporation of post-development site specific conditions.*

### b) Catchment Parameters

Two (2) seperate catchments were identified in the study for the hydrology calculations in order to determine the expected flood peaks, referred to as Catchments A and B (Refer to ortho images below).


Homogeneous catchment characteristics for the different catchments were used for calculation purposes as obtained from appropriate 1:50 000 topographical maps, 1:10 000 ortho photos as well as GISap software data. The main catchment characteristics are summarized below.

The specific sub-catchments are part of quaternary catchment W51D (Assegaai River). The mean annual precipitation (MAP) for the polygon grid covering the total tributary catchment area, based on the GISap software, is given as **887mm.**

**Catchment A (Upper catchment)**

| | |
|---|---|
| Catchment area (km²) | **14,818km²** |
| Vertical difference in height of catchment (m) | **98m** |
| Flow length of longest watercourse (km) | **5 250m** |
| Average slope of catchment (10/85) | **1,87%** |
| Catchment run-off coefficients applied (post-development) | |
| $Q_{50}$ | **0,426** |
| $Q_{100}$ | **0,504** |
| Time of concentration (Tc) | **1,10 hrs** |

**Catchment A&B (Combined total catchments)**

| | |
|---|---|
| Catchment area (km²) | **17,733km²** |
| Vertical difference in height of catchment (m) | **104m** |
| Flow length of longest watercourse (km) | **5 610m** |
| Average slope of catchment (10/85) | **1,85%** |
| Catchment run-off coefficients applied (post-development) | |
| $Q_{50}$ | **0,426** |
| $Q_{100}$ | **0,504** |
| Time of concentration (Tc) | **1,16 hrs** |

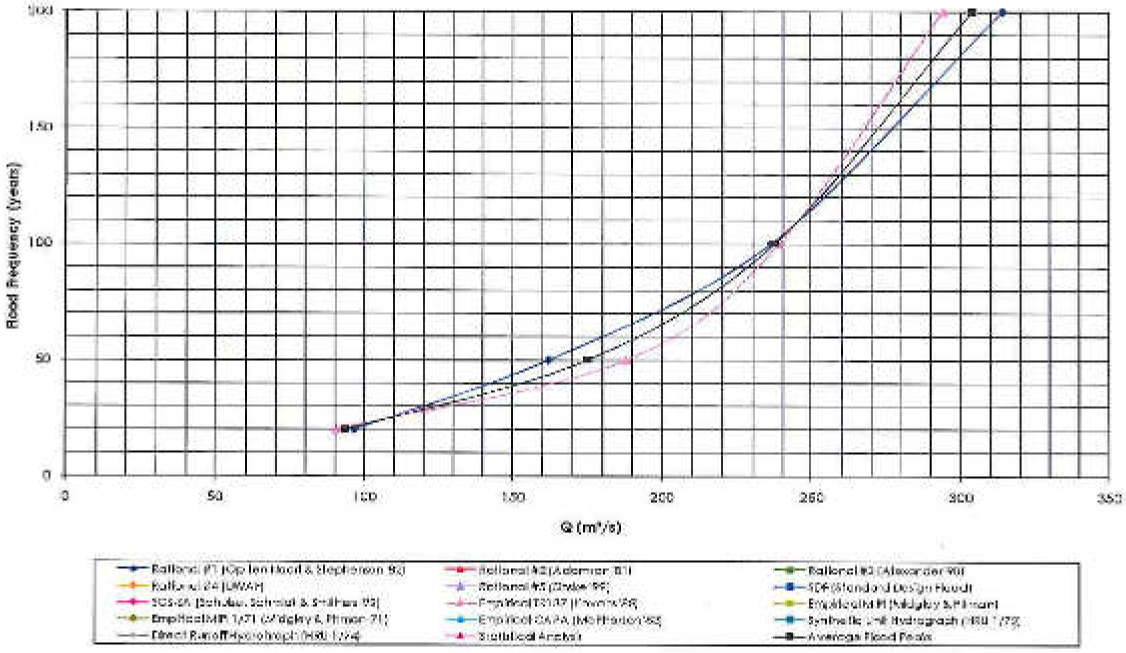
**NB!** Provision was made for urbanization conditions (i.e. 30% of total catchment size) and area reduction factors were applied as the catchments exceed 10km².

### c) Summary of Hydrology

Following the final hydrology calculations, it was found that the post-development flood peak values derived by the rational method implementation (1) had compared favourably with the values calculated utilizing the empirical TR137 method.

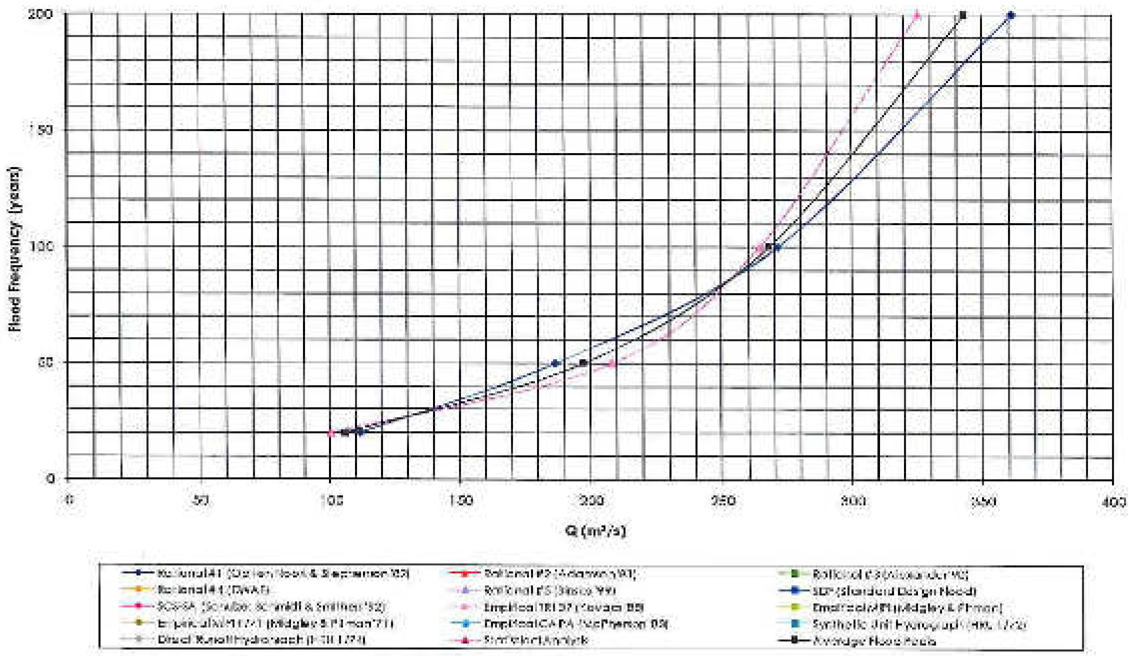
As some disparities were found between the two rational implementations applied (refer to the tables below), it was decided to rather follow a conservative approach by using the average of the two closest corresponding methods applied. The rational method implementation (2) values were therefore omitted. The following parameter sets, as tabled, were derived.

**DERIVED FLOOD PEAKS WITH DIFFERENT INTERVALS - Upper Catchment 14.818km²**




| Flood peaks derived for catchment A (Upper Catchment) | | | |
|---|---|---|---|
| Values in m³/s | $Q_{20}$ | $Q_{50}$ | $Q_{100}$ |
| Rational (a) – Op ten Noort & Stephenson '82 | 96.5 | 161.9 | 236.0 |
| Rational (b) – DWA | 125.2 | 165.4 | 206.6 |
| Empirical – (TR137) $K_e$ - region 5.2 | 90.5 | 188.3 | 238.9 |
| Average of all above | **104.1** | **171.9** | **227.2** |

**DERIVED FLOOD PEAKS WITH DIFFERENT INTERVALS - Combined Catchments 17.733km²**



| Flood peaks derived for catchments A&B (Combined catchments) | | | |
|---|---|---|---|
| Values in $m^3/s$ | $Q_{20}$ | $Q_{50}$ | $Q_{100}$ |
| Rational (a) – Op len Noort & Stephenson '82 | 111.0 | 186.3 | 271.3 |
| Rational (b) – DWA | 142.6 | 187.6 | 233.4 |
| Empirical – (TR 137) $K_e$ - region 5,2 | 100.1 | 208.2 | 264.2 |
| Average of all above | **117.9** | **194.0** | **256.3** |

d) **Recommended Flood Peaks for the Floodline Computations of the different stream flow sections**

The recommended flood peaks adopted for the analysis, were hydrologically balanced between the two catchments, in order to determine the floodlines for each of the following streamflow sections.

**Klipmesselspruit - Section RS100 to RS95**

| | |
|---|---|
| Regional maximum flood (RMF) – calculated for $K_e$ - region 5,2: | 453m³/s |
| Probable maximum flood (PMF) – graphically forecasted: | 1 297m³/s |
| **$Q_{100}$ used for floodlines determination:** | **237m³/s** |

**Klipmesselspruit - Section RS95 to RS85**

| | |
|---|---|
| Regional maximum flood (RMF) – calculated for $K_e$ - region 5,2: | 500m³/s |
| Probable maximum flood (PMF) – graphically forecasted: | 1 434m³/s |
| **$Q_{100}$ used for floodlines determination:** | **268m³/s** |

(See calculations, attached as Appendix A)

e) **Floodlines Computations**

For the computation of the different floodlines, the HEC-RAS (Version 4.1) computer analysis software was used.

