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The uMkhomazi Water Project Phase 1: Module 1: Technical Feasibility Study: Raw Water

WATER REQUIREMENTS AND RETURN FLOWS REPORT

WRITE UP 1:
POSSIBLE WATER SUPPLY FROM SMITHFIELD DAM TO SURROUND COMMUNITIES (SMITHFIELD DAM LOCAL WSS)

FINAL

MAY 2014

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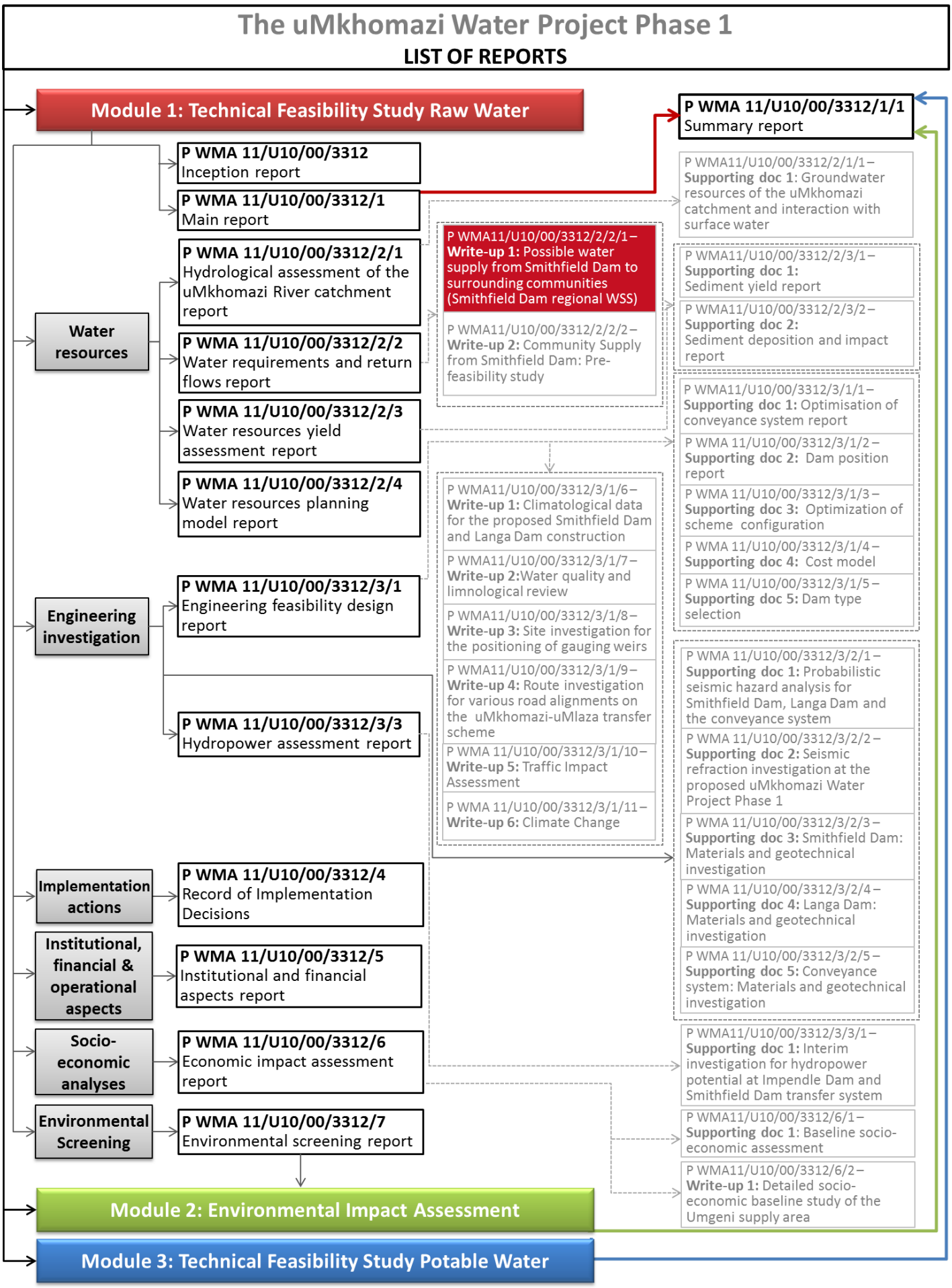
PREAMBLE

In June 2014, two years after the commencement of the uMkhomazi Water Project Phase 1 Feasibility Study, a new Department of Water and Sanitation was formed by Cabinet, including the formerly known Department of Water Affairs.

In order to maintain consistent reporting, all reports emanating from Module 1 of the study will be published under the Department of Water Affairs name.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LIST OF ABBREVIATIONS

DWA	Department of Water Affairs
FSL	Full supply level
masl	Meters above sea level
wsa	Water supply area
WSA	Water Service Authority
WSP	Water Service Provider
WSS	Water supply scheme

LIST OF UNITS

cm	centimetre
ha	hectares
kℓ	kilolitre
km^2	square kilometres
ℓ	litre
ℓ/c/d	litre per capita per day
m	metre
mm	millimetre
m^3	cubic metre
m^3/s	cubic metre per second
million m^3/a	million cubic metres per annum
Mℓ	mega (million) litre

1 INTRODUCTION

The Smithfield Dam site is located within the Ingwe Local Municipality which falls within the Sisonke District Municipality's area of jurisdiction. Currently there are no communities that will be inundated by the proposed dam. However, several scattered communities, many of which are located on top of hills, surround the Smithfield Dam.

As part of the feasibility study for the proposed Smithfield Dam, a desktop-level study was carried out to ascertain the following:

- The current water sources being used by the communities surrounding the dam; and
- The possibility of feasibly supplying these communities from Smithfield Dam in the future.

For this purpose a desk-top design was carried out for a bulk water supply scheme comprising a (1) water treatment works, (2) pumpstation with associated pump(s), and a (3) pipe network with associated reservoirs. For ease of reference this possible scheme will be referred to as the ***Smithfield Dam local water supply scheme (WSS)*** for the purpose of this report.

An assumption had to be made on the supply area of the proposed Smithfield Dam local WSS. As such, 24 communities in relatively close proximity of the Smithfield Dam (both on the south-western side and north-eastern side of the dam) were chosen to be included in the scheme. These communities are listed in **Table 3.1** and their locations shown in **Figure 1.1**. It must be noted that this supply area was assumed and should be confirmed by the relevant authorities, should the need arise at a later stage.

No formal communities (apart from Deepdale, Claremont and Camden which only consists of a 4/5 houses each and weren't defined as separate supply areas by the *2001 Census* (Statistics South Africa, 2002)) currently exist within close proximity of the northern side Smithfield Dam. Impendle, which is a considerable distance from the dam falls within the Impendle Town and Enguga WSS, as defined by the *All Towns Reconciliation Strategy* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011).

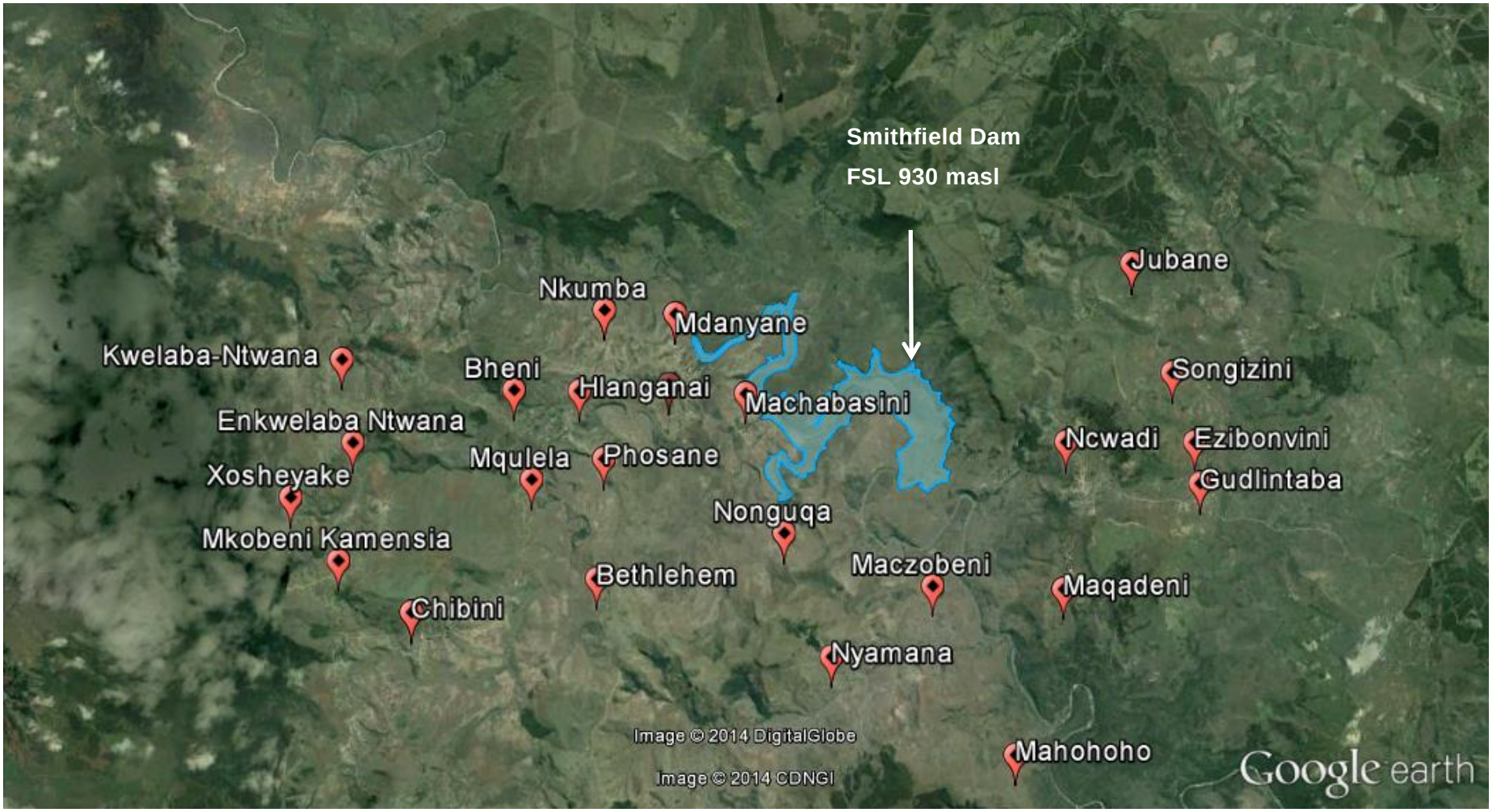

Figure 1.1: Google image of the communities surrounding Smithfield Dam

2 CURRENT AND ALTERNATIVE FUTURE WATER SOURCES

2.1 CURRENT WATER SOURCES

For the purpose of determining the water sources currently being utilised by the communities surrounding the dam (and assumed to be included in the proposed Smithfield Dam local WSS), information from the *2001 Census* (Statistics South Africa, 2002) was used to be consistent with the information integrated as part of the ***water requirements and return flows task*** conducted at the beginning of this study. At the time, information from the *2011 Census* wasn't available yet (this only became available on 30 October 2012). The following categories for ''access to water'' for households were captured during the *2001 Census:*

- Regional/local water scheme (operated by a Water Service Authority or Provider)
  - Piped water (tap) inside dwelling
  - Piped water (tap) inside yard
  - Piped water on community stand: distance less than 200m
  - Piped water on community stand: distance greater than 200m
- Borehole
- Spring
- Rainwater tank (excluded from **Figure 2.1** because less than 0.5%)
- Dam/pool/stagnant water
- River/stream
- Water vendor (excluded from **Figure 2.1** because less than 0.5%)
- Other

Figure 2.1 provides a summary of the 2013 total water sources being used by the communities surrounding the proposed Smithfield Dam. In addition, the individual charts of each community surrounding the dam are included in **Appendix A**. As can be seen from the combined graph 73% of users currently have access to water services in the form of piped water.

It must be noted that, while capturing information on ''access to water'' during the *2001 Census* many households with piped water did not necessarily know where

the water came from. Enumerators were instructed that, in most cases, piped water came from local or local water schemes, boreholes or springs. They were also told that if the piped water was from a local or local scheme, this should take precedence and that the respondent should not answer, for example, 'borehole', even if the scheme used a borehole. The reason for this approach was that the question was intended to be an indicator of water quality rather than convenience and it was assumed that water from a scheme was of good quality. People who did not have access to water from a scheme were asked to indicate one of the other sources. As such, the exact source of piped water, as indicated by **Figure 2.1**, could not be concluded form the *Census 2001* information.

In addition, according to the *All Towns Reconciliation Strategy* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011) the communities within the Bulwer Donnybrook WSS (defined and discussed in the following **Section 2.2**), which include some of the communities surrounding Smithfield Dam, receive their water from ***springs***, ***groundwater*** and ***surface water*** supplies from a ***weir on the Mkobeni River***.

However, the *All Towns Reconciliation* Strategy didn't make a distinction between the sources of supply to each individual community/supply area, thus this information also didn't assist in a conclusion towards the exact source of piped water to communities surrounding Smithfield Dam.

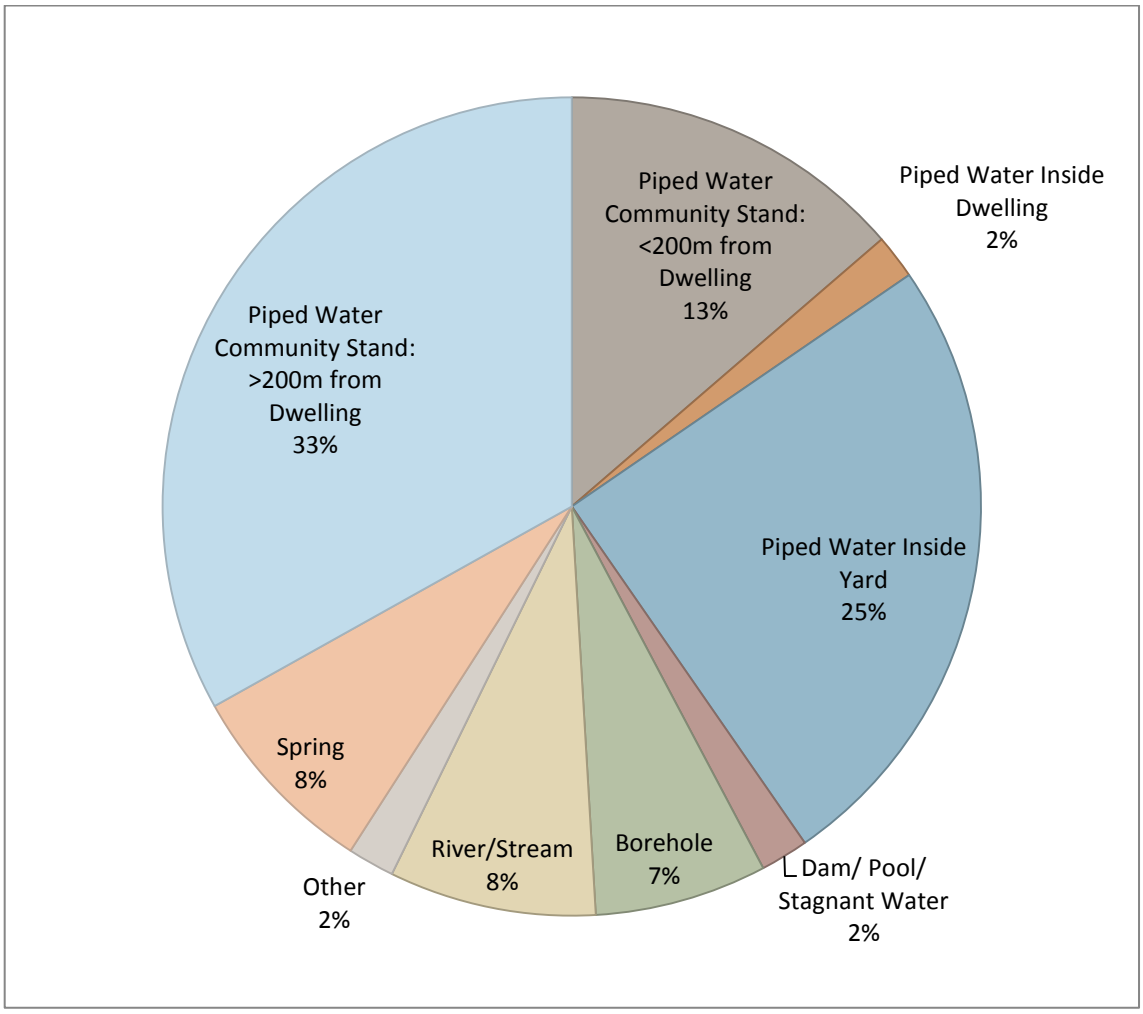

Figure 2.1: Chart showing total sources of water for communities within the Smithfield Dam local WSS

2.2 ALTERNATIVE FUTURE WATER SOURCES

The proposed supply area of the Smithfield Dam local WSS as defined in **Section 1** coincides with the ***Bulwer Donnybrook water supply area***. This water supply area was defined by the *All Towns Reconciliation Strategy* (Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates, 2011) and is shown in **Figure 2.2** (the Bulwer Donnybrook water supply area is indicated in orange). It is planned as a regional bulk water scheme earmarked to be supplied in future by the proposed Bulwer Dam on the Luhane River (to be augmented from the Pholela River at a later stage).

Other than augmentation from the Bulwer Dam, the Bulwer Donnybrook water supply area could also be augmented in future by (1) groundwater development, and (2) the implementation of a WC/WDM programme.

However, the preferred scheme to supply the Bulwer Donnybrook water supply area in future appears to be the development of storage capacity on the Luhane River (Bulwer Dam to be augmented from the Pholela River at a later stage) together with a regional bulk water scheme from this proposed dam. As such, a detailed feasibility study and detailed design have already been completed for the proposed Bulwer Dam and a water use licence and environmental approval has been obtained *(Gray, Personal Communication, 2014)*.

The proposed supply area of the Smithfield Dam local WSS is shown in **Figure 2.3.** This figure also indicates how it coincides with the Bulwer Donnybrook WSS's supply area. The possibility therefore exists to supply the selected communities from the Bulwer Dam, as opposed to implementing a new local WSS.

