DWS Report No. P WMA 09/00/00/0418/21/1

Feasibility Bridging Study for Breede - Berg (Michell's Pass) Water Transfer Scheme (WP11389)

WATER REQUIREMENTS AND LAND USE

DRAFT April 2023

Department of Water and Sanitation
Directorate: Water Resource Development Planning

FEASIBILITY BRIDGING STUDY FOR BREEDE - BERG (MICHELL'S PASS) WATER TRANSFER SCHEME

DRAFT FOR APPROVAL

Title	:	Water Resources Assessment Report - Annexure 1: Land Use and Water Requirements
DWS Report Number	:	P WMA 09/00/00/0418/21/2
Consultants	:	Tlou Integrated Tech cc in association with Bigen Africa Services (Pty) Ltd
Report status	:	Draft
Date	:	April 2023

Study Team

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Bold type indicates this report.

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3	P WMA 09/00/00/0418/21/3	Topographical Surveys
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ACRONYMS AND ABBREVIATIONS

Acronym	**Description**
AIP	Alien invasive plants
ARC	Agricultural Research Council
BBTS	Berg Breede Transfer Scheme
BGCMA	Breede Berg Catchment Management Agency
DoA	Department of Agriculture
DWA	Department of Water Affairs
DWS	Department of Water and Sanitation
IB	Irrigation Board
IDP	Integrated Development Plan
GAAD	Gross annual average demand
km^2	Square kilometres
LM	Local Municipality
mcm	Million cubic meters
RFB	Request for Bid
V&V	Validation and Verification Study
WAAS	Water Availability Assessment Study
WARMS	Water use Authorization & Registration Management System
WMA	Water Management Area
WR2012	Water Resources Project 2012
WRC	Water Research Commission
WRYM	Water Resources Yield Model
WUA	Water Users Association

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1. INTRODUCTION

1.1. Background to study

A Request for Bid (RFB) for Bid Number WP 11339 titled *Appointment of Professional Service Provider for a Feasibility Bridging Study for Breede - Berg (Michell's Pass) Water Transfer Scheme (BBTS)* and due 2 November 2020 was issued by the Department of Water and Sanitation (DWS) on 2 October 2020. This study is hereafter referred to as the BBTS Bridging Study.

The proposed BBTS comprises the diversion of winter water by a new diversion weir from the upper Breede River at the same site as that of the current Artois Canal diversion and transferring the water through a new pipeline to the upper reaches of the Klein Berg River, from where the water will be conveyed via the Klein Berg canal into the Voëlvlei Dam in the adjacent Berg River catchment area. The scheme would also supply the summer and winter irrigation requirements of the existing users of the Artois Canal, including the town of Wolseley, and the ecological water requirements of the Breede River downstream of the proposed weir.

Any transfer of water out of the Upper Breede River Basin will impact on downstream water users. In this case the yield of Brandvlei Dam would be reduced unless the capacity of the infrastructure to pump water into the dam is increased. Therefore, allowance for maintaining the yield of Brandvlei Dam through an upgrade of the pump station at Papenkuils is required.

Tlou Integrated Tech cc, supported by Bigen Africa Services (Pty) Ltd and other sub-consultants, has been appointed by DWS for undertaking the BBTS Bridging Study. The Service Level Agreement between the DWS and the PSP stipulates a contractual project commencement date of 18 August 2021 and Contract Period of 30 months.

1.2. Overview of study area

The BBTS study area lies in the upper reaches of the Breede River Catchment down to the Brandvlei Dam abstraction point (quaternary H10L). For the purposes of this study, the catchment area consists of quaternaries H10A to H10L (the Upper Breede River Catchment), down to the abstraction point for Brandvlei Dam. Quaternaries G10E and G10F are part of the Berg River Catchment which are included in the yield and planning modelling phase of the study. These two quaternaries include the Boontjies River and Klein Berg River as well as Voëlvlei Dam.

A map of the Breede River catchment is provided in **Figure 1.1** (white outlined area), with the extent of the BBTS study area as defined in the ToR (i.e., the Upper Breede River catchment) highlighted in colour.

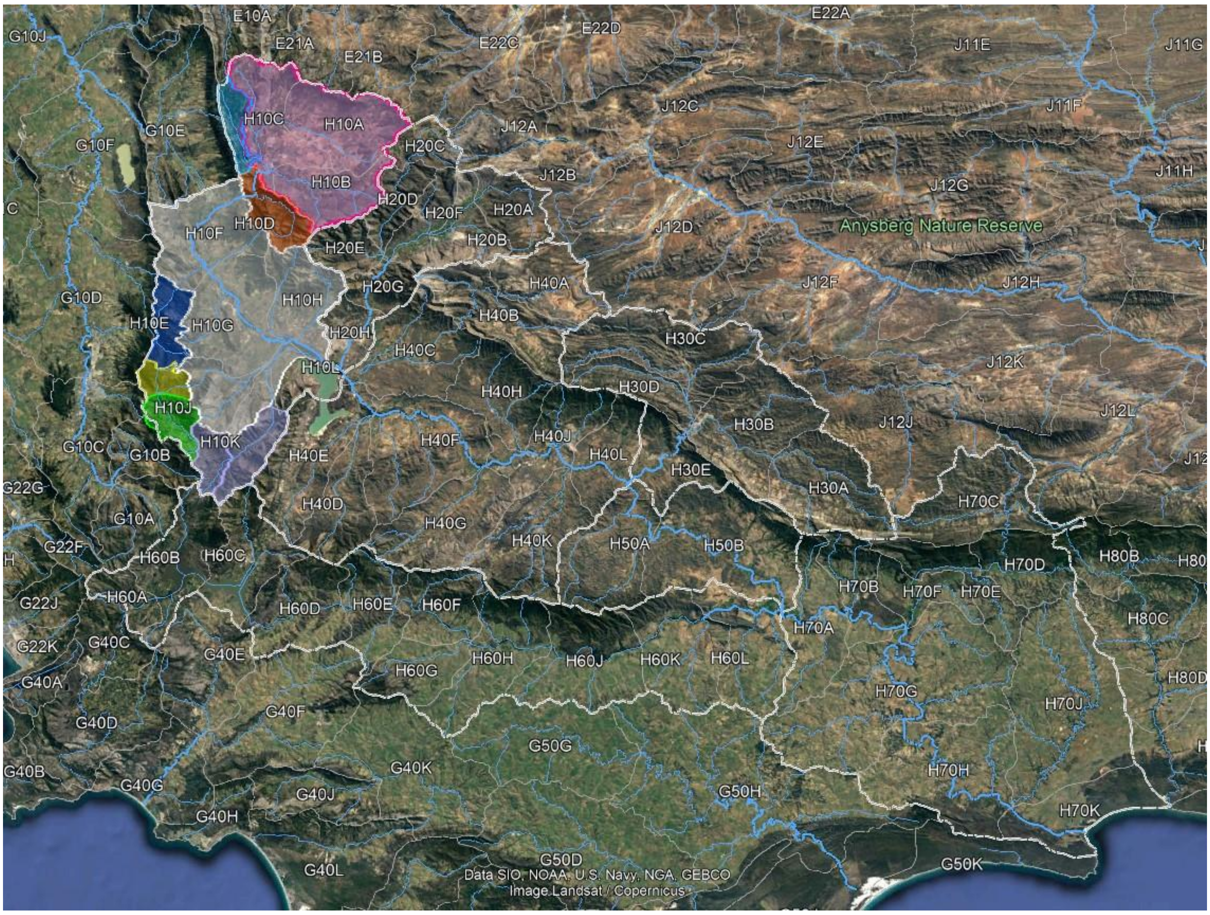


Figure 1.1: Map of the Breede River catchment

The BBTS study area (and the associated quaternary sub-catchments) is shown in **Figure 1.2**.

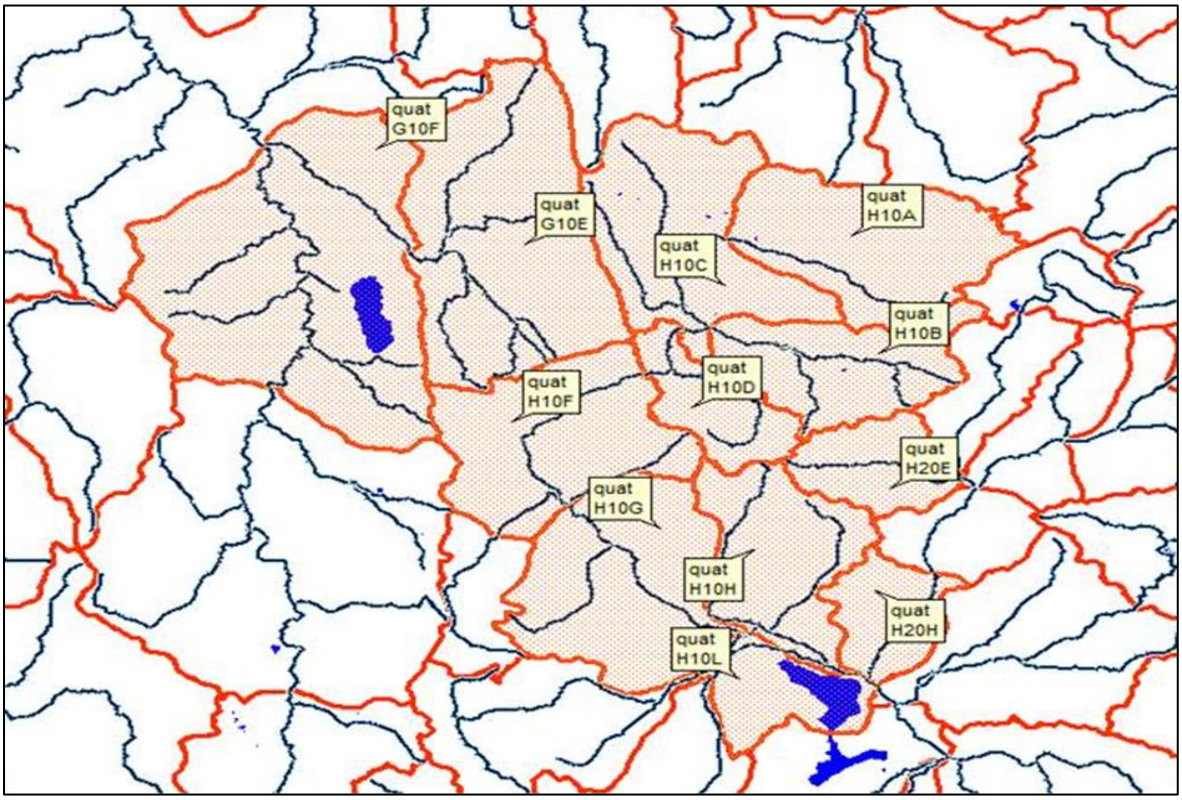


Figure 1.2: Hydrological Study Area

The study area is sparsely populated, the largest town being Worcester. The only major dam in the study area is the Brandvlei Dam which is located at the downstream end of the study area in quaternary catchment H10L. The dominant water use by far is irrigation.

1.3. Purpose of this Water Requirements study

The main purpose of this Water Requirements study is the quantify the historical and current water requirements of all water use sectors. This is required in order to set up and calibrate the WRSM2000 (or Pitman) rainfall-runoff model for the hydrological analysis, and the Water Resources Yield Model (WRYM) to determine dam and system yield characteristics. As such, information from the Water use Authorization & Registration Management System (WARMS) database has been included in this report, which will be used to populate the WRYM under the relevant scenarios.

1.4. Structure of the Report

Section 2 lists the sources of data used for the Land Use and Water Requirements Task.

Section 3 describes existing water requirements, including irrigation, urban and industrial demands.

Section 4 describes future water requirements.

Section 5 describes land use (including alien invasive plants, afforestation and storage).

Appendices are attached are as follows:

Appendix 1: H10 catchment map showing quaternary catchments (red outlines) and WAAS study catchments (coloured areas)

Appendix 2: Location of towns

Appendix 3: Main towns with associated urban water supply supply sources

Appendix 4: Afforestation

2. SOURCES OF AVAILABLE INFORMATION AND DATA

All relevant existing data, previous studies and reports were collected for a review of information. The final sources of data used within the study included the following:

2.1. WARMS Database

The WARMS database was obtained from the DWS on 17 February 2022 for all catchments under the Breede - Gouritz Catchment Management Agency (BGCMA). The information included three sources of information: Surface Water Abstraction (denoted 760); Streamflow Reduction (764), and Storage (762).

The WARMS database is updated regularly, specifically through the Validation and Verification (V&V) Studies which are done for this purpose. It is noted that while an updated WARMS dataset was received in February 2022, which included some verified water use but it did not necessarily reflect all updated information, as this may not yet have been captured into the WARMS database.