Initially sixteen (16) cross-sections were generated from the contour drawings provided. For the purpose of the floodline delineation, additional cross-sections were generated by interpolation. The sections, after interpolation, are approximately 25 meters apart (Refer to 3D schematic and layout drawings attached).

f) **Assumptions**

a) All the above calculations were based on Manning's formula using an n-value (roughness coefficient) of 0,035 for the watercourse canal flow as well as the overbank flow sections as there are no significant differences to be found. This value represents the present scenario at the watercourse in question (i.e. clean, winding, with no significant pools and shoals, and relative undefined bank conditions with short to medium pasture covering).

b) The following "s" – value was adapted for the section boundary condition in the model; Section RS100 to RS85 – 0,01723 m/m (1.72%).

c) All the computations were based on "steady flow stage" conditions with a "subcritical flow regime" due to the retention effects caused by the road bridge as well as the dam / weir.

d) The main road bridge, crossing the Klipmesselspruit, was assumed to have an effective opening of 16m x 6m as measured from the contour layout drawing provided.

e) The dam wall (weir) dimensions incorporated in the analysis were based on an effective overflow width of 84m with a total available freeboard of 1,85m.

The photos above are showing the actual stream flow conditions at the sites analyzed.

## g) Results

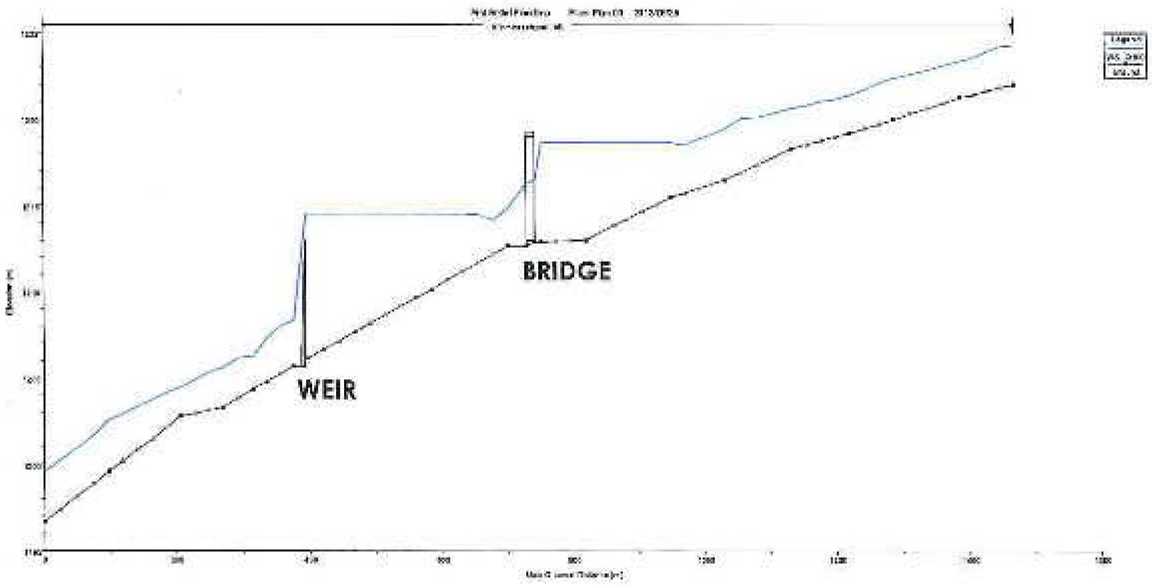
The following tables give a summary of the flow data of the expected 1:100 year flood peak which were calculated for the specific stream flow sections, derived at each of the major cross-sections;

| Klipmesselspruit (Section RS100 to RS85) – 1:100 year flood | | | | |
|---|---|---|---|---|
| Cross-sections (see drawing) | $Q_{100}$-value ($m^3/s$) | Max. flow velocity (m/s) | Max. flow depth (m) | Section top width (m) |
| RS100 | 237 | 4.17 | 2.30 (1224.30) | 48 |
| RS99 | 237 | 3.60 | 2.10 (1223.35) | 60 |
| RS98 | 237 | 2.94 | 2.40 (1222.40) | 97 |
| RS97 | 237 | 3.13 | 2.23 (1221.43) | 89 |
| RS96 | 237 | 2.47 | 2.34 (1220.64) | 109 |

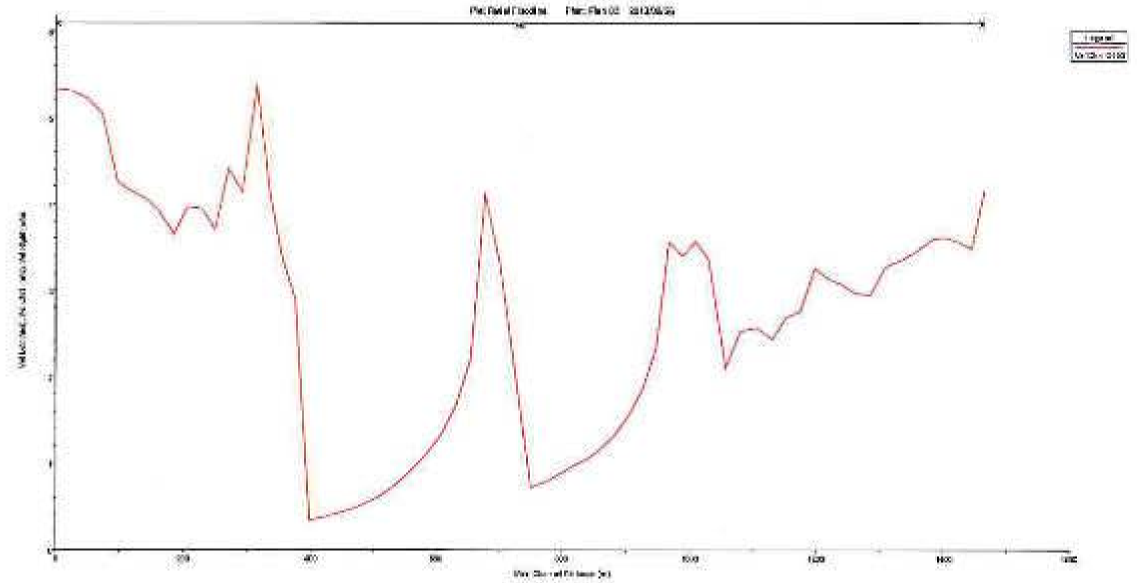
| | | | | |
|---|---|---|---|---|
| RS95 | 268 | 3.29 | 2.90 (1219.40) | 78 |
| RS94 | 268 | 2.92 | 2.79 (1218.29) | 90 |
| RS93 | 268 | 1.02 | 5.26 (1218.26) | 110 |
| RS92 | 268 | 0.75 | 5.35 (1218.26) | 149 |
| RS91 | 268 | 3.28 | 2.08 (1214.78) | 77 |
| **WEIR** | **268** | **2.19** | **1.46 (1214.46)** | **84** |
| RS90 | 268 | 2.76 | 2.58 (1208.29) | 69 |
| RS89 | 268 | 5.30 | 1.80 (1206.20) | 47 |
| RS88 | 268 | 4.30 | 2.23 (1205.53) | 70 |
| RS87 | 268 | 3.85 | 1.62 (1204.42) | 73 |
| RS86 | 268 | 4.17 | 2.89 (1202.49) | 52 |
| RS85 | 268 | 5.18 | 2.82 (1199.52) | 45 |

NB! Corresponding high flow actual contour levels indicated in brackets, in the tables. The section top flow width is rounded up to the nearest meter.

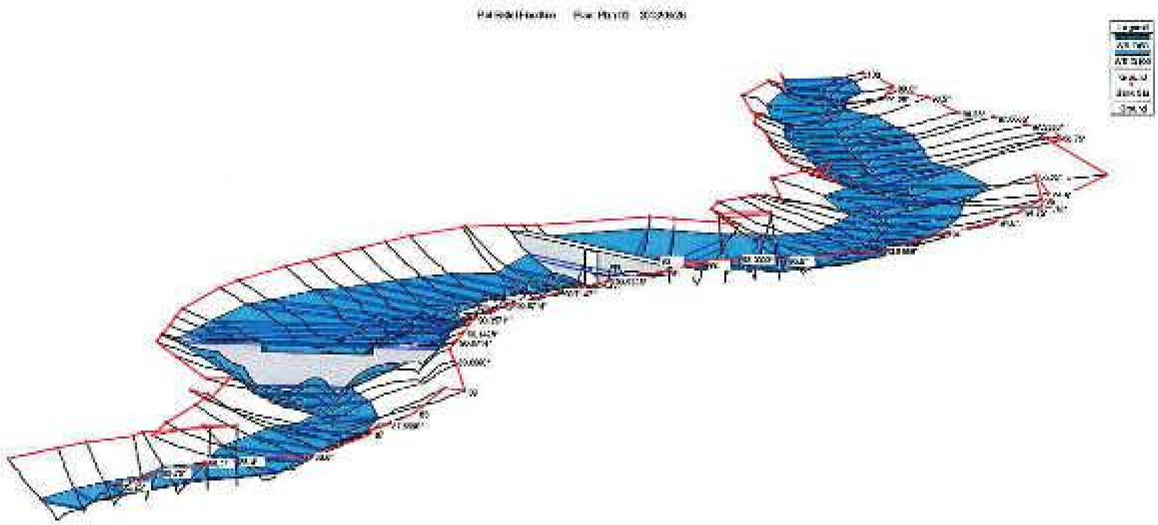
The following graph illustrates the expected water level to be generated by the 1:100 year flood peak over the stream flow section (Klipmesselspruit).




