ANNEXURE E:

IR Consulting Engineers – Preliminary Design Report

CB 357 / 2006: MONTANA SPRUIT CHANNEL IMPROVEMENTS

Preliminary Design Report

Draft

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Prepared For:	Prepared by:
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1. INTRODUCTION

1.1 Terms of Reference:

The City of Tshwane Metropolitan City Council appointed IR Consulting Engineers for the detailed design, construction supervision and monitoring of the Montana Spruit Channel Improvements Project.

This design report has been prepared as part of IR Consulting Engineers scope of services for the CTMM Montana Spruit Channel Improvements Project.

The Montana Spruit Channel Improvement Project is required to mitigate flood damage to the Doornpoort Estate and Residential Development property in the vicinity of Tsamma Road crossing with Montana Spruit. The original design brief identified four preferred flood mitigation options, namely:

1. Channel improvements of the Montana Spruit;
2. Re-alignment of the crossing of Tsamma Road over the Montana Spruit;
3. Improve stormwater drainage along Breed street; and
4. Provide new cut off channels adjacent to the N1.

1.2 Project Layout Area

The project area for the Montana Spruit Channelisation Improvement Project is located within the Doornpoort Estate and Residential development, south of Pretoria, and is defined to include:

- The Montana Spruit Flood Management area
- An area 400m upstream of the Tsamma road stream crossing and to about 500m down stream of the same crossing.
- Tsamma road between Breed Street and the Montana Spruit crossing.

1.3 Project Description

As part of the Doornpoort Residential Development and Doornpoort Estate development, Tsamma road was extended to the east to provide the Doornpoort Extension 6 with a secondary access roaute and local residents of Doornpoort estate access to the shopping areas and schools of the Doornpoort residential area. Tsamma road crosses the Montana Spruit at a low level structure consisting of 6 x 450mm diameter pipe culverts.

The problem is that frequent flooding of the low level crossing and property located in the vicinity of the crossing occurs during heavy rain storms. A flooding problem also occurs at the circle intersection of Tsamma road and Breedt street, east of the low level crossing. Ponding depths up to 300mm have been observed at the intersection of Breed street and Tsamma road which present a hazard to motorist and an impediment to emergency response vehicles who requires access to the Doornpoort Estate and Residential Development.
Flooding at the low level crossing is mainly due the hydraulic incapacity of the structure and the Montana stream to safely convey high stream flows through the structure and downstream during storm evenets. Illegal dumping of building spoil

in the stream area over the years has further reduced the capacity of the stream. Another impacting factor is the unregulated growth found within the stream.

Flooding of the Tsamma circle intersection is the result of both incomplete and inadequate of storm water conveyance capacity along Breed Street.

1.4 Previous Planning Studies

The Montana Spruit Improvements Project Preliminary Design builds on a previous flood management study reports in and around the project area, including the:

- 'Montana Spruit and Breed Street Flood and Stormwater Analysis' carried out in September 2006 by P D Naidoo and Associates;

- 'General Stormwater Master Plan' prepared in 1999 for the Montana Spruit area by Messrs Von Willich & Vrba.

1.5 Purpose of Preliminary Design

The purpose of this preliminary design study is to advance and refine the preferred flood mitigations options identified through previous studies for the Montana Spruit Channel Improvements Project.

The preliminary design report describe the preferred improvements, reasons for selecting specific improvements, design concepts, design criteria, cost estimates, and implementation schedule. The purpose of this phase will be to lay the groundwork for the detailed design phase by finalizing the project scope, defining project components, and beginning the process to obtain project approvals from the CTMM and other affected groups.

1.6 Scope of Project

The CTMM has completed the stormwater drainage system along Breed Street. Due to presumable funding constraints the CTMM deferred the construction of a new cutt-off channel along the N1.

The scope of this preliminary design therefore focuses on:

1. Channelisation of Montana Spruit within a defined project area
2. Lowering of Tsamma Road stream crossing
3. Improvement of Breed Street stormwater

2. CATCHMENT DESCRIPTION

2.1 Area and Size

The catchment for the Montana Spruit Channel Improvement Project has a fairly compact shape with average dimensions being 15 km long by 3 km wide. The total catchment area which is shown on drawing G 0012/001 is 9.9 km^2 to point A and 8.2 km^2 to B.

2.2 Topography and Slope

The Montana Spruit catchment is surrounded by a mountainous range in the south but eventually slopes towards the north at about 2%, the average slope determined according to 10-85 method along the watercourse is about 1.7%. The longest watercourse to the end of the project is about 5.1 km. The maximum elevation in the catchment is about 1372 m and the lowest is 1223 m. The elevation difference is 149 m.

2.3 Land Use

The land use have been determined for two scenarios; namely present state (Scenario 1) and fully developed future state (Scenario 2) as shown in tables below. A complete table is attached in appendix B.

Table 2.3.1: Present Land-use

Summary		
Land Use	Area (km^2)	Land Use (%)
Lawns		
Sandy Flat	3.40	34%
Heavy Flat	1.46	15%
Residential		
Houses	4.10	41%
Business		
Suburban	0.52	5%
Streets	0.46	5%
Total	9.93	100%

Table2.3.2: Future land use

Summary		
Land Use	Area (km^2)	Land Use (%)
Lawns		
Sandy Flat	1.76	18%
Heavy Flat	0.75	8%
Residential		
Houses	5.25	53%
Business		
Suburban	1.72	17%
Streets	0.46	5%
Total	9.93	100%

The future fully developed state has been determined using the following assumptions:

- 50% of the vacant properties along Zambezi road and the corner of Breed and Zambezi Road will be developed as business areas and the other 50% as residential areas
- Vacant land elsewhere will be developed as residential
- Areas which are not shown on the cadastral map (provided by SRK) as stands will remain as they are
- All vacant stands to the west and north of Zambezi road will be developed.

2.4 Channel Cross Sections

A detail survey of the Montana Spruit main channel and flood banks has been completed for the project area during June 2007. The purpose of the survey was to collect most recent survey data to define the Montana Spruit channel geometry.