2.2. Validation and Verification Study

In 2015, the BGCMA commission a V&V study which included the applicable Upper Breede River catchment. It is understood that the then Aurecon carried out this study, but no reports or background information was forthcoming from the BGCMA. The BGCMA obtained the raw data from the V&V study, which was then captured into the WARMS database. The WARMS database only indicates the volume of water that may legally be abstracted and this can and does differ from actual abstraction volumes. This is especially relevant to irrigators whose water use varies with climatic conditions and the availability of water. Also, the extent of unlawful water use is unknown.

2.3. Water Resources of South Africa 2012 (WR2012)

The Water Resources of South Africa 2012 Project (WR2012) was an extensive study commissioned by the South African Water Research Commission (WRC) (WRC, 2015), for the estimation of the water resources of South Africa, Lesotho, and Swaziland (now Eswatini) for the period 1920 - 2009. The WR related projects have been updated over the years commencing with WR90, major technical and data updates referred to as WR2005 and the latest project completed in 2015 is referred to as WR2012. The WR2012 project includes the Pitman Model setups for the above-mentioned countries, as well as all the data behind the modelling.

However, it is important to note that the WR2012 study did not include an update of the data within the Pitman Model, including, *inter alia*, the hydrology, water requirements, and land use. The project focus was the conversion of the previous study (WR2005) books into a digital platform. However, some catchments/areas have been updated on an ad-hoc basis, where possible. The H10 tertiary has a record period of 1920 - 2009 (hydrological years, i.e., October 1920 to September 2010).

2.4. Assessment of Water Availability in the Berg River Catchment (WMA 19) by means of Water Resources Related Models

The previous update of the hydrology for the Upper Breede River was carried out by Ninham Shand (now Zutari) and Umvoto in 2009, for the DWA (DWA, 2009). This study was the *Assessment of Water Availability in the Berg River Catchment (WMA 19) by Means of Water Resources Related Models* Study, (hereafter referred to as the WAAS Study). The study was commissioned to aid in quantifying the amount of water available in the catchment area. These studies are crucial for the allocation of water and are utilised for the required licencing process in South Africa, which all water users must adhere to.

This was the most relevant and detailed study which was obtained for the Breede River Catchment. The study used the Pitman Model (SSI, 2003) for the hydrology, including water requirements and land use, for a record period of 1924 - 2004. An update of the study was carried out in 2016; however, it did not include updated water requirements or land use and therefore, the updated study was not used for this study task.

A suite of reports was published under WAAS with assigned report and volume numbers. The following specific reports/volumes were used for this study task:

- **Report No. 1:** Summary Report **(**DWA**,** 2009a**)**;
- **Report No. 5:** Update of Catchment Hydrology**, Volume 2:** Upper Breede River (DWA, 2009b);
- **Report No. 4:** Land Use and Water Requirements**, Volume 3:** Water Use and Water Requirements (DWA, 2009c);
- **Report No. 4:** Land Use and Water Requirements**, Volume 1:** Data in Support of Catchment Modelling (DWA, 2009d);
- **Report No. 4:** Land Use and Water Requirements**, Volume 2:** Invasive Alien Plant Mapping (DWA, 2009e), and
- **Report No. 2:** Rainfall Data Preparation and MAP Surface (DWA, 2009f).

2.5. Department of Agriculture, Western Cape Government

The Department of Agriculture (DoA) "*Cape Farm Mapper'* website (CFM 2.6.10 (elsenburg.com), (accessed 2022) has an array of data in the form of maps. For this study, the detailed Cape Farm Mapper data for areas under irrigation within the H10 tertiary was obtained from the DoA. The data represents the year of 2017. It was verified using spots check on Google Earth Pro and proved to be extremely detailed and accurate. The data obtained included details on crops and irrigation systems used per quaternary catchment.

2.6. Development of Reconciliation Strategies for All Towns

Information from the *Development of Reconciliation Strategies for All Towns in the Southern Planning Region* (DWS, 2016) for the following regions were used:

- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: Worcester (DWS, 2016);
- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: Rawsonville (DWS, 2016);
- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: Ceres (DWS, 2016), and
- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: De Doorns, Orchard and Sandhills (DWS, 2016).
- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: Wolseley (DWS, 2016).
- Development of Reconciliation Strategies for All Towns in the Southern Planning Region: Tulbagh (DWS, 2016).

2.7. Water Services Development Plans and Integrated Development Plans

Information from the following Water Services Development Plans (WSDPs) and Integrated Development Plans (IDPs) produced by the associated Local Municipalities (LM) were consulted/used in this study:

- Breede Valley Local Municipality Final Fifth Generation Integrated Development Plan for 2022 - 2027
- Breede Valley Local Municipality Final Review of the Integrated Development Plan for 2021 – 2022
- Breede Valley Local Municipality Third Generation Integrated Development Plan for 2012 - 2027

- Breede Valley Local Municipality Water Services Development Plan for 2022 - 2023 (Revision 1, July 2022)
- Witzenberg Local Municipality Integrated Development Plan – Adopted with Amendments ITO Section 25 (3) for 2022 - 2027
- Witzenberg Local Municipality Draft Integrated Development Plan for 2022 - 2023
- Witzenberg Local Municipality Integrated Development Plan for 2017 - 2022
- Witzenberg Local Municipality Water Services Development Plan for 2022 - 2023 (Revision 1, July 2022)

The latest WSDPs for both municipalities (listed above) were received from the DWS in December 2022.

2.8. Other information

The sources described in **Sections 2.1** to **2.7** were the primary sources for the task of updating the water requirements and land use. However, other reports, studies, datasets, and personal communications were obtained and used, primarily for comparison. Such information included the following:

- The suite of reports published under the *Pre-Feasibility and Feasibility Studies for Augmentation of the Western Cape Water Supply System by Means of Further Surface Water Developments p*roject (DWA, 2012):
    - **Report No 3, Vol 2:** Update of Catchment Hydrology for the Upper Breede River
    - Report No 3, Vol 2, **Appendix 5**
    - Report No 3, Vol 2, **Appendix 6**
    - Report No 3, Vol 2, **Appendix 7**
- Background Information Document for the Augmentation of the Western Cape Water Supply Scheme: Bridging Study for Breede-Berg (Michell's Pass) Water Transfer Scheme (DWS, 2018)
- Assess Surplus Winter Water Breede: Interim Report (Aurecon, 2020)
- Agricultural Research Council spreadsheet on invasive alien plants (ARC, 2011)
- Correspondence with the BGCMA (Ms Elkerine Rossouw, 2022)
- Correspondence with Dr David le Maitre (2022)
- Witzenberg Municipality Annual Report for 2020/2021 Report (Witzenberg Municipality, 2021)
- DWS List of Registered Dams database
- Correspondence with representatives of Irrigation Boards, including:

  - Louis Bruwer: e-mail and verbal discussion at conference
  - Etienne Weidemann: e-mail
  - Schalk Albertyn: e-mail
- Correspondence with the BGCMA
  - Elkerine Rossouw: e-mail and telephone
- Correspondence with DWS, Western Cape Regional Office
  - John Roberts: e-mail

2.9. Data summary

The Pitman Model is the standard model used in South Africa for rainfall – runoff modelling and was used for the WR2012 and WAAS studies. A detailed comparison of existing data for these studies was performed. However, some issues were encountered. In modelling, the sub-catchments are typically based on the quaternary catchments of the study area (and split further into quinary catchments, if required). The WR2012 study was modelled in this way. However, the WAAS study sub-catchments were modelled based on the locations of the streamflow gauges in the catchment. This made a direct comparison between the two project models (and associated data) difficult, and in some cases, not possible. However, a comparison task was still performed to evaluate the data. These sources were used for all water requirements as well as land use and dam storage. A detailed comparison was carried out for each demand type and the most reliable data were used for each demand type, as detailed in **Sections 3** to **5**.

For the irrigation demands, the DoA data was used, as it was the most recent data, and found to be very reliable when checked against Google Earth Pro. It is also extremely detailed data.

3. HISTORICAL WATER REQUIREMENTS

Using the data sources listed in **Section 2**, the most reliable water requirements and land use data were determined.

3.1. Irrigation Water Requirements

The predominant water use in the Breede River Catchment is irrigation, which covers almost the entire catchment area. Therefore, this was the most crucial data, and several sources were used.

The WR2012 and WAAS studies both used the Pitman Model for their analyses. However, the demands were generally incomparable, for two reasons. First, WR2012 modelled sub-catchments which were based on quaternary catchments (and quinary, if required). This is a typical method in South Africa, especially for this study as uniformity was required. However, the WAAS study was modelled based on sub-catchments delineated by the location of the streamflow gauges. Therefore, only some quaternaries, or groups of quaternaries, were comparable. The second issue was that irrigation water requirements can be modelled using two different methods in the Pitman Model. The first method involves modelling the irrigated area using the Irrigation Block feature, based on a physical crop area, the type of crop, rainfall, evapotranspiration, and other information. It then performs an internal water balance for the area and calculates the balance (deficit or surplus) of water. If there is a deficit, it will draw water from the river for the irrigation. This method also calculates any return flows which may be generated from the irrigated area and diverts them back into the river. Alternatively, crop areas can be modelled externally to the model and applied in the system using a direct abstraction file. The two Pitman Model setups (WR2012 and WAAS) used different combinations of these two methods, tailored for their own catchments and modelling approaches, which made them generally incomparable.

To simplify the modelling process, it is typical to group (lump) demand centres, irrigation areas, or dams together. This is generally when the number of items is substantial, and each is relatively small. This is based on location and/or characteristics. In the WAAS study, many requirements were modelled using direct releases from upstream dams (high rainfall areas) to the downstream (lumped) smaller farm dams (lower rainfall areas). This is acceptable for modelling purposes; however, it is a subjective method, and it can make it difficult to determine the quaternary in which the actual, separate, abstractions occur. The WR2012 and WAAS studies grouped the requirements differently, based on their modelling techniques and preferences. Therefore, this reiterated the lack of comparable data between the studies.

For this reason, to make the two studies more comparable, the studies' models were obtained and re-run. Therefore, the modelled areas (using the Irrigation Block) could be represented as supply volumes, providing a comparative basis on volume only. The modelled supply volumes to the areas were recorded and added to the volumes directly abstracted from the system, to obtain a total volume supply for irrigation in the whole catchment. This provided a more comparative basis for irrigation as areas were used to obtain volumes and the comparison was done based only on volumes. However, this method could not be used conclusively, as the WAAS study excluded some requirements which were supplied from groundwater or had unknown areas. The WR2012 did not model groundwater as a resource, and all abstractions were from surface water (rivers and dams). Therefore, WR2012 provided a much higher total irrigation supply than the WAAS study. Additionally, in one specific case, the WAAS study subtracted an area from an existing irrigation block as the area was known, but the details of the water use were not. Therefore, to adjust for this, that area was excluded from the modelling, which also reduces the irrigation supply. It should be noted that modelling approaches differ, based on the preferences of the modellers, their data, and systems, making the comparison of data and results difficult.

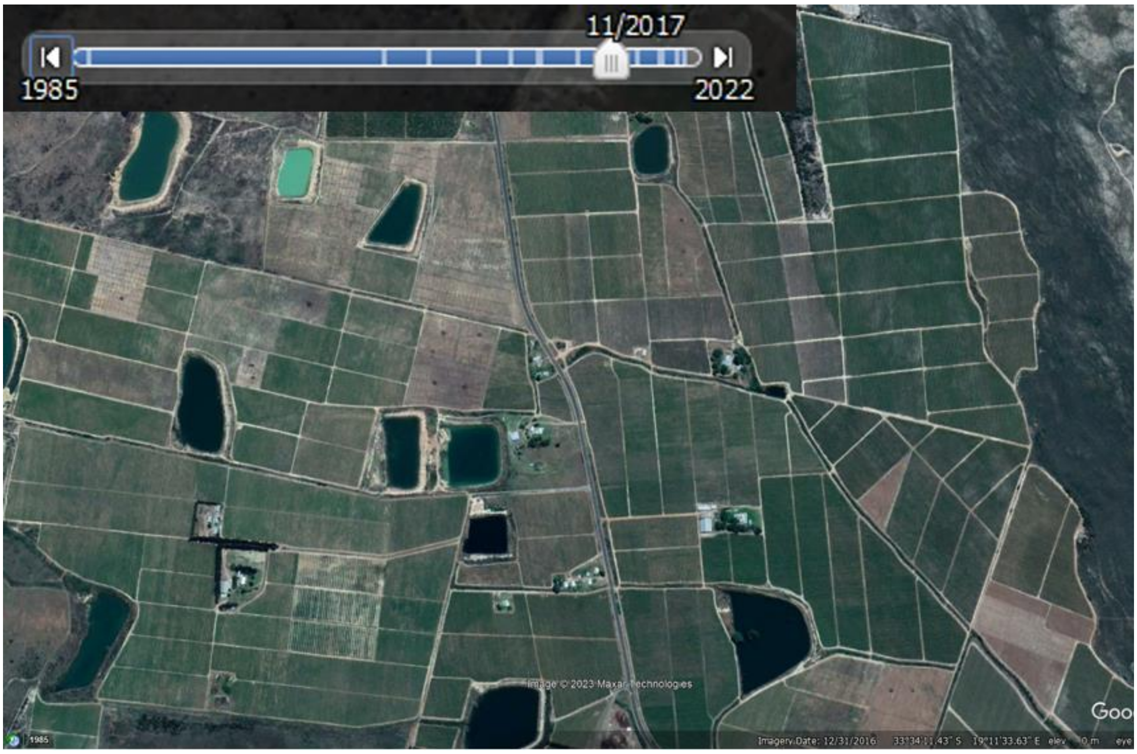
The WARMS data is a database of registered water volumes, and not actual use. Where the use has been verified through the V&V process, this only confirms whether the water use is lawful but does not provide additional information on actual use. It was therefore not possible to use WARMS data for a direct comparison with other data sources of actual water use. However, the WARMS data was included initially for comparative purposes. Also, the WARMS data is important for yield modelling and quantifying the available water resources and therefore the WARMS data is included in this report.