Graph on next page illustrates the expected variances in the flow velocities of the Klipmesselspruit stream flow section, during the 1:100 year recurrence intervals (Flow from right to left).



Following is a 3D schematic illustration of the high water level, during the expected 1:100 year flood peak.



(See calculations attached as Appendix A, and cross-sections attached as Appendix B).

**h) XY Co-ordinates of the 1:100 Year Floodlines for reference (WGS84) Lo31°**

The following tables give the exact XY co-ordinates of the 1:100 year floodlines as determined, for both the left and right banks of the applicable section of the Klipmesselspruit analyzed, with reference to each of the major cross-sections (refer to attached drawings). These co-ordinates can be utilized by a professional surveyor to set out the different floodlines.

| 1:100 Year Floodlines | | | | | |
|---|---|---|---|---|---|
| Left bank | | | Right bank | | |
| Cross-section | X | Y | Cross-section | X | Y |
| RS100 | 2 988 621 | 18 969 | RS100 | 2 988 618 | 19 017 |
| RS99 | 2 988 686 | 19 009 | RS99 | 2 988 670 | 19 067 |
| RS98 | 2 988 785 | 19 008 | RS98 | 2 988 755 | 19 101 |
| RS97 | 2 988 844 | 19 031 | RS97 | 2 988 819 | 19 116 |
| RS96 | 2 988 937 | 19 032 | RS96 | 2 988 895 | 19 134 |
| RS95 | 2 989 009 | 19 098 | RS95 | 2 988 956 | 19 159 |
| RS94 | 2 989 074 | 19 189 | RS94 | 2 988 975 | 19 221 |
| RS93 | 2 989 061 | 19 336 | RS93 | 2 988 954 | 19 284 |
| RS92 | 2 989 050 | 19 350 | RS92 | 2 988 897 | 19 381 |
| RS91 | 2 988 986 | 19 410 | RS91 | 2 988 908 | 19 426 |
| RS90 | 2 989 132 | 19 649 | RS90 | 2 989 082 | 19 711 |
| RS89 | 2 989 173 | 19 704 | RS89 | 2 989 134 | 19 734 |
| RS88 | 2 989 205 | 19 729 | RS88 | 2 989 151 | 19 777 |
| RS87 | 2 989 233 | 19 793 | RS87 | 2 989 165 | 19 826 |
| RS86 | 2 989 232 | 19 899 | RS86 | 2 989 179 | 19 886 |
| RS85 | 2 989 217 | 19 986 | RS85 | 2 989 171 | 19 988 |

## SECTION 3: CONCLUSIONS

- For the analysis of the 1:100 year floodlines, cross-sections were generated from 0,5m-interval contours which were provided by Lekwa Consulting Engineers (Pty) Ltd. The 0,5m-interval contours are based on a recent survey conducted for the development area by Reed & Partners Professional Land Surveyors.
- The floodlines derived from the analysis are indicated on attached (A3) drawings PB-13-286-FL01 & PB-13-286-FL02, Appendix C. An electronic file with the floodlines and grid layers will be e-mailed.
- During final analysis the retention effects caused by the main road bridge as well as the dam wall / weir were incorporated.
- NB! It is important to note that any foreign / manmade obstacles (i.e. ponds, access walkways etc) in the watercourse may result in the alteration of the present specified floodline.
- It is hereby **certified** that the floodlines indicated on the attached contour layout drawings, along the watercourse with a catchment area exceeding one square kilometre, represent the maximum flood level likely to be reached on an average every 100 years, by floodwater in the watercourse.

## SECTION 4: LIST OF APPENDICES

| | |
|---|---|
| Appendix A: | Hydrology and hydraulic calculations spreadsheets |
| Appendix B: | Cross-sections with 1:100 year flow depths indicated with "blue" lines (scales adjusted to fit pages) |
| Appendix C: | Floodlines (indicated on layout drawings attached (reduced to fit A3) |
| Appendix D: | Floodline certificate |

## SECTION 5: REFERENCES

a) Alexander WJR (1990)
Flood hydrology for Southern Africa, SANCOLD

b) HRU (1972)
Design flood determination in South Africa, HRU Report 1/72, Wits University

c) Kovacs Z (1988)
Regional maximum flood peaks in Southern Africa, Z Kovacs, Technical Report TR137, Department of Water Affairs and Forestry

d) Midgley DC & Pitman WV (1978)
A depth-duration-frequency diagram for point rainfall in Southern Africa, HRU Report 1/78, Wits University

e) Op ten Noort & Stephenson (1982)
Regional DDF-equations representing the HRU 1/78 DDF-relationships

| Compiled by: | Certified by: |
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| **M.F. Joubert** (Civil Eng Tech) | **P.J. Gouws** (Pr Eng) – Reg No. 880061 |
| *F&B Consulting Engineering Services* | *PG Consulting Engineers* |
| **23/08/2013** | **26/08/2013** |
| Date | Date |

# APPENDIX A

Appendix A1

## Piet Retief Town - Portions 100, 123 & 126 (Upper catchment)

# CALCULATION OF (RMF) REGIONAL MAXIMUM FLOOD AND THE RECOMMENDED (SEF) SAFETY EVALUATION FLOOD

*(TR 137 "DWAF" KOVACS - BASED ON THE FRANCOU-RODIER MODEL)*

**EMPIRICAL METHOD**

| | | |
|---|---|---|
| Ke - determined value if applicable | 0.0 | Ke value if determine otherwise "0" |
| Ke - envelope value | 5.2 | 2.8 / 3.4 / 4 / 4.6 / 5 / 5.2 / 5.4 / 5.6 |
| Watersurface at FSL (ha.) | N/A | In hectare |
| Areal catchment area (sq. km.) | 14.818 | Smaller than 10 use other methods |
| Is the dam in the Southwest-Cape (Y/N) ? | N | Important for region 5 |

| Zone | Transition zone |
|---|---|
| **RMF** | **452.5** |
| Q200 | 294.1 |
| Q100 | 238.9 |
| Q50 | 188.3 |
| Q20* | 90.5 |
| **RDF** | **188.3** |
| ** RMF - <> | 384.9 |
| ** RMF + <> | 532.0 |

| | |
|---|---|
| **PMF (Grafic)** | **1297.1** |
| **PMF (K-max)** | **625.4** |
| **PMF (Avg)** | **961.2** |
| Q175 | 280.3 |
| Q150 | 266.5 |
| Q125 | 252.7 |
| Q75 | 221.2 |
| Q25 | 110.1 |

| | Recommended SEF |
|---|---|
| PMF based | 192.2 |
| RMF based | 384.9 |
| **Average SEF** | **288.6** |
| SEF (Cat. I) < 10km² – Q175 | N/A |

**Appendix A2**

## Piet Retief Town - Portions 100, 123 & 126 (Combined catchments)

### CALCULATION OF (RMF) REGIONAL MAXIMUM FLOOD AND THE RECOMMENDED (SEF) SAFETY EVALUATION FLOOD

***(TR 137 "DWAF" KOVACS - BASED ON THE FRANCOU-RODIER MODEL)***

**EMPIRICAL METHOD**

| | | |
|---|---|---|
| Ke - determined value if applicable | 0.0 | Ke - value if determine otherwise "0" |
| Ke - envelope value | 5.2 | 2.8 / 3.4 / 4 / 4.6 / 5 / 5.2 / 5.4 / 5.6 |
| Watersurface at FSL (ha.) | N/A | In hectare |
| Areal catchment area (sq. km.) | 17.73 | Smaller than 10 use other methods |
| Is the dam in the Southwest-Cape (Y/N) ? | N | Important for region 5 |

| Zone | Transition zone |
|---|---|
| **RMF** | **500.4** |
| Q200 | 325.3 |
| Q100 | 264.2 |
| Q50 | 208.2 |
| Q20* | 100.1 |
| **RDF** | **208.2** |
| ** RMF - <> | 421.1 |
| ** RMF + <> | 594.6 |

| | |
|---|---|
| **PMF (Gratic)** | **1434.3** |
| **PMF (K-max)** | **706.6** |
| **PMF (Avg)** | **1070.5** |
| Q175 | 310.0 |
| Q150 | 294.7 |
| Q125 | 279.5 |
| Q75 | 244.6 |
| Q25 | 121.7 |

| | Recommended SEF |
|---|---|
| PMF based | 914.1 |
| RMF based | 421.1 |
| **Average SEF** | **317.6** |
| SEF (Cat. I) < $10km^2$ = Q175 | N/A |