In order to determine the most feasible scheme to supply the communities around Smithfield Dam it is recommended that the URV of the Smithfield Dam local WSS be compared to that of the Bulwer Donnybrook WSS to be supplied from Bulwer Dam. However, it must be noted that:

- the supply areas of the two schemes differs (with the Bulwer Donnybrook WSS covering a larger area i.e. a greater number of communities will be supplied by this scheme); and
- the proposed Smithfield Dam local WSS is at least ten years away from possible completion due to the anticipated possible implementation dates of the uMWP1. Other localised sources of water will most likely be able to be made available sooner.

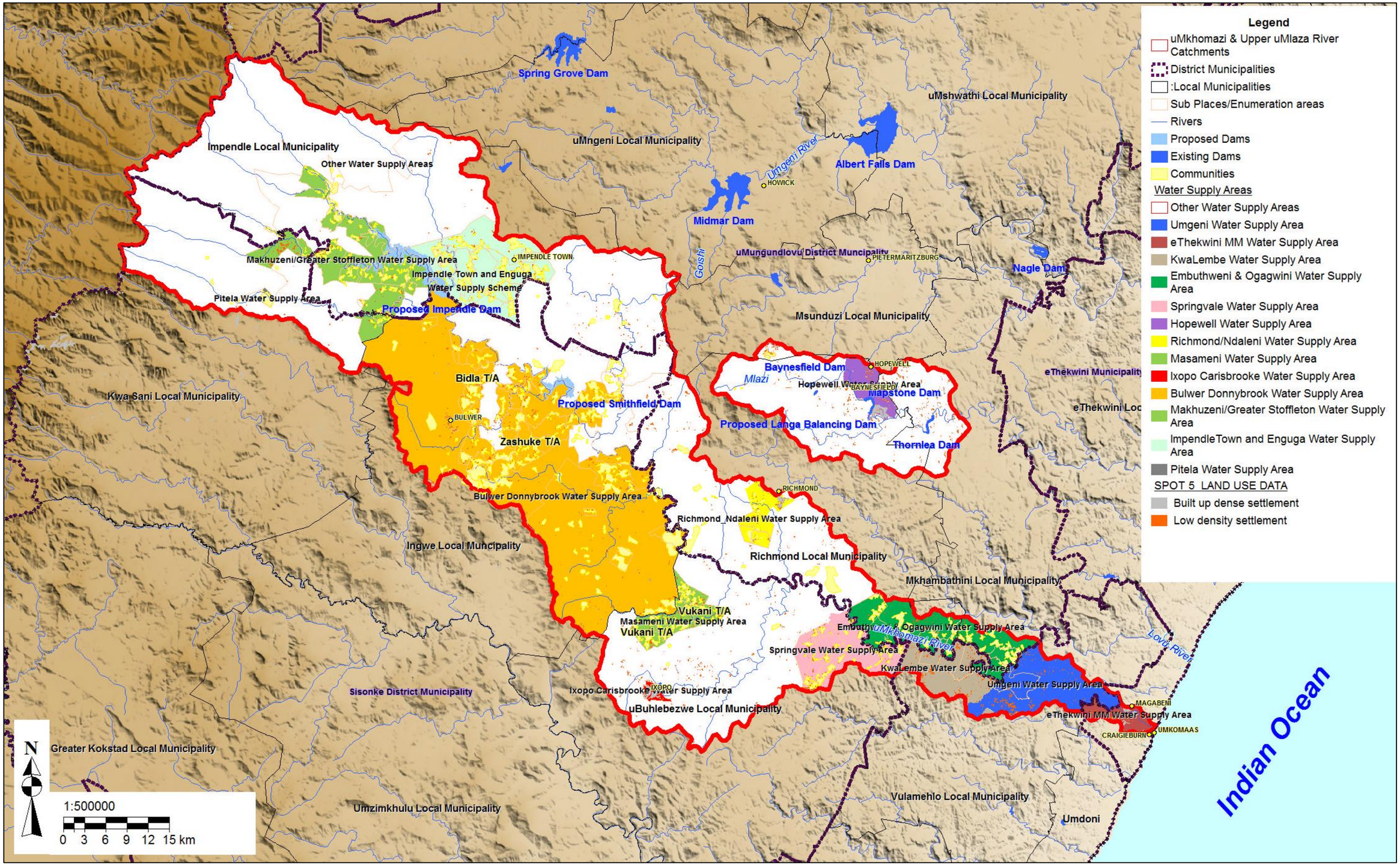

Figure 2.2: Water supply areas within the uMkhomazi River catchment as defined by the *All Towns Reconciliation Strategy* Communities

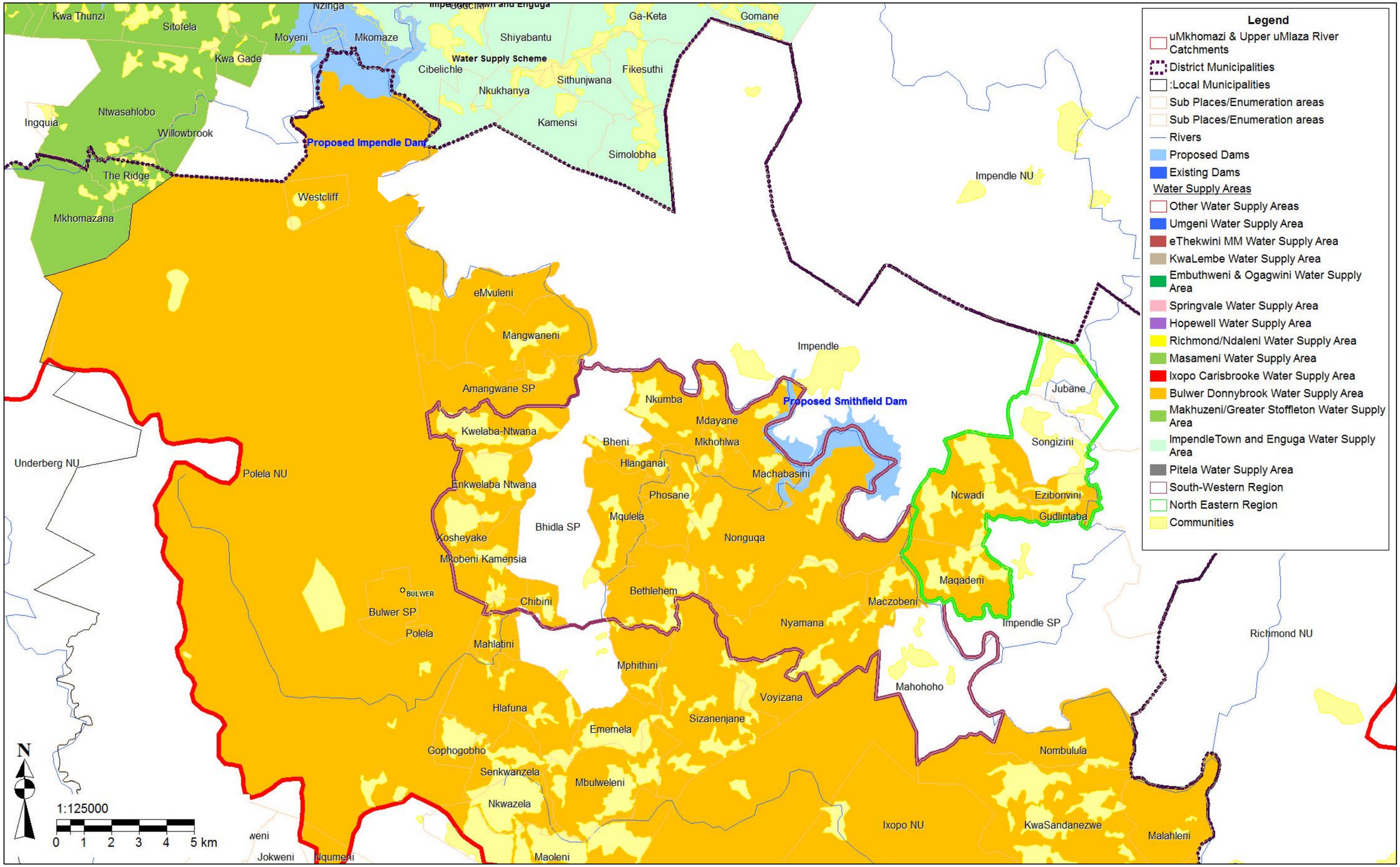

Figure 2.3: Proposed supply area of the Smithfield Dam local Water Supply Scheme

3 FEASIBILITY OF WATER SUPPLY FROM SMITHFIELD DAM (SMITHFIELD DAM LOCAL WSS)

3.1 DESIGN OF THE SMITHFIELD DAM LOCAL WSS

3.1.1 Description

The supply area of the proposed Smithfield Dam local WSS has been divided into two regions feeding communities to the south and north of the uMkhomazi River. For ease of reference these two regions will be referred to as the ***south-western*** and ***north-eastern*** regions respectively.

The proposed Smithfield Dam local WSS has been designed to include the following infrastructure:

- A ***pipeline*** to abstract water from Smithfield Dam's outlet works;
- A ***water treatment works*** at the downstream side of the dam wall to treat the raw water from the dam to potable water standards;
- A ***pumpstation*** at the downstream side of the dam wall with a ***pump*** requiring 263 kW of power, to circulate the water through the system. With friction losses, the pump connected to the bulk mainlines would be required to pump to a pressure head of 744 m.
- Two bulk ***mainlines*** which would deliver water to ***bulk reservoirs*** at heights of 1369 masl (south-western line) and 1416 masl (north-eastern line), indicated with yellow markers in **Figure 3.1**.
- ***Reserve water storage reservoirs*** for each community and for each bulk supply line. In this regard two days reserve storage has been allowed for in order to ensure a continued supply to the communities in case of maintenance or malfunction of the system.
- A number of ***gravity lines*** to deliver water from the bulk reservoirs to the various communities;
- A ***booster pump*** requiring 50 kW of power for the supply of water to Kwelaba-Ntwana, Enkwelaba Ntwana, Mkobeni Kamensia and Xosheyake from the 1369 masl storage tank (south-western line). This pump would need to supply a further 504 m of pressure head, respectively, when friction losses are taken into consideration.

3.1.2 Water requirements

For the purpose of determining the water requirements of communities within the Smithfield Dam local WSS, population data per sub-place/enumeration area from the *2001 Census* (Statistics South Africa, 2002) was used in conjunction with an average per capita consumption of ***60 ℓ/capita/day*** (associated with ''piped water inside yard'' typical for these type of rural areas). This is the preferred allocation for domestic water consumption for households with dry sanitation as given by ***Table 9.11: Water consumption in areas equipped with standpipes, yard connections and house connections (adapted from Department of Water Affairs & Forestry, (1992): Guidelines for the selection of design criteria*** from the *Red Book (CSIR Building and Construction Technology, 2000)*.

Taking a population growth rate of 1.1% for the Ingwe Local Municipality as taken from ***Table 3.9 Annual population growth rates (2001 to 2012)*** of report ***P WMA 11_U10_00_3312_2_2 - Water Requirements and Return Flows*** and applying this growth rate over the lifespan of the pipeline (50 years) to the water demand; these values were used to calculate the water supply design requirements of the system.

The results of these calculations are included in **Table 3.1** and show a total water requirement for the Smithfield Dam local WSS of **0.58 million m^3/a** in 2013 and an ultimate water requirement in 2063 of **0.89 million m^3/a** based on growth in population over 50 years.

If a future increase in service level is assumed and the average per capita consumption are increased to ***90 ℓ/capita/day*** in 2063 (which assumes that households will be upgraded to ''piped water inside dwelling'') the ultimate water requirement in 2063 is estimated to be **1.34 million m^3/a**.

The current design, i.e. pipeline network, of the Smithfield Dam local WSS (as discussed in the following section) will be able to accommodate this increased water requirement, however, the pumping requirements will become extensive and will necessitate a re-evaluation of the inclusion of some of the high-lying communities within the scheme.

As this design was only conducted on desktop-level, and the supply area of the Smithfield Dam WSS is still uncertain as discussed in **Section 1**, it is

recommended that an allocation of **1 million m^3/a** be made from Smithfield Dam, to be confirmed at a later stage.

This water requirement is deemed sufficient as the current design assumes that the communities within the Smithfield Dam local WSS will ***only*** be supplied from the dam in future. In actual fact, they may be dually supplied by their current sources i.e. ***springs***, ***groundwater*** and ***surface water*** supplies from a ***weir on the Mkobeni River***, and only augmented from the Smithfield Dam / Bulwer Dam, depending on which scheme are implemented first.

3.1.3 Design

For the determination of the (1) pumps and pumpstation and (2) pipeline planning requirements and costing the *Vaal Augmentation Planning Study - VAPS (DWAF, 1996)* was used as a guide. For this purpose the elevations of the communities, their height above the FSL of the dam (i.e. 930 masl) and the required length of pipeline to supply them with water have been calculated and are summarised in **Table 3.1**. Further to this rates from the *VAPS* were updated to be representative of 2014 costs.

In the case of the (3) water treatment work and the (4) bulk reservoirs and reserve water storage reservoirs unit costs were used to estimate the costs.

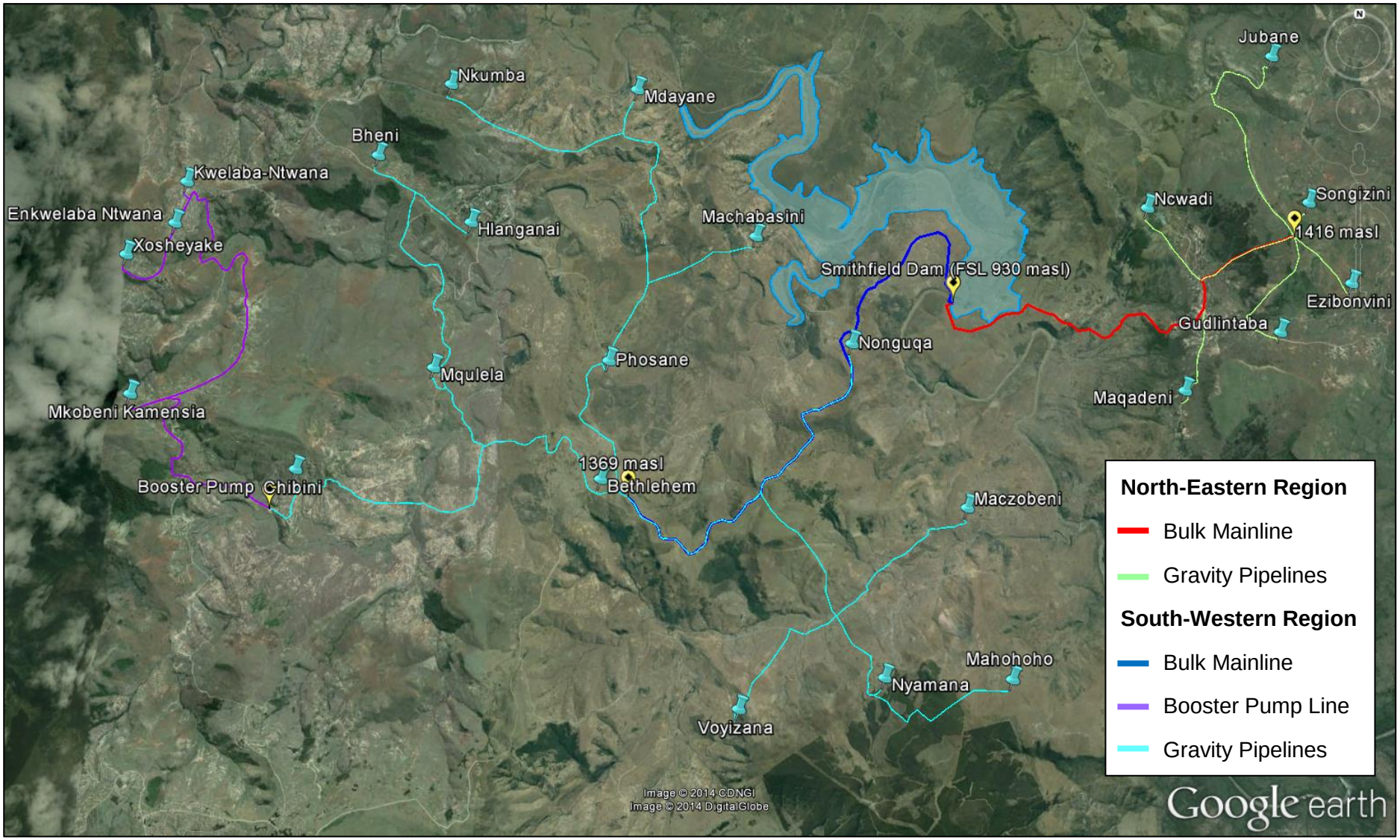

Figure 3.1: Proposed layout of the Smithfield Dam local WSS

Table 3.1: Communities surrounding Smithfield Dam

Sub-place / Community	Total Population (Current - 2013) *(number)*	Total Population in 50 years (2063) assuming 1.1% growth *(number)*	Ultimate total water requirement in 2063 (at a rate of 60 ℓ/capita /day) (m^3/day)	Pipeline distance to supply water to community from Smithfield Dam (km)	Elevation of community (masl)	Elevation of community above the FSL (930 masl) of the Smithfield Dam (m)
South-western line						
Bethlehem	1501	2327	174	11.8	1311	381
Bheni	291	451	34	21.3	1270	340
Chibini	435	674	51	19.4	1256	326
Enkwelaba Ntwana	1831	2838	213	30.6	1352	422
Hlanganai	401	622	47	21.6	1190	260
Kwelaba-Ntwana	2305	3573	268	30.0	1347	417
Machabasini	546	846	63	17.3	1036	106
Maczobeni	497	770	58	20.1	971	41
Mahohoho	845	1310	98	21.5	1185	255
Mdayane	257	398	30	19.3	1032	102
Mkhohlwa	442	685	51	16.6	1036	106
Mkobeni Kamensia	983	1524	114	24.7	1427	497
Mqulela	908	1407	106	16.6	1162	232
Nonguqa	1658	2570	193	17.9	1081	151
Nyamana	1782	2762	207	18.9	1110	180
Nkumba	872	1352	101	22.1	1175	245
Phosane	694	1076	81	14.3	1176	246
Xosheyake	786	1218	91	32.0	1425	495
North-eastern line						
Ezibonvini	369	572	43	9.4	1126	196
Gudlintaba	400	620	47	10.4	1109	179
Jubane	361	560	42	12.7	1133	203
Maqadeni	877	1359	102	12.0	1136	206
Ncwadi	1458	2260	169	11.2	1289	359
Songizini	510	791	59	8.5	1175	245
Total						
Total water requirement in 2063			2442	(m^3/day)		
			2.44	(Mℓ/day)		
			0.89	(Mm^3/a)		

** Water requirement values are inclusive of a peak factor of 1.25*

3.2 COSTS OF THE SMITHFIELD DAM LOCAL WSS

3.2.1 Capital costs

a) Pumps and pumpstations

As mentioned in **Section 3.1** the suggested piping network would require two pumps requiring 288 kW and 50 kW of power respectively, to circulate the water through the system. The capital costs of these, inclusive of civil (30%) and mechanical and electrical (70%) works, were estimated at **R 20.17 million** (excl. VAT). A detailed bill of quantities (BoQ) (based on that obtained from the *Vaal Augmentation Planning Study (DWAF, 1996)*) is included in **Appendix B**).

b) Pipelines

The total capital cost of the pipeline network, including civil works (50%), was found to be approximately **R 47.07 million** (excl. VAT). A detailed BoQ (based on that obtained from the *Vaal Augmentation Planning Study (DWAF, 1996)*) is included in **Appendix C**).

c) Water Treatment Works (WTW)

As stated in **Section 3.1** the Smithfield Dam local WSS needs to deliver potable water to communities surrounding the dam. Hence, the costs of treating the raw water to potable water standards needed to be included. As such the capital cost of a WTW located at the dam was determined and is calculated to be approximately **R 8.55 million** (excl. VAT) (based on a unit cost of R3.5 million/Mℓ/day).

d) Reserve water storage

For each community and for each bulk supply line, 2 days reserve storage has been allowed for as pointed out in **Section 3.1**. The total cost of implementation of the required reservoirs was estimated to be **R 18.96 million** (excl. VAT).

e) Total cost of implementation

Based on the costs as mentioned in **Sections 3.2.1 a)** to **c)** the total cost of installing the bulk infrastructure necessary to supply potable water to the

communities surrounding Smithfield Dam has been estimated as **R 94.75 million** (excl. VAT).