Finally, far more recent data (2017) was obtained from the DoA *Cape Farm Mapper* website database for all irrigated areas in the catchment (DOA, 2017). These were provided in the format of tables and shape files for Google Earth, and it was verified that these areas were extremely accurate. There are a total number of 173 individual irrigated areas and each area is associated with additional detail, including the crop type and irrigation method (refer to **Table 3.1).**

Table 3.1: Irrigation areas per quaternary under different methods of irrigation from the DoA (2017)

Quaternary Catchment	Irrigation Method							Total
	Drip	Micro	Floppy	Pivot	Sprinkler	Other	Side-roll	
H10A	8.24	3.21	0.08	0.43	0.07	0.00	0.00	**12.03**
H10Bb	12.33	3.58	0.00	0.62	0.07	0.00	0.00	**16.60**
H10C	30.23	7.58	0.00	1.85	1.50	0.00	0.00	**41.17**
H10D	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10E	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
H10D	33.40	3.16	0.00	0.09	0.74	0.00	0.00	**37.39**
H10E	84.74	0.82	0.00	0.04	0.21	0.00	0.00	**85.81**
H10F	28.36	0.40	0.01	0.10	0.06	0.00	0.12	**29.05**
H10G	4.59	0.00	0.00	0.00	0.00	0.00	0.00	**4.59**
H10H	6.59	0.00	0.00	0.00	0.04	0.00	0.00	**6.62**
H10J	0.40	0.00	0.00	0.00	0.00	0.00	0.00	**0.40**
H10K	208.88	18.74	0.09	3.14	2.69	0.00	0.13	**233.67**
H10L	8.24	3.21	0.08	0.43	0.07	0.00	0.00	**12.03**
Total	208.88	18.74	0.09	3.14	2.69	0.00	0.13	**233.67**

Figure 3.1 shows the accuracy of the 2022 irrigation data provided by the DoA, against Google Earth Pro which clearly shows separate fields of crops. The date of the image is shown in the top left hand corner of the image.



Google Earth 2017 image

Overlay of DoA 2017 data

Figure 3.1: Comparison of DoA 2017 irrigation information against Google Earth Pro, in H10G (DoA, received April 2022)

Table 3.2 and **Table 3.1** show the initial comparisons between the sources of information for irrigation for areas and flow, respectively.

Table 3.2: Comparison of irrigated areas in H10 (km^2)

Quaternary	WAAS	WR2012	DoA
H10A		13.34	12.03
H10B	22.91	26.21	16.60
H10C		83.79	41.70
Sub-total	22.91	123.34	70.33
H10D	0	0	0
H10E	0	0	0
Sub-total	0.00	0.00	0.00
H10F		31.16	37.39
H10G		22.20	85.81
H10H	65.37	16.00	29.05
H10J		0.10	4.59
H10K		4.41	6.62
H10L		15.80	0.40
Sub-total	65.37	89.67	163.86
Total per study	**88.28***	**213.01**	**234.19**

** Note: The WAAS study report states that total area under irrigation is actually 206 km^2.*

Table 3.2 shows a large discrepancy between the WAAS data, with the relatively similar WR2012 and DoA data. This is owing to the differences stated above. Furthermore, the detailed WAAS study reports state that although not modelled, the total area under irrigation in the catchment is 206 km^2, which correlates well with both the WR2012 and the DoA information. The modelling approach taken in the WAAS study excluded some demands for various reasons, such as unknown water consumption, supply from groundwater, and demands considered negligible to the total catchment runoff. In addition, some demands were modelled with a time series file of monthly demands, and therefore the area for these is not included. **Table 3.2** only listed areas modelled as irrigation blocks. This accounts for the large difference between the actual agricultural area (206 km^2) versus the modelled area of 88.28 km^2.

Table 3.1 below shows the comparison of areas from the three sources of data (as opposed to flow in **Table 3.2** above).

Table 3.1: Comparison of total irrigation requirements in H10 (million m^3/annum)

Quaternary	WAAS (modelled)	WR2012 (modelled)	WARMS(verified)
H10A	15.28	3.68	18.97
H10B		2.41	51.67
H10C		8.03	72.77
H10D	5.50	15.99	0.21
H10E	4.90	4.90	0.38
H10F	7.47	4.60	34.25
H10G		3.40	63.75
H10H		2.33	25.73
H10J		0.20	6.82
H10K		2.27	6.36
H10L		0.36	32.17
Total per study	**33.15**	**48.17**	**313.07**

** Note: The DoA data does not include water volumes.*

To check the WARMS data as well as possible, the volumes of the different sources were analysed. For the modelling studies (WAAS and WR2012), both irrigation blocks and direct abstractions were considered in the flows in **Table 3.1**, representing the total supply to irrigation demands within the catchment. The WAAS and WR2012 flows are relatively similar; however, it is noted that this should be higher for the WAAS study if all areas were included. However, the verified WARMS data has a far higher volume than either of the others, but represents the maximum water requirement and not necessarily the actual use. The basis on which the WARMS verified water requirements were derived (i.e., crop types, irrigation system) was not made available to the study team and hence it is not possible to comment on the accuracy of these water requirements.

3.2. Urban Water Requirements

3.2.1. Catchment Overview

Two LMs cover the catchment area under study. These are the Breede Valley LM (in the south), and the Witzenberg LM (in the north). Within the catchment, there are only a few small towns with urban water abstractions, and some of those are provided solely by groundwater. The two main towns in the catchment area are Worcester, approximately 10 km north-east of Brandvlei Dam, and Ceres, which is located in the north–western part of the catchment.

The WARMS database shows a total urban demand of 18.4 million m^3/annum for the entire tertiary. This includes urban (14.83 million m^3/annum); recreation (0.47 million m^3/annum); Schedule 1 Use (0.01 million m^3/annum), and Water Supply Services (3.05 million m^3/annum). Of the 18.4 million m^3/annum, 13.2 million m^3/annum is for Ceres, Prince Hamlet, Wolseley, Rawsonville, and Worcester. There is an additional 0.45 million m^3/annum diverted at the Artois Canal, which is used for both Wolseley (urban) and irrigators. Of the remaining 4.72 million m^3/annum (which did not have specified towns associated with the allocations), 2.37 million m^3/annum comes from surface water, and the remaining 2.35 million m^3/annum is from groundwater. It is clear that the WARMS data does not compare well to the values obtained from other sources and therefore, barring the Wolseley urban water allocation, the WARMS database has only been considered for reference.

The 2016 Reconciliation Strategy studies estimated the projected gross annual average demands (GAAD) for low, medium, and high scenarios, with growth rates varying between 0.5% (low) to 2.5% (high). The projected current (2022) GAADs from the Reconciliation Strategy studies are indicated below for each applicable town.

The latest WSDPs for the Witzenberg and Breede Valley LMs for 2022 - 2023 (received from the DWS in December 2022) do not include information on urban demands, population numbers, or growth values for the separate towns/settlements.

Due the discrepancies in the various data source, Mr John Roberts from DWS Western Cape Regional Office was contacted to assist with additional information, specifically on domestic water use.

Maps of the towns and water resources are shown in **Appendix A**.

3.2.2. Breede Valley Local Municipality

The Breede Valley LM includes the towns of Worcester (H20H), Rawsonville, De Doorns and Touws River, as well as Orchard (settlement) and Sandhills (township). Of these, only Rawsonville lies within the H10 catchment; however, Rawsonville and Worcester obtain their water from H10.

The Breede Valley LM WSDP Report for 2022 – 2023 (Revision 1) only lists consumption and metered values for the entire LM region and not the separate towns. However, the report does state that the water resources from the dams are currently under strain due to drought.

Sub-sections 3.2.2.1 to **3.2.2.3** provide detail on the urban demands for the main urban demands within the Breede Valley LM located in the study area.

3.2.2.1. Worcester

Worcester is located just outside of the catchment's eastern boundary in the adjacent tertiary of H20. However, the town's urban water demand is supplied from Stettynskloof Dam (H10K), with a licensed allocation of 10.955 million m^3/annum, and is supplemented by Fairy Glen Dam (H10H), with an allocation of 0.085 million m^3/annum (Reconciliation Strategy Report, 2016). The V&V database lists the licenced allocation from Fairy Glen Dam as 0.52 million m^3/annum but most of this is used for irrigation in the town which explains the discrepancy with the 2016 Reconciliation Strategy Report. According to DWS (Roberts, 2023), Worcester also has an irrigation allocation of between 2 and 3 million m^3/annum from the Hex River.

Owing to the large difference between the Reconciliation Strategy study allocation listed specifically for the town, and the much larger (total) allocation in the WARMS database, it is assumed that the Fairy Glen WARMS allocation (0.52 million m^3/annum) is not only for Worcester urban supply. The town is also supplemented by the Lower Hex River; however, according to the Worcester Reconciliation Strategy Report, this amount is unmetered and used for the irrigation of sports fields. However, this allocation/demand is not applicable to this study as the Hex River does not affect the surface water resources of the H10 tertiary. Therefore, this demand has not been included in the current study. An additional amount of 0.62 million m^3/annum is available from groundwater for the urban demand.

The 2005 demands in the WAAS and WR2012 datasets were 12.50 and 12.54 million m^3/a, showing good agreement between the datasets. In addition, the latest year of the WR2012 Study was 2009, at 12.82 million m^3/a. Applying the same method used in the Worcester Reconciliation Strategy Study, backdating to 2005 at a medium growth of 1.5 % per annum, the 2005 demand was 12.46 million m^3/a. This demonstrates the agreement between these three data sources.

DWS (Roberts, 2023) indicated that current water use by Worcester is 12.7 million m^3/a which is consistent with most other sources of information.

The 2016 Worcester Reconciliation Strategy Study estimated the projected GAAD for the low (1.0%), medium (1.5%), and high (2.0%) growth rate scenarios for the current (2022) year to be 15.42, 16.04, and 16.69 million m^3/annum, respectively.

The Fifth Generation IDP for the Breede Valley LM for 2022 – 2027 states that the available yield of the main water resources for the combined Worcester and Rawsonville urban demand (Stettynskloof and Fairy Glen Dams) is 26 000 Ml/a (equivalent to 26 million m^3/annum) and is sufficient for current and future (no years provided) demands. The actual demands are not provided. As indicated in **Section 3.2.2.2**, the Rawsonville urban demand is less than 0.5 million m^3/annum (2016 Rawsonville Reconciliation Strategy Report).

3.2.2.2. Rawsonville

Rawsonville falls within the Breede Valley LM and is located in H10G near the outlet of the catchment, less than 10 km west of Brandvlei Dam. The urban water supply for Rawsonville is supplied from the Smalblaar River diversion weir in the winter months (located on the Smalblaar River) with an allocation of 0.27 million m^3/annum (according to the V&V), which is shared between the urban demand and irrigators. The Smalblaar River is located between the town and Brandvlei Dam in H10L. There are four municipal boreholes which augment the supply during summer. There is also a bulk supply line through the Breede Valley Municipality's Stettynskloof bulk water supply scheme. According to the WAAS Study, Rawsonville had a very small demand of 0.2 million m^3/annum in 2004 and was therefore excluded, as it was considered negligible in comparison to the total catchment runoff. The WR2012 Study did also not include an urban demand for this town. According to the Reconciliation Strategy Report, the calculated backdated 2004 demand under the medium scenario (growth = 1.5%) was 0.31 million m^3/annum, which is similar to the other data sources.

DWS (Roberts, 2023) estimates the current water use by Rawsonville at 0.32 million m^3/a which consistent with other sources of information.

The 2016 Rawsonville Reconciliation Strategy study estimated the projected GAAD for the low (0.5%), medium (1.0%), and high (1.5%) growth rate scenarios for the current (2022) year to be 0.373, 0.388, and 0.403 million m^3/annum, respectively.

As stated previously, the Fifth Generation IDP for the Breede Valley LM for 2022 – 2027 states that the available yield of water resources available for the combined Worcester and Rawsonville urban demand (Stettynskloof and Fairy Glen Dams) is 26 000 Ml/a (equivalent to 26 million m^3/a) and is sufficient for current and future (no years provided) demands. The actual demands are not provided.