# RATIONAL METHOD # 1

**Based on the Regional DDF-Equations representing the HRU 1/78 DDF-relationships (Op ten Noort & Stephenson, 1982)**

| PROJECT | Piet Retief Development Ptn 100 & 123 (Upper catchment) |
|---|---|

## CATCHMENT CHARACTERISTICS

| | | | |
|---|---|---|---|
| Catchment Area | Total (A) | 14.818 | km² |
| Areal Weighting Factors: x+y+z = 1 | | | |
| x (Rural) | y (Urban) | z (Lakes) | |
| 0.70 | 0.30 | | |

| | | |
|---|---|---|
| Effective (Ae) | 14.8180 | km² |
| Dolomitic (Ad) | | km² |
| Ratio of Ad / A | | % |
| Channelised Flow (Y/N) | | Y |
| Overland Flow (Y/N) | | N |

| | | |
|---|---|---|
| Longest Watercourse (L) | 5.230 | km |
| Height Difference (H) 10/85 | 78 | m |
| Mean Slope (S) | 1.87 | % |
| Mean Annual Rainfall (MAP) | 687 | mm |
| Time of Concentration (tc) | 1.10 | hour |
| | 66.1 | min |

| | |
|---|---|
| Inland (Y/N) | Y |
| Coastal (Y/N) | N |

## C1

| Steepness % | | %A | Factor | Avg |
|---|---|---|---|---|
| 10/85 Slope | < 1 | | | |
| | 1 - 3 | 100 | 0.05 | 0.050 |
| | 3 - 10 | | | |
| | 10 - 30 | | | |
| | 30 - 50 | | | |
| | > 50 | | | |
| Total % | | 100 | Cs | 0.050 |

| Soil Permeability | %A | Factor | Avg |
|---|---|---|---|
| Very Permeable | | | |
| Permeable | 5 | 0.08 | 0.004 |
| Semi-Permeable | 90 | 0.16 | 0.144 |
| Impermeable | 5 | 0.26 | 0.013 |
| Total % | 100 | Cp | 0.161 |
| Total C1 Value | | 0.291 | |

| Vegetation | %A | Factor | Avg |
|---|---|---|---|
| Forest Plantation | 55 | 0.04 | 0.022 |
| Dense Bush, Wood | | | |
| Thin Bush | | | |
| Cultivated Land | 40 | 0.11 | 0.044 |
| Grassland | | | |
| Bare Surface | 5 | 0.26 | 0.014 |
| Total % | 100 | Cv | 0.080 |

## C2

| Urban for T < 21 Years | | | |
|---|---|---|---|
| Occupation | %A | Factor | Avg |
| Lawns, Parks | 10 | | 0.015 |
| Sandy flat < 2% | | | |
| Sandy 2 - 7% | | | |
| Sandy steep > 7% | | | |
| Heavy soil flat < 2% | 10 | 0.150 | 0.015 |
| Heavy soil 2 - 7% | | | |
| Heavy soil > 7% | | | |
| Residential | 40 | | 0.160 |
| Single family area | 40 | 0.400 | 0.160 |
| Apartment dwellings | | | |
| Industrial | 30 | | 0.195 |
| Light areas | 30 | 0.650 | 0.195 |
| Heavy areas | | | |
| Business | 10 | | 0.085 |
| Downtown | 10 | 0.850 | 0.085 |
| Neighbourhood | | | |
| Streets | 10 | 0.850 | 0.085 |
| Total % | 100 | | 0.540 |

| Urban for T 21 to 50 Years | | | |
|---|---|---|---|
| Occupation | %A | Factor | Avg |
| Lawns | 10 | 0.450 | 0.045 |
| Other | 90 | 0.500 | 0.510 |
| Total % | 100 | | 0.555 |
| Urban for T > 50 Years | | | |
| All included | 100 | 1.000 | 1.000 |
| Total C2 for T < 21 | | | 0.540 |
| Total C2 for T 21 - 50 | | | 0.655 |
| Total C2 for T > 50 | | | 1.000 |

| Surface Condition Factor (f) | 0.35 |
|---|---|

## STORM RAINFALL

STORM DURATION (AS MULTIPLES OF tc) IN HOURS

| Flood Frequency in Years | 0.5 | tc (h) = | 0.55 | 1.0 | tc (h) = | 1.10 | 2.0 | tc (h) = | 2.20 | 3.0 | tc (h) = | 3.30 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | D (mm) | ARF | I (mm/h) | D (mm) | ARF | I (mm/h) | D (mm) | ARF | I (mm/h) | D (mm) | ARF | I (mm/h) |
| 2 | 31 | 0.970 | 55.49 | 35 | 0.985 | 35.17 | 46 | 1.000 | 20.94 | 52 | 1.000 | 15.84 |
| 5 | 41 | 0.970 | 72.97 | 52 | 0.985 | 46.27 | 61 | 1.000 | 27.57 | 65 | 1.000 | 19.79 |
| 10 | 51 | 0.970 | 89.83 | 64 | 0.985 | 56.79 | 75 | 1.000 | 33.74 | 81 | 1.000 | 24.57 |
| 20 | 64 | 0.970 | 110.60 | 78 | 0.985 | 70.17 | 92 | 1.000 | 41.76 | 99 | 1.000 | 30.05 |
| 50 | 83 | 0.970 | 145.79 | 105 | 0.985 | 92.36 | 121 | 1.000 | 55.00 | 130 | 1.000 | 39.47 |
| 100 | 102 | 0.970 | 179.24 | 127 | 0.985 | 112.71 | 149 | 1.000 | 67.72 | 161 | 1.000 | 48.62 |
| 200 | 125 | 0.970 | 220.67 | 157 | 0.985 | 140.23 | 184 | 1.000 | 83.37 | 190 | 1.000 | 57.56 |
| PMF | 405 | 0.970 | 713.58 | 508 | 0.983 | 452.71 | 594 | 1.000 | 269.56 | 640 | 1.000 | 193.57 |

## RUN-OFF COEFFICIENT

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| Rural | C1 | 0.102 | 0.112 | 0.122 | 0.136 | 0.169 | 0.204 | 0.244 | 0.590 |
| Urban | C2 | 0.162 | 0.166 | 0.179 | 0.197 | 0.237 | 0.300 | 0.300 | 0.300 |
| Combined | C | 0.274 | 0.290 | 0.302 | 0.334 | 0.425 | 0.504 | 0.544 | 0.890 |
| C1 adjusted for Ad | | | | | | | | | |
| Final adjusted C | | 0.264 | 0.290 | 0.300 | 0.334 | 0.426 | 0.504 | 0.544 | 0.890 |

* PMF = Cs + Cp max + Cv max

## PEAK DISCHARGE

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| Q (m³/s) | 0.5 tc | 60.29 | 84.15 | 111.01 | 152.13 | 255.23 | 371.92 | 494.92 | 2616.17 |
| | 1.0 tc | 38.22 | 53.38 | 70.43 | 96.52 | 161.92 | 235.95 | 313.99 | 1659.74 |
| | 2.0 tc | 22.76 | 31.79 | 41.94 | 57.47 | 96.42 | 140.51 | 186.98 | 988.36 |
| | 3.0 tc | 16.34 | 22.83 | 30.11 | 41.27 | 69.24 | 100.89 | 134.25 | 709.60 |

## FLOOD VOLUMES

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| V (m³) | 0.5 tc | 359 271 | 500 394 | 660 151 | 904 645 | 1 517 790 | 2 211 657 | 2 943 099 | 15 557 256 |
| | 1.0 tc | 227 294 | 317 458 | 418 795 | 573 942 | 962 907 | 1 403 116 | 1 867 155 | 9 869 870 |
| | 2.0 tc | 135 351 | 189 040 | 249 384 | 341 779 | 573 402 | 835 540 | 1 111 875 | 5 877 421 |
| | 3.0 tc | 97 186 | 135 729 | 179 071 | 245 411 | 411 728 | 599 936 | 798 375 | 4 220 245 |