Further to this, an additional 10% can be added for engineering fees and 10% for environmental and social costs, bringing the total cost to **R 113.70 million** (excl. VAT).

It is important to note that the initial capital cost of supplying the site with electricity (for the operation of the pumps and WTW) has not been accounted for in this report as the cost of ESKOM infrastructure required for the supply of electricity to the site has been included in the greater ***uMkhomazi Water Project Phase 1*** project requirements.

3.2.2 Operational and maintenance costs

The estimated amount presented in **Section 3.2.1 e)** only represents the capital costs of implementing the scheme and is therefore not inclusive of any of the following:

- Electricity and associated running costs;
- Maintenance of pumps, pumpstation, pipelines and water treatment works; and
- Employment of professional persons to manage and operate water treatment works and pumpstations and to inspect pipelines.

These costs would be ongoing for the duration of the time that water is treated and pumped to the local communities and are estimated at **R 2.86 million/annum** for operational (electricity) costs and **R 1.60 million/annum** for maintenance costs in 2023, growing to **R 4.43 million/annum** for operational (electricity) costs and **R 1.91 million/annum** for maintenance costs in 2063.

3.3 FEASIBILITY OF THE SMITHFIELD DAM LOCAL WSS

To assess the economic efficiency of the Smithfield Dam local WSS a Unit Reference Value (URV) calculation was conducted. A URV is a common measure in South Africa to assess the economic efficiency of proposed water projects. This found that implementing, operating and maintaining the system from 2023 to 2063 would cost approximately **R 20.84/m^3** of water supplied. General assumptions for calculating the URV are included in **Appendix D**.

This URV can now be compared to that of other schemes that are proposed to supply the communities surrounding Smithfield Dam e.g. the Bulwer Donnybrook WSS to be supplied from proposed Bulwer Dam as mentioned in **Section 2.2**

It must be noted that this URV is very high, and reflects the nature of supplying communities spread out on high lying areas from a large dam low down in a valley. More practical solutions may be sourcing water closer to the communities and at higher elevations. This could for example be the proposed Bulwer Donnybrook WSS for those communities closer to Bulwer, and local ground or surface water for other remote communities.

4 CONCLUSIONS

The following can be concluded with regard to the feasibility of supplying surrounding communities from Smithfield Dam:

Current water resources:

- Based on information from the *2001 Census* (Statistics South Africa, 2002) ***73%*** of users surrounding Smithfield Dam currently have access to some form of piped water.
- However, the exact source of piped water could not be concluded from the *Census 2001* information and might be sourced from either ***springs***, ***groundwater*** and/or ***surface water (i.e. a weir on the Mkobeni River)***.
- In addition, it could also not be concluded whether the water supply of these communities is sufficient and whether the quality of water is acceptable.

Current and future water supply requirements:

- The current combined water requirement of communities within the Smithfield Dam local WSS is in the order of **0.58 million m^3/a** in 2013 growing to an ultimate future water requirement in 2063 of **0.89 million m^3/a**. This is based on an average per capita consumption of ***60 ℓ/capita/day*** (associated with ''piped water inside yard'' typical for these type of rural areas).
- If an increase in service level is assumed and the average per capita consumption are increased to ***90 ℓ/capita/day*** in 2063 (which assumes that households will be upgraded to ''piped water inside dwelling'') the ultimate water requirement in 2063 is calculated to be **1.34 million m^3/a**. This is still quite small for a local scheme covering such a large spatial area.

Water supply cost implications:

- The total capital cost of installing the bulk infrastructure necessary to supply potable water to the communities surrounding Smithfield Dam has been estimated as **R 113.70 million** (including engineering fees and environmental and social costs).
- In addition the operational (electricity) and maintenance costs that would be ongoing for the duration of the time that water is treated and pumped to the local communities is estimated at an ultimate cost of **R 4.43 million/annum** and **R 1.91 million/annum** respectively.

- These high costs can mainly be ascribed to the fact that:
  - The communities are spread far apart which would require an extensive piping system in order to provide them with water.
  - The communities have a large elevation difference between them and the FSL of Smithfield Dam (930 masl) resulting in high operation costs

Future water resources:

- Some of the communities surrounding Smithfield Dam are already earmarked to possibly be supplied from the Bulwer Donnybrook WSS. This scheme is currently in planning phase and will be supplied from the proposed Bulwer Dam.

Feasibility of the scheme:

- The URV of the Smithfield Dam-scheme was found to be **R 20.84/m^3** which is high for a water supply project.

Impact on the uMkhomazi Water Project

- The ultimate supply of water to the Smithfield Dam local WSS of **0.89 million m^3/a** will not have any significant impact on the yield of the dam as it is relatively small (when compared to the transfer of water to the integrated Mgeni WSS that is estimated to be in the order of 336 million m^3/a by 2063).

5 RECOMMENDATIONS

The following can be recommended with regard to the feasibility of supplying surrounding communities from Smithfield Dam:

Current water resources:

- An estimated water requirement of approximately **1 million m^3/a** should be made from Smithfield Dam for the supply of communities surrounding the dam.

Smithfield Dam local WSS vs. Bulwer Donnybrook WSS:

- In order to determine the most feasible scheme to supply the communities around Smithfield Dam it is recommended that the URV of the Smithfield Dam local WSS be compared to that of other schemes proposed for the area i.e. the Bulwer Donnybrook WSS to be supplied from Bulwer Dam.
- However, it must be noted that:
  - the supply areas of the two schemes differs (with the Bulwer Donnybrook WSS covering a larger area i.e. a greater number of communities will be supplied by this scheme);
  - the proposed Smithfield Dam local WSS is at least ten years away from possible completion due to the anticipated possible implementation dates of the uMWP1;
  - Other localised sources of water will therefore most likely be able to be made available sooner i.e. groundwater and management interventions such as Water Conservation/Water Demand Management (WC/WDM).
- Still, a recommendation is made that:
  - the water supply area from the Smithfield Dam (i.e. the Smithfield Dam local WSS) be extended to supply the exact communities earmarked to be supplied from the Bulwer Donnybrook WSS and the URV be re-calculated and compared to that of the last-mentioned scheme.
  - the current water available to the communities within the Bulwer Donnybrook WSS be reconciled with the water requirements of these up to 2023 to assess their capacity to await the completion of Smithfield Dam.
  - a water balance and reconciliation study be conducted between the two options to determine the most efficient use of the available water resources.

- In this way:
  - The capital costs of building another stand-alone dam, i.e. Bulwer Dam, can be put off, as the Smithfield Dam will most likely be built to alleviate the current water shortages within the integrated Mgeni WSS, and in this way can be used to fulfil the dual role of supplying local as well as national communities in future.

Detailed feasibility study:

- Based on the above a detailed study should be conducted to analyse and confirm the:
  - ***Supply area*** of the Smithfield Dam local WSS/Bulwer Donnybrook WSS.
  - ***Current water sources*** utilised by each individual community within the Smithfield Dam local WSS/Bulwer Donnybrook WSS and the ***portion of the water requirement*** that could still feasibly be supplied from current, local sources in future (i.e. springs, groundwater and surface water supplies from a weir on the Mkobeni River). It is highly recommended that communities should continue to use their current water sources for as long as possible.
  - ***Ultimate water requirement*** of the Smithfield Dam local WSS/Bulwer Donnybrook WSS.
  - ***The preferred scheme*** (either the Smithfield Dam local WSS or Bulwer Donnybrook WSS) to supply this area in future.

General:

- It is recommended that the Smithfield Dam local WSS be included as a component in the uMWP1 scheme (and as such the capital cost of the scheme should also be included) with an allocation of 1 million m^3/a.
- The possibility of a Smithfield Dam local WSS and treatment plant should be included in the Scoping Report of the EIA.

6 REFERENCES

CSIR Building and Construction Technology. (2000). *Guidelines for Human Settlement Planning and Design* (Vol. 2). Pretoria: CSIR Building and Construction Technology.

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Gray, R. (2014). Personal Communication. Pietermaritzburg, South Africa: Jeffares & Green (Pty) Ltd.

Statistics South Africa. (2002). *Census 2001.* Pretoria, South Africa: Statistics South Africa.

Water for Africa, Aurecon, Water Geosciences, & Charles Sellick and Associates. (2011). *Development of a Reconciliation Strategy for All Towns in the Eastern Region; First Stage Reconciliation Strategy for Bulwer Donnybrook Water Supply Scheme Area - Ingwe Local Municipality (Contract WP 9712).* Pretoria, South Africa: Department of Water Affairs (DWA).

Appendix A

Individual charts of current (2013) water resources utilised by communities surrounding Smithfield Dam