3.2.3. Witzenberg Valley Local Municipality

The Witzenberg LM includes Ceres (H10C), and the smaller towns of Wolseley, Tulbagh, and Prince Alfred Hamlet. The towns are clustered together in the north–western area of the catchment. Tulbagh and Prince Alfred Hamlet fall outside the catchment boundary; however, they obtain their water supply from resources within the H10 catchment. The small settlement of Op – die – Berg has been excluded as it obtains it water from groundwater.

The urban demands for Wolseley, Tulbagh, and Prince Alfred Hamlet were excluded from the WAAS Study, as they were considered negligible in comparison to the total catchment runoff.

According to the latest Witzenberg IDP Study for 2022 – 2027, the annual average growth rate of the whole LM for 2001 – 2013 was 3.1%, with a slightly lower current growth rate of 2.67%.

The latest Witzenberg WSDP for 2022 – 2023 (Witzenberg LM, Revision 1: July 2022 (received from DWS in December 2022) provides no information on water demands or allocations for the towns within the Witzenberg LM.

Sub-sections 3.2.3.1 to **3.2.3.3** provide detail on the urban demands for the main towns within the Witzenberg LM.

3.2.3.1. Ceres

Ceres lies within the north–western part of the H10 tertiary. The Ceres Koekedouw Dam (also referred to as the Koekedouw or Ceres Dam) supplies the town of Ceres with water. The dam is located on the Koekedouw River, a tributary of the Dwars River, which eventually flows into the Breede River. There is a formal agreement between the Koekedouw Irrigation Board (IB) and the Witzenberg LM for the use of the dam's water supply, as it was constructed by both parties. Ceres is licenced to abstract 7 million m^3/annum from Koekedouw Dam. Previously 0.9 million m^3/annum of this was allocated to Prince Alfred Hamlet, which increased to 1.0 million m^3/annum in 2017 (Ceres Reconciliation Strategy Report, 2017 – 2022). According to the Witzenberg Municipality Annual 2021 Report, six boreholes serve as a backup source of supply for the town, if required.

The WR2012 Study had a 2004 urban demand of 11.59 million m^3/annum and the same year for the WAAS dataset had a demand of 13.08 million m^3/annum in 2004. However, this abstraction also includes some water which is supplied for irrigation, and not just the urban demand of Ceres. The WARMS data shows 0.22 million m^3/annum which specifically indicates that it is allocated for Ceres (including urban, recreational, water supply service and Schedule 1 water use), which is considerably lower than the WAAS and WR2012 studies. However, this demand is likely underestimated due to the fact that not all allocations in the WARMS database have associated details (i.e., it is assumed that additional allocations in the WARMS database are for Ceres but have not been indicated as such).

In the 2016 Reconciliation Report for Ceres (including Prince Alfred Hamlet), the historical population growth rate was calculated to be 1.18% per annum. The study estimated the projected GAAD for the low (1.0%), medium (1.5%), and high (2.0%) growth scenarios for the current (2022) year to be 5.172, 5.380, and 5.596 million m^3/annum, respectively.

According to the latest Witzenberg IDP Study for 2022 – 2027, the current (2022) growth rate for Ceres is 2.67%. According to the study, the current GAAD from Ceres Koekedouw Dam for Ceres is 3.9 million m^3/annum.

DWS (Roberts, 2023) does have a recent record of water use by Ceres and estimates the use to be about 5 million m^3/a, including the demand of Prince Alfred Hamlet which has an estimate current water usage of 0.27 million m^3/a. Hence the water use by Ceres is approximately 4.7 million m^3/a.

There are significant differences in the current urban demand for Ceres from the different data sources. The abstraction from the dam in the WAAS study included a portion for irrigation (but the split between irrigation and urban is not provided). It can be assumed that WR2012 used the same modelling methodology of lumping more than one demand from one resource (Ceres Koekedouw Dam). Therefore, the estimate from DWS is accepted as the most reliable data source on the current (2022) Ceres urban demand.

3.2.3.2. Prince Alfred Hamlet

According to the Witzenberg 2017 – 2022 IDP Report, Prince Alfred Hamlet has four water sources (no demand provided). These are the Wabooms River Weir, one fountain, one borehole, and a supply line from the Ceres Koekedouw Dam (discussed in **Section 3.2.3.1** above), as part of the Ceres urban demand. The Ceres Reconciliation Strategy Report states that in 2017 the allocation from the dam increased from 0.9 to 1.0 million m^3/a. The WAAS Study did not model an urban demand for the town, as it was considered insignificant

(0.4 million m^3/annum) in comparison to the total catchment runoff. The WR2012 did also not include a separate demand for this town.

The latest IDP for the Witzenberg LM (2022 – 2027) does not provide current or projected demands or growth rates for Prince Alfred Hamlet. However, the primary water allocation of 1.0 m^3/annum is included within the Ceres allocation (Ceres Reconciliation Strategy Report, 2017 – 2022).

DWS (Roberts, 2023) estimates the current water use by the Prince Alfred Hamlet at 0.27 million m^3/a.

3.2.3.3. Tulbagh

The Klein Berg, Moordenaarskloof and Tierkloof Rivers are the main water supply sources for Tulbagh. In addition, according to the Witzenberg LM IDP 2017 – 2027, construction was recently completed for the provision of an additional 1.2 million m^3/annum from the Klein Berg River (transfer from adjacent catchment). There is also a borehole which supplies additional water to Tulbagh. The IDP and V&V study do not list a requirement for the town, and the WAAS and WR2012 studies did not include an urban demand for Tulbagh. The latest Witzenberg LM IDP (for 2022 – 2027) does not provide current or projected growth rates for Tulbagh, and there is no information on demands or allocations of water in the latest Witzenberg WSDP received from DWS in December 2022.

DWS (Roberts, 2023) estimates the allocation to Tulbach at 2.2 million m^3/a but only 0.2 million m^3/a of this is supplied from the Breede River catchment.

3.2.3.4. Wolseley

Wolseley lies on the north–eastern boundary of the catchment. It receives its water supply from the Tierhokkloof weir on the Tierhokkloof River. There is no storage on the river and therefore has previously been identified as a critical risk for growth in Wolseley, as the town does not have a sustainable water supply. According to the WARMS database, the allocation from the Tierhokkloof River for Wolseley is 1.16 million m^3/annum. Local springs and groundwater are used to supplement surface water supply for the town. According to the WAAS Study, the 2004 urban demand for Wolseley was 0.9 million m^3/annum. However, the demand was excluded as it was considered insignificant in comparison to the total catchment runoff. An urban demand for Wolseley was not included in WR2012. The latest IDP (2022 – 2027) for the Witzenberg LM does not provide current or projected demands for Wolseley and there is no information on demands or allocations of water in the latest Witzenberg WSDP.

Currently an average of 19 million m^3/annum water from the Breede River is diverted at Witbrug into the Artois Diversion Canal diversion at Michell's Pass, of which 15 million m^3/annum is shared by the Artois irrigators and the town of Wolseley, and the remaining 4 million m^3/annum flows into the into the Klein Berg River catchment. This water transfer occurs year – round from the manually controlled gated canal intake structure at the DWS flow gauging station H1H006, into the canal and across the catchment divide from the Breede River Water Management Area (WMA) into the Berg River WMA.

DWS (Roberts, 2023) estimates the water use by Wolseley at 1.75 million m^3/a which includes the use from the Artois Diversion Canal.

3.2.4. Summary of Urban Water Use

Table 3.4 presents a summary of the urban water use.

Table 3.2: Summary of urban water use

Town	Location	Current water use (million m^3/annum)
Worcester	H20H	12.7
Ceres	H10C	4.7
Rawsonville	H10G	0.3
Prince Alfred Hamlet	H10C	0.3
Wolseley	H10F	1.8
Tulbagh	G10E	0.2
Total		**20.0**

Note that the towns of De Doorns, Sand Hills and Orchards do not fall within the study area.

3.3. Industrial Water Requirements

The WAAS Study included a demand for the Ceres Hydropower Plant, which was an annual demand of 4.38 million m^3/annum in quaternary H10C.

Ceres previously had a hydropower plant associated with Ceres Koekedouw Dam. A report by the CSIR in 2001 indicated that the hydropower generated was a nominal capacity of 1 MW and was dependent upon the volume of Ceres Koekedouw Dam. The report did not specify the date of commissioning.

A report by the United Nations in 2013 further stated that the Ceres Hydropower Plant was constructed in the 1920s, and upgraded in the 1950's; however, it is no longer operational. Hydro4Africa (Hydro4Africa.net) also lists this plant as decommissioned.

The WARMS database indicates a total of 1.04 million m^3/annum for industrial use in the catchment. This probably relates to fruit processing and wine farms in the area.

4. UPDATE OF FUTURE WATER REQUIREMENTS

Using the data sources listed in **Section 2**, the most reliable information on water requirements were used to establish future water requirements. Future water requirements are necessary for the water resources yield and planning modelling. Owing to the vast agricultural development in the catchment, which essentially covers the entire study area, it is assumed that there will be negligible agricultural growth in future, as well as negligible industrial demand growth in the Upper Breede River catchment. Consequently, the future water requirements considered in this study are only urban demands.

The Development of Reconciliation Strategies for All Towns in the Southern Planning Region (DWS) were used to extend the projections, according to the existing information and methodology used in the strategies. Additional information was obtained from the Witzenberg LM Annual Report for 2020/2021, which covered Ceres, Tulbagh, Wolseley and Prince Alfred Hamlet.

The Development of Reconciliation Strategies for All Towns in the Southern Planning Region (DWS, 2016) for the following regions were used for future urban water requirements:

- Ceres (Witzenberg LM)
- Worcester (Breede Valley LM)
- Rawsonville (Breede Valley LM)

According to the Reconciliation Strategies for All Towns Studies (DWS, 2016) the 2011 population was recorded from the 2011 Census. The 2014 population was estimated based on the three – monthly water balance data submitted to the DWS by the LMs. The historical population growth rate was calculated (using data from 2001 – 2011), and a percentage projected population increase per annum was estimated and agreed upon by the DWS and the LMs (DWS, 2016). Furthermore, three growth scenarios were considered: low; medium, and high (based upon the 2014 estimated growth rate). All Reconciliation Strategy reports state that the high scenario adequately allows for future development of the areas.

Based on the projected future urban demands in the Reconciliation Strategy studies, the projected demands for the main towns have been updated and extended for Worcester, Ceres Tulbagh, Wolseley, Prince Alfred Hamlet and Rawsonville, as detailed below. De Doorns, Orchard, and Sandhills are excluded as they do not obtain their water from the H10 tertiary.

The WSDPs and IDPs for each municipality were also used in this assessment.

4.1. Breede Valley Local Municipality

The Breede Valley LM IDP for 2022 – 2027 states that the strategic focus for the period of 2020 – 2025 is on providing more opportunities for people to live in better locations with improved conditions. Specifically, the Priority Housing Development Areas will be used for high – density, mixed – use, mixed – income, and mixed – tenure developments. There is also an Informal Settlement Support Plan to enhance and accelerate the upgrading of informal settlements. This IDP report furthermore states the projected population for 2022 is 197 736; however, it does not provide water demands or growth rates for the separate towns/settlements in the LM, which are required for demand projections. The projected growth rate for the whole LM region for 2021 – 2025 is 0.8% per annum. This average value is less than the growth rates projected in the various Reconciliation Strategies which range between 1.0% and 2.5%.

4.1.1. Worcester

According to 2011 Census, the 2011 population was 96 594, and the estimated 2014 population was 102 506. The historical population growth rate was 1.93 % per annum, and the projected population increase was 2.0 % per annum. The growth scenarios considered were 1.0 % (low); 1.5 % (medium) and 2.0 % (high). **Table 4.1Table 4.1: Population data projections for Worcester (based on Worcester Reconciliation Study data, DWS, 2016)** shows the projections of population and the associated urban water demands are shown in **Table 4.2**.

