Hydrological Assessment for a Proposed Dam on Portion 17 of Farm 232 Redford, The Crags, Western Cape.

FINAL REPORT

For:

Ecosense/Blue Pebble

By:

Dr. J.M. Dabrowski

Confluent Environmental

June 2022

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10 June 2022

EXECUTIVE SUMMARY

This report summarises the hydrological yields to a dam located on Portion 17 of Farm 232 Redford for the purposes of a WULA. The dam will be constructed to store water for the irrigation of 28 ha of macadamia trees under drip irrigation on Portions 12, 15 and 17 of Farm 232. The main findings can be summarised as follows:

- The mean estimated irrigation requirements for 28 ha of macadamia trees under drip irrigation is approximately 81 000 m^3 per annum, with maximum demand reaching up to 116 000 m^3.
- A catchment modelling exercise indicates that the furrow system (50 000 m^3 per annum) and surface runoff from the immediate catchment area (12 200 m^3 per annum) of the dam is expected to yield a combined average of 62 200 m^3 per annum. This estimate assumes that all flow from the river below 0.078 m^3/s is directed into the furrow and also does not consider transmission losses along the furrow system. This scenario is therefore likely to over-predict flows from the furrow into the dam.
- Flows measured by a user on the furrow suggest that actual flows produced by the furrow may be as much as 50 % lower than predicted by the modelling approach adopted in this study (i.e. a mean annual flow of approximately 25 000 m^3). This implies that more of the instream flow volumes bypass the furrow than estimated by the modelling approach adopted in this study. Transmission losses along the pipeline and furrow system are also likely to be significant. The WRSM/Pitman flow output values were therefore decreased by 50 % to approximate actual measured flow volumes.
- The combined furrow allocations and surface runoff from the catchment area will be insufficient to meet the irrigation requirements for 28 ha of macadamia trees and the deficit in mean annual irrigation requirements will need to be supplied by a borehole.
- An annual average abstraction of 69 000 m^3 from the borehole in addition to the estimated 12 200 m^3 from the catchment area of the dam and the furrow allocation will be sufficient to meet the mean annual irrigation demands of the trees such that irrigation requirements will be met 95 % of the time.
- Based on a detailed monthly water balance based on weather data covering a 50-year period, a dam size of 70 000 m^3 is expected to be sufficient to ensure security of supply over the long term, even under drought conditions. Lower dam volumes will result in monthly irrigation deficits occurring for drier months, resulting in maximum irrigation deficits of up to 22, 48 and 61 % for a 60 000 m^3, 50 000 m^3 and 40 000 m^3 dam, respectively.
- Assuming all instream flows are captured by the dam, flows to the catchment immediately downstream of the dam would be reduced by approximately **25 %**. The impact on the reserve of the stream reach immediately below the dam is considered to be negligible as it is a non-perennial river that receives intermittent flow following rainfall events. The stream reach is not anticipated to host diverse aquatic biota that are dependent on regular instream flows. The primary function of the stream reach is to therefore deliver flows to more seasonal and perennial watercourses downstream. The impact on the reserve of the larger catchment area immediately below the dam is expected to be low, as **75 %** of the catchment area remains un-impounded and can therefore still generate runoff to the larger stream network.

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1 INTRODUCTION

1.1 Project Background

Applicants are in the process of developing the farm for the cultivation of various crops, including macadamia orchards. The storage of water is necessary for the sustainable irrigation of the crops, for purposes of which a storage dam on Portion 17 is intended. The dam will store water derived from surface and ground water resources on Portions 12, 15 and 17. Initial clearing and excavation works have been suspended pending the necessary authorization of the storage dam, which forms part of a multiple WULA (s 21 (a) (taking of ground water), (b), (c) and (i)). To determine the desired size of the storage dam for optimal irrigation of 28 ha under drip, a hydrological assessment has been undertaken, the outcome of which is summarized in this report.

1.2 Scope of Work

The scope of work for this report includes the following:

- Assess the yield of surface water flows available in the immediate catchment of the dam;
- Assess the yield of surface water flows that enter the furrow system and estimate the volume of water that can realistically be derived from the furrow system;
- Estimate the irrigation requirements of the proposed macadamia plantation and determine whether the surface water yield is sufficient to meet these requirements; and
- Develop a water balance for the dam and estimate the size of the dam required to meet the irrigation requirements.