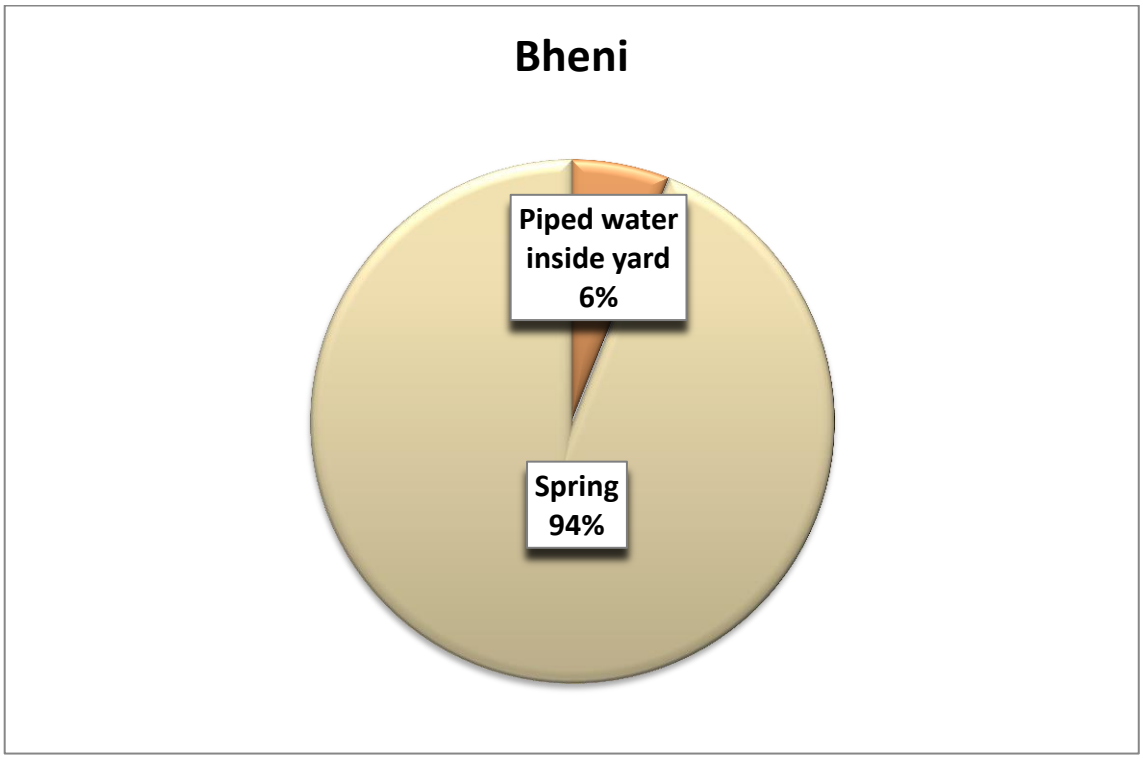

Figure A.1: Current water sources of Bheni residents

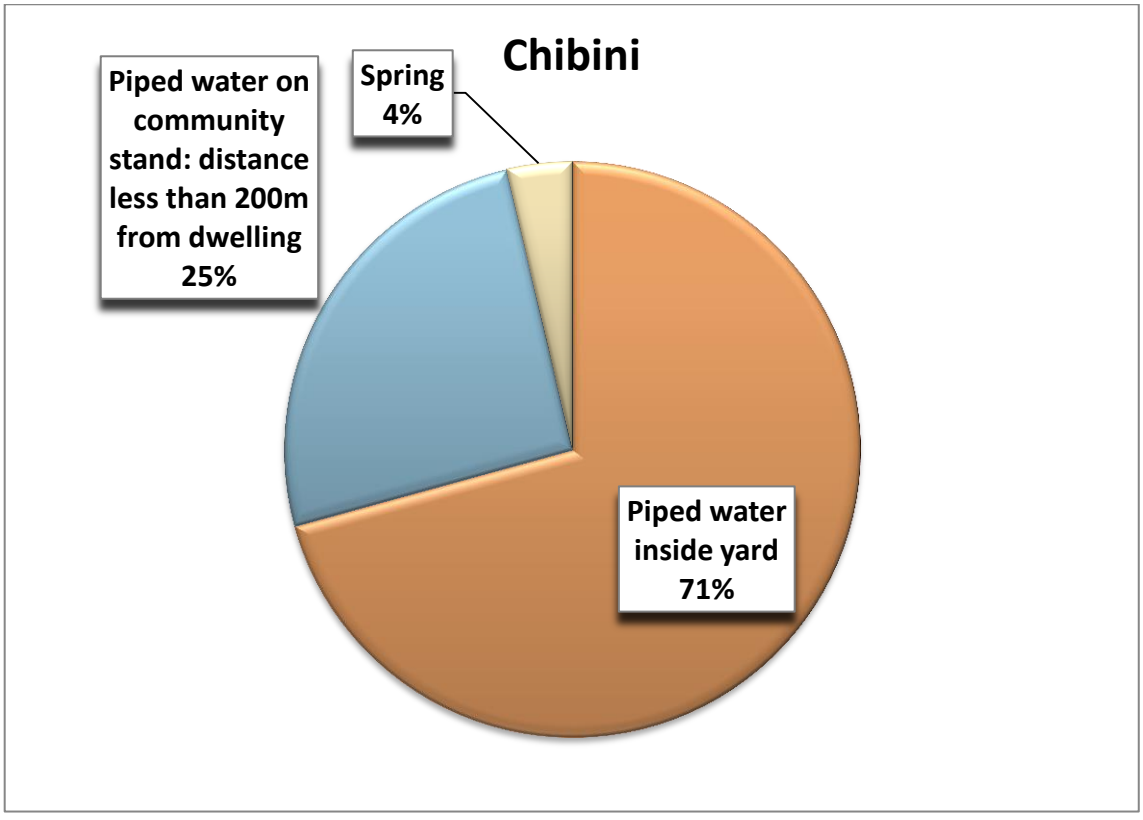

Figure A.2: Current water sources of Chibini residents

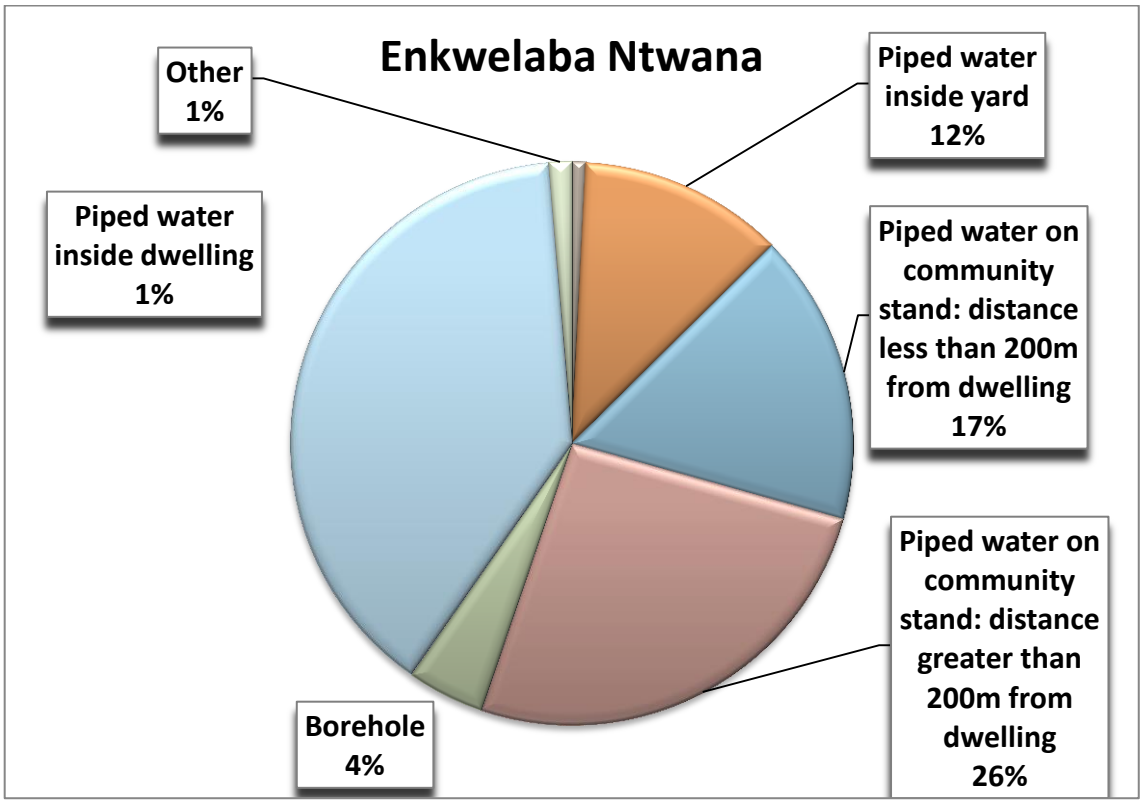

Figure A.3: Current water sources of Enkwelaba Ntwana residents

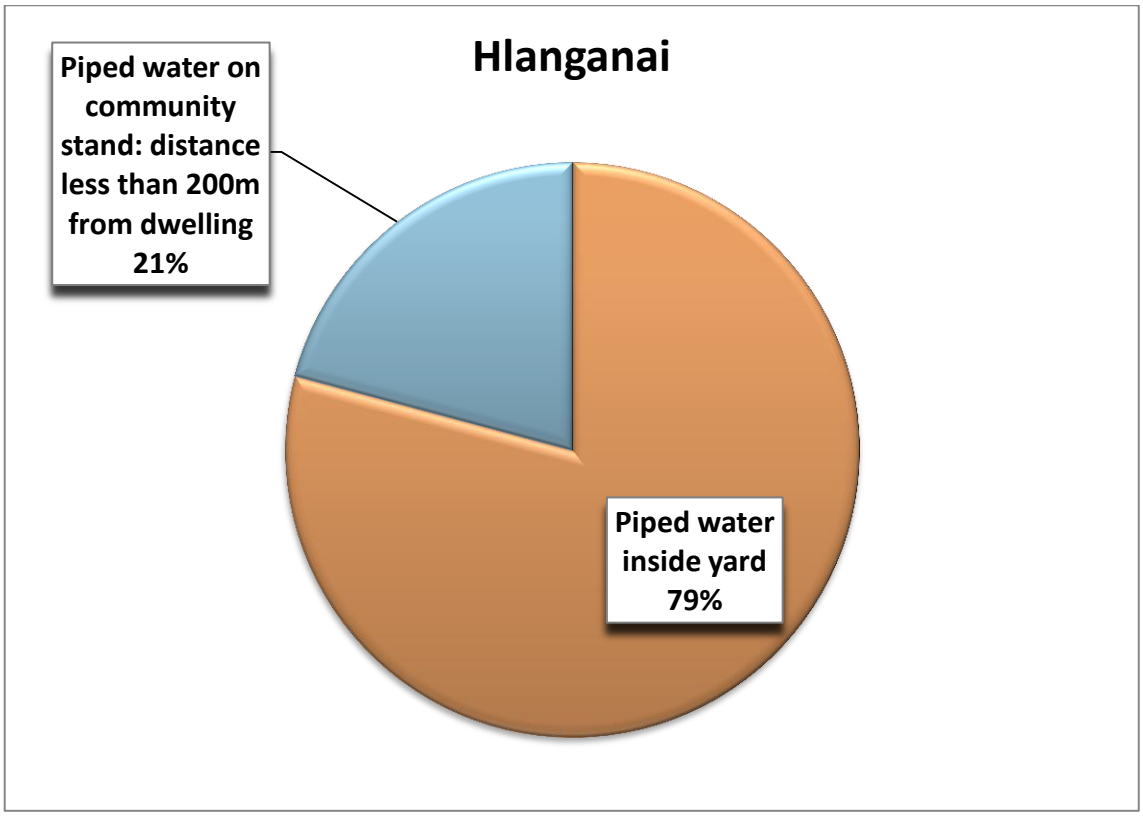

Figure A.4: Current water sources of Hlanganai residents

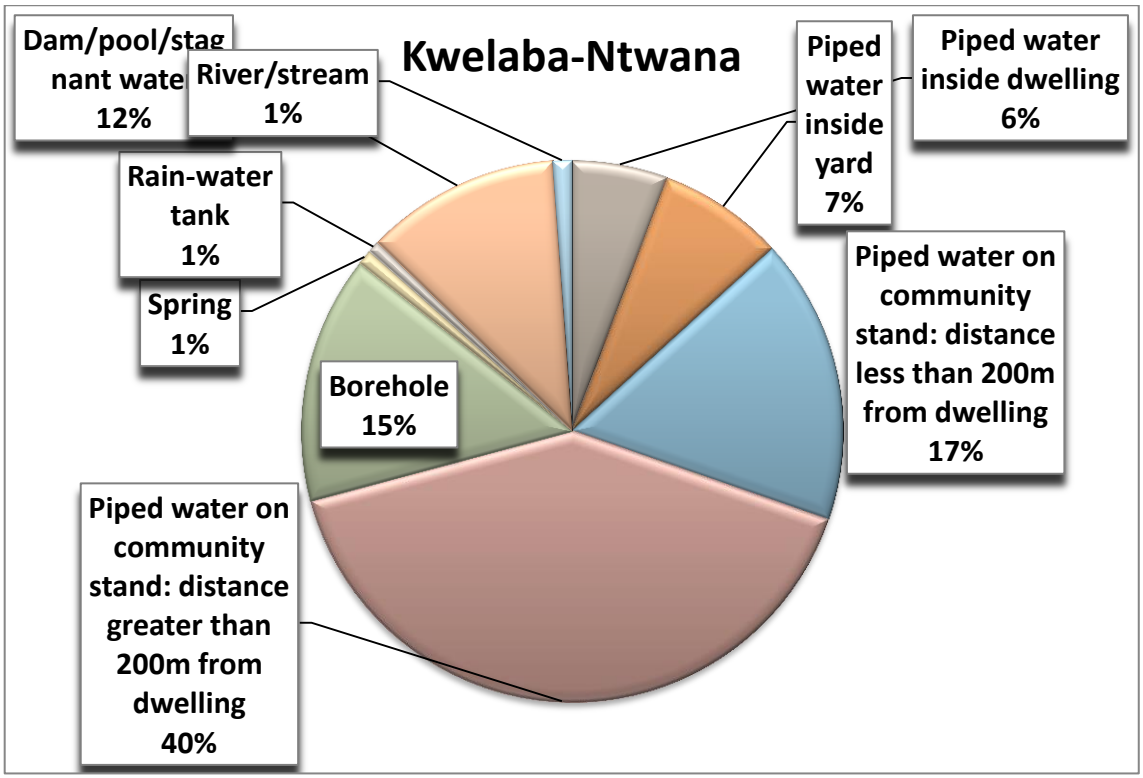

Figure A.5: Current water sources of Kwelaba-Ntwana residents

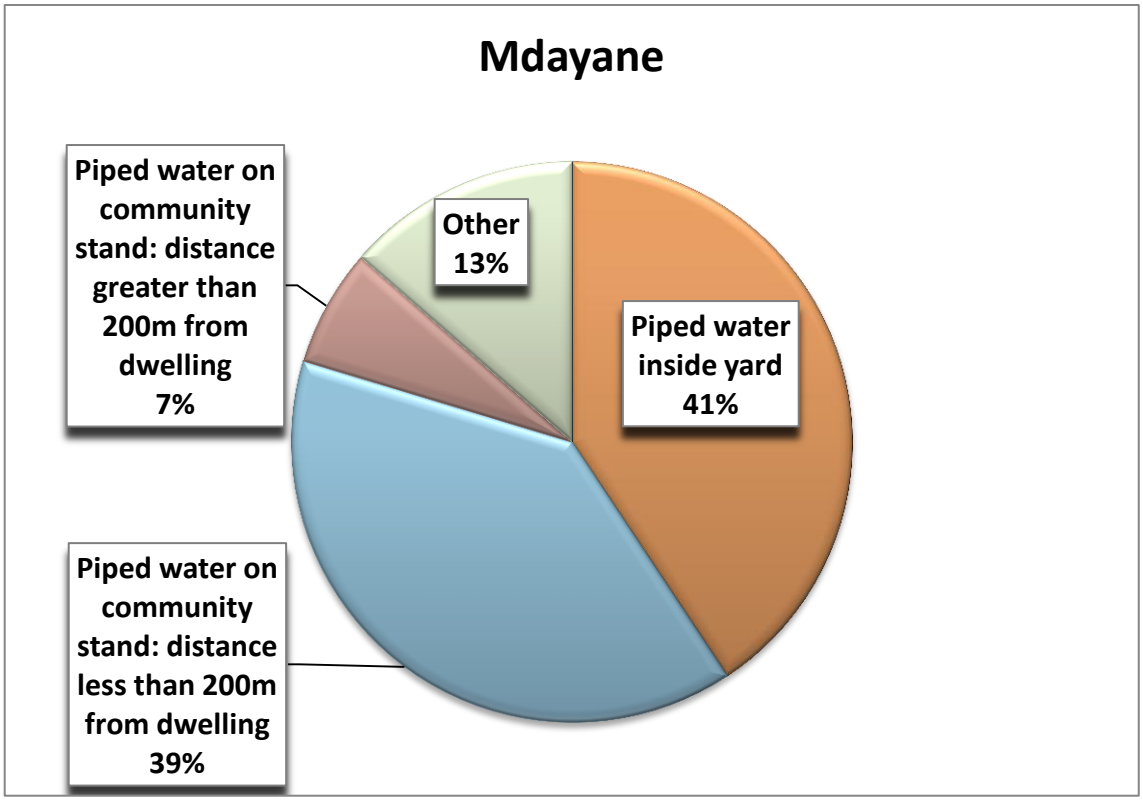

Figure A.6: Current water sources of Mdayane residents

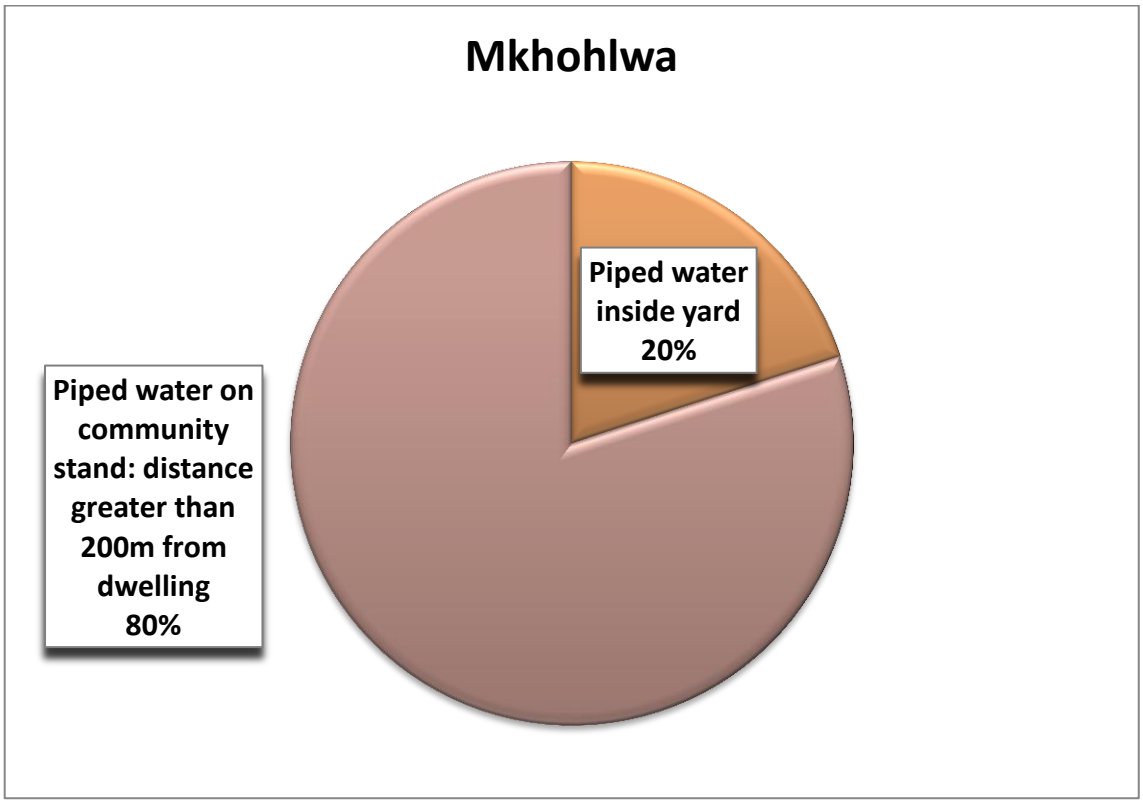

Figure A.7: Current water sources of Mkhohlwa residents

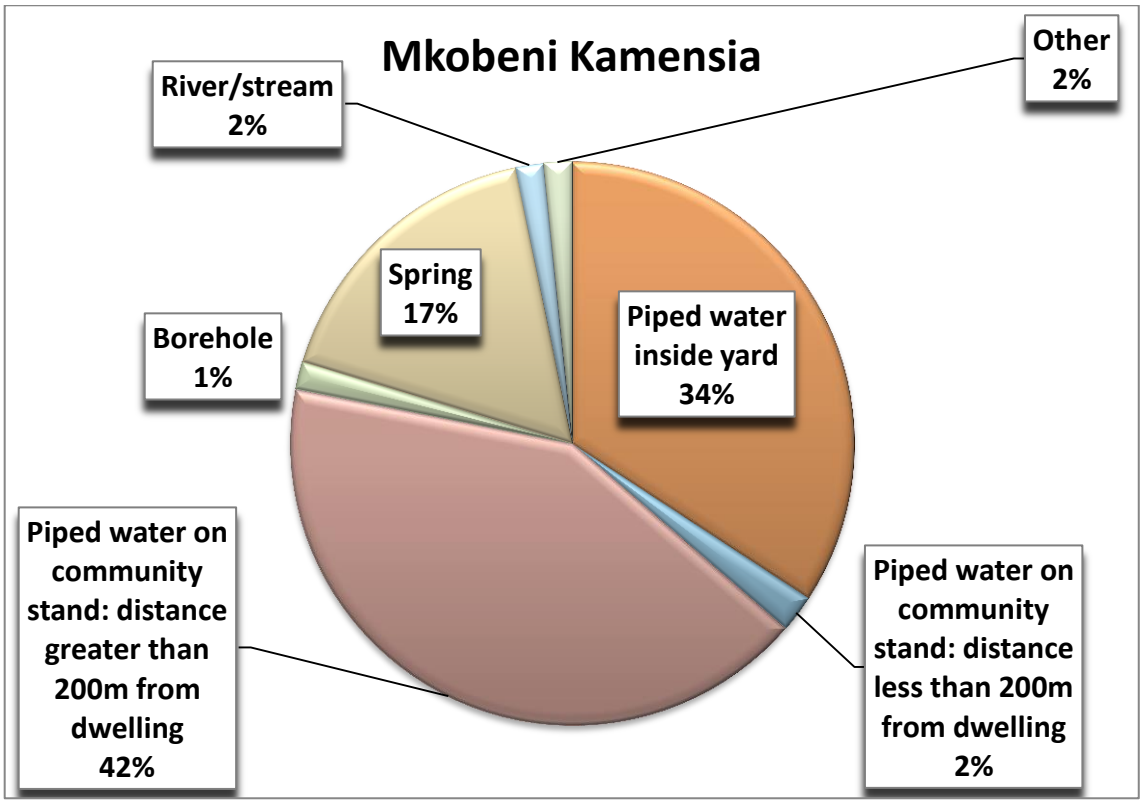

Figure A.8: Current water sources of Mkobeni Kamensia residents

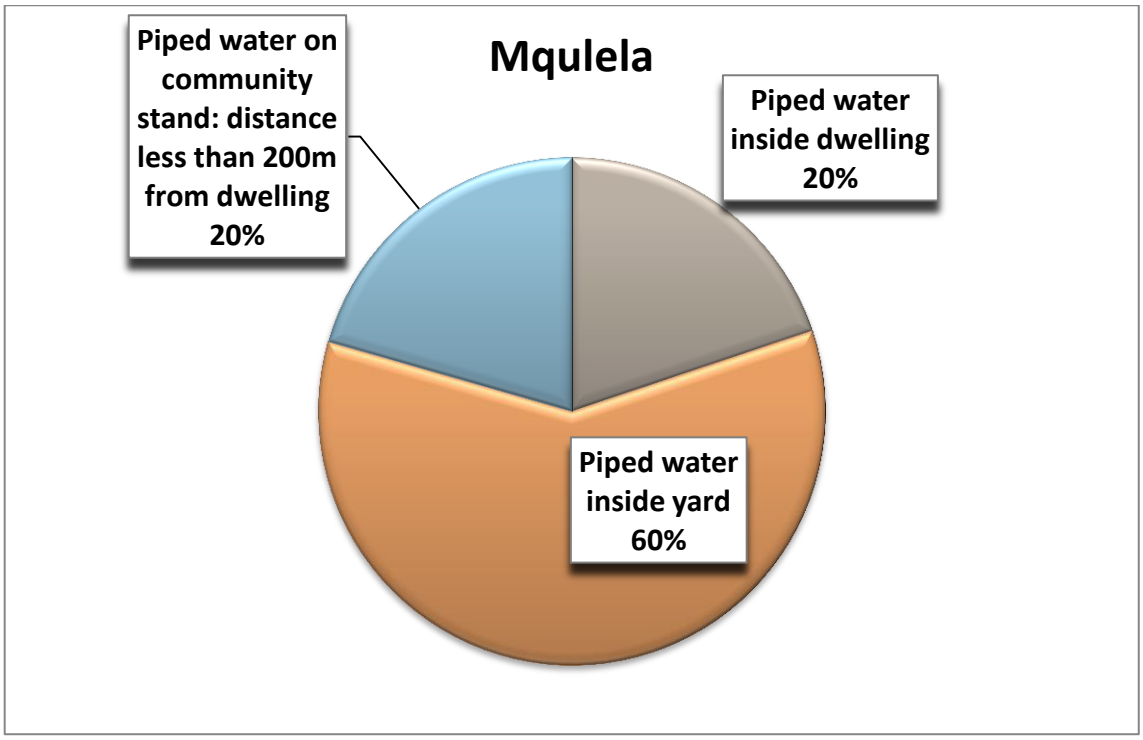

Figure A.9: Current water sources of Mqulela residents

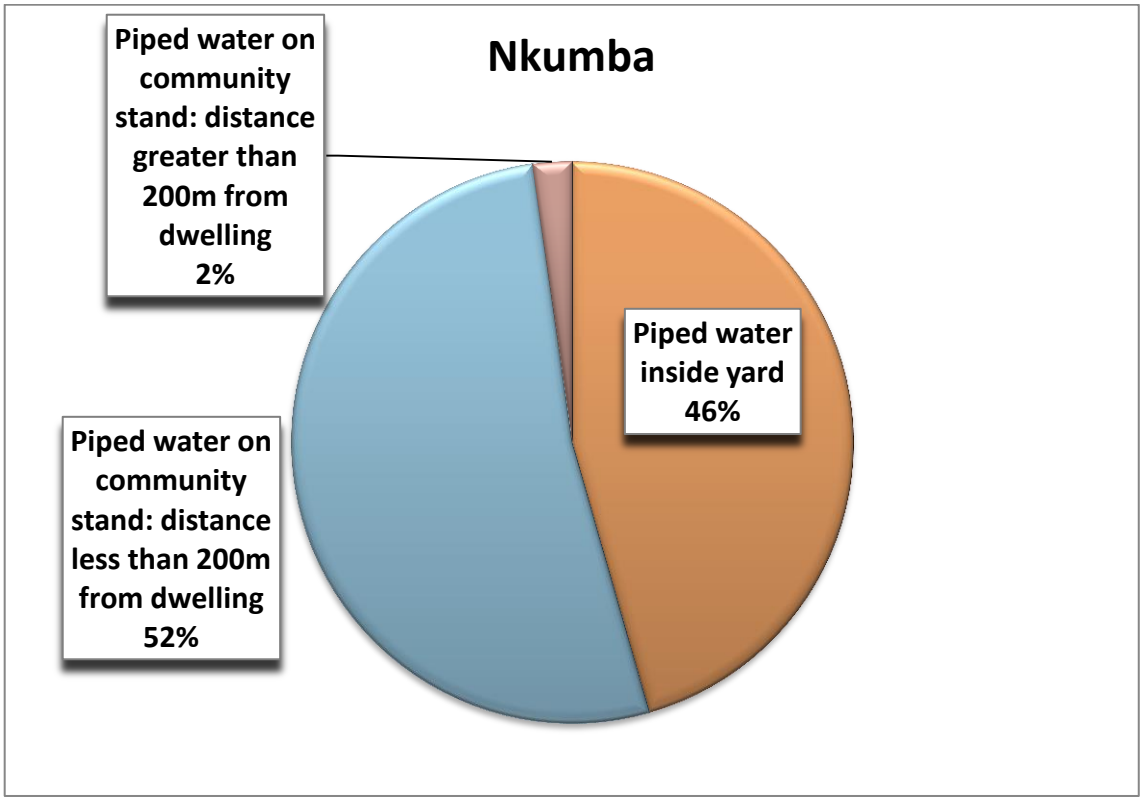

Figure A.10: Current water sources of Nkumba residents

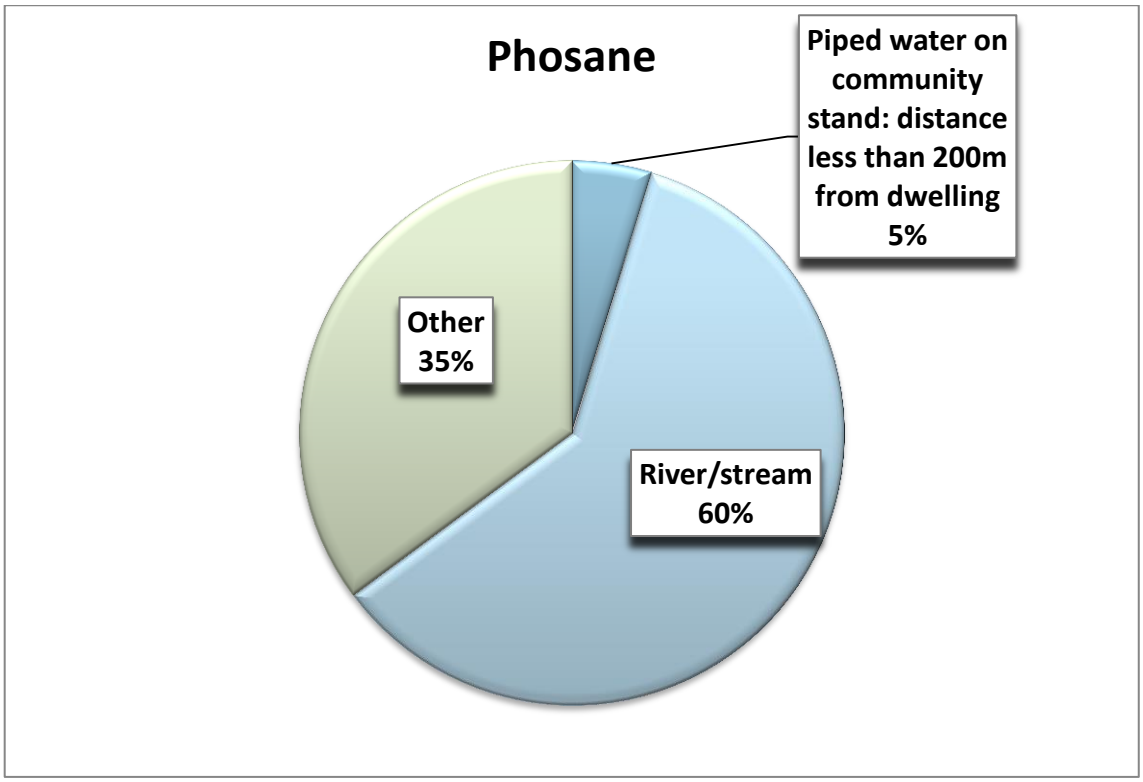

Figure A.11: Current water sources of Phosane residents

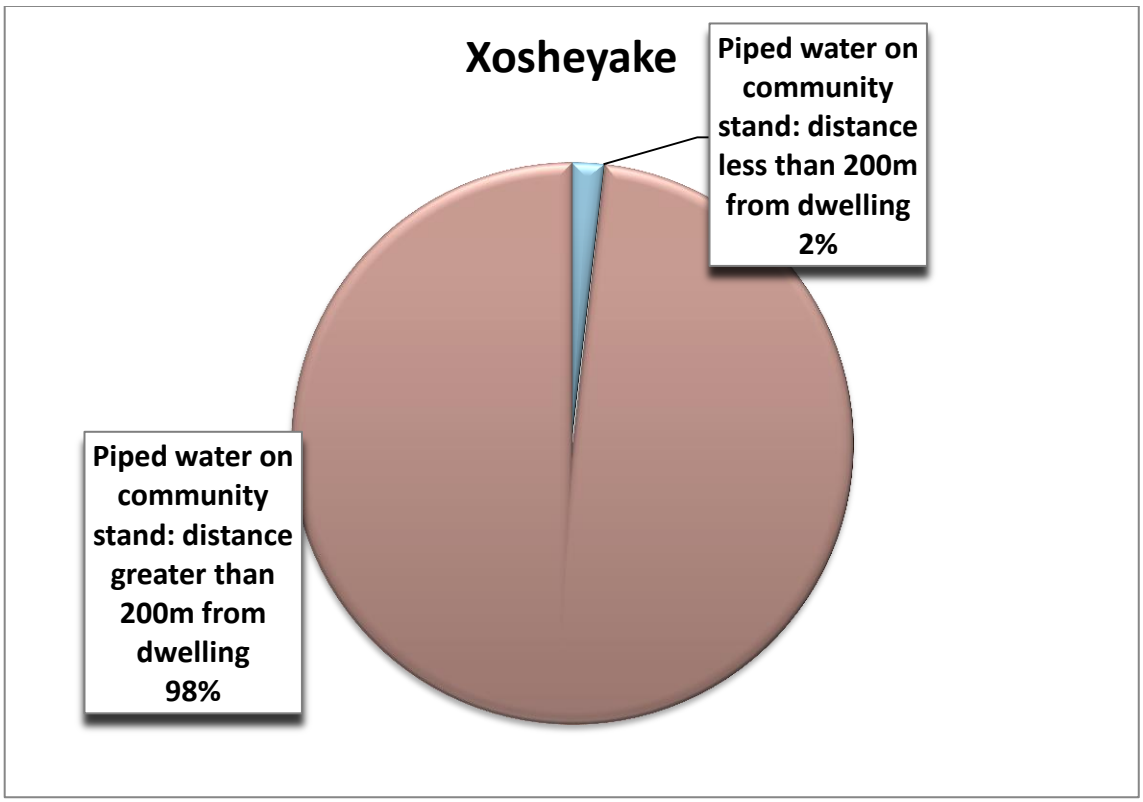

Figure A.12: Current water sources of Xosheyake residents

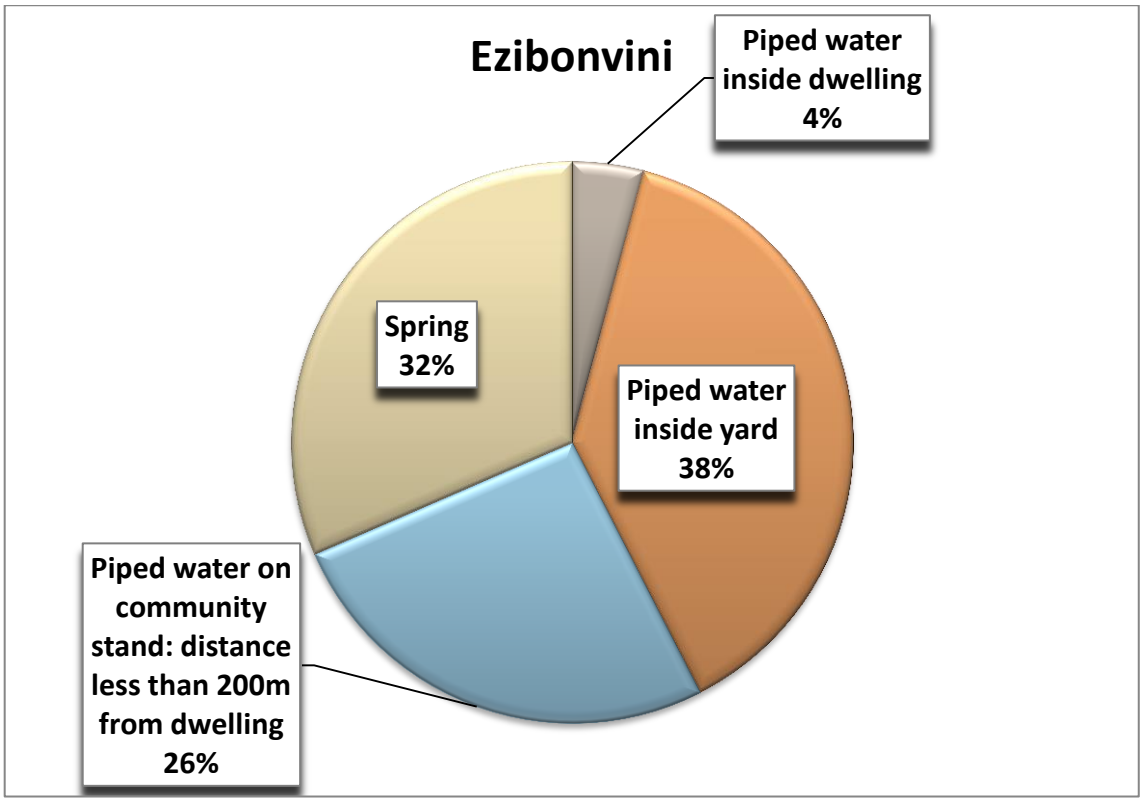

Figure A.13: Current water sources of Ezibonvini residents

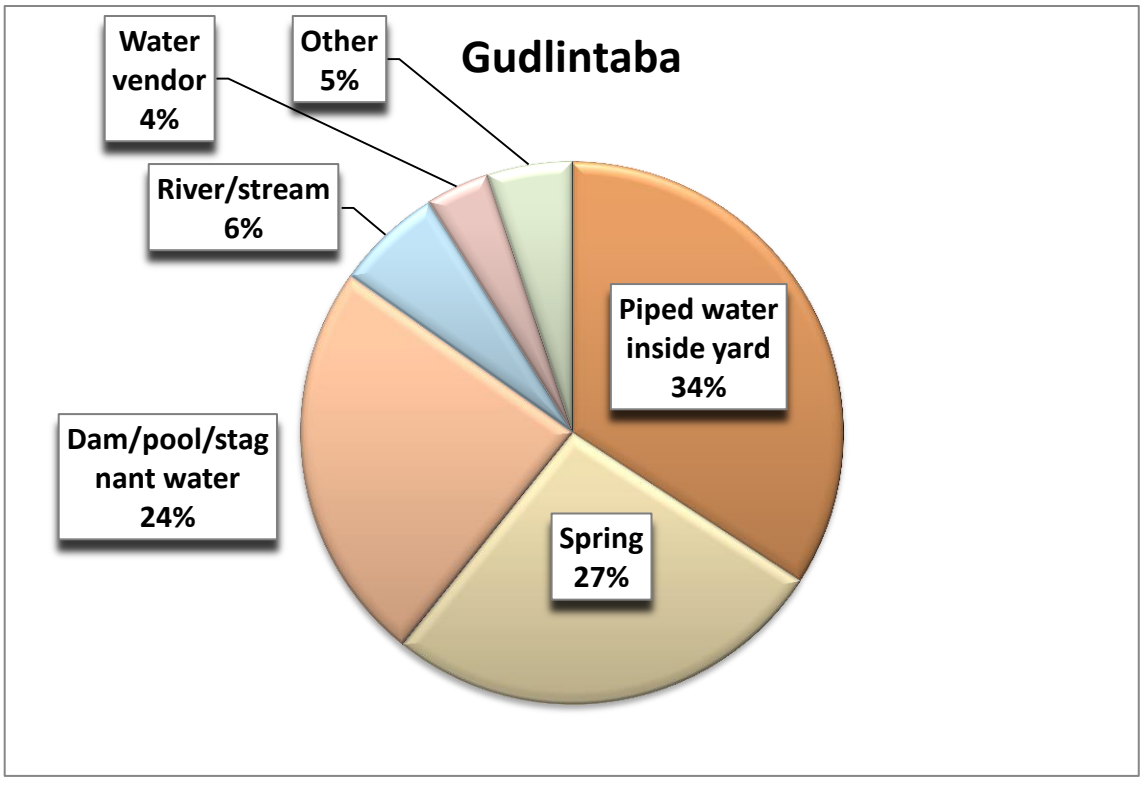

Figure A.14: Current water sources of Gudlintaba residents

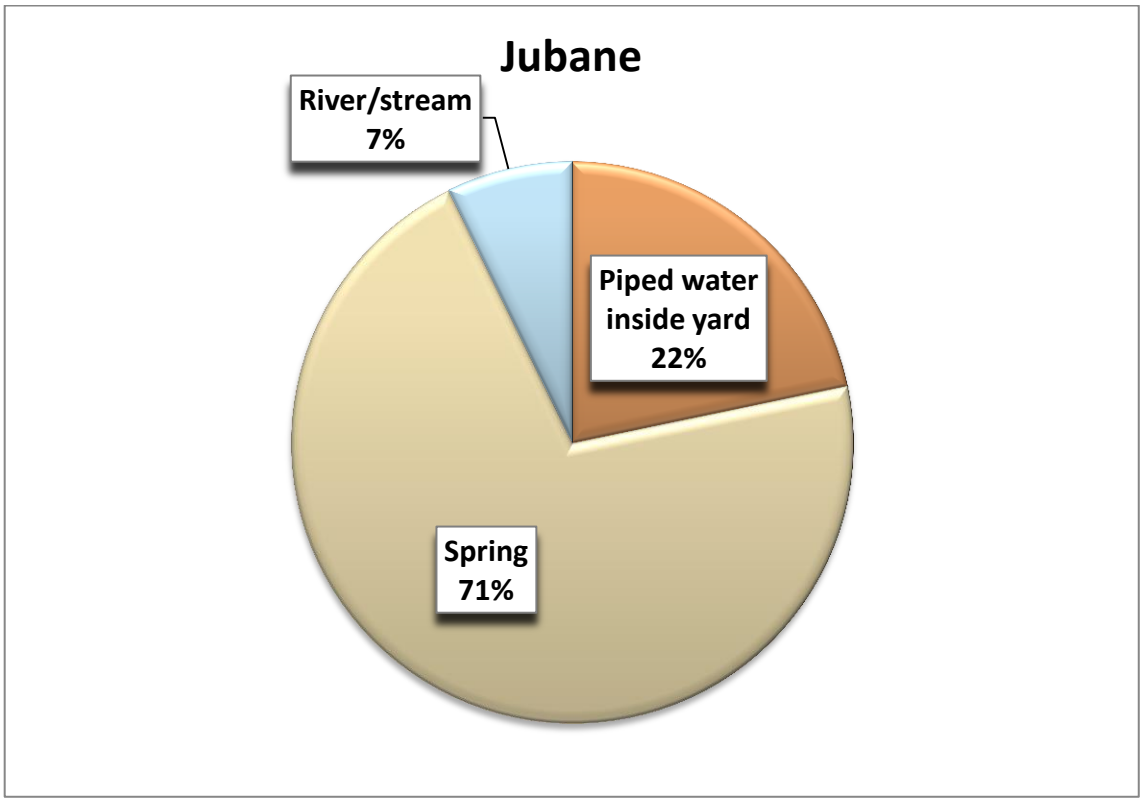

Figure A.15: Current water sources of Jubane residents

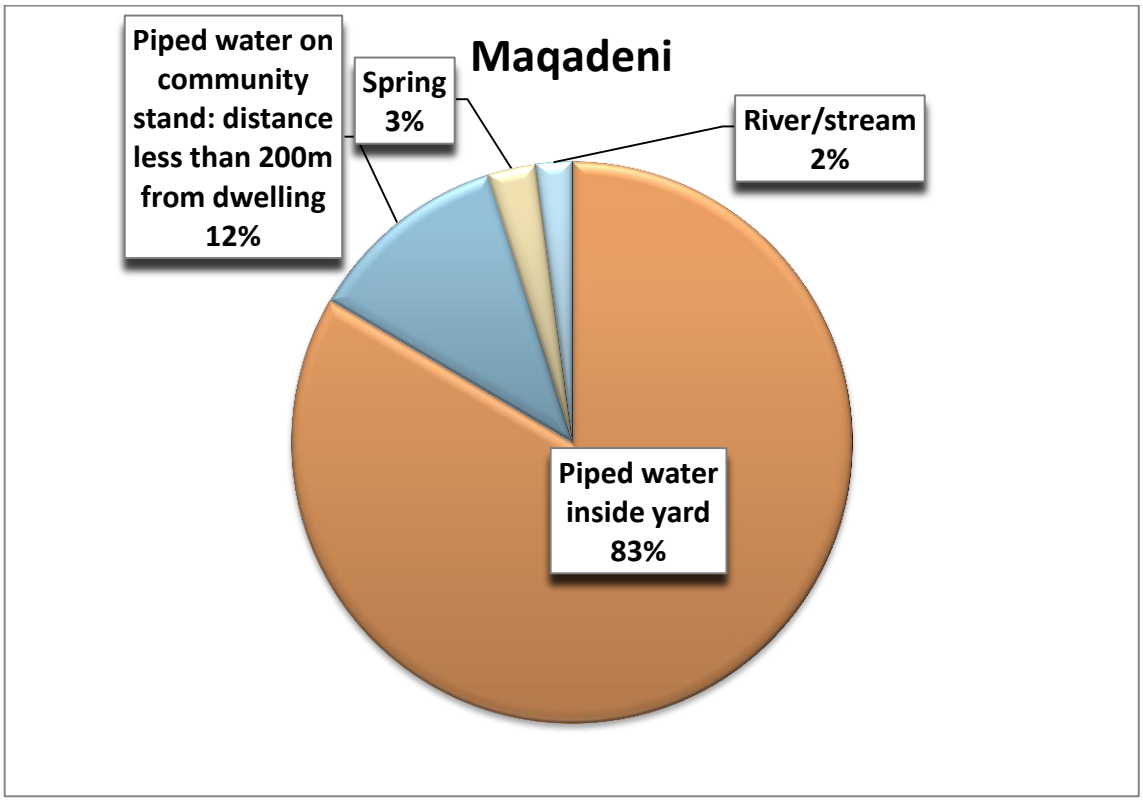

Figure A.16: Current water sources of Maqadeni residents

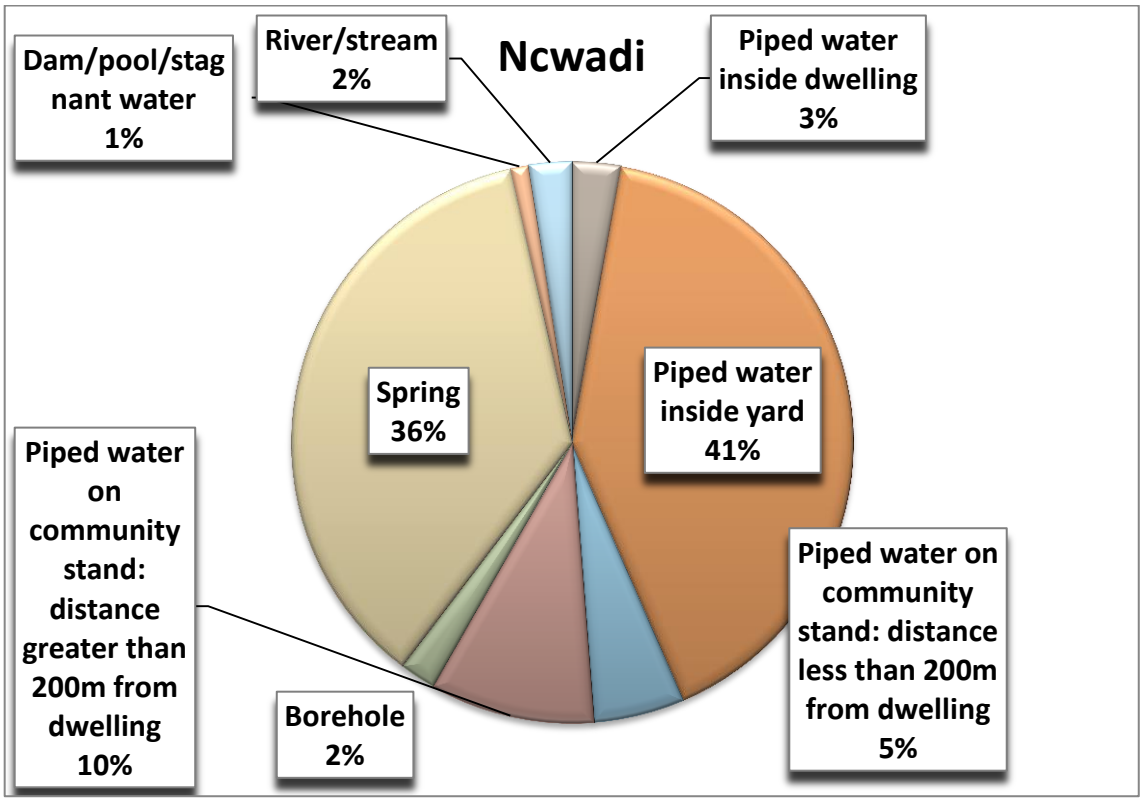

Figure A.17: Current water sources of Ncwadi residents

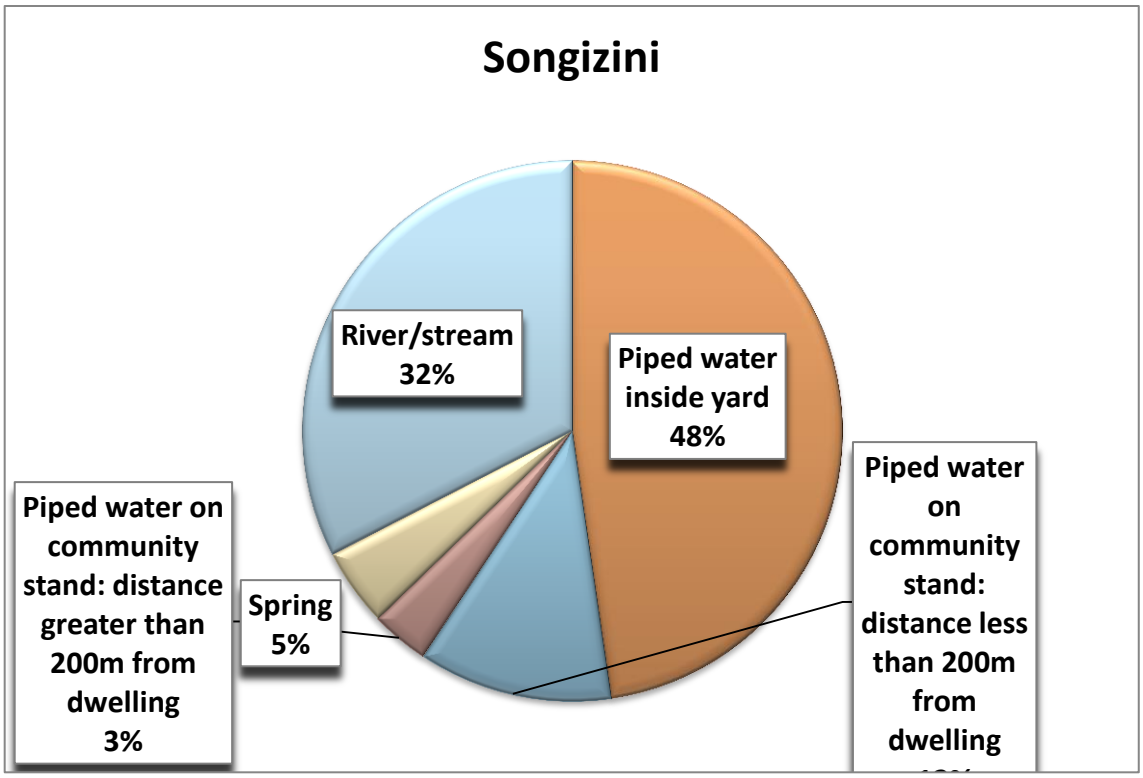

Figure A.18: Current water sources of Songizini residents

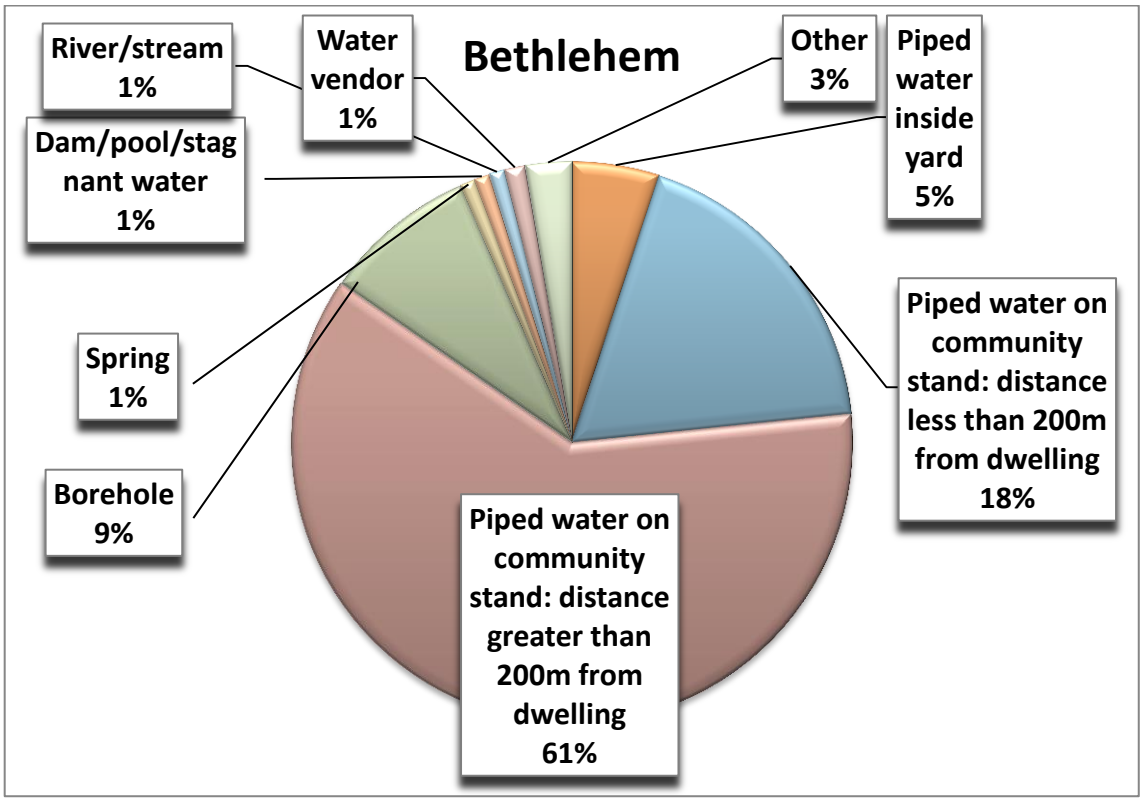

Figure A.19: Current water sources of Bethlehem residents

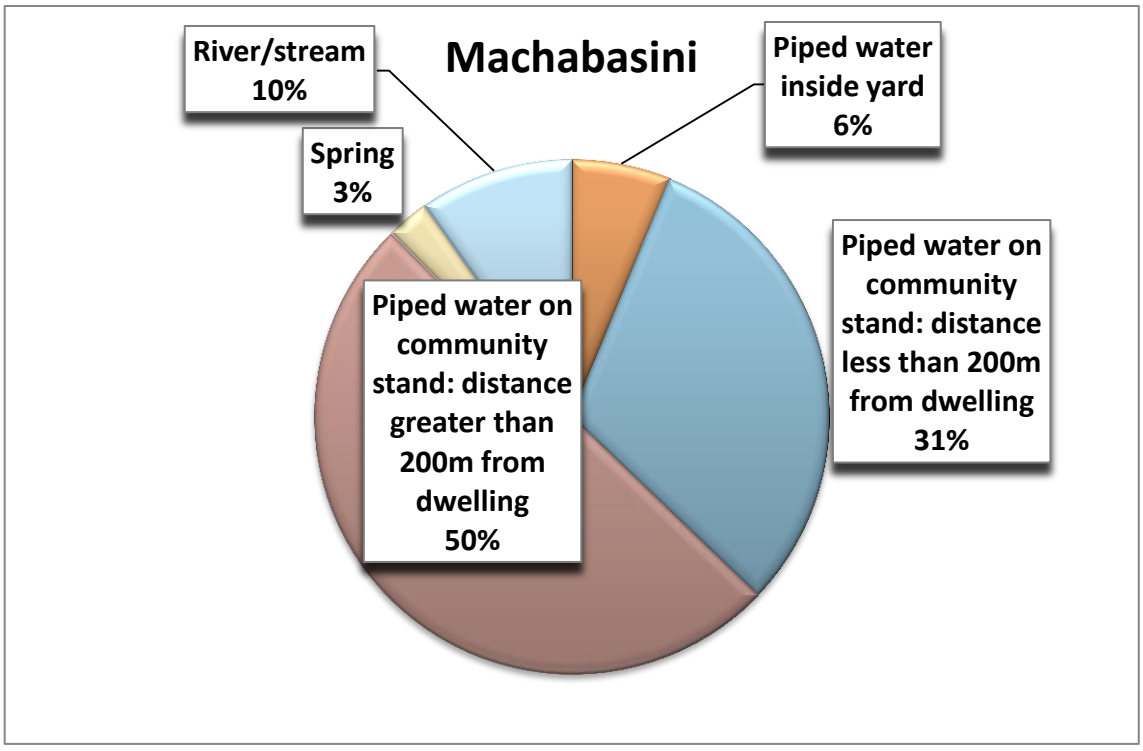

Figure A.20: Current water sources of Machabasini residents

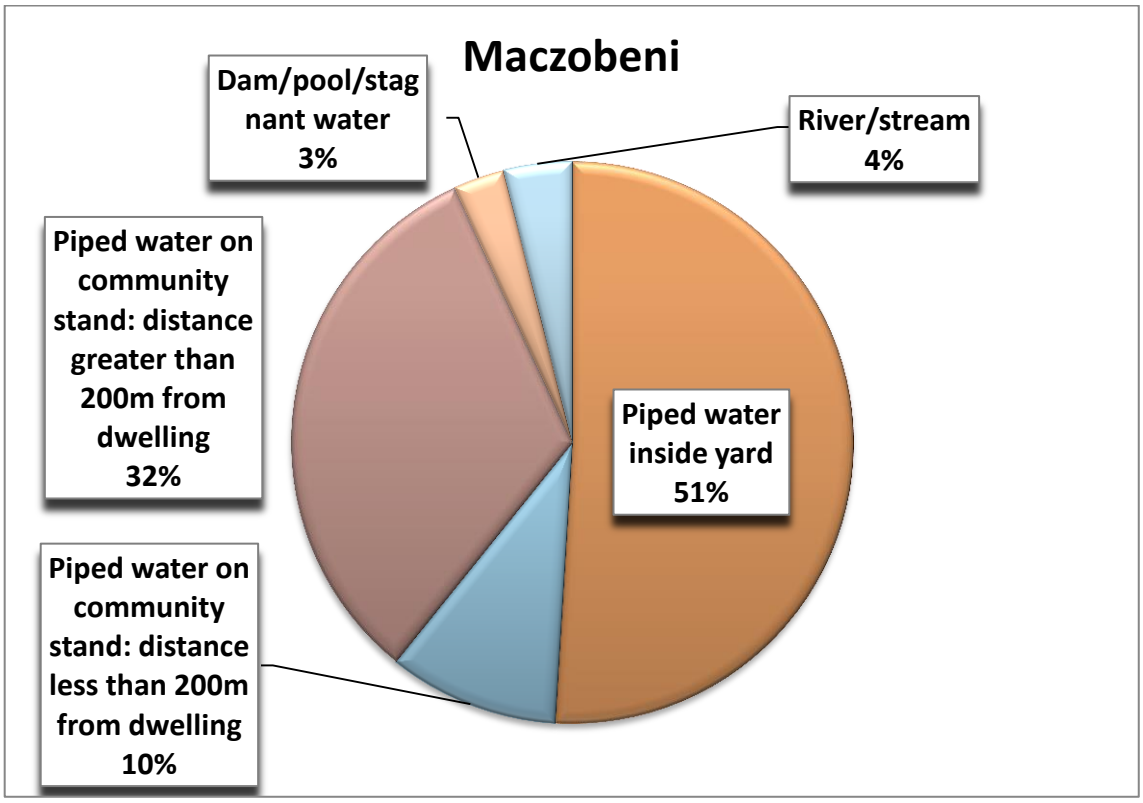

Figure A.21: Current water sources of Maczobeni residents

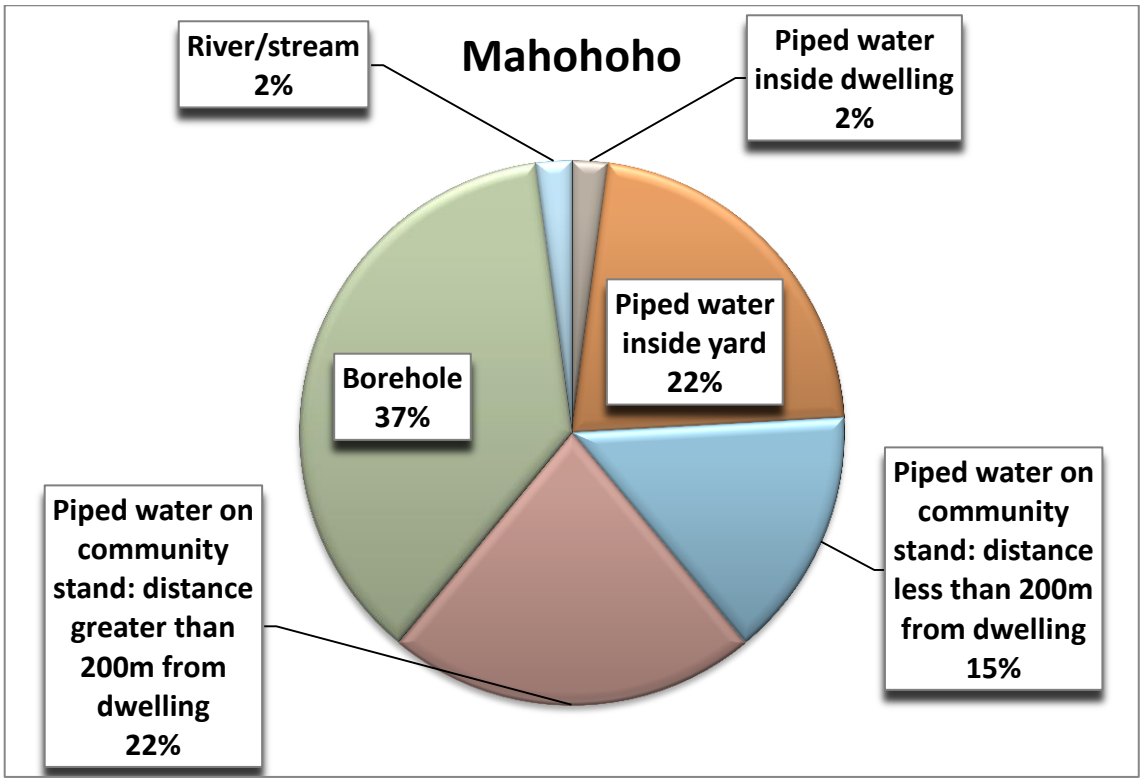

Figure A.22: Current water sources of Mahohoho residents

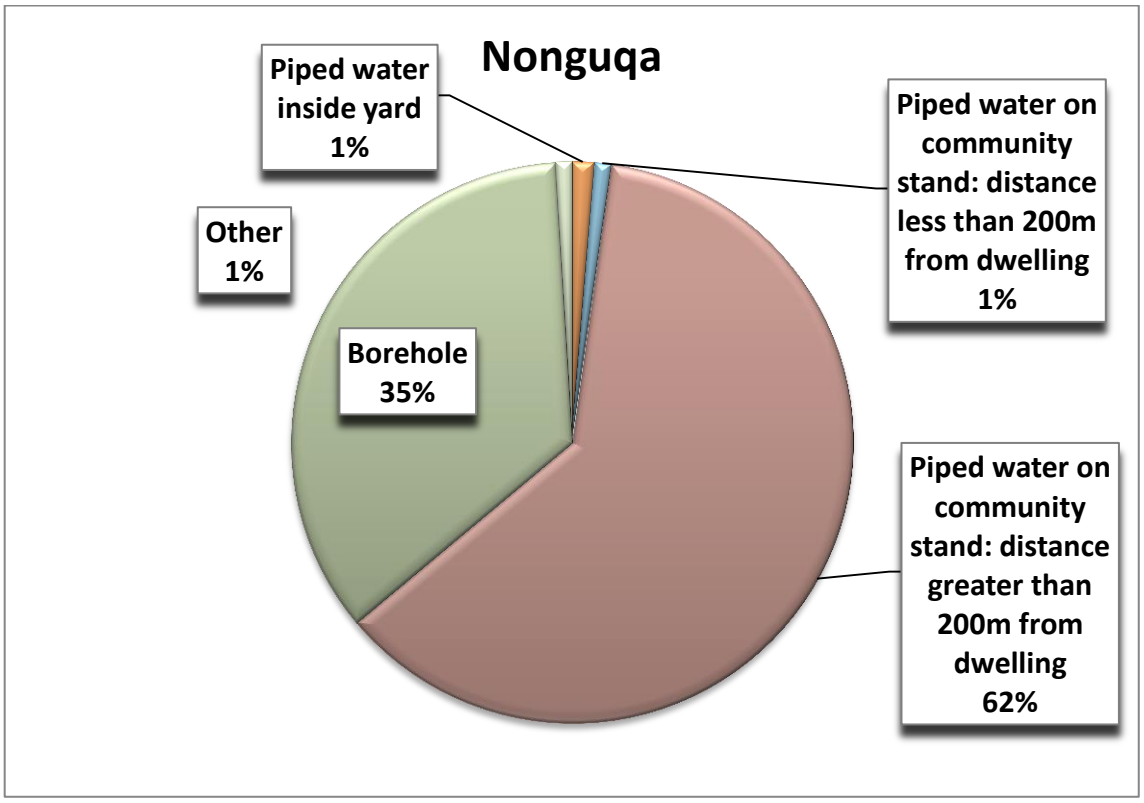

Figure A.23: Current water sources of Nonguqa residents

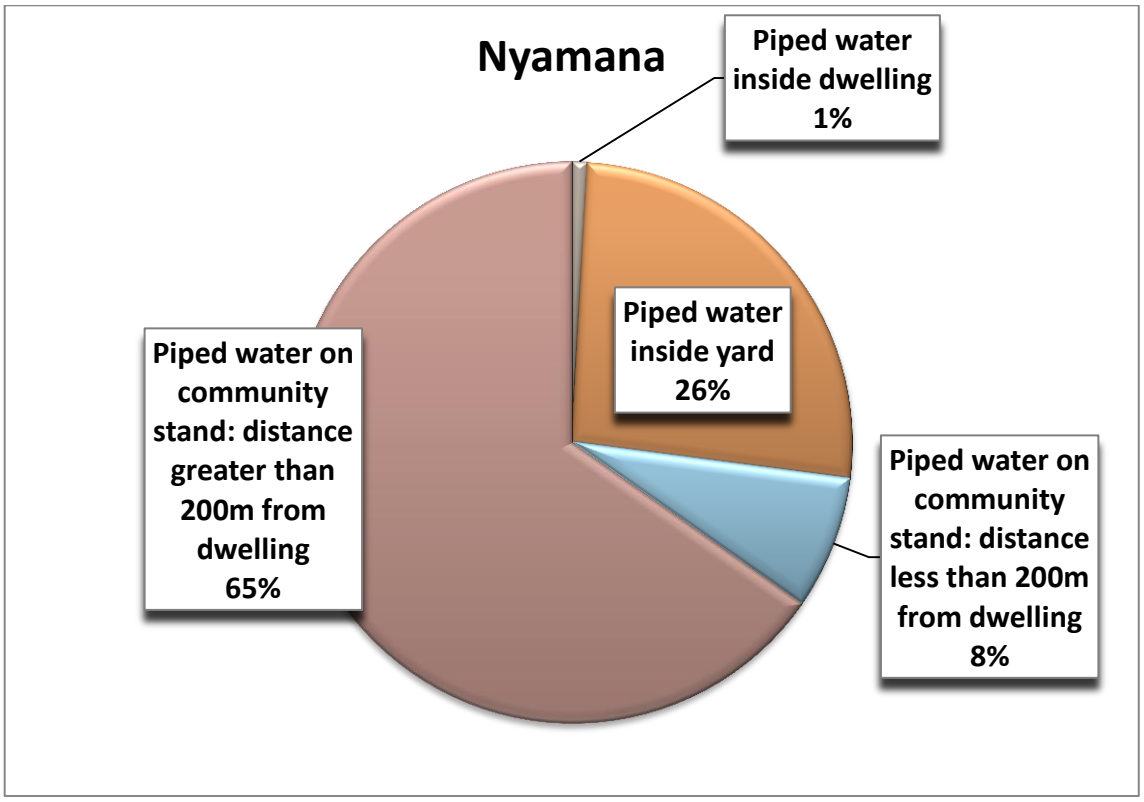

Figure A.24: Current water sources of Nyamana residents

Appendix B