Table 4.1: Population data projections for Worcester (based on Worcester Reconciliation Study data, DWS, 2016)

Year	Population		
	Low	Medium	High
Growth rate	*1.0%*	*1.5%*	*2.0%*
2022	110 999	115 472	120 102
2025	114 363	120 747	127 453
2030	120 196	130 079	140 719
2040	132 772	150 962	171 535
2050	146 662	175 197	209 101
2060	162 007	203 323	254 893
2070	178 956	235 965	310 713
2080	197 679	273 847	378 757

Table 4.2: Worcester gross annual average demand projections (based on Worcester Reconciliation Study data, DWS, 2016)

Gross Annual Average Demand (million m³/annum)			
Year	**Low**	**Medium**	**High**
Growth rate	*1.0%*	*1.5%*	*2.0%*
2022	15.42	16.04	16.69
2025	15.89	16.78	17.71
2030	16.70	18.07	19.55
2040	18.45	20.97	23.83
2050	20.38	24.34	29.05
2060	22.51	28.25	35.41
2070	24.86	32.78	43.17
2080	27.47	38.05	52.63

**Assumptions made: the per capita consumption (pp/d) and the non – revenue water volume (%) remain unchanged*

The 2016 Worcester Reconciliation Strategy Report states that shortfalls were already being experienced during 2014, and these shortfalls were expected to grow to between 4.679 and 10.065 million m^3/annum by 2040. Interpolating the shortfalls for 2020 and 2025, the current (2022) shortfall would be between 1.66 and 2.94 million m^3/annum. However, the 2022 – 2027 IDP states that there is "*sufficient yield from these two resources"* to meet current and future demands (the period for future demands is not provided). The two sources referred to in this report are understood to be the Stettynskloof and Fairy Glen Dams

The IDP refers specifically to the yield available from Stettynskloof and Fairy Glen Dams (i.e., 26 million m^3/a), and not the allocation or actual use. As discussed in **Section 3.2.2.1**, according to the 2016 Reconciliation Strategy study, the total licenced allocation for the town is 11.04 million m^3/annum (10.955 and 0.085 million m^3/annum for Stettynskloof and Fairy Glen Dams, respectively) and both the Reconciliation Strategy study and the 2022 – 2027 IDP list the available combined yield as 26 million m^3/annum. Therefore, it is assumed that the IDP based the statement on sufficient water resources to meet the demand on available yield (i.e., possible resources), as opposed the Reconciliation Strategy study, which is referring to allocation.

Although the 2022 – 2027 IDP states that there are sufficient resources to meet the demand, it does not provide a demand or growth rate for the town.

4.1.2. Rawsonville

The three growth rate scenarios considered for Rawsonville in the 2016 Reconciliation Strategy were 0.5 % (low), 1.0 % (medium), and 1.5 % (high). **Table 4.3** and **Table 4.4** show the extended population and GAAD projections for Rawsonville, respectively.

Table 4.3: Population data projection for Rawsonville (based on Rawsonville Reconciliation Report, DWS, 2016)

Population			
Year	**Low**	**Medium**	**High**
Growth rate	*0.5%*	*1.0%*	*1.5%*
2022	3 524	3 667	3 814
2025	3 577	3 667	3 579
2030	3 667	3 854	4 049
2040	3 855	4 257	4 699
2050	4 052	4 703	5 454
2060	4 259	5 195	6 329
2070	4 477	5 738	7 345
2080	4 706	6 338	8 524

Table 4.4: Rawsonville gross annual average demands (based on Rawsonville Reconciliation Report, DWS, 2016)

Gross Annual Average Demand (million m^3/annum)			
Year	**Low**	**Medium**	**High**
Growth rate	*0.5%*	*1.0%*	*1.5%*
2022	0.373	0.388	0.403
2025	0.367	0.376	0.386
2030	0.376	0.395	0.415
2040	0.396	0.437	0.482
2050	0.416	0.483	0.560
2060	0.437	0.533	0.649
2070	0.459	0.589	0.754
2080	0.483	0.650	0.875

There is no information on the urban water demand or growth rates for Rawsonville in the Breede Valley 2022 – 2027 IDP or WSDP reports.

4.1.3. De Doorns, Orchards and Sandhills

De Doorns, Orchards and Sandhills do not receive water from the H10 tertiary and are therefore not required in this study.

4.2. Witzenberg Valley Local Municipality

The Witzenberg LM Amended IDP for 2017 – 2022 states that one of the four identified key performance areas is the provision for the needs of informal settlements, which include programmes and projects that focus on the provision of bulk infrastructure for urban development (housing projects). The 2022 – 2023 Witzenberg LM IDP states that the historic growth rate for the whole LM was 3.1% per annum (2001 – 2013) and the current rate is 2.0% (up to the start of 2023). The latest Witzenberg IDP (2022 – 2027) states that the future growth rate for the whole LM is 1.6% per annum.

4.2.1. Ceres and Prince Alfred Hamlet

The 2016 Reconciliation Report for Ceres (including Prince Alfred Hamlet) states that the 2011 Census showed a population of 32 728, with an estimated population of 34 223 for 2014 (calculated using the three – monthly water balance data by the Municipality provided to the DWS). A historical population growth rate was calculated to be 1.18% per annum and a future growth rate of 1.55 % per annum was estimated. **Table 4.5** and **Table 4.6** show the population and GAAD projections, respectively, for the low (1.0%), medium (1.5 %) and high (2.0 %) scenarios.

The Witzenberg LM IDP (2022 – 2027) states that the available water from the Ceres Koekedouw Dam will be sufficient to meet the Ceres demand for the next 20 years, with a current demand (Ceres only) of 3.9 million m^3/annum. This estimate does not include the additional available groundwater, which can meet 20% of the GAAD for Ceres. The IDP does not include a projected growth rate for Ceres. However, therefore, the current growth rate for Ceres (2.67%) has been included in **Table 4.5** and **Table 4.6**, based upon the current (2022) usage of 3.9 million m^3/annum.

Table 4.5: Ceres and Prince Alfred Hamlet population data projections

Year	Population			
	Ceres Reconciliation Report			2022 – 2027 IDP
	Low	Medium	High	
Growth rate	*1.0%*	*1.5%*	*2.0%*	*2.67%*
2022	37 059	38 552	40 098	40 900
2025	38 182	40 313	42 552	44 264
2030	40 129	43 428	46 981	50 497
2040	44 328	50 401	57 269	65 721
2050	48 965	58 492	69 811	85 354
2060	54 088	67 882	85 099	111 320
2070	59 747	78 780	103 736	144 881
2080	65 998	91 428	126 453	188 559

Table 4.6: Ceres and Prince Alfred Hamlet gross annual average demand projections

	Gross Annual Average Demand (million m^3/annum)			
Year	Ceres Reconciliation Report			2022 – 2027 IDP
	Low	Medium	High	
Growth rate	*1.0%*	*1.5%*	*2.0%*	*1.6%*
2022	5.172	5.380	5.596	5.596
2025	5.329	5.626	5.939	5.869
2030	5.601	6.061	6.557	6.354
2040	6.187	7.034	7.993	7.447
2050	6.833	8.163	9.743	9.727
2060	7.548	9.473	11.876	10.229
2070	8.339	10.994	14.477	11.988
2080	9.210	12.759	17.647	14.501

**Assumptions made in the Reconciliation study: the per capita consumption (pp/d) and split in service levels remains the same, and the non – revenue water volume (%) remains unchanged*

4.2.2. Tulbagh

As discussed in **Section 3.2.3.3**, the main supply source for Tulbagh's urban demand is the Klein Berg River (inter – catchment transfer). For this reason, no future requirement for Tulbagh was included in this study.

4.2.3. Wolseley

The 2016 Reconciliation Report for Wolseley states that the 2011 Census showed a population of 12 132, with an estimated population of 13 257 for 2014 (calculated using the three – monthly water balance data by the Witzenberg Municipality provided to the DWS). A historical population growth rate was calculated to be 3.00% per annum and a future growth rate is estimated to remain at 3% per annum. **Table 4.5** and **Table 4.6** show the population and GAAD projections, respectively, for the low (1.0%), medium (1.5 %) and high (2.0 %) scenarios.

Table 4.7: Wolseley gross annual average demand projections

Year	Population		
	Wolseley Reconciliation Report		
	Low	Medium	High
Growth rate	*2.5%*	*3.0%*	*3.5%*
2020	15 374	15 830	16 296
2025	17 394	18 351	19 355
2030	19 680	21 274	22 987
2040	25 192	28 590	32 426

Table 4.8: Wolseley gross annual average demand projections

Year	Gross Annual Average Demand (million m^3/annum)		
	Wolseley Reconciliation Report		
	Low	Medium	High
Growth rate	*2.5%*	*3.0%*	*3.5%*
2020	1.43	1.48	1.52
2025	1.62	1.71	1.80
2030	1.83	1.98	2.14
2040	2.35	2.67	3.02

**Assumptions made in the Reconciliation study: the per capita consumption (pp/d) and split in service levels remains the same, and the non – revenue water volume (%) remains unchanged*

Neither the Witzenberg IDP nor the WSDP provided population or water requirement projections for Wolseley.

5. LAND USE

Land use is the way in which the land is used or has been changed and the relevance of this to water use or catchment runoff. This would include, for example, paved area (cities), afforestation, alien vegetation, natural vegetation, and dams. The main land use required for modelling purposes are the two streamflow reduction activities of afforestation and alien invasive plants (AIPs), as they both use a large amount of water and are not indigenous/natural to the catchment area. Each is included in the Pitman Model as a separate module, which generates runoff for a specified area.

Other land use includes dams, lakes, and wetlands.

The data used was based upon the same data sources as used for water requirements, where possible, and additional sources were used. Sources of data for the AIPs included the Breede River Basin Study (DWS, 2003), the BBTS Pre – feasibility and Feasibility studies (DWS, 2012), the DWS WARMS database, and the DWS Dam Safety Register and spatial and satellite imagery including Google Earth.

5.1. Invasive Alien Plants

Since the WARMS database lists only registered users, AIPs are not included. **Table 5.1** shows the comparison of AIP areas.

Table 5.1: Areas of invasive alien plants per quaternary (km^2)

<table>
<tr><th>Quaternary</th><th>WAAS Study</th><th>WR2012</th></tr>
<tr><td>H1AA</td><td rowspan="3">2.40</td><td>0.70</td></tr>
<tr><td>H10B</td><td>0</td></tr>
<tr><td>H10C</td><td>18.10</td></tr>
<tr><td>H10D</td><td>0.00</td><td>12.80</td></tr>
<tr><td>H10E</td><td>0.00</td><td>12.40</td></tr>
<tr><td>H10F</td><td rowspan="6">17.20</td><td>27.00</td></tr>
<tr><td>H10G</td><td>14.40</td></tr>
<tr><td>H10H</td><td>10.40</td></tr>
<tr><td>H10J</td><td>27.10</td></tr>
<tr><td>H10K</td><td>24.10</td></tr>
<tr><td>H10L</td><td>0</td></tr>
<tr><td>Total</td><td>19.60</td><td>147.00</td></tr>
</table>

Upon inspection of the catchment using Google Earth Pro, it was estimated that there is very little alien vegetation in the catchment, and that there has been a decrease since the WAAS study in 2004. Therefore, AIPs have been excluded from this study.

5.2. Afforestation

The WARMS database was used for the determination of afforestation areas within the catchment, and Google Earth was used to verify these areas.

The WARMS database listed three areas of afforestation within the H10 tertiary. Two areas are listed as located in H10C, with allocated volumes of 0.6 million m^3/annum and 0.7 million m^3/annum. However, when plotted using the coordinates in the database, one of these areas (0.06 million m^3/annum) falls outside of H10 and was therefore not considered further. When delineated using Google Earth, the second area (0.07 million m^3/annum) is 2.47 km^2. The third afforestation area is located in H10F (allocation = 0.04 million m^3/annum, and area of 0.61 km^2, according to WARMS). However, when plotted, it falls within the town of Wolseley and was not considered further. Therefore, there was only plausible area in the WARMS database, which was considered suspect owing to the inaccuracies of the other two areas, as well as the discrepancy on Google Earth.

The WAAS and WR2012 datasets showed very different afforestation areas. **Table 5.2** shows the comparison of the different sources of afforestation data.

Table 5.2: Areas of afforestation per quaternary (km^2)

Quaternary	WAAS Study	WR2012	WARMS	Google Earth verification
H10A	1.40	0.00*	0	0
H10B		0	0	0
H10C		0	***	2.47
H10D	0	0	0	0
H10E	0	0	0	0
H10F	6.50	0.00*	0.61**	0
H10G		0	0	0
H10H		0	0	0
H10J		0	0	0
H10K		0	0	0
H10L		0	0	0
Total	**7.90**	**0.00**	**0.16**	**2.47**

** Area was previously greater than zero.*
*** This area falls within Wolseley.*

*** *No area provided, only an allocated volume (0.13 million m³/annum).*

Upon inspection of Google Earth, it was concluded that there is only one small area in H10C (2.47 km²), as per **Table 5.2** above.

5.3. Dams

Using the data sources mentioned in **Section 3**, information on dams were compared to establish the characteristics for each. **Table 5.3** shows all storage and surface areas (at full supply capacity) of the dams within the tertiary catchment. The WAAS dataset was not based on quaternary catchments and the storages are therefore for lumped catchments.

Brandvlei Dam can appear as one large dam on maps or satellite imagery. However, it is two separate dams; Brandvlei Dam (the upstream part of the dam, in H10L) and Kwaggaskloof Dam (downstream, in H40E), which together form the Greater Brandvlei Dam. The different sources used for this study show that WR2012 and WARMS refer to Brandvlei Dam, while the DWS List of Registered Dams shows the 'Greater Brandvlei Dam'. Additionally, Brandvlei Dam was not included in the WAAS Study as it was not part of the study area. Therefore, to make a direct comparison for H10, **Table 5.3** shows the total storage of the catchment excluding and including Brandvlei Dam. **Table 5.4** shows the volumes and surface areas of the main (named) dams within the catchment.