A generalization of the Montana Spruit existing cross section are shown in Figure 2.4. The stream is a deep, with very steep banks, thick bush along the main channel. The main channel is an irregular shape, on the outer limits, particularly on the western side

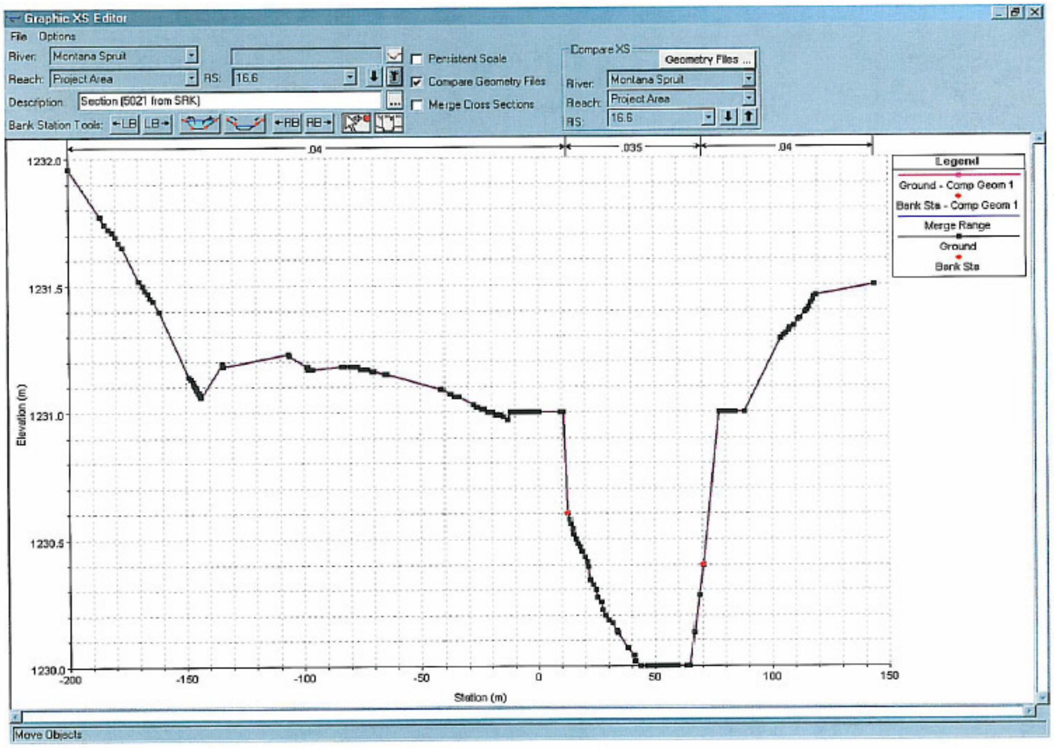

Figure 2.4: Typical Cross section of the existing Montana Spruit

2.5 Channel Profile

The channel longitudinal profile of the Montana Spruit Main existing channel is shown in Fig 2.5. The main channel can be describes as having a flat slope averaging ….% over the project reach.

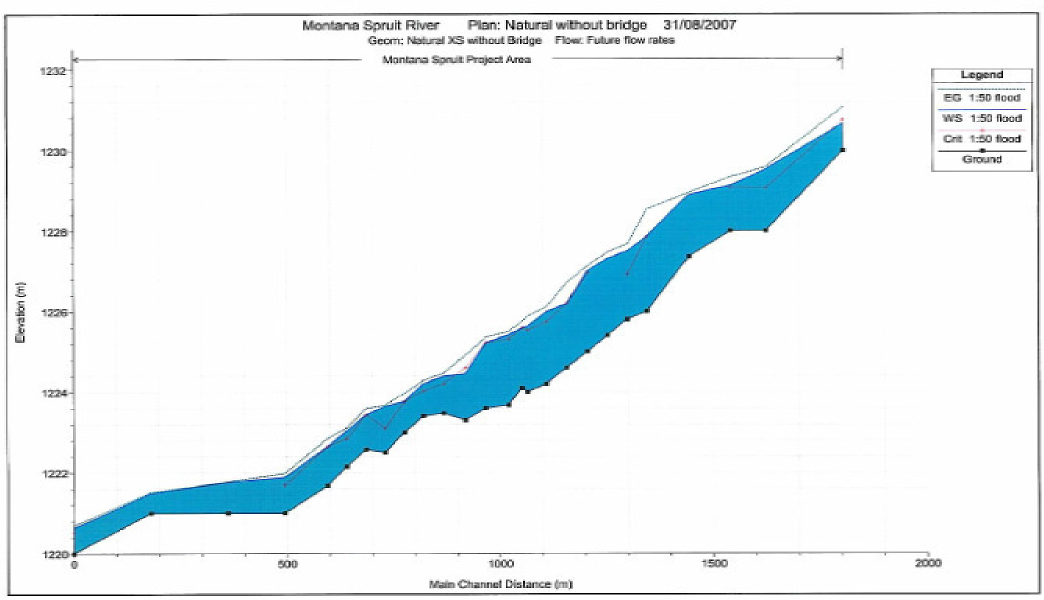

Figure 2.5: Longitudinal profile of the existing Montana Spruit

2.6 Geology and Soils

A total of eleven (11) borings were performed by the Messrs Geo Civilab in June 2007 along the alignment of the existing Montana Spruit channel . The spacing between borings ranges from about (50) to (100) meters. All the borings were terminated at approximately 2.5m below the existing ground surface.

The Montana Spruit area in general is covered by a transported clayey sand which varies in thickness and show possible potential expansive properties and the N1 area collapsible properties. The following formation was observed on the Site and confirmed on the 1:50 000 Geological Map 2628 CB Pretoria. Both Sites Montana Spruit and the N1 areas is underlain by – **Norite, Gabbro Unit**, **Bushveld Igeneous Complex, Post Transvaal.**

A generalized subsurface profile is provided in Fig 2.7 Appendices A contain the preliminary geotechnical study results for the project.