# RATIONAL METHOD # 1

**Based on the Regional DDF-Equations representing the HRU 1/78 DDF-relationships (Op Ten Noort & Stephenson, 1982)**

| PROJECT | Piet Retief Development Ptn 100 & 123 (Total catchment) |
|---|---|

**CATCHMENT CHARACTERISTICS**

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Catchment Area | Total (A) | 17.723 | km² | Effective (Ae) | 17.330 | km² | Longest Watercourse (L) | 5.610 | km |
| Areal Weighting Factors: x + y + z = 1 | | | | Dolomitic (Ad) | | km² | Height Difference (H) 10/85 | 104 | m |
| x (Rural) | y (Urban) | z (Lakes) | | Ratio of Ad / A | | % | Mean Slope (S) | 1.85 | % |
| 0.70 | 0.30 | | | Channelised Flow (Y/N) | Y | | Mean Annual Rainfall (MAP) | 637 | mm |
| | | | | Overland Flow (Y/N) | N | | Time of Concentration (tc) | 1.16 | hour |
| | | | | | | | | 69.7 | min |

| | |
|---|---|
| Inland (Y/N) | Y |
| Coastal (Y/N) | N |

**C1**

| Steepness % | | %A | Factor | Avg | Soil Permeability | %A | Factor | Avg | Vegetation | %A | Factor | Avg |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10/85 Slope | < 1 | | | | Very Permeable | | | | Forest Plantation | 55 | 0.04 | 0.022 |
| | 1 - 3 | 100 | 0.05 | 0.050 | Permeable | 5 | 0.08 | 0.004 | Dense Bush, Wood | | | |
| | 3 - 10 | | | | Semi-Permeable | 90 | 0.16 | 0.144 | Thin Bush | | | |
| | 10 - 30 | | | | Impermeable | 5 | 0.26 | 0.013 | Cultivated Land | 40 | 0.11 | 0.044 |
| | 30 - 50 | | | | | | | | Grassland | | | |
| | > 50 | | | | Total % | 100 | Cp | 0.161 | Bare Surface | 5 | 0.28 | 0.014 |
| Total % | | 100 | Cs | 0.050 | Total C1 Value | | 0.291 | | Total % | 100 | Cv | 0.080 |

**C2**

| Urban for T < 21 Years | | | |
|---|---|---|---|
| Occupation | %A | Factor | Avg |
| Lawns, Parks | 10 | | 0.015 |
| Sandy flat < 2% | | | |
| Sandy 2 - 7% | | | |
| Sandy steep > 7% | 10 | 0.150 | 0.015 |
| Heavy soil flat < 2% | | | |
| Heavy soil 2 - 7% | | | |
| Heavy soil > 7% | | | |
| Residential | 40 | | 0.160 |
| Single family area | 40 | 0.400 | 0.160 |
| Apartment dwelling | | | |
| Industrial | 30 | | 0.195 |
| Light areas | 30 | 0.650 | 0.195 |
| Heavy areas | | | |
| Business | 10 | | 0.085 |
| Downtown | 10 | 0.850 | 0.085 |
| Neighbourhood | | | |
| Streets | 10 | 0.850 | 0.085 |
| Total % | 100 | | 0.540 |

| Urban for T 21 to 50 Years | | | |
|---|---|---|---|
| Occupation | %A | Factor | Avg |
| Lawns | 10 | 0.450 | 0.045 |
| Other | 90 | 0.900 | 0.810 |
| Total % | 100 | | 0.855 |
| Urban for T > 50 Years | | | |
| All included | 100 | 1.000 | 1.000 |
| Total C2 for T < 21 | | | 0.540 |
| Total C2 for T 21 - 50 | | | 0.855 |
| Total C2 for T > 50 | | | 1.000 |

| Surface Condition Factor (F) | 0.55 |
|---|---|

**STORM RAINFALL**

| Flood frequency in Years | STORM DURATION (AS MULTIPLES OF tc) IN HOURS | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0.5 | tc (h) = | 0.58 | 1.0 | tc (h) = | 1.16 | 2.0 | tc (h) = | 2.32 | 3.0 | tc (h) = | 3.48 |
| | P (mm) | ARF | I (mm/h) | P (mm) | ARF | I (mm/h) | P (mm) | ARF | I (mm/h) | P (mm) | ARF | I (mm/h) |
| 2 | 32 | 0.970 | 53.60 | 40 | 0.985 | 33.91 | 47 | 1.000 | 20.56 | 50 | 1.000 | 14.39 |
| 5 | 42 | 0.970 | 70.56 | 52 | 0.985 | 44.30 | 61 | 1.000 | 26.40 | 66 | 1.000 | 18.93 |
| 10 | 52 | 0.970 | 86.87 | 65 | 0.985 | 54.79 | 76 | 1.000 | 32.50 | 81 | 1.000 | 23.30 |
| 20 | 64 | 0.970 | 106.95 | 80 | 0.985 | 67.45 | 93 | 1.000 | 40.05 | 100 | 1.000 | 28.69 |
| 50 | 84 | 0.970 | 140.78 | 105 | 0.985 | 88.77 | 122 | 1.000 | 52.68 | 132 | 1.000 | 37.77 |
| 100 | 104 | 0.970 | 173.33 | 129 | 0.985 | 109.32 | 151 | 1.000 | 64.85 | 162 | 1.000 | 46.50 |
| 200 | 128 | 0.970 | 213.39 | 159 | 0.985 | 134.58 | 186 | 1.000 | 79.84 | 200 | 1.000 | 57.25 |
| PMF | 413 | 0.970 | 690.02 | 513 | 0.985 | 435.20 | 600 | 1.000 | 258.17 | 645 | 1.000 | 185.12 |

**RUN-OFF COEFFICIENT**

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| Rural | C1 | 0.102 | 0.112 | 0.122 | 0.136 | 0.169 | 0.204 | 0.241 | 0.595 |
| Urban | C2 | 0.162 | 0.168 | 0.178 | 0.197 | 0.257 | 0.300 | 0.300 | 0.300 |
| Combined | C | 0.264 | 0.280 | 0.300 | 0.334 | 0.426 | 0.504 | 0.544 | 0.890 |
| (C) adjusted for Ad | | | | | | | | | |
| Final adjusted C | | 0.264 | 0.280 | 0.300 | 0.334 | 0.426 | 0.504 | 0.544 | 0.890 |

* PMF = Cs + Cp max + Cv max

**PEAK DISCHARGE**

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| Q (m³/s) | 0.5 tc | 69.72 | 97.57 | 128.46 | 176.05 | 292.36 | 430.39 | 577.74 | 3027.46 |
| | 1.0 tc | 43.97 | 61.41 | 81.02 | 111.03 | 186.28 | 271.45 | 363.22 | 1909.42 |
| | 2.0 tc | 26.09 | 36.43 | 48.06 | 65.87 | 110.51 | 161.03 | 214.79 | 1132.75 |
| | 3.0 tc | 18.70 | 26.12 | 34.46 | 47.23 | 79.24 | 115.46 | 153.65 | 812.25 |

**FLOOD VOLUMES**

| Flood Frequency (Years) | | 2 | 5 | 10 | 20 | 50 | 100 | 200 | PMF* |
|---|---|---|---|---|---|---|---|---|---|
| V (m³) | 0.5 tc | 437 479 | 611 012 | 806 064 | 1 104 685 | 1 853 359 | 2 700 620 | 3 593 773 | 18 996 851 |
| | 1.0 tc | 275 915 | 385 366 | 508 386 | 696 726 | 1 168 903 | 1 703 285 | 2 266 593 | 11 981 342 |
| | 2.0 tc | 163 697 | 228 618 | 301 596 | 413 320 | 693 443 | 1 010 461 | 1 344 642 | 7 107 641 |
| | 3.0 tc | 117 362 | 163 922 | 216 250 | 296 364 | 497 212 | 724 520 | 964 104 | 5 096 459 |

# Utility Programs for Drainage
# Flood calculations

Sinotech

| | |
|---|---|
| Project name: | Floodline Analysis (Upper Catchment) |
| Analysed by: | MJ Joubert |
| Name of river: | Klipmesselspruit |
| Description of site: | Piet Retief Town - Portions 100 & 123 |
| Filename: | C:\Documents and Settings\Francis\My Documents\LEK\Piet Retief\Hydrology upper.fld |
| Date: | 26 August 2013 |



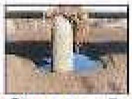
```
Flood Frequency Analysis: Rational Method

Project                                = Floodline Analysis (Upper Catchment)
Analysed by                            = MJ Joubert
Name of river                          = Klipmesselspruit
Description of site                    = Piet Retief Town - Portions 100 & 123
Date                                   = 2013/08/26
Area of catchment                      = 15.835 km²
Dolomitic area                         = 0.0 %
Mean annual rainfall (MAR)             = 892.00 mm
Length of longest watercourse          = 8.38 km
Flow of water                          = Defined water course
Height difference along 10-85 slope    = 39.0 m
Rainfall region                        = Inland
Area distribution                      = Rural: 70 %, Urban: 30 %, Lakes: 0 %

Catchment description - Urban area (%)
Lawns                      Residential and Industry Business
Sandy, flat (<2%)      0   Houses              40   City centre       10
Sandy, steep (>7%)     0   Flats                0   Suburban           0
Heavy soil, flat (<2%) 10  Light industry      30   Streets           10
Heavy soil, steep (>7%) 0  Heavy industry       0   Maximum flood      0

Catchment description - Rural area (%)
Surface slopes             Permeability             Vegetation
Lakes and pans         0   Very permeable       0   Thick bush & forests          55
Flat area            100   Permeable            5   Light bush & cultivated land  45
Hilly                  0   Semi-permeable      90   Grasslands                     0
Steep areas            0   Impermeable          5   Bare                           0
------------------------------------------------------------------------------------
Average slope                          = 0.00465 m/m
Time of concentration                  = 59.3 min
Run-off factor
Rural - C1                             = 0.211
Urban - C2                             = 0.440
Lakes - C3                             = 0.000
Combined - C                           = 0.280
The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.
```

| Return period (years) | Time of concentration (hours) | Point rainfall (mm) | ARF (%) | Average intensity (mm/h) | Factor Ft | Runoff coefficient (%) | Peak flow (m³/s) |
|---|---|---|---|---|---|---|---|
| 1:2 | 0.99 | 45.6 | 97.2 | 46.0 | 0.75 | 23.2 | 54.71 |
| 1:5 | 0.99 | 55.2 | 97.1 | 54.4 | 0.80 | 24.2 | 76.16 |
| 1:10 | 0.99 | 65.8 | 96.5 | 66.3 | 0.85 | 28.5 | 99.20 |
| 1:20 | 0.99 | 86.3 | 96.4 | 81.8 | 0.90 | 36.4 | 135.33 |
| 1:50 | 0.99 | 112.2 | 96.1 | 107.8 | 0.95 | 35.5 | 161.41 |
| 1:100 | 0.99 | 138.3 | 95.7 | 139.8 | 1.00 | 39.7 | 208.43 |