Table 5.3: H10 storage (volume and surface area) per quaternary

<table>
<tr><th rowspan="2">Quat.</th><th colspan="2">List of Reg. Dams</th><th colspan="2">WAAS dataset</th><th colspan="2">WARMS database</th><th colspan="2">WR2012 dataset</th></tr>
<tr><th>Full Supply Capacity</th><th>Full Supply Area</th><th>Full Supply Capacity</th><th>Full Supply Area</th><th>Full Supply Capacity</th><th>Full Supply Area</th><th>Full Supply Capacity</th><th>Full Supply Area</th></tr>
<tr><td>H10A</td><td>6.21</td><td>1.64</td><td rowspan="3">49.54</td><td rowspan="3">15.66</td><td>120.07</td><td>3.58</td><td>14.65</td><td>2.11</td></tr>
<tr><td>H10B</td><td>15.79</td><td>3.70</td><td>49.90</td><td>1.76</td><td>12.56</td><td>1.90</td></tr>
<tr><td>H10C</td><td>34.64</td><td>6.17</td><td>135.90</td><td>11.53</td><td>53.09</td><td>7.61</td></tr>
<tr><td>H10D</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>H10E</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td><td>0</td></tr>
<tr><td>H10F</td><td>2.90</td><td>0.55</td><td rowspan="7">37.34</td><td rowspan="7">6.55</td><td>5.26</td><td>1.55</td><td>8.42</td><td>1.44</td></tr>
<tr><td>H10G</td><td>2.81</td><td>1.10</td><td>9.97</td><td>1.18</td><td>8.90</td><td>2.96</td></tr>
<tr><td>H10H</td><td>1.47</td><td>0.21</td><td>44.58</td><td>2.41</td><td>9.41</td><td>1.53</td></tr>
<tr><td>H10J</td><td>0</td><td>0</td><td>0.02</td><td>0.00</td><td>0</td><td>0</td></tr>
<tr><td>H10K</td><td>15.12</td><td>0.93</td><td>15.02</td><td>0.92</td><td>18.54</td><td>1.80</td></tr>
<tr><td>H10L (excluding Brandvlei Dam)</td><td>-</td><td></td><td>1.24</td><td>0.14</td><td>0.72</td><td>0.33</td></tr>
<tr><td>Total excluding Brandvlei Dam</td><td>78.93</td><td>14.30</td><td>86.88</td><td>22.21</td><td>381.96</td><td>23.07</td><td>126.29</td><td>19.68</td></tr>
<tr><td>Brandvlei Dam (L)</td><td>456.00</td><td>41.10</td><td>n/a</td><td>n/a</td><td>286.04</td><td>24.25</td><td>289.19</td><td>24.49</td></tr>
<tr><td>Total including Brandvlei Dam</td><td>534.93</td><td>55.40</td><td>n/a</td><td>n/a</td><td>668.00</td><td>47.32</td><td>415.48</td><td>44.17</td></tr>
</table>

Units are: Full Supply Capacity: million m^3 and Full Supply Area: km^2

Table 5.4: Dams storage for named dams within H10 (volume and surface area)

Quat.	Dam	List of Reg. Dams		WAAS dataset		WARMS database		WR2012 dataset		Google Earth
		Full Supply Capacity	Full Supply Area	Full Supply Capacity	Full Supply Area	Full Supply Capacity	Full Supply Area	Full Supply Capacity	Full Supply Area	Full Supply Capaicty
H10B	Ben Etive	0.15	0.03	0.15	0.06	-	-	*	*	0.03
H10C	Ceres Koekedouw	17.20	1.07	13.65	1.02	0.16	0.0001	30.50	4.78	0.98
H10B	Rooikloof	0.54	0.16	0.50	0.18	0.54	0.02	*	*	0.15
H10K	Stettynskloof	15.00	0.90	15.39	0.98	14.75	0.09	15.39	1.00	0.82
H10L	Brandvlei (upper)	n/a		n/a	n/a	286.04	2.43	289.19	24.49	22.80
H40E	Brandvlei (lower)	n/a				n/a	n/a	n/a	n/a	14.40
H10L/ H1040E	Brandvlei (total)	456.00	41.10			n/a	n/a	n/a	n/a	37.20

** Not included as a separate dam*

The storage capacities for the dams are reasonably similar, except for Ceres Koekedouw Dam, which shows considerably different capacities for the different data sources. The WR2012 reservoir data indicates that other (unnamed) dams were lumped together with the Ceres Koekedouw Dam, which accounts for the large capacity of this dam. However, the WR2012 dataset shows an incorrect modelling methodology of most of the dams (including the larger dams in the system of Stettynskloof and Brandvlei Dams), which indicates that the WR2012 reservoir data should be considered suspect. However, due to the fact that this is a common error made when using the model, it does not indicate that the other information in the WR2012 database should also therefore be considered suspect. The WARMS data for Ceres Koekedouw Dam is also clearly incorrect. The DWS List of Registered Dams is the most credible information source for reservoir data.

6. SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

The water use within the upper Breede catchment is summarised in **Table 6.1**.

Table 6.1: Summary of water use in the Upper Breed catchment (units are million m3/annum)

Quaternary catchment	Domestic (million m^3/annum)	Irrigation*		Industrial (million m^3/annum)	Total (million m^3/annum)
		km^2	million m^3/annum*		
H10A	0.0	12.0	7.2	0.0	7.2
H10B	0.0	16.6	10.0	0.0	10.0
H10C	5.0	41.7	25.0	1.0	31.0
H10D	0.0	0.0	0.0	0.0	0.0
H10E	0.0	0.0	0.0	0.0	0.0
H10F	2.0	37.4	22.4	0.0	24.4
H10G	0.30	85.1	51.1	0.0	51.8
H10H	12.7	29.1	17.5	0.0	30.2
H10J	0.0	4.6	2.8	0.0	2.8
H10K	0.0	6.6	4.0	0.0	4.0
H10L	0.0	0.4	0.2	0.	0.2
Total	**20.0**	**233.5**	**140.1**	**1.0**	**161.6**

**Preliminary estimate based on 6 000 m^3/ha/annum*

While there are large discrepancies between the various sources of information on irrigation water requirements and water allocations, this study has made use of a previously overlooked source, namely that of the DoA. The DoA GIS shapefile shape and linked database provide very detailed irrigation areas together with crop types and irrigation systems being applied. This data source was compared with Google Earth in a test catchment and found to be very accurate. With this information it will be possible to accurately estimate actual water with the aid of an irrigation model. This will be done as part of the Hydrological Modelling task. A preliminary estimate of the irrigation requirements expressed as a volume is given in **Table 6.1** based on an application rate of 6 000 m^3/ha/annum which is the application rate currently applied to irrigation boards in the Breede River catchment (Rossouw, 2022).

While recent domestic use records were not forthcoming from municipalities, the BGCMA or the WSDPs, reasonable estimates of current domestic were obtained from the Reconciliation Strategy studies (DWS, 2016). Since domestic use is only a small percentage of the total use, theses estimated are adequate for the purpose of this study.

The lack of observed water use within the Breede River catchment is a concern. Legislation has been passed requiring users to measure their water use but it is not clear which organisation (if any) is collecting this data. It is recommended that a central database be developed to store and disseminate this information. This will greatly facilitate planning and management of the available water resource.

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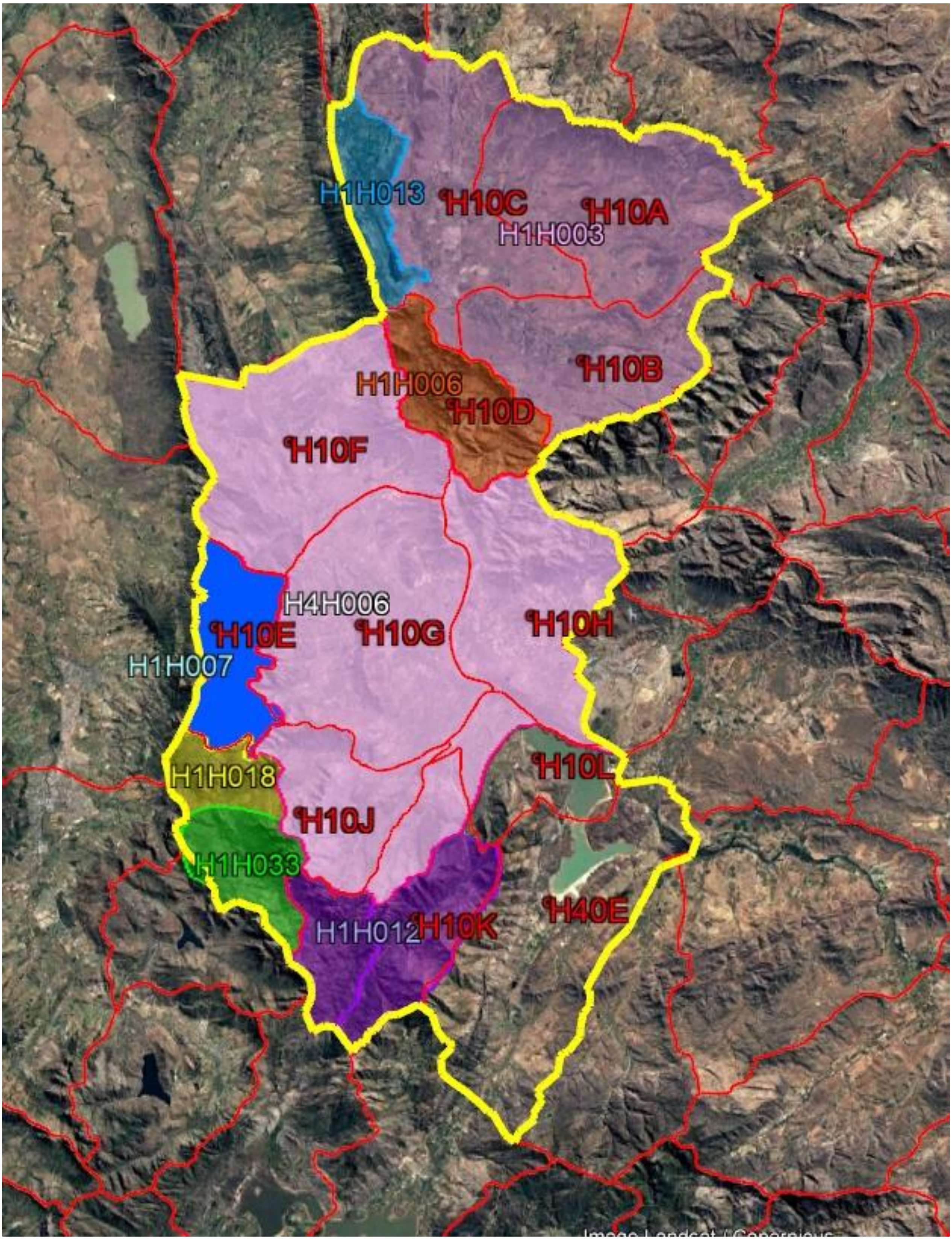
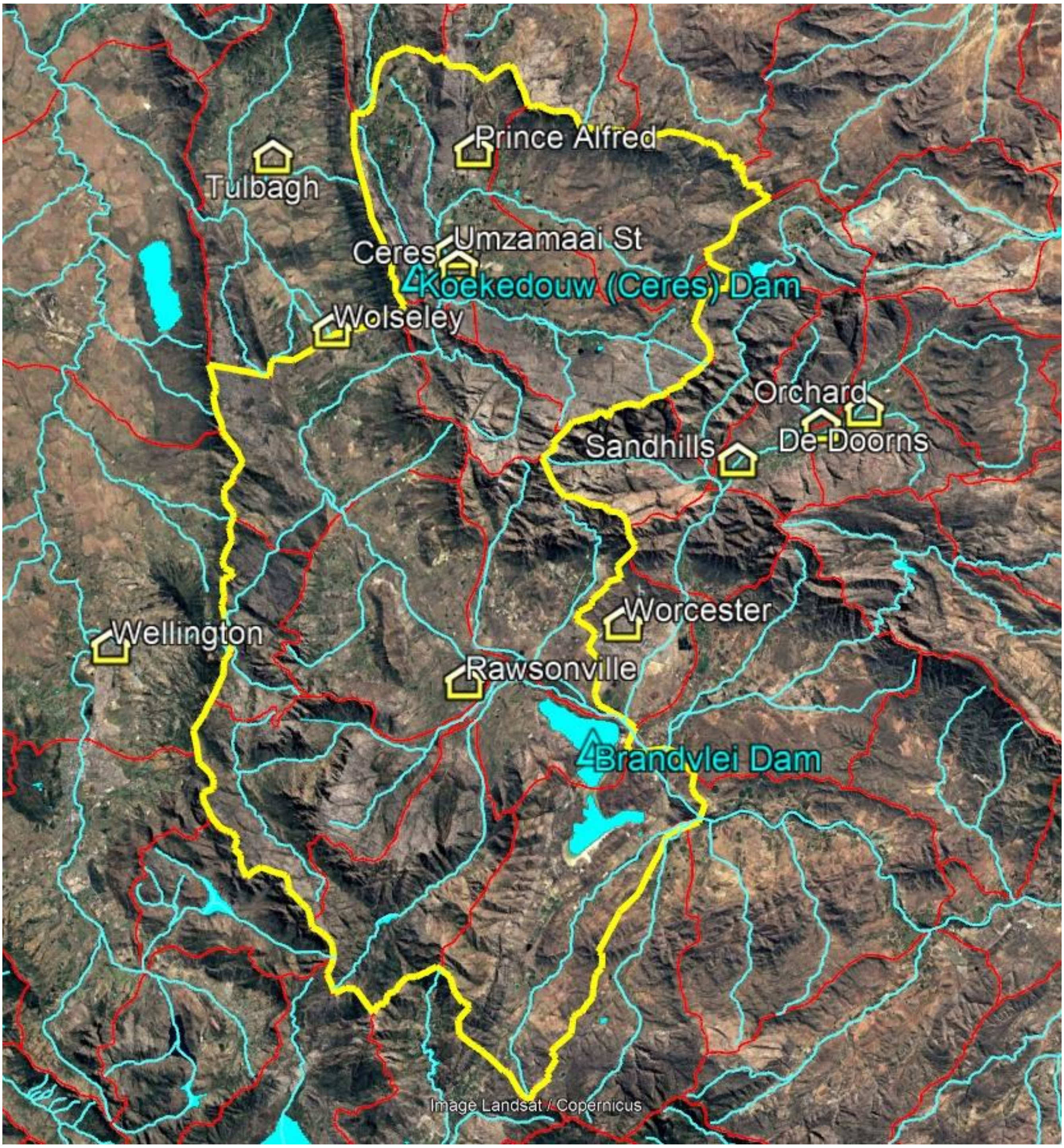
APPENDICES