Detailed BoQ of the pumps and pumpstation required to supply the Smithfield Dam local WSS from the dam (based on VAPS)

Table B.1: Bill of quantities (BoQ) for the bulk pumpstation

Bulk Pumpstation BoQ						
	Description		**Units**	**2014 Rates**	**Quantity**	**Amount**
1	Mechanical and Electrical		Sum	R 6 971 781	1	R 6 971 781
2	Civils	(% of 1)	%	30%		R 2 091 534
3	Landscaping	(% of 1-2)	%	2%		R 181 266
4	Miscellaneous	(% of 1-2)	%	10%		R 906 332
	SUB-TOTAL A					**R 10 150 913**
5	Preliminary and General	(% of sub-total A)	%	30%		R 3 045 274
6	Preliminary Works	a) access roads	km			R 0
		b) electricity to site	Sum			R 0
		c) Water to site (for construction)	Sum			R 0
		d) Railhead and materials handling	Sum			R 0
7	Accommodation		Sum			R 0
	SUB-TOTAL B					**R 13 196 187**
8	Contingencies	(% of sub-total B)	%	10%		R 1 319 619
	SUB-TOTAL C					**R 14 515 806**
9	Planning design and supervision	(% of sub-total C)	%	15%		R 2 177 371
	SUB-TOTAL D					**R 16 693 177**
10	VAT	(% of sub-total D)	%	0%		R 0
	NETT PROJECT COST					**R 16 693 177**
11	Cost of relocations		Sum			R 0
12	Cost of land acquisition		Sum			R 0
	TOTAL PROJECT COST					**R 16 693 177**

Table B.2: Bill of quantities (BoQ) for the Kwelaba-Ntwana, Enkwelaba Ntwana, Mkobeni Kamensia and Xosheyake booster pumpstation

Kwelaba-Ntwana, Enkwelaba Ntwana, Mkobeni Kamensia and Xosheyake Booster Pumpstation BoQ						
	Description		**Units**	**Rate**	**Quantity**	**Amount**
1	Mechanical and Electrical		Sum	R 1 716 313	1	R 1 716 313
2	Civils	(% of 1)	%	30%		R 514 894
3	Landscaping	(% of 1-2)	%	2%		R 44 624
4	Miscellaneous	(% of 1-2)	%	10%		R 223 121
	SUB-TOTAL A					**R 2 498 951**
5	Preliminary and General	(% of sub-total A)	%	10%		R 249 895
6	Preliminary Works	a) access roads b) electricity to site c) Water to site (for construction) d) Railhead and materials handling	km Sum Sum Sum			R 0 R 0 R 0 R 0
7	Accommodation		Sum			R 0
	SUB-TOTAL B					**R 2 748 847**
8	Contingencies	(% of sub-total B)	%	10%		R 274 885
	SUB-TOTAL C					**R 3 023 731**
9	Planning design and supervision	(% of sub-total C)	%	15%		R 453 560
	SUB-TOTAL D					**R 3 477 291**
10	VAT	(% of sub-total D)	%	0%		R 0
	NETT PROJECT COST					**R 3 477 291**
11	Cost of relocations		Sum			R 0
12	Cost of land acquisition		Sum			R 0
	TOTAL PROJECT COST					**R 3 477 291**

Appendix C

Detailed BoQ of the pipeline network required to supply the Smithfield Dam local WSS from the dam (based on VAPS)

Table C.1: Bill of quantities (BoQ) for the pipeline network