Run-off coefficient percentage includes adjustment (correction factors (Ft)) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

# Utility Programs for Drainage
# Flood calculations



Sinotech

| | |
|---|---|
| Project name: | Floodline Analysis (Combined Catchments) |
| Analysed by: | MF Joubert |
| Name of river: | Klipmesselspruit |
| Description of site: | Piet Retief Town - Portions 108 & 123 |
| Filename: | C:\Documents and Settings\Francois\My Documents\LEK\Piet Retief\Hydrology (ott).ttd |
| Date: | 26 August 2013 |



Flood Frequency Analysis: Rational Method

| | |
|---|---|
| Project | = Floodline Analysis (Combined Catchments) |
| Analysed by | = MF Joubert |
| Name of river | = Klipmesselspruit |
| Description of site | = Piet Retief Town - Portions 108 & 123 |
| Date | = 2013/08/26 |
| Area of catchment | = [illegible] km² |
| Dolomitic area | = 0.0 % |
| Mean annual rainfall (MAP) | = 865.00 mm |
| Length of longest watercourse | = 8.43 km |
| Flow of water | = Defined water course |
| Height difference along 10-85 slope | = 104.0 m |
| Rainfall region | = Inland |
| Area distribution | = Rural: 70 %, Urban: 30 %, Lakes: 0 % |

Catchment description - Urban area (%)

| Lawns | | Residential and industry | | Business | |
|---|---|---|---|---|---|
| Sandy, flat (<2%) | 0 | Houses | 40 | City centre | 10 |
| Sandy, steep (>7%) | 0 | Flats | 0 | Suburban | 0 |
| Heavy soil, flat (<2%) | 10 | Light industry | 40 | Streets | 10 |
| Heavy soil, steep (>7%) | 0 | Heavy industry | 0 | Maximum flood | 0 |

Catchment description - Rural area (%)

| Surface slopes | | Permeability | | Vegetation | |
|---|---|---|---|---|---|
| Lakes and pans | 0 | Very permeable | 0 | Thick bush & forests | [illegible] |
| Flat area | 100 | Permeable | [illegible] | Light bush & cultivated land | [illegible] |
| Hilly | 0 | Semi-permeable | [illegible] | Grasslands | [illegible] |
| Steep areas | 0 | Impermeable | [illegible] | Bare | [illegible] |

| | |
|---|---|
| Average slope | = [illegible] m/m |
| Time of concentration | = [illegible] h |
| Run-off factor | |
| Rural - C1 | = 0.321 |
| Urban - C2 | = [illegible] |
| Lakes - C3 | = [illegible] |
| Combined - C | = [illegible] |

The HRU, Report 2/78, Depth-Duration-Frequency diagram was used to determine the point rainfall.

| Return period (years) | Time of concentration (hours) | Point rainfall (mm) | ARF (%) | Average intensity (mm/h) | Factor FT | Runoff coefficient (%) | Peak flow (m³/s) |
|---|---|---|---|---|---|---|---|
| 1:2 | [illegible] | 41.2 | [illegible] | [illegible] | [illegible] | 33.1 | 62.76 |
| 1:5 | [illegible] | 56.1 | [illegible] | [illegible] | [illegible] | 34.2 | [illegible] |
| 1:10 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |
| 1:20 | [illegible] | [illegible] | [illegible] | [illegible] | 0.90 | [illegible] | [illegible] |
| 1:50 | [illegible] | 113.5 | [illegible] | [illegible] | 0.95 | [illegible] | [illegible] |
| 1:100 | [illegible] | [illegible] | [illegible] | [illegible] | 1.00 | [illegible] | [illegible] |

Run-off coefficient percentage includes adjustment saturation factors (FT) for steep and impermeable catchments

Calculated using Utility Programs for Drainage 1.1.0

Plan: Plan 03 Klipmesselspruit AB RS: 100 Profile: Q50

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1224.80 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.76 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1224.05 | Reach Len. (m) | 20.50 | 20.50 | 20.50 |
| Crit W.S. (m) | 1224.20 | Flow Area (m2) | | 45.60 | |
| E.G. Slope (m/m) | 0.017234 | Area (m2) | | 45.60 | |
| Q Total (m3/s) | 175.00 | Flow (m3/s) | | 175.00 | |
| Top Width (m) | 43.55 | Top Width (m) | | 43.55 | |
| Vel Total (m/s) | 3.84 | Avg. Vel. (m/s) | | 3.84 | |
| Max Chl Dpth (m) | 2.05 | Hydr. Depth (m) | | 1.05 | |
| Conv. Total (m3/s) | 1333.0 | Conv. (m3/s) | | 1333.0 | |
| Length Wtd. (m) | 20.50 | Wetted Per. (m) | | 44.08 | |
| Min Ch El (m) | 1222.00 | Shear (N/m2) | | 174.91 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 671.27 | |
| Frctn Loss (m) | | Cum Volume (1000 m3) | | 201.31 | |
| C & E Loss (m) | | Cum SA (1000 m2) | | 124.54 | |

Plan: Plan 03 Klipmesselspruit AB RS: 100 Profile: Q100

| | | | | | |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1225.19 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.89 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1224.30 | Reach Len. (m) | 20.50 | 20.50 | 20.50 |
| Crit W.S. (m) | 1224.48 | Flow Area (m2) | | 56.86 | |
| E.G. Slope (m/m) | 0.017231 | Area (m2) | | 56.86 | |
| Q Total (m3/s) | 237.00 | Flow (m3/s) | | 237.00 | |
| Top Width (m) | 47.97 | Top Width (m) | | 47.97 | |
| Vel Total (m/s) | 4.17 | Avg. Vel. (m/s) | | 4.17 | |
| Max Chl Dpth (m) | 2.30 | Hydr. Depth (m) | | 1.19 | |
| Conv. Total (m3/s) | 1805.3 | Conv. (m3/s) | | 1805.3 | |
| Length Wtd. (m) | 20.50 | Wetted Per. (m) | | 48.54 | |
| Min Ch El (m) | 1222.00 | Shear (N/m2) | | 197.98 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 825.19 | |
| Frctn Loss (m) | | Cum Volume (1000 m3) | | 247.44 | |
| C & E Loss (m) | | Cum SA (1000 m2) | | 137.86 | |

Plan: Plan 03 Klipmesselspruit AB RS: 99 Profile: Q50

| | | | | | |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1223.68 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.44 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1223.24 | Reach Len. (m) | 25.00 | 25.00 | 25.00 |
| Crit W.S. (m) | 1223.18 | Flow Area (m2) | | 59.43 | |
| E.G. Slope (m/m) | 0.010527 | Area (m2) | | 59.43 | |
| Q Total (m3/s) | 175.00 | Flow (m3/s) | | 175.00 | |
| Top Width (m) | 58.67 | Top Width (m) | | 58.67 | |
| Vel Total (m/s) | 2.94 | Avg. Vel. (m/s) | | 2.94 | |
| Max Chl Dpth (m) | 1.99 | Hydr. Depth (m) | | 1.01 | |
| Conv. Total (m3/s) | 1705.6 | Conv. (m3/s) | | 1705.6 | |
| Length Wtd. (m) | 25.00 | Wetted Per. (m) | | 59.02 | |
| Min Ch El (m) | 1221.25 | Shear (N/m2) | | 103.94 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 306.10 | |
| Frctn Loss (m) | 0.25 | Cum Volume (1000 m3) | | 197.01 | |
| C & E Loss (m) | 0.01 | Cum SA (1000 m2) | | 120.30 | |

Plan: Plan 03 Klipmesselspruit AB RS: 99 Profile: Q100

| | | | | | |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1224.01 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.66 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1223.35 | Reach Len. (m) | 25.00 | 25.00 | 25.00 |
| Crit W.S. (m) | 1223.42 | Flow Area (m2) | | 65.83 | |
| E.G. Slope (m/m) | 0.014125 | Area (m2) | | 65.83 | |
| Q Total (m3/s) | 237.00 | Flow (m3/s) | | 237.00 | |