APPENDIX 1: H10 CATCHMENT MAP SHOWING QUATERNARY CATCHMENTS (RED) AND WAAS STUDY CATCHMENTS (COLOURED)

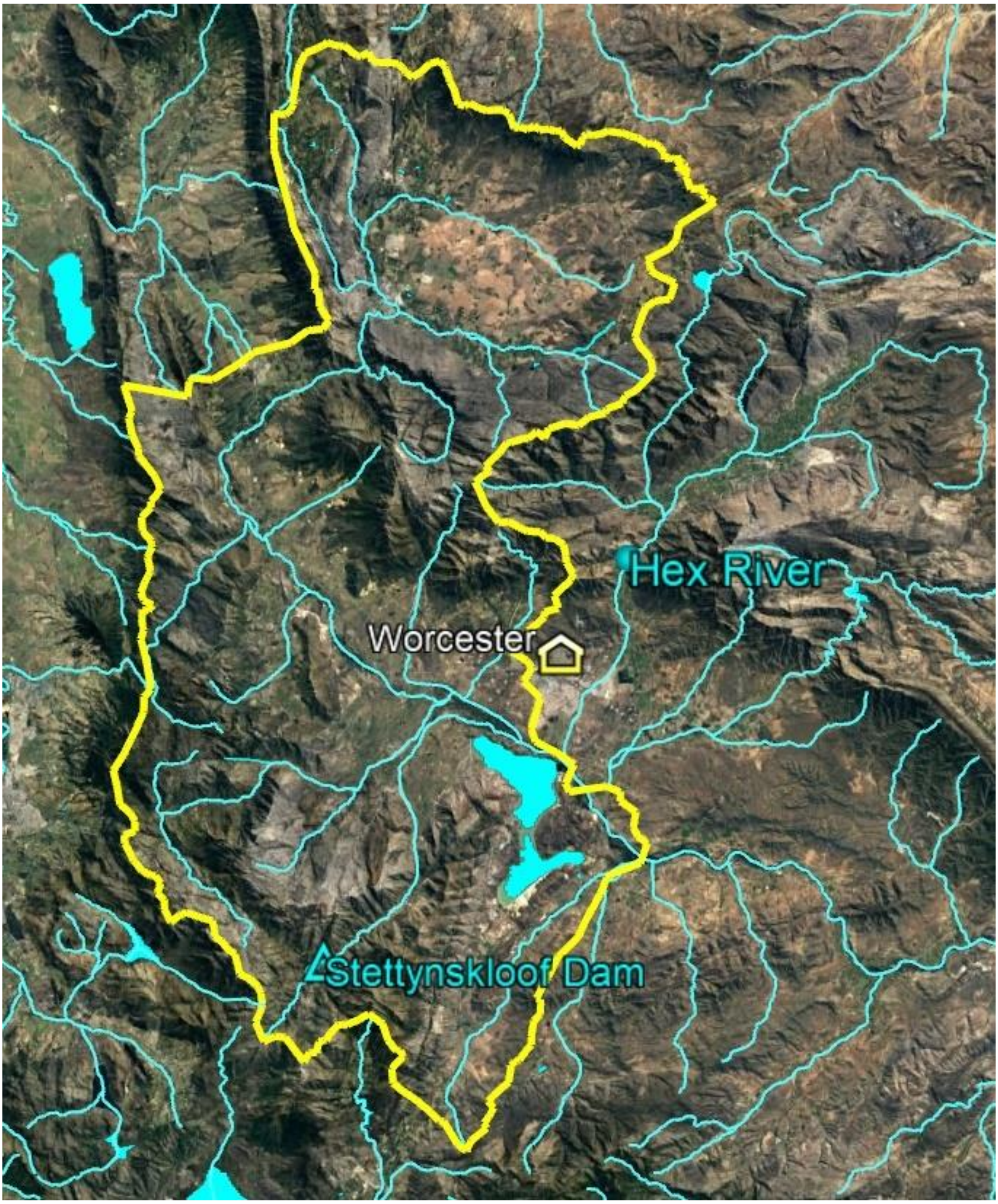


APPENDIX 2: LOCATION OF TOWNS

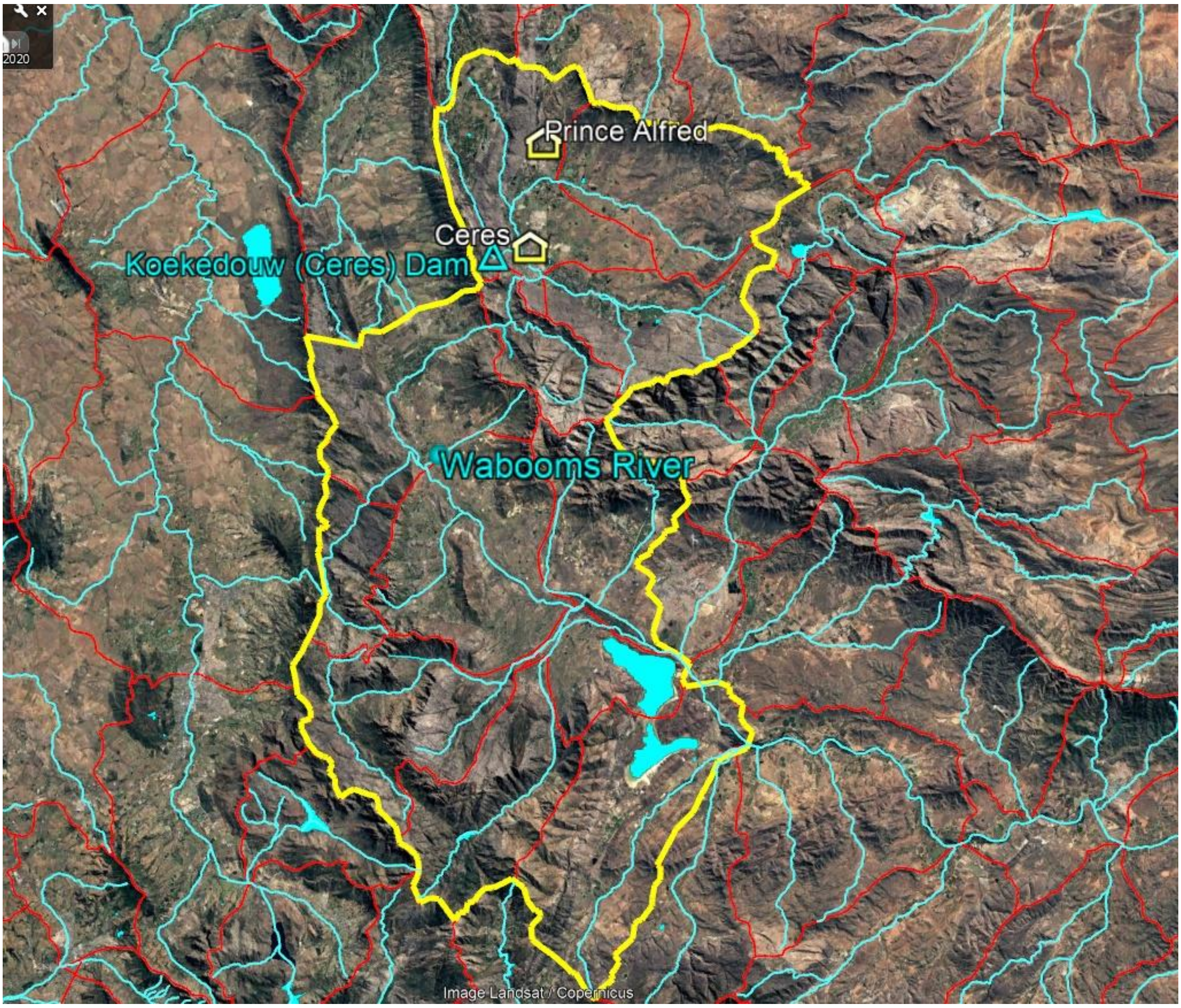


APPENDIX 3: MAIN TOWNS WITH ASSOCIATED URBAN WATER SUPPLY SUPPLY SOURCES

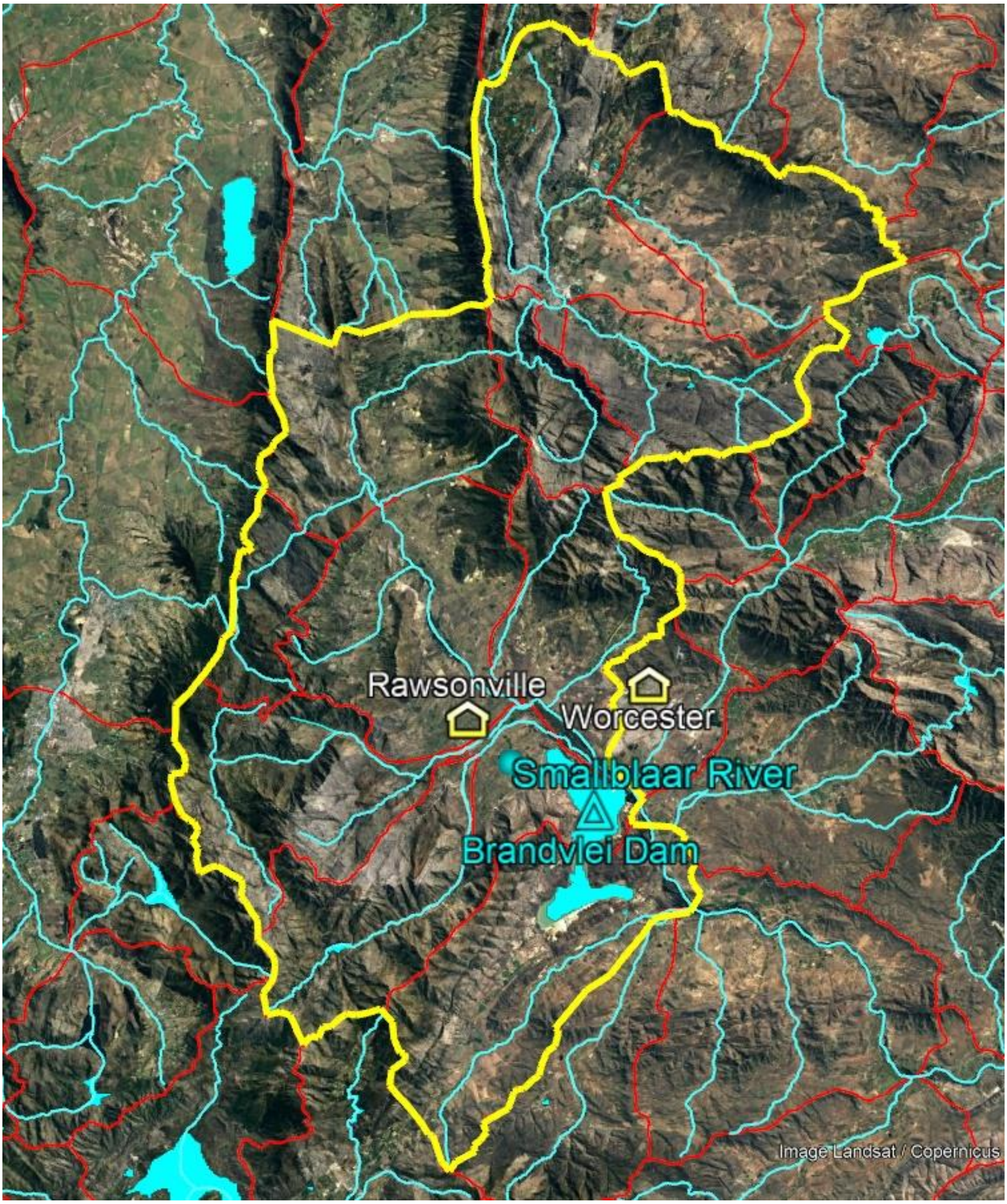
Worcester Urban Demand Surface Supply Sources