Pipeline network - Bill of Quantities						
	Description		**Units**	**Rate**	**Quantity**	**Amount**
1	Route Clearing & grubbing	a) sparse	ha	R 5 641	0	R 0
		b) bush	ha	R 16 924	90	R 1 520 560
		c) trees	ha	R 28 207	0	R 0
2	River and Road Crossings		Sum	R 32 750	12	R 393 000
3	Benching (Forming and Terrace)	a) all materials	m^3	R 36	0	R 0
		b) extra over for rock	m^3	R 85	0	R 0
4	Trench excavation and Backfilling	a) all materials	m^3	R 81	104961	R 8 459 122
		b) extra over for rock (% of a)	m^3	R 0		R 845 912
		c) bed preparation	m	R 40	89844	R 3 620 381
5	Pipelines	a) supply of pipes to site	m	R 6 892 816	1	R 5 277 266
		b) laying and jointing (% of a)	%	20%	1	R 1 055 453
		c) cathodic protection	m	R 9	48578	R 563 514
6	Concrete including Formwork	a) valve chambers & manholes	Sum	R 10 600	162	R 1 717 200
		b) thrust blocks & encasings	m^3	R 1	8984	R 9 143
7	Reinforcing		t	R 10 074	0	R 0
8	Mechanical Items	a) Isolating valves 50mm	Sum	R 1 551	4	R 6 204
		63 mm	Sum	R 1 551	2	R 3 102
		75 mm	Sum	R 1 551	3	R 4 653
		90 mm	Sum	R 1 724	4	R 6 896
		110 mm	Sum	R 1 939	1	R 1 939
		125 mm	Sum	R 2 155	1	R 2 155
		140 mm	Sum	R 2 427	0	R 0
		160 mm	Sum	R 2 577	3	R 7 731
		200 mm	Sum	R 3 845	0	R 0
		b) Air valves 25mm	Sum	R 9 844	69	R 679 237
		50mm	Sum	R 14 964	21	R 314 244
		c) Scour valves 50mm	Sum	R 3 811	9	R 34 299
		63 mm	Sum	R 4 971	4	R 19 883
		75 mm	Sum	R 6 379	5	R 31 895
		90 mm	Sum	R 8 947	7	R 62 631
		110 mm	Sum	R 13 090	3	R 39 269
		125 mm	Sum	R 13 090	2	R 26 179
		140 mm	Sum	R 16 155	0	R 0
		160 mm	Sum	R 16 155	6	R 96 930
		200 mm	Sum	R 24 191	0	R 0
		d) Surge protection valves 50mm	Sum	R 1 569	4	R 6 275
		63 mm	Sum	R 3 159	2	R 6 319
		75 mm	Sum	R 3 159	3	R 9 478
		90 mm	Sum	R 4 592	4	R 18 370
		110 mm	Sum	R 4 592	1	R 4 592
		125 mm	Sum	R 11 248	1	R 11 248
		140 mm	Sum	R 11 248	0	R 0
		160 mm	Sum	R 11 248	3	R 33 743
		200 mm	Sum	R 7 275	0	R 0
		b) structural steelwork	t	R 20 148	0	R 0
9	Landscaping	(% of 1-8)	%	5%		R 1 244 441
10	Miscellaneous	(% of 1-8)	%	10%		R 2 488 882
	SUB-TOTAL A					**R 28 622 147**
11	Preliminary and General	(% of sub-total A)	%	30%		R 8 586 644
12	Preliminary Works	a) access roads	km	R 241 778	0	R 0
		b) electricity to site	Sum	R 0	0	R 0
		c) Water to site (for construction)	Sum	R 0	0	R 0
		d) Railhead and materials handling	Sum	R 0	0	R 0
13	Accommodation		Sum	R 0	0	R 0
	SUB-TOTAL B					**R 37 208 791**
14	Contingencies	(% of sub-total B)	%	10%		R 3 720 879
	SUB-TOTAL C					**R 40 929 670**