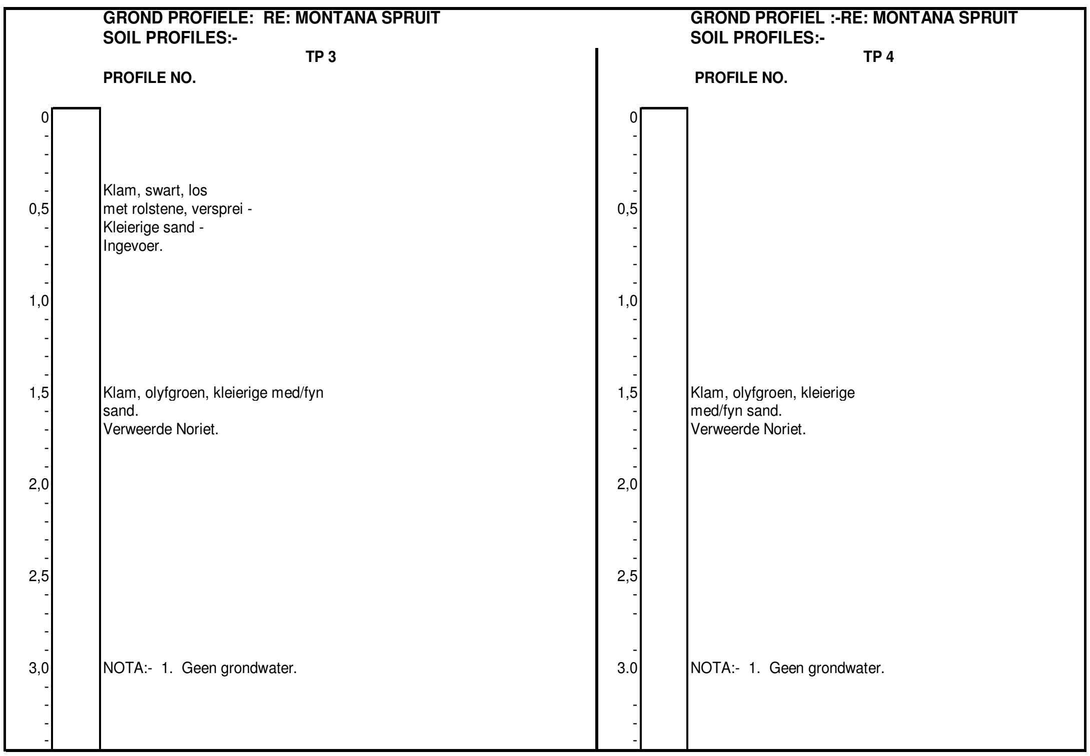

Figure 2.6: General Soil Profile of Montana Spruit

Photo 2.6.1: Norite material at TP 3 and TP4

2.7 Site Services

No municipal services were found that cross the Montana Spruit within the project reaches. The only structure crossing the Spruit is the 6 pipe culvert Tsamma road crossing.

A number of residential properties encroached on the existing flood plain areas. A list of the properties is attached as Appendix B.

Photo 2.7.1: Montana Spruit erf no 39/295

Photo 2.7.2: Dam close to erf 38/295

Photo 2.7.3: Thick overgrown from pipe culvert downstream at Tsamma Road

Photo 2.7.4: Tsamma Street West – East

Photo 2.7.5: Tsamma Street East – West

Photos 2.7.6: Breed Street south of Bougainvillea Drive

Photo 2.7.7: Breed Street – Tsamma Street Circle Intersection

3. HYDROLOGY

3.1 Methodology

Various catchment methods were employed to calculate the peak flow and runoff volumes in the Montana Spruit catchment and sub-catchment areas. The methods include:

- The Rational Method
- The Standard Design Flood method
- The Empirical Method and
- The Alternative Rational Method

The results of these methods were compared to each other and to results obtained from previous studies. The results of the Rational Method and Alternative Rational Method were ultimately selected to determine peak flows and runoff volume for the project.

3.2 Design Criteria

The preliminary design stage hydrology for the Montana Spruit Channel Improvement Project is largely and update of previous studies and a check or confirmation of previous studies results and recommendations. After review the design criteria adopted in the previous studies have been maintained for the preliminary design.

The 1:50 and 1:100 year return period has been adopted for the determination of design peak flows for the Montana Spruit flooding problems
The 1:25 year return period has been adopted for the determination of design peak flows for Breed Street flood problems
The 1:50 year return period has been adopted for the determination of the design peak flows for the N1 cut-off channel.

3.3 Model Parameters

The input parameters selected for the Rational Methods are as shown below;

Montana Spruit stormwater

Catchment area	:	9.9 km^2
Slope	:	1.65 %
C	:	0.404
Time of concentration	:	66 minutes

Breed Street stormwater

Catchment area	:	071km^2
Slope	:	1.25 %
C	:	0, 705
Time of concentration	:	33 minutes

N1 stormwater

Catchment area	:	0, 681 km^2
Slope	:	1, 627 %
C	:	0, 656
Time of concentration	:	39, 3 minutes

3.4 Rainfall

The Montana area falls within the summer rainfall region, with numerous rainfall stations located around the area. The nearest stations are Koedoespoort, Kamelia, Silverton and Rietondale. The average mean annual precipitation of these stations is 690 mm, see attached sheet on Appendix B. For other methods other than the rational methods, the Silverton rain station was used as the representative station.