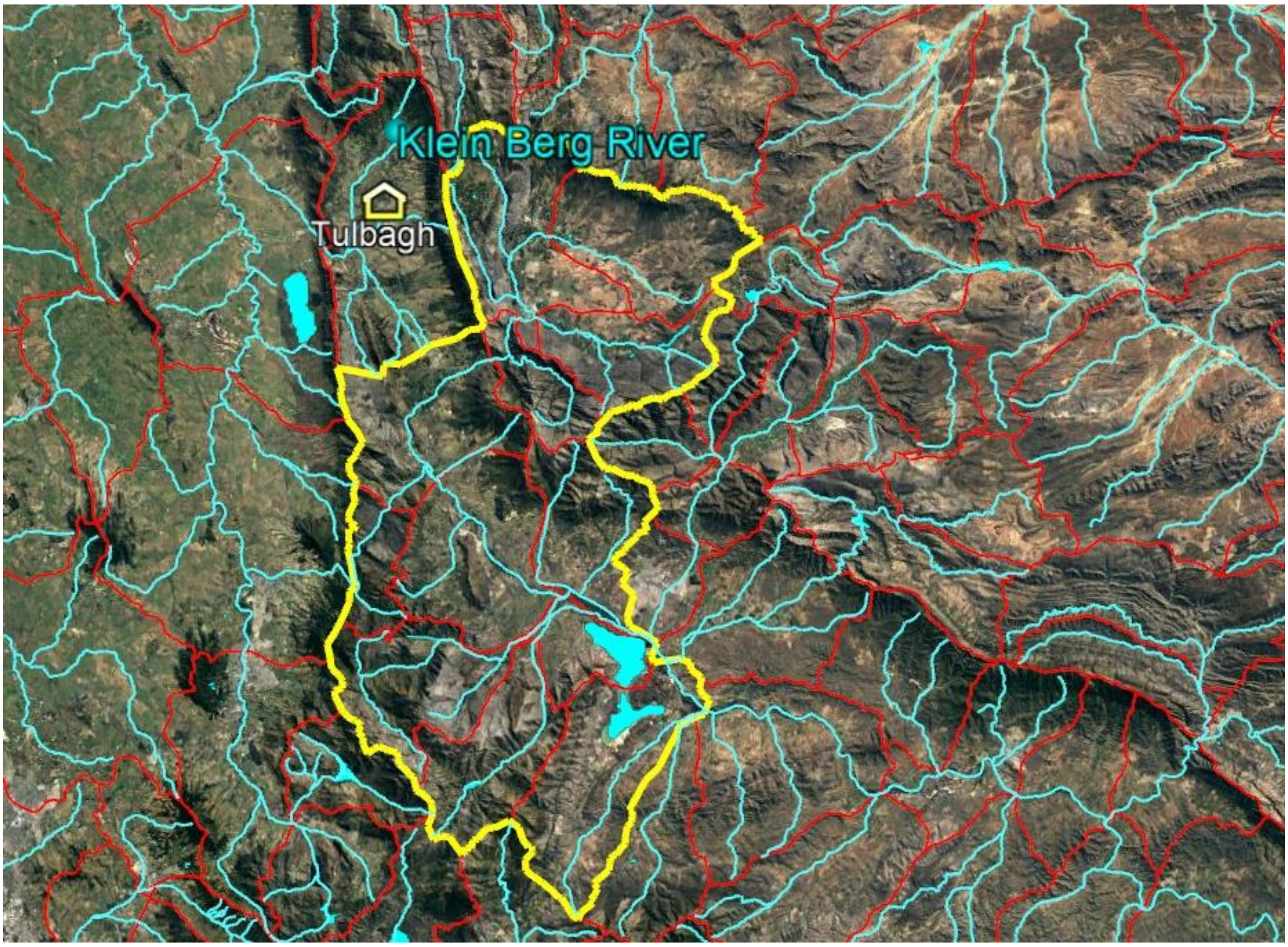
Ceres and Prince Alfred Hamlet Urban Demand Surface Supply Sources



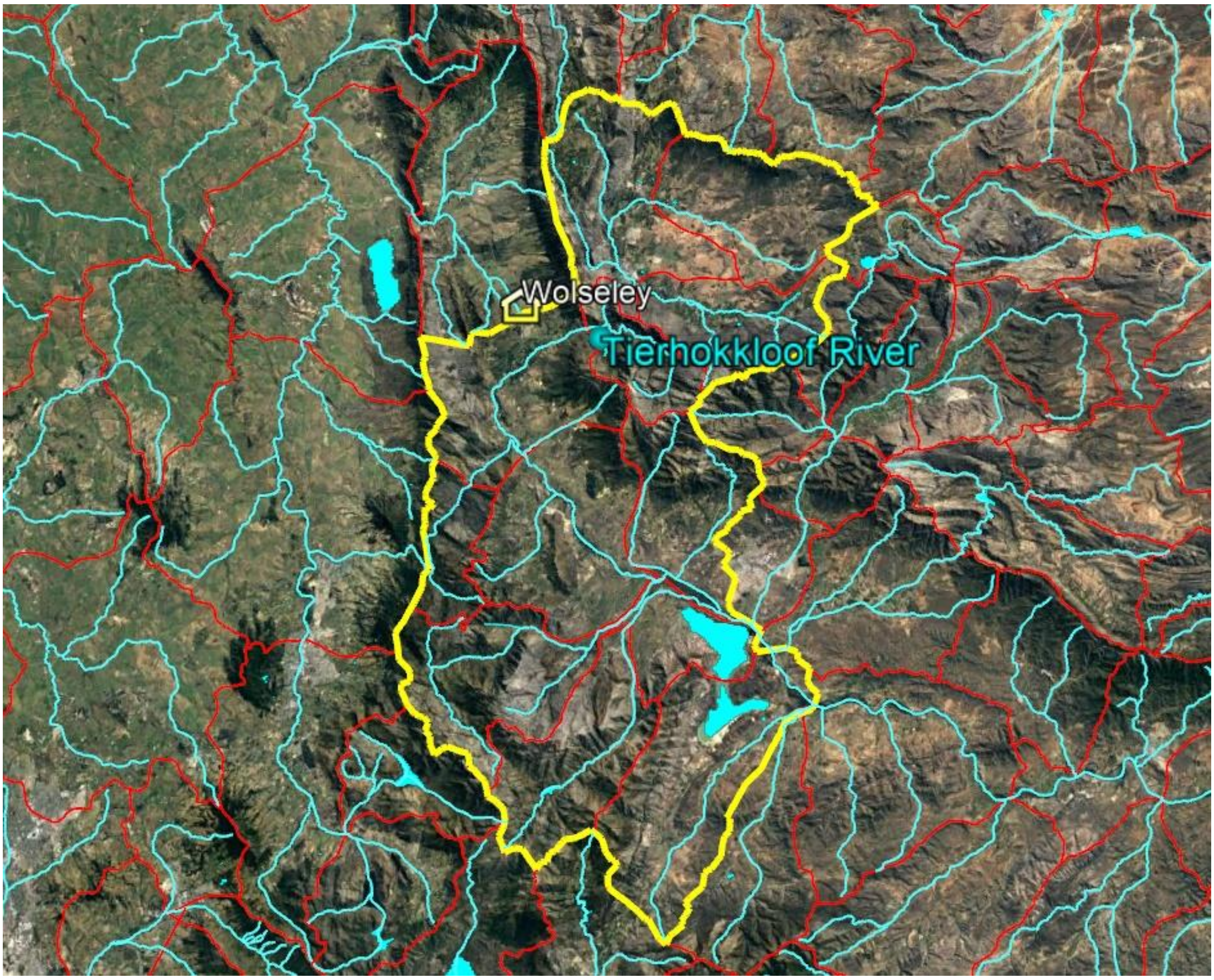
Rawsonville Urban Demand Surface Supply Sources



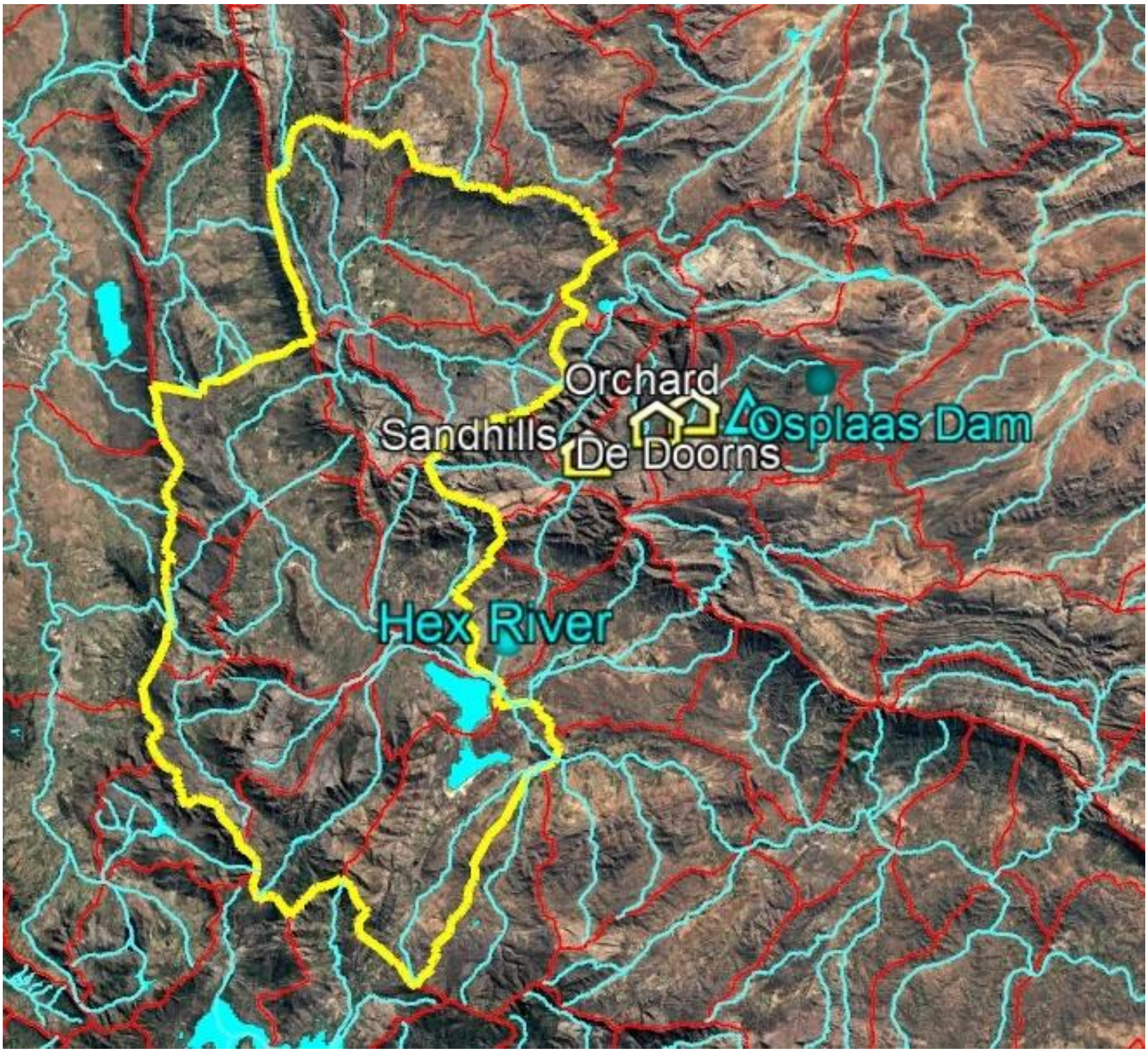
Tulbagh Demand Surface Supply Sources



Wolseley Urban Demand Surface Supply Sources



De Doorns, Orchard, and Sandhills Urban Demands Surface Supply Sources



APPENDIX 4: WARMS H10 AFFORESTATION