Plan: Plan 03 Klipmesselspruit AB RS: 99 Profile: Q100 (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Top Width (m) | 59.93 | Top Width (m) | | 59.93 | |
| Vel Total (m/s) | 3.60 | Avg. Vel. (m/s) | | 3.60 | |
| Max Chl Dpth (m) | 2.10 | Hydr. Depth (m) | | 1.10 | |
| Conv. Total (m3/s) | 1994.1 | Conv. (m3/s) | | 1994.1 | |
| Length Wtd. (m) | 25.00 | Wetted Per. (m) | | 60.31 | |
| Min Ch El (m) | 1221.25 | Shear (N/m2) | | 151.21 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 544.37 | |
| Frctn Loss (m) | 0.28 | Cum Volume (1000 m3) | | 242.06 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 133.16 | |

Plan: Plan 03 Klipmesselspruit AB RS: 98 Profile: Q50

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1222.60 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.37 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1222.23 | Reach Len. (m) | 21.67 | 21.67 | 21.67 |
| Crit W.S. (m) | 1222.22 | Flow Area (m2) | | 64.71 | |
| E.G. Slope (m/m) | 0.013792 | Area (m2) | | 64.71 | |
| Q Total (m3/s) | 175.00 | Flow (m3/s) | | 175.00 | |
| Top Width (m) | 89.10 | Top Width (m) | | 89.10 | |
| Vel Total (m/s) | 2.70 | Avg. Vel. (m/s) | | 2.70 | |
| Max Chl Dpth (m) | 2.23 | Hydr. Depth (m) | | 0.73 | |
| Conv. Total (m3/s) | 1490.1 | Conv. (m3/s) | | 1490.1 | |
| Length Wtd. (m) | 21.67 | Wetted Per. (m) | | 89.44 | |
| Min Ch El (m) | 1220.00 | Shear (N/m2) | | 97.86 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 264.64 | |
| Frctn Loss (m) | 0.30 | Cum Volume (1000 m3) | | 190.51 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 112.94 | |

Plan: Plan 03 Klipmesselspruit AB RS: 98 Profile: Q100

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1222.84 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.44 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1222.40 | Reach Len. (m) | 21.67 | 21.67 | 21.67 |
| Crit W.S. (m) | 1222.40 | Flow Area (m2) | | 80.64 | |
| E.G. Slope (m/m) | 0.013641 | Area (m2) | | 80.64 | |
| Q Total (m3/s) | 237.00 | Flow (m3/s) | | 237.00 | |
| Top Width (m) | 96.67 | Top Width (m) | | 96.67 | |
| Vel Total (m/s) | 2.94 | Avg. Vel. (m/s) | | 2.94 | |
| Max Chl Dpth (m) | 2.40 | Hydr. Depth (m) | | 0.83 | |
| Conv. Total (m3/s) | 2036.7 | Conv. (m3/s) | | 2036.7 | |
| Length Wtd. (m) | 21.67 | Wetted Per. (m) | | 97.02 | |
| Min Ch El (m) | 1220.00 | Shear (N/m2) | | 110.37 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 324.38 | |
| Frctn Loss (m) | | Cum Volume (1000 m3) | | 234.95 | |
| C & E Loss (m) | | Cum SA (1000 m2) | | 126.52 | |

Plan: Plan 03 Klipmesselspruit AB RS: 97 Profile: Q50

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1221.68 | Element | Left OB | Channel | Right OB |
| Vel Head (m) | 0.33 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1221.35 | Reach Len. (m) | 22.25 | 22.25 | 22.25 |
| Crit W.S. (m) | 1221.29 | Flow Area (m2) | | 68.32 | |
| E.G. Slope (m/m) | 0.010762 | Area (m2) | | 68.32 | |
| Q Total (m3/s) | 175.00 | Flow (m3/s) | | 175.00 | |
| Top Width (m) | 84.80 | Top Width (m) | | 84.80 | |
| Vel Total (m/s) | 2.56 | Avg. Vel. (m/s) | | 2.56 | |
| Max Chl Dpth (m) | 2.15 | Hydr. Depth (m) | | 0.81 | |
| Conv. Total (m3/s) | 1686.9 | Conv. (m3/s) | | 1686.9 | |
| Length Wtd. (m) | 22.25 | Wetted Per. (m) | | 85.06 | |
| Min Ch El (m) | 1219.20 | Shear (N/m2) | | 84.78 | |

Plan: Plan 03 Klipmesselspruit AB RS: 97 Profile: Q50 (Continued)

| | | | | | |
|---|---|---|---|---|---|
| Alpha | 1.00 | Stream Power (N/m s) | | 217.14 | |
| Frctn Loss (m) | 0.24 | Cum Volume (1000 m3) | | 106.35 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 107.41 | |

Plan: Plan 03 Klipmesselspruit AB RS: 97 Profile: Q100

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1221.93 | Wt. n-Val. | | 0.035 | |
| Vel Head (m) | 0.50 | Reach Len. (m) | 22.25 | 22.25 | 22.25 |
| W.S. Elev (m) | 1221.43 | Flow Area (m2) | | 75.66 | |
| Crit W.S. (m) | 1221.47 | Area (m2) | | 75.66 | |
| E.G. Slope (m/m) | 0.014771 | Flow (m3/s) | | 237.00 | |
| Q Total (m3/s) | 237.00 | Top Width (m) | | 86.06 | |
| Top Width (m) | 86.06 | Avg. Vel. (m/s) | | 3.13 | |
| Vel Total (m/s) | 3.13 | Hydr. Depth (m) | | 0.88 | |
| Max Chl Dpth (m) | 2.20 | Conv. (m3/s) | | 1950.0 | |
| Conv. Total (m3/s) | 1950.0 | Wetted Per. (m) | | 89.32 | |
| Length Wtd. (m) | 22.25 | Shear (N/m2) | | 124.10 | |
| Min Ch El (m) | 1219.20 | Stream Power (N/m s) | | 388.72 | |
| Alpha | 1.00 | Cum Volume (1000 m3) | | 229.67 | |
| Frctn Loss (m) | 0.32 | Cum SA (1000 m2) | | 119.52 | |
| C & E Loss (m) | 0.00 | | | | |

Plan: Plan 03 Klipmesselspruit AB RS: 96 Profile: Q50

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1220.72 | Wt. n-Val. | | 0.035 | |
| Vel Head (m) | 0.26 | Reach Len. (m) | 25.00 | 25.00 | 25.00 |
| W.S. Elev (m) | 1220.46 | Flow Area (m2) | | 77.14 | |
| Crit W.S. (m) | | Area (m2) | | 77.14 | |
| E.G. Slope (m/m) | 0.008623 | Flow (m3/s) | | 175.00 | |
| Q Total (m3/s) | 175.00 | Top Width (m) | | 97.21 | |
| Top Width (m) | 97.21 | Avg. Vel. (m/s) | | 2.27 | |
| Vel Total (m/s) | 2.27 | Hydr. Depth (m) | | 0.79 | |
| Max Chl Dpth (m) | 2.16 | Conv. (m3/s) | | 1884.5 | |
| Conv. Total (m3/s) | 1884.5 | Wetted Per. (m) | | 97.56 | |
| Length Wtd. (m) | 25.00 | Shear (N/m2) | | 66.86 | |
| Min Ch El (m) | 1218.30 | Stream Power (N/m s) | | 151.89 | |
| Alpha | 1.00 | Cum Volume (1000 m3) | | 180.10 | |
| Frctn Loss (m) | 0.22 | Cum SA (1000 m2) | | 99.48 | |
| C & E Loss (m) | 0.00 | | | | |

Plan: Plan 03 Klipmesselspruit AB RS: 96 Profile: Q100

| | | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1220.95 | Wt. n-Val. | | 0.035 | |
| Vel Head (m) | 0.31 | Reach Len. (m) | 25.00 | 25.00 | 25.00 |
| W.S. Elev (m) | 1220.64 | Flow Area (m2) | | 96.04 | |
| Crit W.S. (m) | | Area (m2) | | 96.04 | |
| E.G. Slope (m/m) | 0.008523 | Flow (m3/s) | | 237.00 | |
| Q Total (m3/s) | 237.00 | Top Width (m) | | 108.56 | |
| Top Width (m) | 108.56 | Avg. Vel. (m/s) | | 2.47 | |
| Vel Total (m/s) | 2.47 | Hydr. Depth (m) | | 0.88 | |
| Max Chl Dpth (m) | 2.34 | Conv. (m3/s) | | 2523.2 | |
| Conv. Total (m3/s) | 2523.2 | Wetted Per. (m) | | 108.92 | |
| Length Wtd. (m) | 25.00 | Shear (N/m2) | | 76.29 | |
| Min Ch El (m) | 1218.30 | Stream Power (N/m s) | | 188.25 | |
| Alpha | 1.00 | Cum Volume (1000 m3) | | 222.47 | |
| Frctn Loss (m) | 0.22 | Cum SA (1000 m2) | | 110.92 | |
| C & E Loss (m) | 0.00 | | | | |