3.5 Design Flows

3.5.1 Montana Spruit Catchment

The results of the flood peak flow calculations for the Montana Spruit catchment (present and future states flood peak) for the various methods utilised are shown in table 3.5.1 below:

Table 3.5.1: Present State Flood peaks (Scenario 1)

Return Period	SDF Method	Alternative Rational Method	Rational Method	Empirical Method	RMF	Selected peak flood
2	6.09	22.54	25.51		314.6	24
5	21.38	38.02	34.64			36
10	35.58	49.74	43.71	25.4		47
20	51.65	61.45	53.78	34.5		58
50	75.63	76.93	69.55	47.9		73
100	95.78	88.65	85.14	60.6		87
200	117.16	100.36				100

3.5.2 Future State Flood Peak Flows

Table 3.5.2: Future State Flood peaks (Scenario 2)

Return Period	SDF Method	Alternative Rational Method	Rational Method	Empirical Method	RMF	Selected peak flood
2	6.09	30.92	35.00		314.6	33
5	21.38	52.16	47.51			50
10	35.58	68.23	59.96	26.6		64
20	51.65	84.29	73.78	36.1		79
50	75.63	105.53	95.40	50.0		100
100	95.78	121.60	116.80	63.3		119
200	117.16	137.67				138

The empirical method is normally applicable for larger areas. It yields results which are inconsistent with the rest of the methods and we recommend that this method should be ignored.

The SDF method is not dependant on the specific runoff coefficient and is therefore not perfectly suited for small catchments in urban areas.
The rational method and the alternative rational method yielded similar results and were therefore used to determine the peak floods in the area. The selected peak floods are average values of the two methods.

3.6 <u>Breed Street Sub-Catchment</u>

The results of the flood peak flow calculations for the Breed Street catchment upstream of Tsamma Road crossing, for the various return periods, as under 4.3 table 4.3.

For convenience, the naming convention used by Von Willich & Vrba is adopted in this report. The stormwater master plan drawing is attached in Appendix C drawing no. 98 09.8.

The design peak flows for selected drainage nodes along Breed Street are shown below:

Node	Design Peak Flow
862	0.5 m^3/s
861	1.1 m^3/s
860	2.2 m^3/s
859	3.05 m^3/s
800	4.0 m^3/s

3.7 N 1 Sub-Catchment

The results of the flood peak flow calculations for the N1 cutt-off channel sub catchments, for the various return periods, are tabled as under 4.4 table 4.4.2.

For convenience, the naming convention used by Von Willich & Vrba is adopted in this report. The stormwater master plan drawing is attached in Appendix C drawing no. 98 09.8.

The design peak flows for selected drainage nodes along N1 are shown below:

Node	Design Peak Flow
816	14.4 m^3/s
797	24.6 m^3/s

4. HYDRAULIC ANALYSIS

Hydraulic computations for the Montana Spruit Channel were performed using the HEC-RAS software program. Water surface levels were computed for the following conditions and 1:50 and 1:100 design peak flow events

Natural River State: With and without low level stream crossing
Modified River State: Widening of stream

4.1 Montana Spruit

Pre-determined cross-sections within specified limits as previously determined by PDNA were used to do the hydraulic computations as to ensure that the maximum width of the river state is utilised.

4.1.1 Flood lines for Natural River State

The results of the hydraulic calculations and the hydraulic profiles are attached in Appendix B. The floodlines for recurrence periods of 1:50 and 1:100 years are shown in drawing No G 0012 / 003 attached in Appendix E.

The water surface levels at our Section 0.6 (SRK section 3412) were calculated using a Hec Ras model configured by SRK Consulting for the river reach situated downstream of Section 0.6, and for the natural (existing) river state. The inlet design flows used to determine the water surface levels were as shown in Table 3.5.2. We have not reviewed the model configuration. We have however noticed that some of the sections used were incomplete (did not extend beyond the floodline level) and the flows used by SRK were substantially lower than these estimated in Table 3.5.2.

4.1.2 Flood Lines for Modified River State

In an attempt to contain the 1:50 year floodlines within the specified limit as determined previously by PDNA, the river reach have been modified to enlarge the available flow area. As far as possible, we have tried to maintain the natural condition of the defined stream. The existing dam downstream of Tsamma Road, at section 1.8 has been kept as is. The embankment Section 14 (close to the Old Age Home) has been kept.

The hydraulic calculations were repeated for the modified river state. The results of the hydraulic calculations and the hydraulic profiles are attached in Appendix B.

The floodlines for recurrence periods of 1:50 and 1:100 years are shown in drawing No G 0012 / 004 attached in Appendix E.

The water surface levels at our Section 0.6 (SRK section 3412) were calculated using a Hec Ras model configured by SRK Consulting for the river reach situated downstream of Section 0.6, and for the natural (existing) river state. If and when the river reach downstream of Section 0.6 is modified by the developer, the modified floodlines for this project area could change owing to the revised downstream conditions.

The inlet design flows used to determine the water surface levels were as shown in Table 3.5.2. We have not reviewed the model configuration. We have however noticed that some of the sections used were incomplete (did not extend beyond the floodline level) and the flows used by SRK were substantially lower than these estimated in Table 3.5.2.

The hydraulic results for Montana Spruit confirms the following:

- Under existing conditions some properties lie within the 1: 100 year floodline;
- The flow depth during the 1:100 year flood event is in most cases below 0.5m;
- Containment of the 1:100 year floodline out of reach of property is possible through changing the dimension of the Montana Spruit channel where the flooding problems occur, and by providing stormwater retaining structures in places.
- Construction of 0.5m high levee will contain the 1:100 year flood out of reach of property, but is not considered a environmentally friendly option;
- The preferred option for containment of the 1:100 year flood is to channelize the Montana Spruit through widening.

4.2 TSAMMA ROAD CROSSING

Tsamma Street crosses the Montana Spruit by means of low-level river crossing structure, which includes 6 x 450 mm pipe culvers. The effect of this structure on the existing floodlines was analysed for the 1:50 year recurrence period for the natural river state.

The flow profiles were modelled with and without the structure in order to determine the impact on the floodlines. It is concluded that the structure has minimal impact on the floodlines (raising the 1:50 year flood line by 150 mm at the structure, which reduces to 0 just 60 m upstream). The results of the analysis are summarised in Table 6 below. More detailed hydraulic date is attached in Appendix C.

However this condition may change or worsen should the downstream conditions of the canal design by SRK Consulting changes. From discussions with them it is evident that the cross-sectional dimension of the Montana Spruit will reduce dramatically, which will have a substantial influence on the 1:50 year and 1:100 year flood line levels.