1.3 Assumptions & Limitations

- While flow volumes were modelled using a well-established model that has been calibrated for the broader quaternary catchment, there is uncertainty associated with methods used to estimate the proportion of this flow volume that is diverted into the furrow system.
- The Rondebosch River Water User Association (RRWUA) has commenced monitoring daily discharge in the furrow system and provided a limited amount of data which was used to calibrate the model predictions as best as possible.
- Hydrological estimates were based on rainfall data collected from 1920 to 2009. The model therefore provides a good indication of anticipated hydrological flows associated with rainfall records that cover a long time period. The model may however not account for recent shifts in rainfall volumes associated with climate change impacts that may have occurred within the last ten years.

2 METHODOLOGY

Data and model configurations developed as part of the Water Resources of South Africa 2012 (WR2012) Study (Bailey and Pitman, 2016) were used to estimate hydrological flows originating from the catchment areas of the dam and furrow system, respectively. The WR2012 study developed long-term monthly time-step simulated streamflow timeseries for most quaternary catchments throughout South Africa. The timeseries represent the volume of water discharged from each quaternary catchment over a 90-year time period (i.e. October 1920 to September 2010). The data is produced by the WRSM-Pitman Model which is a rainfall-runoff model that simulates streamflow from long-term monthly rainfall data. As part of the WR2012 Study, the outputs of the model were calibrated against real-time measured hydrological data collected from streamflow gauging stations located throughout the country. The WR2012 therefore provides the most comprehensive database of the estimated flow volumes for quaternary catchments throughout the country. The WRSM2000-Pitman Model modelled all land and water use activities upstream of the flow gauging stations to estimate the reduction in streamflow due to human development over time. The model can therefore be used to simulate Present-Day (PD) flow conditions over the long-term and to assess the impact of additional activities (e.g. construction of a dam) on hydrological flows over the long term.

For this study the calibrated WRSM2000/Pitman model for the quaternary catchment K60E (as produced by WR2012) was adjusted to reflect the size and land use of the catchment area of the furrow, and then used to simulate the long-term PD flow timeseries to the point at which the furrow diverts water out of the stream. The catchment area of the furrow as well as the immediate catchment area of the proposed dam was determined through a hydrological analysis of a Digital Elevation Model (DEM) for the area. The DEM was obtained from the USGS Earth Explorer website (https://earthexplorer.usgs.gov/).

Based on a field inspection of the aqueduct and according to the RRWUA business plan, the aqueduct is capable of diverting most of the water out of the stream, but will be limited by the maximum conveyance (i.e. the maximum flow rate or discharge) of the aqueduct. The maximum conveyance of the aqueduct was calculated using Mannings formula, and was calculated for an average depth that would result in the aqueduct overflowing at its lowest point of elevation (i.e. prior to discharging into the pipeline):

$$Q = VA = \left(\frac{1}{n}\right) A R^{\frac{2}{3}} \sqrt{S}$$

Where:

Q = Flow Rate, (m^3/s)

v = Velocity, (m/s)

A = Flow Area, (m^2)

n = Manning's Roughness Coefficient (0.023 for a rough channel)

R = Hydraulic Radius, (m)

S = Channel Slope, (m/m)

The aqueduct was constructed from gravel, giving the surface a coarse, rough finish. A Manning's Roughness Coefficient of 0.023 was therefore used in the calculation of the conveyance of the aqueduct. Q (m^3/s) was then converted m^3/month and was used to re-configure the monthly time series produced by the WRSM2000/Pitman model, such that all flow volumes below the maximum monthly conveyance were diverted into the aqueduct (i.e.

the aqueduct is capable of accommodating these flow volumes). Flow volumes that exceeded the maximum monthly conveyance were capped at this maximum monthly conveyance value (i.e. the balance of flow volumes exceeding the maximum monthly conveyance value passed downstream into the river and not into the furrow). Mean monthly furrow volumes were calculated and divided proportionally between the 31 properties so as to determine an estimated allocation per property. These assumptions and calculations are likely to over-estimate the quantity of water diverted into the furrow system for the following reasons:

- It is likely that relatively small quantities of surface flows do bypass the aqueduct which would reduce the estimated flow volumes entering the furrow system. Field observations did indicate that flows did bypass the aqueduct but that these flows are expected to be minor, relative to the total flow volume in the river;
- The maximum conveyance does not take transmission losses (e.g. due to leaks) that are likely to occur along the pipeline;
- The furrow allocation per property does also not take transmission losses that are likely to occur along the open furrow system (e.g. due to leaks and unlined earth sections of the furrow).

In summary, estimated furrow flow volumes and allocations per property are likely to be over-estimated by the WRSM modelling approach. Modelled volumes were therefore compared to flows that had been measured by a landowner on the furrow system. These flows were measured by an ultrasonic water level sensor at a V notch on the eastern furrow.