15	Planning design and supervision	(% of sub-total C)	%	15%		R 6 139 451
	SUB-TOTAL D					**R 47 069 121**
16	VAT	(% of sub-total D)	%	0%		R 0
	NETT PROJECT COST					**R 47 069 121**
17	Cost of relocations		Sum	R 0		R 0
18	Cost of land acquisition		Sum	R 0		R 0
	TOTAL PROJECT COST					**R 47 069 121**

Appendix D

General assumptions for the URV calculation of the Smithfield Dam WSS

1. CAPITAL COST

a) Prices representative of 2013 prices.

b) 10% for engineering fees and 10% for environmental and social costs is added.

c) VAT is excluded as the capital gain for governmental purposes is not included in the cost to the economy.

2. OPERATION AND MAINTENANCE

a) Maintenance costs based on:
   - Civil: 0.25% of the capital cost as an annual maintenance cost
   - Pipelines: 0.5% of the capital cost as an annual maintenance cost
   - Mechanical & Electrical: 4.0% of the capital cost as an annual maintenance cost

b) Operation costs based on pumping requirements and the marginal cost of coal or nuclear power:
   - Coal: R0.60/kWh for coal fired power with the following transmission fees:
     - Natal 10%
   - Nuclear: R1.20/kWh for nuclear power with the following transmission fees:
     - Natal 2%

c) Coal fired power assumed R0.60/kWh up to 2019, with a blend of coal and nuclear from 2020 onwards at R0.90/kWh. Transmission fees taken as 5% across the country for the coal/nuclear blend.

3. WATER DELIVERY AND PROJECT TIMING

a) The ***Smithfield Dam local WSS*** to start delivering water in the same year than the anticipated end of construction of Smithfield Dam in 2023.

b) Water delivery was grown based on the anticipated growth in population from 2013 to 2063.

4. URV CALCULATIONS

a) URV calculated for a discount rate of 8% and discounted back to 2013 prices.

b) URV calculated over a 50 year period (40 years from date of first water delivery).

c) No allowance made for residual values.

5. PUMPING

a) Pumping 22 hours out of 24 per day (this is 92% of the time which is slightly conservative, but compatible with the DWA standard of 95%).

b) 33% of the capital cost for pump stations assumed to be civil costs and the remainder (67%) mechanical and electrical costs.

6. TREATMENT COSTS

a) As the ***Smithfield Dam local WSS*** needs to deliver potable water to communities the costs of treating the raw water from Smithfield Dam to potable water standards were included in the URV calculation.

b) An average operating and maintenance costs of treatment of R1/m^3 was used.