Table 6: Water surface profiles at and upstream of Tsamma Road

Section	Description	Distance to crossing	Water surface level (m)		Difference (mm)
			With crossing	Without crossing	
7.6	Crossing	0	1225.73	1225.58	150
7.8	Immediately upstream	10	1225.73	1225.58	150
8	river	20	1225.68	1225.63	30
9	river	60	1225.98	1225.98	0

The hydraulic results for Montana Spruit confirms the following:

- The existing stream crossing structure at Tsamma Road raises the 1:100 year flood level with about 150mm.
- Channelisation of Montana Spruit in the vicinity of the stream crossing will reduce the 1:100 year flood level by 150mm if the structure is left in place.
- The 1:100 year flood flow depth on Tsamma Road stream crossing is about 500mm, after channelisation and if the existing structure is left in place.
- The 1:100 year flow depth on Tsamma Road crossing will be about 350mm, after channelisation and if the existing structure is lowered.

4.3 BREED STREET

The peak flow at each node in the area between Bougainvillea Drive and Tsamma Street was estimated using rational method as shown in Table 4.3.

Table 4.3 Peak flow at storm water nodes in Breed Street

Storm water Node	Area (Km2)	Peak flow (m^3/s) Return Period (Years)						
		2	5	10	20	25	50	100
		41	55	65	75		89	99
862	0.048	0.25	0.34	0.40	0.46	0.5	0.55	0.61
861	0.1131	0.59	0.79	0.94	1.08	1.1	1.29	1.43
860	0.2189	1.15	1.54	1.82	2.10	2.2	2.49	2.77
859	0.3059	1.60	2.15	2.54	2.93	3.05	3.48	3.87
800	0.4	2.10	2.81	3.32	3.83	4	4.55	5.06
4	0.094	0.49	0.66	0.78	0.90	0.94	1.07	1.19
2	0.134	0.70	0.94	1.11	1.28	1.41	1.52	1.70

The Manning pipe flow calculation method was used to size the pipe system proposed along Breed Street for a 1:25 year return period.

The hydraulic results for the Breed Street catchment area confirms that the following sizes is required to conform with a 1:25 year return period flood.

The proposed pipe sizes are shown below:

Node	Pipe Size
862 to 861	1000 mm
861 to 860	1200 mm
860 to 859	1300 mm
859 to 800	1500 mm
800 to 04	900 mm
04 to 02	100 mm
02 to 01	1200 mm

The hydraulic result for Breed Street confirms the following:

- The 1:100 year and 1:50 year estimated return period design peak of PDNA and Von Willich Vrba is correct.
- The 1:100 year flow depth on Breed Street, Tsamma Road intersection is about 400mm.
- The provision of a 1:25 year stormwater pipe system will reduce the flodding problem at the intersection significantly.
- The provision of a cut-off stormwater canal left to the N1 freeway will reduce the catchment area of Breed Street, and therefore eliminate the flooding problem in Breed Street entirely.

4.4 N1 Concrete Lined Channel

A number of culverts along the N1 Highway discharge stormwater (generated in the catchment to the east of the highway), into the residential area to the west of that highway (between Bospoort and Breed Streets). In order to avoid flooding of the residential area, the construction of the intercepting Channels 1 and 2 has been recommended by the Master Plan.

The previously estimated 1:50 year return period node are correct and can be used. The previously estimated channel sizes were found to be inadequate and should be revised as per the table below. The channels are assumed to have a rectangular cross section. The longitudinal slopes are relatively steep and would result in supercritical flow with Frude Number values in the range of 1.10 to 1.80. A free board of 250 mm has been included in the recommended section depths.

Table 4.4.1: Recommended sizing parameters for Channel 1

Reach		Gradient	Q50 (m3/s)	Channel sections (m)	
Node Upstream	Node downstream			Depth	Width
815	814	0.010	0.56	0.70	0.60
814	813	0.012	1.00	0.70	1.00
813	812	0.020	2.04	0.70	1.20
812	811	0.021	3.06	0.80	1.50
811	810	0.023	6.44	1.10	1.50
810	809	0.019	6.80	1.20	1.50
809	816	0.020	12.22	1.30	2.00
816	outlet	0.020	14.44	1.50	2.50

Table 4.4.2: Recommended sizing parameters for Channel 2

Reach		Gradient	Q50 (m3/s)	Channel sections (m)	
Node Upstream	Node downstream			Depth	Width
808	807	0.024	0.32	0.50	0.60
807	806	0.011	0.56	0.70	0.60
806	805	0.10	1.34	0.80	1.00
805	804	0.011	8.78	1.30	2.00
804	803	0.011	9.38	1.30	2.00
803	802	0.009	12.78	1.50	2.50
802	801	0.007	13.04	1.50	2.50
801	800	0.011	18.92	1.60	3.50
800	Outlet	0.012	24.62	1.80	3.50

For reference of node numbers and positions of channels see appendix E, plan 9809-8 (Von Willich and Vrba).

The hydraulic analysis of the catchment area east of the N1 freeway confirms the following:

- The previous estimated 1:50 year return period design peak flows of Von Willich Vrba is correct.
- The provision a concrete lined stormwater canal is critical as to prevent run-off to contribute to the Breed Street problem and the Montana Spruit flooding problem.

5. PRELIMINARY DESIGN PROPOSALS

5.1 FLOOD MITIGATION OPTIONS TO BE CONSIDERED

PDNA & Associates:

The key findings and preferred flood mitigation options identified in previous flood management studies by PDNA and Associates of the project areas are summarized below.