2.1 Irrigation Requirements

Irrigation requirements were estimated for 28 ha of macadamia under irrigation. The SAPWAT 4.0 model was used to estimate irrigation requirements and the following assumptions were made in the estimation of irrigation requirements:

- Water requirements were estimate for Macadamia under drip irrigation;
- The default setting of 75 % was used for water distribution efficiency; and
- Irrigation scheduling was set to take place when readily available water (RAW) reached 70 %.

3 CATCHMENT CHARACTERISTICS

3.1 Study Site

The proposed dam is located on Portion 17 of Farm 232 Redford in quaternary catchment K60E (Figure 1). This property and two adjoining properties (Portions 12 and 15) are all owned by the landowner and all three properties receive a proportional allocation of water from the Rondebosch Furrow system that supplies 31 properties in total. The furrow allocation for all three properties is planned to be stored in the one dam located on Portion 17 of Farm 232 Redford. The furrow is fed by the Rondebosch River, which drains an intensive commercial forestry area. The delineated catchment area of the furrow is approximately 6.21 km^2 and that of the dam is 0.14 km^2 (Figure 2). This catchment falls within the South-Eastern Coastal Belt ecoregion which is characterised by year-round rainfall and a mean annual precipitation (MAP) of 775 mm. Precipitation occurs throughout the year, but generally peaks from the end of winter into the beginning of summer (August to November).

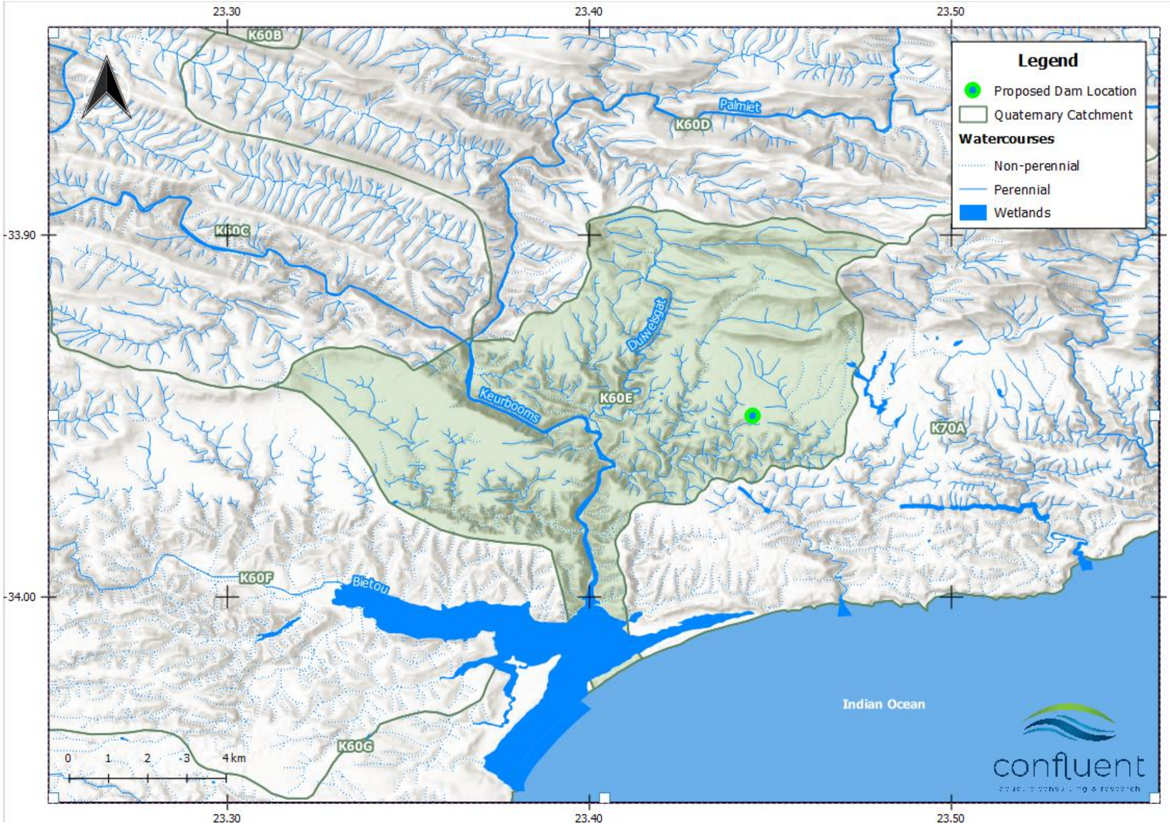

Figure 1: Location of the proposed dam within the context of quaternary catchment K60E.