Appendix E

URV calculation

Table E.1: URV calculation sheet 1

DETERMINING OF URV @ 8% OVER 50 YEARS (R/m³)

Yield	0.892	Mcm/a
Cap cost	114	R million
Discount rate =	8	%
Base year =	2023	

	YEAR	DAM			NPC			Water Supply	NPV
		CAP.	MAINTENANCE	ENERGY	CAP.	MAINTENANCE	ENERGY	(mcm)	(m^3)
	2013	0	0	0	0	0	0	0	0
1	2014	0	0	0	0	0	0	0	0
2	2015	0	0	0	0	0	0	0	0
3	2016	0	0	0	0	0	0	0	0
4	2017	0	0	0	0	0	0	0	0
5	2018	0	0	0	0	0	0	0	0
6	2019	0	0	0	0	0	0	0	0
7	2020	0	0	0	0	0	0	0	0
8	2021	0	0	0	0	0	0	0	0
9	2022	0	0	0	0	0	0	0	0
10	2023	113 702 657	1 597 127	2 858 013	52 666 330	739 779	1 323 813	0.576	266 575
11	2024	0	1 605 041	2 897 311	0	688 374	1 242 607	0.583	250 223
12	2025	0	1 612 954	2 936 609	0	640 526	1 166 168	0.591	234 830
13	2026	0	1 620 867	2 975 906	0	595 990	1 094 235	0.599	220 345
14	2027	0	1 628 781	3 015 204	0	554 536	1 026 560	0.607	206 717
15	2028	0	1 636 694	3 054 502	0	515 954	962 906	0.615	193 899
16	2029	0	1 644 607	3 093 800	0	480 045	903 051	0.623	181 846
17	2030	0	1 652 521	3 133 097	0	446 625	846 779	0.631	170 515
18	2031	0	1 660 434	3 172 395	0	415 522	793 889	0.639	159 865
19	2032	0	1 668 347	3 211 693	0	386 576	744 188	0.647	149 856
20	2033	0	1 676 261	3 250 990	0	359 639	697 494	0.655	140 454
21	2034	0	1 684 174	3 290 288	0	334 571	653 635	0.663	131 622
22	2035	0	1 692 087	3 329 586	0	311 243	612 446	0.670	123 328
23	2036	0	1 700 001	3 368 883	0	289 536	573 772	0.678	115 540
24	2037	0	1 707 914	3 408 181	0	269 337	537 468	0.686	108 229
25	2038	0	1 715 827	3 447 479	0	250 542	503 394	0.694	101 368
26	2039	0	1 723 741	3 486 776	0	233 053	471 418	0.702	94 929
27	2040	0	1 731 654	3 526 074	0	216 780	441 418	0.710	88 888
28	2041	0	1 739 567	3 565 372	0	201 640	413 276	0.718	83 221
29	2042	0	1 747 481	3 604 669	0	187 553	386 880	0.726	77 906
30	2043	0	1 755 394	3 643 967	0	174 446	362 128	0.734	72 921
31	2044	0	1 763 307	3 683 265	0	162 253	338 919	0.742	68 248
32	2045	0	1 771 221	3 722 562	0	150 908	317 162	0.750	63 867
33	2046	0	1 779 134	3 761 860	0	140 354	296 769	0.758	59 760
34	2047	0	1 787 047	3 801 158	0	130 535	277 657	0.765	55 911
35	2048	0	1 794 961	3 840 456	0	121 401	259 747	0.773	52 305
36	2049	0	1 802 874	3 879 753	0	112 904	242 968	0.781	48 926
37	2050	0	1 810 787	3 919 051	0	105 000	227 249	0.789	45 761
38	2051	0	1 818 701	3 958 349	0	97 647	212 526	0.797	42 796
39	2052	0	1 826 614	3 997 646	0	90 807	198 737	0.805	40 019
40	2053	0	1 834 527	4 036 944	0	84 445	185 824	0.813	37 419
41	2054	0	1 842 441	4 076 242	0	78 527	173 734	0.821	34 985
42	2055	0	1 850 354	4 115 539	0	73 023	162 416	0.829	32 706
43	2056	0	1 858 267	4 154 837	0	67 903	151 821	0.837	30 572
44	2057	0	1 866 181	4 194 135	0	63 141	141 905	0.845	28 575
45	2058	0	1 874 094	4 233 432	0	58 711	132 624	0.852	26 706
46	2059	0	1 882 007	4 272 730	0	54 592	123 940	0.860	24 958
47	2060	0	1 889 921	4 312 028	0	50 761	115 815	0.868	23 322
48	2061	0	1 897 834	4 351 325	0	47 197	108 213	0.876	21 791
49	2062	0	1 905 747	4 390 623	0	43 884	101 103	0.884	20 359
50	2063	0	1 913 661	4 429 921	0	40 802	94 451	0.892	19 020
		113 702 657	**71 971 155**	**149 402 651**	**52 666 330**	**10 067 062**	**19 621 105**	**30.085**	**3 951 082**
					64	12	24		

Discount rate	**8**	**%**
NPV cost	**82 354 497**	
NPV water	**3 951 082**	
URV (R/m3)	**20.84**	

Table E.2: URV calculation sheet 2 (Capital, maintenance and operational costs)

		NPC										Water supply						Operation/Energy Costs						
						Pumping Stations		Other infrastructure (WTW and Reservoirs)																
No.	Year	Capital costs	Maintenance costs	Energy costs	Pipeline	Civil	Mechanical and Electrical	Civil	Mechanical and Electrical	Engineering fees	Environmental	Social	System Water Demand	System Availability	Required augmentation	Yield Potential	Water pumped/ released	Water Delivery	Energy Requirement	Energy Cost	Pipeline	Pumping Station	Other infrastructure (WTW and Reservoirs)	WTP operation (Excl. elec)	Total Maintenance Cost
																	River losses	0%							
	2013	0	0		0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
1	2014	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
2	2015	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
3	2016	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
4	2017	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
5	2018	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
6	2019	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
7	2020	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
8	2021	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
9	2022	0	0	0	0	0	0	0	0	0	0	0	0.00	0	0.00	0.00	0.00	0.00	0	0	0	0	0	0	0
10	2023	113 702 657	1 597 127	2 858 013	47 069 121	6 656 254	13 514 214	23 238 607	4 274 018	9 475 221	4 737 611	4 737 611	0.58	0	0.58	0.89	0.58	0.58	2 474	2 858 013	235 346	557 209	229 057	575 515	1 597 127
11	2024	0	1 605 041	2 897 311	0	0	0	0	0	0	0	0	0.58	0	0.58	0.89	0.58	0.58	2 508	2 897 311	235 346	557 209	229 057	583 429	1 605 041
12	2025	0	1 612 954	2 936 609	0	0	0	0	0	0	0	0	0.59	0	0.59	0.89	0.59	0.59	2 543	2 936 609	235 346	557 209	229 057	591 342	1 612 954
13	2026	0	1 620 867	2 975 906	0	0	0	0	0	0	0	0	0.60	0	0.60	0.89	0.60	0.60	2 577	2 975 906	235 346	557 209	229 057	599 255	1 620 867
14	2027	0	1 628 781	3 015 204	0	0	0	0	0	0	0	0	0.61	0	0.61	0.89	0.61	0.61	2 611	3 015 204	235 346	557 209	229 057	607 169	1 628 781
15	2028	0	1 636 694	3 054 502	0	0	0	0	0	0	0	0	0.62	0	0.62	0.89	0.62	0.62	2 645	3 054 502	235 346	557 209	229 057	615 082	1 636 694
16	2029	0	1 644 607	3 093 800	0	0	0	0	0	0	0	0	0.62	0	0.62	0.89	0.62	0.62	2 679	3 093 800	235 346	557 209	229 057	622 995	1 644 607
17	2030	0	1 652 521	3 133 097	0	0	0	0	0	0	0	0	0.63	0	0.63	0.89	0.63	0.63	2 713	3 133 097	235 346	557 209	229 057	630 909	1 652 521
18	2031	0	1 660 434	3 172 395	0	0	0	0	0	0	0	0	0.64	0	0.64	0.89	0.64	0.64	2 747	3 172 395	235 346	557 209	229 057	638 822	1 660 434
19	2032	0	1 668 347	3 211 693	0	0	0	0	0	0	0	0	0.65	0	0.65	0.89	0.65	0.65	2 781	3 211 693	235 346	557 209	229 057	646 735	1 668 347
20	2033	0	1 676 261	3 250 990	0	0	0	0	0	0	0	0	0.65	0	0.65	0.89	0.65	0.65	2 815	3 250 990	235 346	557 209	229 057	654 649	1 676 261
21	2034	0	1 684 174	3 290 288	0	0	0	0	0	0	0	0	0.66	0	0.66	0.89	0.66	0.66	2 849	3 290 288	235 346	557 209	229 057	662 562	1 684 174
22	2035	0	1 692 087	3 329 586	0	0	0	0	0	0	0	0	0.67	0	0.67	0.89	0.67	0.67	2 883	3 329 586	235 346	557 209	229 057	670 475	1 692 087
23	2036	0	1 700 001	3 368 883	0	0	0	0	0	0	0	0	0.68	0	0.68	0.89	0.68	0.68	2 917	3 368 883	235 346	557 209	229 057	678 389	1 700 001
24	2037	0	1 707 914	3 408 181	0	0	0	0	0	0	0	0	0.69	0	0.69	0.89	0.69	0.69	2 951	3 408 181	235 346	557 209	229 057	686 302	1 707 914
25	2038	0	1 715 827	3 447 479	0	0	0	0	0	0	0	0	0.69	0	0.69	0.89	0.69	0.69	2 985	3 447 479	235 346	557 209	229 057	694 215	1 715 827
26	2039	0	1 723 741	3 486 776	0	0	0	0	0	0	0	0	0.70	0	0.70	0.89	0.70	0.70	3 019	3 486 776	235 346	557 209	229 057	702 129	1 723 741
27	2040	0	1 731 654	3 526 074	0	0	0	0	0	0	0	0	0.71	0	0.71	0.89	0.71	0.71	3 053	3 526 074	235 346	557 209	229 057	710 042	1 731 654
28	2041	0	1 739 567	3 565 372	0	0	0	0	0	0	0	0	0.72	0	0.72	0.89	0.72	0.72	3 087	3 565 372	235 346	557 209	229 057	717 955	1 739 567
29	2042	0	1 747 481	3 604 669	0	0	0	0	0	0	0	0	0.73	0	0.73	0.89	0.73	0.73	3 121	3 604 669	235 346	557 209	229 057	725 869	1 747 481
30	2043	0	1 755 394	3 643 967	0	0	0	0	0	0	0	0	0.73	0	0.73	0.89	0.73	0.73	3 155	3 643 967	235 346	557 209	229 057	733 782	1 755 394
31	2044	0	1 763 307	3 683 265	0	0	0	0	0	0	0	0	0.74	0	0.74	0.89	0.74	0.74	3 189	3 683 265	235 346	557 209	229 057	741 695	1 763 307
32	2045	0	1 771 221	3 722 562	0	0	0	0	0	0	0	0	0.75	0	0.75	0.89	0.75	0.75	3 223	3 722 562	235 346	557 209	229 057	749 609	1 771 221
33	2046	0	1 779 134	3 761 860	0	0	0	0	0	0	0	0	0.76	0	0.76	0.89	0.76	0.76	3 257	3 761 860	235 346	557 209	229 057	757 522	1 779 134
34	2047	0	1 787 047	3 801 158	0	0	0	0	0	0	0	0	0.77	0	0.77	0.89	0.77	0.77	3 291	3 801 158	235 346	557 209	229 057	765 435	1 787 047
35	2048	0	1 794 961	3 840 456	0	0	0	0	0	0	0	0	0.77	0	0.77	0.89	0.77	0.77	3 325	3 840 456	235 346	557 209	229 057	773 349	1 794 961
36	2049	0	1 802 874	3 879 753	0	0	0	0	0	0	0	0	0.78	0	0.78	0.89	0.78	0.78	3 359	3 879 753	235 346	557 209	229 057	781 262	1 802 874
37	2050	0	1 810 787	3 919 051	0	0	0	0	0	0	0	0	0.79	0	0.79	0.89	0.79	0.79	3 393	3 919 051	235 346	557 209	229 057	789 175	1 810 787
38	2051	0	1 818 701	3 958 349	0	0	0	0	0	0	0	0	0.80	0	0.80	0.89	0.80	0.80	3 427	3 958 349	235 346	557 209	229 057	797 089	1 818 701
39	2052	0	1 826 614	3 997 646	0	0	0	0	0	0	0	0	0.81	0	0.81	0.89	0.81	0.81	3 461	3 997 646	235 346	557 209	229 057	805 002	1 826 614
40	2053	0	1 834 527	4 036 944	0	0	0	0	0	0	0	0	0.81	0	0.81	0.89	0.81	0.81	3 495	4 036 944	235 346	557 209	229 057	812 915	1 834 527
41	2054	0	1 842 441	4 076 242	0	0	0	0	0	0	0	0	0.82	0	0.82	0.89	0.82	0.82	3 529	4 076 242	235 346	557 209	229 057	820 829	1 842 441
42	2055	0	1 850 354	4 115 539	0	0	0	0	0	0	0	0	0.83	0	0.83	0.89	0.83	0.83	3 563	4 115 539	235 346	557 209	229 057	828 742	1 850 354
43	2056	0	1 858 267	4 154 837	0	0	0	0	0	0	0	0	0.84	0	0.84	0.89	0.84	0.84	3 597	4 154 837	235 346	557 209	229 057	836 655	1 858 267
44	2057	0	1 866 181	4 194 135	0	0	0	0	0	0	0	0	0.84	0	0.84	0.89	0.84	0.84	3 631	4 194 135	235 346	557 209	229 057	844 569	1 866 181
45	2058	0	1 874 094	4 233 432	0	0	0	0	0	0	0	0	0.85	0	0.85	0.89	0.85	0.85	3 665	4 233 432	235 346	557 209	229 057	852 482	1 874 094
46	2059	0	1 882 007	4 272 730	0	0	0	0	0	0	0	0	0.86	0	0.86	0.89	0.86	0.86	3 699	4 272 730	235 346	557 209	229 057	860 395	1 882 007
47	2060	0	1 889 921	4 312 028	0	0	0	0	0	0	0	0	0.87	0	0.87	0.89	0.87	0.87	3 733	4 312 028	235 346	557 209	229 057	868 309	1 889 921
48	2061	0	1 897 834	4 351 325	0	0	0	0	0	0	0	0	0.88	0	0.88	0.89	0.88	0.88	3 767	4 351 325	235 346	557 209	229 057	876 222	1 897 834
49	2062	0	1 905 747	4 390 623	0	0	0	0	0	0	0	0	0.88	0	0.88	0.89	0.88	0.88	3 801	4 390 623	235 346	557 209	229 057	884 135	1 905 747
50	2063	0	1 913 661	4 429 921	0	0	0	0	0	0	0	0	0.89	0	0.89	0.89	0.89	0.89	3 835	4 429 921	235 346	557 209	229 057	892 049	1 913 661
	Sum	**113 702 657**	**71 971 155**	**149 402 651**	**47 069 121**	**6 656 254**	**13 514 214**	**23 238 607**	**4 274 018**	**9 475 221**	**4 737 611**	**4 737 611**	**30**	**0**	**30**	**37**	**30**	**30**	**129 353**	**149 402 651**	**9 649 170**	**22 845 576**	**9 391 347**	**30 085 062**	**71 971 155**

Table E.3: URV calculation sheet 3 (Operational costs)

Pumping info			Pipeline info		
			Design volume		mcm/a
Pumping efficiency	86	%	design velocity		m/s
Hours operating per 24 hour	20	hrs	Pipe size		
	2013		*2063*		
Full delivery	18.237	l/s	28.267	l/s	
Full delivery	0.576	Mcm/a	0.892	Mcm/a	
Energy for full delivery	2 474.470	MWh/a			
Marginal cost of power	0.600	Rand	1.1		
Transmission factor	0.900	(cape 15%; PE 12	1.05		

Design energy requirement MWc

Energy usage 4.30

		Water supply		
		Water pumping schedule	MWh per annum required	Energy cost
No.	Year	(Mcm/a)	(MWh/a)	(R)
	2013		0	0
1	2014		0	0
2	2015		0	0
3	2016		0	0
4	2017		0	0
5	2018		0	0
6	2019		0	0
7	2020		0	0
8	2021		0	0
9	2022		0	0
10	2023	0.58	2 474	2 858 013
11	2024	0.58	2 508	2 897 311
12	2025	0.59	2 543	2 936 609
13	2026	0.60	2 577	2 975 906
14	2027	0.61	2 611	3 015 204
15	2028	0.62	2 645	3 054 502
16	2029	0.62	2 679	3 093 800
17	2030	0.63	2 713	3 133 097
18	2031	0.64	2 747	3 172 395
19	2032	0.65	2 781	3 211 693
20	2033	0.65	2 815	3 250 990
21	2034	0.66	2 849	3 290 288
22	2035	0.67	2 883	3 329 586
23	2036	0.68	2 917	3 368 883
24	2037	0.69	2 951	3 408 181
25	2038	0.69	2 985	3 447 479
26	2039	0.70	3 019	3 486 776
27	2040	0.71	3 053	3 526 074
28	2041	0.72	3 087	3 565 372
29	2042	0.73	3 121	3 604 669
30	2043	0.73	3 155	3 643 967
31	2044	0.74	3 189	3 683 265
32	2045	0.75	3 223	3 722 562
33	2046	0.76	3 257	3 761 860
34	2047	0.77	3 291	3 801 158
35	2048	0.77	3 325	3 840 456
36	2049	0.78	3 359	3 879 753
37	2050	0.79	3 393	3 919 051
38	2051	0.80	3 427	3 958 349
39	2052	0.81	3 461	3 997 646
40	2053	0.81	3 495	4 036 944
41	2054	0.82	3 529	4 076 242
42	2055	0.83	3 563	4 115 539
43	2056	0.84	3 597	4 154 837
44	2057	0.84	3 631	4 194 135
45	2058	0.85	3 665	4 233 432
46	2059	0.86	3 699	4 272 730
47	2060	0.87	3 733	4 312 028
48	2061	0.88	3 767	4 351 325
49	2062	0.88	3 801	4 390 623
50	2063	0.89	3 835	4 429 921

28.949

Pipeline info

Pumping efficiency	86	%
Hours operating per 24 hour	20	hrs
Transfer volume	0.576	mcm/a
Transfer volume	0.02	m^3/s

	Calculated	Assumed		
Design volume	0.022		0.018	m^3/s
Design velocity	1.200	0.010	0.008	m/s
Friction loss slope	0.012	0.000	0.000	m/m
Pipe size	0.152	1.700		m

	Head	Design MWc	Annual energy requirement		Capital Cost	
Pumpstation 1	744	0.184	1475	MWh/a	16 693 177	
Pumpstation 2	504	0.124	999	MWh/a	3 477 291	
Pumpstation 3	0	0.00	0	MWh/a	0	
Pumpstation 4	0	0	0	MWh/a	0	
Pumpstation 5	0	0	0	MWh/a	0	
Pumpstation 6	0	0	0	MWh/a	0	
Pumpstation 7	0	0	0	MWh/a	0	
Total	**1248**	**0.308**	**2474**		**20 170 468**	20 170 468
Annual energy requiremer		2474	MWh/a			