Montana Spruit flood mitigation:

- *The estimated design peak flow, for the 1:100 year flood event, used for the Montana Spruit Flood Analyses at the Tsamma Road crossing is 120 m3/s;*
- *Under existing conditions some properties lie within the 1: 100 year floodline;*
- *The flow depth during the 1:100 year flood event is in most cases below 0.5m;*
- *Containment of the 1:100 year floodline out of reach of property is possible through changing the dimension of the Montana Spruit channel where the flooding problems occur;*
- *Construction of 0.5m high levee will contain the 1:100 year flood out of reach of property, but is not considered a environmentally friendly option;*
- *The preferred option for containment of the 1:100 year flood is to channelize the Montana Spruit.*

Tsamma Road stream crossing flood mitigation:

- *The existing stream crossing structure at Tsamma Road raises the 1:100 year flood level with about 150mm under existing stream conditions.*
- *The 1:100 year flood level will reduce by 280mm after Channelisation of Montana Spruit in the vicinity of the stream crossing and with the structure removed*
- *The 1:100 year flood flow depth on Tsamma Road stream crossing is about 500mm, after channelisation and if the existing structure is left in place.*
- *The 1:100 year flow depth on Tsamma Road crossing will be about 320mm, after channelisation and if the existing structure is lowered.*
- *The preferred solution for the Tsamma Road stream crossing flooding problems is to reduce Tsamma Road from a Class 3 to a Class 5 A road, since the Bougainville Drive is functional for vehicle and pedestrian crossing over Montana Spruit.*

Breed Street flood mitigation:

- *Breed street act as a stormwater collector channel that drains towards the intersection with Tsamma Road and subsequently floods the intersection;*
- *The expected 1:100 year flood flow depth along Breed Street is estimated between 150 and 190mm above road level.*
- *Residents reported flood flow depth at the circle of 300 – 400mm*
- *The preferred solution for the Breed Street flooding problem is to construct a open channel stormwater collecting channel along Breed Street to accommodate at least the 1:25 year flood event.*
- *Adequate provision for diversion of flow to Montana Spruit from Breed Street channel is also proposed by construction of a stormwater outlet channel 100m south of Tsamma Road*

Von Willich & Vrba:

- *Von Willich & Vrba prepared a general stormwater master plan for area in 1999.*

- *For convenience, the naming convention used by Von Willich & Vrba is adopted in this report. The stormwater master plan drawing is attached in Appendix C drawing no. 98 09.8.*
- *According to this master plan there are four major water drainage nodes in the area. Three of these nodes are found upstream of the Tsamma Road. At the first major node the stormwater flows directly into the steam. In the other three nodes the stormwater leads to the Montana Spruit by means of an artificial channel, designed to accommodate the 1:50 year stormwater flow.*
- *Of the two collecting channels upstream of Tsamma Road the first which is referred to as Channel-1 in the master plan drawing, is found about 1.8 km south of the road. This channel runs along the National Road (N1) for one kilometre and crosses Breed Street as shown in the master plan drawing toward the Spruit. Part of this channel, which runs from Breed Street to the Spruit, has been constructed but it needs to be connected with the remaining part of the channel.*
- *The second, which is referred to as Channel-3 in the master plan drawing, is only half a kilometre south of Tsamma Road. This channel has not yet been constructed.*
- *Channel-2 runs from node No. 801 to node No. 797, as shown in the master plan drawing, along N1 and then diverted to east toward the Montana Spruit. This channel is also not constructed.*
- *The stormwater drainage along Breed Street was designed to be a pipe system to accommodate a 1:25-year return period peak flow. Right at the junction of Tsamma and Breed Streets there is a collecting node. Similar to the pipe system this node was also designed for 2 year return period peak flow.*
- *Bougainvillea Drive has been constructed to connect the residential area with the shopping centre. Since the traffic in Breed Street from the Hornbill junction to the north is expected to reduce. As a result, this portion of Breed Street will be reduced from existing Class 3 to Class 5 A road class.*

5.2 Montana Spruit stormwater channel

IR Consulting Engineers have analysed the hydrology analysis and above to opted for the following solutions:

- Channelize the Montana Spruit by changing the existing channel through excavating & shaping and widening.

- The overall objective of any natural stream channelisation improvement design should be to provide enough space to meet flood conveyance targets, increase vegetation in the channel, improve habitat conditions, and improve water quality in the stream.

- A well-designed stream channelization will typically have three zones on either side of the watercourse: a streamside zone, a middle zone, and an outer zone (Figure 5.2).

The three zones transit from a riparian forest to grasses to the desired land use outside the stream channel. The streamside zone protects the physical and ecological integrity of the stream ecosystem. This forested corridor provides shade, nutrients, woody debris, erosion protection and habitat.

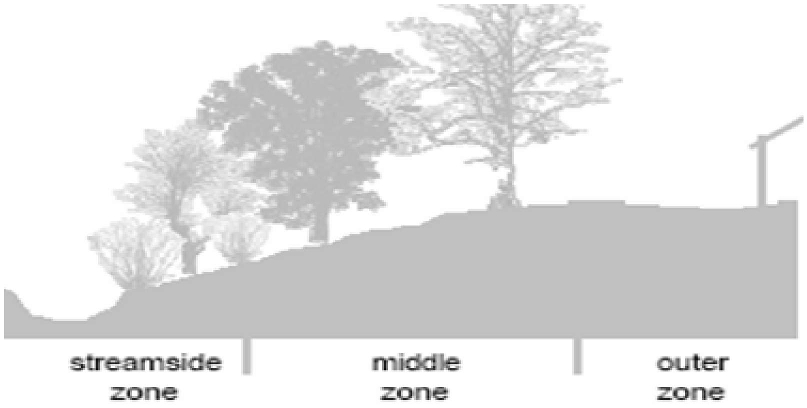

Figure 5.2 Schematic of the three-zone urban stream buffer system (not to scale)

The middle zone acts as a transition and buffer between the forested riparian zone and other land uses. It can be forested or grassy and is generally managed for recreation, flood control, access, or other uses. The primary function of the middle zone is to remove sediment and nutrients from runoff and subsurface flows. The middle zone is usually sized to include the 100-year flood zone and any riparian wetlands in need of protection. The outer zone is the buffer's buffer. It is generally an additional 5-10 meters between the middle zone and any concreted, paved, or permanent structure. It is typically a grassy strip designed to encourage infiltration and disperse concentrated flows

The solution to this conflict is to increase the size and configuration of the channel (Figure 5.2). The increased size will allow for more vegetation and still meet flood control targets. By modifying the cross section to create a two-stage channel in the stream, we allow for greater diversity and improved habitat conditions for fish, reptiles, and amphibians. Reducing the slope of the banks will also improve access and increase safety in the stream channel.