Plan: Plan 03 Klipmesselspruit AB RS: 95 Profile: Q50

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1219.64 | Element | | | |
| Vel Head (m) | 0.50 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1219.14 | Reach Len. (m) | 21.00 | 21.00 | 21.00 |
| Crit W.S. (m) | 1219.14 | Flow Area (m2) | | 63.14 | |
| E.G. Slope (m/m) | 0.012845 | Area (m2) | | 63.14 | |
| Q Total (m3/s) | 197.00 | Flow (m3/s) | | 197.00 | |
| Top Width (m) | 66.36 | Top Width (m) | | 66.36 | |
| Vel Total (m/s) | 3.12 | Avg. Vel. (m/s) | | 3.12 | |
| Max Chl Dpth (m) | 2.64 | Hydr. Depth (m) | | 0.95 | |
| Conv. Total (m3/s) | 1738.2 | Conv. (m3/s) | | 1738.2 | |
| Length Wtd. (m) | 21.00 | Wetted Per. (m) | | 66.76 | |
| Min Ch El (m) | 1216.50 | Shear (N/m2) | | 119.13 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 371.69 | |
| Frctn Loss (m) | 0.27 | Cum Volume (1000 m3) | | 173.02 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 90.77 | |

Plan: Plan 03 Klipmesselspruit AB RS: 95 Profile: Q100

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1219.95 | Element | | | |
| Vel Head (m) | 0.55 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1219.40 | Reach Len. (m) | 21.00 | 21.00 | 21.00 |
| Crit W.S. (m) | 1219.40 | Flow Area (m2) | | 81.45 | |
| E.G. Slope (m/m) | 0.012395 | Area (m2) | | 81.45 | |
| Q Total (m3/s) | 268.00 | Flow (m3/s) | | 268.00 | |
| Top Width (m) | 77.02 | Top Width (m) | | 77.02 | |
| Vel Total (m/s) | 3.29 | Avg. Vel. (m/s) | | 3.29 | |
| Max Chl Dpth (m) | 2.90 | Hydr. Depth (m) | | 1.06 | |
| Conv. Total (m3/s) | 2407.2 | Conv. (m3/s) | | 2407.2 | |
| Length Wtd. (m) | 21.00 | Wetted Per. (m) | | 77.43 | |
| Min Ch El (m) | 1216.50 | Shear (N/m2) | | 127.87 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 420.70 | |
| Frctn Loss (m) | 0.26 | Cum Volume (1000 m3) | | 213.32 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 100.99 | |

Plan: Plan 03 Klipmesselspruit AB RS: 94 Profile: Q50

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1218.43 | Element | | | |
| Vel Head (m) | 0.46 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1217.96 | Reach Len. (m) | 21.50 | 21.50 | 21.50 |
| Crit W.S. (m) | 1217.96 | Flow Area (m2) | | 65.36 | |
| E.G. Slope (m/m) | 0.013206 | Area (m2) | | 65.36 | |
| Q Total (m3/s) | 197.00 | Flow (m3/s) | | 197.00 | |
| Top Width (m) | 74.24 | Top Width (m) | | 74.24 | |
| Vel Total (m/s) | 3.01 | Avg. Vel. (m/s) | | 3.01 | |
| Max Chl Dpth (m) | 2.46 | Hydr. Depth (m) | | 0.88 | |
| Conv. Total (m3/s) | 1710.4 | Conv. (m3/s) | | 1710.4 | |
| Length Wtd. (m) | 21.50 | Wetted Per. (m) | | 74.57 | |
| Min Ch El (m) | 1215.50 | Shear (N/m2) | | 114.03 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 343.70 | |
| Frctn Loss (m) | 0.31 | Cum Volume (1000 m3) | | 167.75 | |
| C & E Loss (m) | 0.02 | Cum SA (1000 m2) | | 84.92 | |

Plan: Plan 03 Klipmesselspruit AB RS: 94 Profile: Q100

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| E.G. Elev (m) | 1218.72 | Element | | | |
| Vel Head (m) | 0.43 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1218.29 | Reach Len. (m) | 21.50 | 21.50 | 21.50 |
| Crit W.S. (m) | 1218.22 | Flow Area (m2) | | 91.80 | |
| E.G. Slope (m/m) | 0.010085 | Area (m2) | | 91.80 | |
| Q Total (m3/s) | 268.00 | Flow (m3/s) | | 268.00 | |

Plan: Plan 03 Klipmosselspruit AB RS: 94 Profile: Q100 (Continued)

| | | | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Top Width (m) | 89.10 | Top Width (m) | | 89.10 | |
| Vel Total (m/s) | 2.92 | Avg. Vel. (m/s) | | 2.92 | |
| Max Chl Dpth (m) | 2.79 | Hydr. Depth (m) | | 1.03 | |
| Conv. Total (m3/s) | 2668.7 | Conv. (m3/s) | | 2668.7 | |
| Length Wtd. (m) | 21.50 | Wetted Per. (m) | | 89.44 | |
| Min Ch El (m) | 1215.50 | Shear (N/m2) | | 101.50 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 296.34 | |
| Frctn Loss (m) | 0.14 | Cum Volume (1000 m3) | | 206.67 | |
| C & E Loss (m) | 0.05 | Cum SA (1000 m2) | | 94.28 | |

Plan: Plan 03 Klipmosselspruit AB RS: 93 Profile: Q50

| E.G. Elev (m) | 1217.35 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (m) | 0.07 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1217.28 | Reach Len. (m) | 22.33 | 22.33 | 22.33 |
| Crit W.S. (m) | | Flow Area (m2) | | 166.59 | |
| E.G. Slope (m/m) | 0.000746 | Area (m2) | | 166.59 | |
| Q Total (m3/s) | 197.00 | Flow (m3/s) | | 197.00 | |
| Top Width (m) | 88.71 | Top Width (m) | | 88.71 | |
| Vel Total (m/s) | 1.18 | Avg. Vel. (m/s) | | 1.18 | |
| Max Chl Dpth (m) | 4.28 | Hydr. Depth (m) | | 1.88 | |
| Conv. Total (m3/s) | 7201.0 | Conv. (m3/s) | | 7201.0 | |
| Length Wtd. (m) | 22.33 | Wetted Per. (m) | | 89.52 | |
| Min Ch El (m) | 1213.00 | Shear (N/m2) | | 13.66 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 16.15 | |
| Frctn Loss (m) | 0.02 | Cum Volume (1000 m3) | | 155.11 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 74.81 | |

Plan: Plan 03 Klipmosselspruit AB RS: 93 Profile: Q100

| E.G. Elev (m) | 1218.31 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (m) | 0.05 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1218.26 | Reach Len. (m) | 22.33 | 22.33 | 22.33 |
| Crit W.S. (m) | | Flow Area (m2) | | 262.45 | |
| E.G. Slope (m/m) | 0.000401 | Area (m2) | | 262.45 | |
| Q Total (m3/s) | 268.00 | Flow (m3/s) | | 268.00 | |
| Top Width (m) | 109.22 | Top Width (m) | | 109.22 | |
| Vel Total (m/s) | 1.02 | Avg. Vel. (m/s) | | 1.02 | |
| Max Chl Dpth (m) | 5.26 | Hydr. Depth (m) | | 2.40 | |
| Conv. Total (m3/s) | 13376.4 | Conv. (m3/s) | | 13376.4 | |
| Length Wtd. (m) | 22.33 | Wetted Per. (m) | | 110.15 | |
| Min Ch El (m) | 1213.00 | Shear (N/m2) | | 9.38 | |
| Alpha | 1.00 | Stream Power (N/m s) | | 9.58 | |
| Frctn Loss (m) | 0.01 | Cum Volume (1000 m3) | | 183.33 | |
| C & E Loss (m) | 0.00 | Cum SA (1000 m2) | | 80.84 | |

Plan: Plan 03 Klipmosselspruit AB RS: 92 Profile: Q50

| E.G. Elev (m) | 1217.30 | Element | Left OB | Channel | Right OB |
|---|---|---|---|---|---|
| Vel Head (m) | 0.04 | Wt. n-Val. | | 0.035 | |
| W.S. Elev (m) | 1217.26 | Reach Len. (m) | 50.00 | 50.00 | 50.00 |
| Crit W.S. (m) | 1215.85 | Flow Area (m2) | | 217.18 | |
| E.G. Slope (m/m) | 0.000520 | Area (m2) | | 217.18 | |
| Q Total (m3/s) | 197.00 | Flow (m3/s) | | 197.00 | |
| Top Width (m) | 130.88 | Top Width (m) | | 130.88 | |
| Vel Total (m/s) | 0.91 | Avg. Vel. (m/s) | | 0.91 | |
| Max Chl Dpth (m) | 4.36 | Hydr. Depth (m) | | 1.66 | |
| Conv. Total (m3/s) | 8638.2 | Conv. (m3/s) | | 8638.2 | |
| Length Wtd. (m) | 50.00 | Wetted Per. (m) | | 132.22 | |
| Min Ch El (m) | 1212.90 | Shear (N/m2) | | 8.38 | |