5.2.1 Channel Alignment

- The horizontal alignments decided for the proposed Montana Spruit Improvements will follow the existing stream bed line.
- The eastern side of Montana Spruit is the bounded by the Doornpoort Estate Development. Therefore, the stream would only be widened toward the western side.

5.2.2 Channel Shape and Lining

To enhance the ecological conditions, natural bedding and excavated stream flood banks with re-vegetation will be provided for the Montana Spruit Channelisation. To make the proposed Spruit more environmentally friendly, the stream banks will be lined with natural substrates to produce a suitable environment similar to the existing main stream condition. The existing riverbed should remain untouched as far as possible.

<u>Channel Deepening</u>

This concept involves deepening the channel by invert excavation of the active stream channel for entire project length. This provides a larger cross-section for flow conveyance and may also provide for a more hydraulically efficient channel due to clearing of weeds. This option is not recommended because of the disturbance to the natural stream bed and ecological system. It will also negatively impact the maintenance of low flow conditions in the stream. This type of excavation will only be permitted where dumping occurred within the main stream bed.

<u>Channel Widening</u>

This concept involves widening the cross-sectional area of the stream channel by excavating one or both banks outwards to provide a larger cross-section for flow conveyance. This option is preferred because it does not disturb flow and natural ecological activities in the main stream influence.

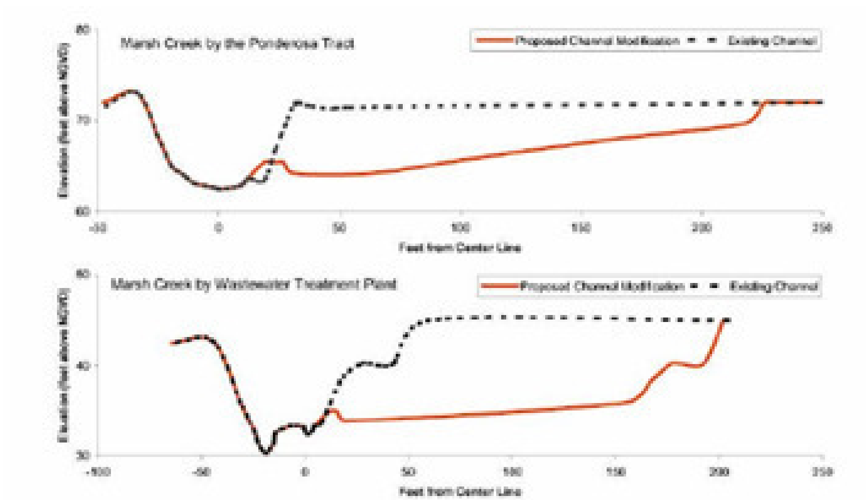

Figure 5.2.1: Typical Modified cross-section of the Montana Spruit

The extend of the Montana Spruit is indicated as shown drawings no ……Attached as annexure D.

5.2.3 Collection of Local Run-off

At some locations, the proposed stream channelisation improvements will cut off the existing watercourses. It is proposed to connect the existing watercourses to the proposed channel through either a pipe or a culvert such that the flow can be maintained.

At locations where embankments might be required along the proposed channel improvements, the surface runoff from the adjacent areas behind the embankments will be intercepted by the channels and discharged into the proposed channel through embankment drains.

5.2.4 Embankment Protection

From the hydraulic analysis for a 1:50 year and 1:100 year return period flood it is evident that substantial embankment erosion might occur especially along the eastern embankment of the Montana Spruit.

The hydraulic analysis indicates a high velocity of flows of between 3, 0 – 5, 0 m/s with Fraud no. of equal to 1 and greater than 1. This implies that flows are critical and super critical.

The areas of concern are listed in table 5.2.4 below as shown on drawing no……

Table: 5.2.4

ERF NO	CROSS – SECTION NO	FRAUD NO.	VEL CHAL M/S	EXTEND OF EMBANKMENT PROTECTION
30, 31, 32	12, 13, 14	0, 99 1, 0 0,93	1, 93 2, 49 3, 24	Extensive gabion wall + mattress approx. 2,0m high
33, 34	7.4	1, 15	2, 35	Gabion wall approx. 2,0 m high
37, 38	2	1, 0	1, 77	Gabion walls approx. 2, 0m high
Old Age Home	14 16, 3	0, 99	2, 31	Earthwall lined with (2, 0m high) concrete blocks

5.2.5 Re-vegetation of Montana Spruit

The 150 and 1:100 year return period flood may cause extensive surface erosion and it is important that the slope and surfaces be protected by grass

5.2.6 Existing stormwater dam north of Tsamma Street

For the purpose of this report it is suggested that no remedial measures be taken at the existing stormwater dam. The hydraulic conditions and analysis show that insignificant erosion may occur. This situation might however change depending on the downstream conditions of the canal proposed by SRK Consulting Engineers.

5.3 TSAMMA STREET CROSSING

- The preferred solution for the Tsamma Road storm crossing flooding is to lower the stormwater crossing and simultaneously lower the longitudinal alignment of the road. To be similar to the cross-sectional dimensions of the Montana Spruit. The pipe culvert access or crossings will be demolished and re-provided in the form of a reinforced concrete slab drift across the stream.

- The vertical road alignment is to be similar to the cross-sectional dimensions of the Montana Spruit and will be adjusted in such a way as to allow the traffic to travel with a minimum speed of 40 km/h.

- The road will be reconstructed by replacing the subbase, base layer and brick paved on both sides of the proposed reinforced concrete slab.

- Concrete pillars of approximately 400mm high must be constructed on both sides of the of the concrete slab as to indicate to motorists the extend of the road width during floods.

5.4 BREED STREET STORMWATER MANAGEMENT

- The City of Tshwane has constructed an 1100mm Ǿ stormwater pipe along Breed Street with catchpits from Bougainville Drive to the node 800. The 1100mm Ǿ stormwater pipe discharge into an open ground channel which lead into the Montana Spruit next to erf no. 30(channel no. 03 according to Von Willich Vrba)

- This stormwater pipe system can accommodate a 1:25 year flood event. However it is felt that the amount of catchpits provided is not sufficient to collect all the stormwater run-off from the road.

- Two additional catchpits are to be constructed and connected to the 1100mm stormwater pipe system in Breed Street.

- The existing 900mm dia stormwater pipe in Tsamma Street discharges into the Montana Spruit. This pipe is connected to only one catchpit at the circle in Breed Street.

- This pipe must be extended southward in Breed Street to the node 04, or erf 28 (channel no. 03 according to Von Willich Vrba). This is important since a lot of stormwater does not enter the stormwater catchpit and outlet at channel 3, and proceeds to carry on toward the circle intersection.

- The provision of a cut-off channel from node 809 to node 797 and beyond approximately 3800m is the most important solution to the problem in Breed Street as 75 % of the area run-off will be diverted from Breed Street.

5.5 Provision of Concrete Lined Channel Along the N1 Freeway

- As mentioned under item 5.4 this canal is essential as to eliminate stormwater problem is Breed Street.
- The canal is to be built along the N1 freeway from the node 815 northwards to the turn-of from the N1 to the N4 freeway as to allow the water to discharge on to the natural stormwater plain adjacent to the N4 freeway.
- It is proposed that this canal be a trapezoidal shape with flow capacity as indicated under section 4 with a total length of approximately 3800m.
- Presently there are no indication whether SANRAL will grant permission for the canal to be constructed in the road reserve
- It is proposed that this work be carried out under a different contract, and that negotiations with SANRAL be undertaken in this regard.

6. PRELIMINARY COST ESTIMATE

6.1 Montana Spruit Improvements:

ITEM	Description	Amount	
1.0	**Preliminary and General**	R	793,520.62
1.1	Site Establishment	R	300,000.00
2.0	**Montana Spruit Rehabilitation:**		
3.1	Site Clearance	R	2,584,450.00
3.2	Earthworks	R	553,383.60
3.2	Landscaping	R	1,764,516.20
4.0	**Stormwater Outlet Structures:**		
4.1	Earthworks	R	59,941.20
4.2	Gabion Walls and matrassed	R	334,312.00
5.0	**Grass Channels Outflows:**		
5.1	Earthworks	R	91,766.40
	Subtotal	***R***	***6,481,890.02***
	Contingency	*R*	*648,189.00*
	Subtotal	***R***	***7,130,079.02***
	VAT	*R*	*998,211.06*
	Total	***R***	***8,128,290.09***

6.2 Tsamma Street Crossing:

ITEM	Description	Amount	
	Site Establishment	R	80,000.00
	Prelim and General	R	104,485.20
	Site Clearance	R	-
	Earthworks	R	54,912.00
	Put additional chutes between channel3 and Tsamma Road	R	3,300.00
	Put hump	R	22,000.00
	Subbase	R	1,237.50
	Base Course	R	5,197.00
	Segmented Paving	R	295,659.10
	Stormwater Concrete Drifts	R	192,362.50
	Subtotal	***R***	***759,153.30***
	Contingency	*R*	*75,915.33*
	Subtotal	***R***	***835,068.63***
	VAT	*R*	*116,909.61*
	Total	***R***	***951,978.24***

6.3 Breed Street Stormwater Improvements

	Pipe System 1:		
	Site Establishment	R	200,000.00
	Site Clearance	R	1,980.00
	Trenching	R	35,508.00
	Prefabricated culverts and stormwater sewers	R	882,200.00
		R	**1,286,904.00**
	Preliminary and General	R	209,106.00
	Pipe System 2:		
	Site Clearance	R	7,425.00
	Trenching	R	43,208.00
	Prefabricated culverts and stormwater sewers	R	1,099,450.00
		R	**1,359,189.00**
	Subtotal	***R***	***2,646,093.00***
	Contingency	*R*	*264,609.30*
	Subtotal	***R***	***2,910,702.30***
	VAT	*R*	*407,498.32*
	Total	***R***	***3,318,200.62***

6.4 Cut-Off Concrete Channel Along the N1 Freeway

ITEM	***Description***	***Amount***	
	Site Establishment	R	300,000.00
	Preliminary and General	R	569,796.53
	Site Clearance	R	223,603.60
	Earthworks	R	340,252.33
	Open Drains	R	2,570,025.33
	Landscaping	R	110,000.00
	Subtotal	***R***	***4,113,677.79***
	Contingency	*R*	*411,367.78*
	Subtotal	***R***	***4,525,045.57***
	VAT	*R*	*633,506.38*
	Total	***R***	***5,158,551.95***

The preliminary design cost estimate to implement the proposed works is R 17, 557, 020.90 and is based on the above estimate of construction quantities

7. IN CONCLUSION

With the existing stream conditions there is a risk of flooding during heavy rainstorms in the Doornpoort area near Tsamma road crossing. The potential consequences of such flooding include

- Flooding will persist during big storm events.
- Development in the area will be hindered.
- The existing drainage system will not provide the flood protection standard required for future development.
- Further development will increase the frequency, severity and extent of flooding.
- Damage to properties, blockage of roads and accesses, nuisance to the public and risk to lives will remain.

If the Project does not proceed, these risks to the community in the Doornpoort area will continue and some future development may need to be compromised. There are no simple, small-scale works that can be implemented to reduce these risks.

The only effective solution to provide adequate flood relief is to implement the drainage improvement works identified in this Preliminary Design Report.

APPENDIX A:

CATCHMENT LAYOUT

APPENDIX B:

HYDRAULIC RESULTS

APPENDIX C

HYDRAULIC CROSS-SECTIONS

APPENDIX D:

VON WILLICH MASTER PLAN

APPENDIX E:

DRAWINGS