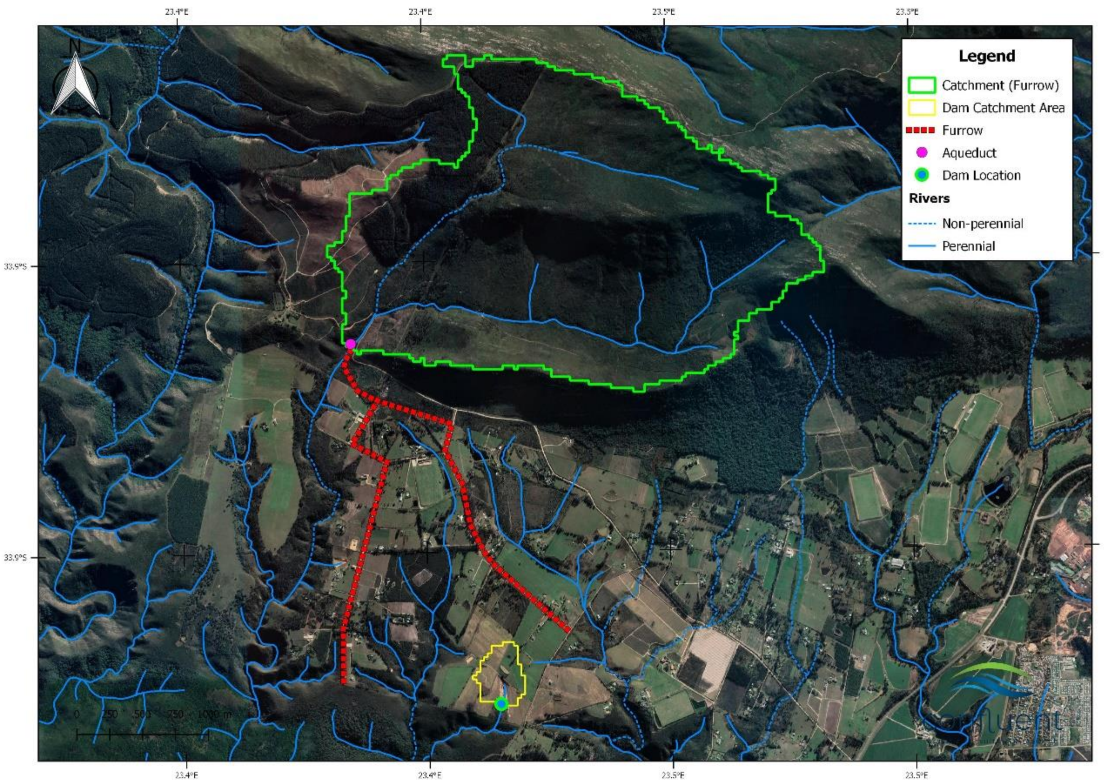

Figure 2: Delineated catchment area of the Rondebosch Furrow (green) and the proposed dam.

3.2 Rondebosch Furrow

The furrow diversion comprises an aqueduct that diverts water out of a natural pool in the Rondebosch River. The aqueduct crosses the river and drains into a 200 mm asbestos pipe which delivers water to a man-made open furrow system. This furrow has three branches that deliver water to the 31 properties included in the Rondebosch River Water User's Association (RRWUA). Each property has a splitter box at the property boundary from where the water allocation is diverted and controlled to the property by means of a splitter plate. The water runs continuously, and no specific times are allocated for individual extraction. Unused water returns to the system at the end of each furrow. According to information obtained from the RRWUA the furrow can take all of the water out of the Rondebosch River. The aqueduct and associated furrow system was constructed in 1906. Based on the National Water Act (NWA), the diversion of water out of the river by the aqueduct is therefore considered an Existing Lawful Use (ELU).

Figure 3: Photograph of the aqueduct that diverts water out of the Rondebosch River and into the furrow system.

3.2.1 Water Users

According to the RRWUA the total area supplied by the furrow is 400 ha. A variety of activities take place on properties including a polo field, horse breeding, cattle breeding, bird breeding, plant nurseries, compost production, honeybush tea production and macadamia and grape growers. All operations are generally small scale requiring limited irrigation. The main use of the water is domestic and most property owners have their own system of purification and a small dam where water is stored. All water used for irrigation comes from the direct water allocation to the member that has been stored.

4 WATER RESOURCES DEVELOPMENT PLAN

4.1 Water Source Analysis - Catchment

Graphs showing the results of the hydrological flow modelling are presented in Figure 4 to Figure 6. Annual flow volumes up to the point of the aqueduct are highly variable ranging from just over 200 000 m^3 to 1 800 000 m^3 per annum with a mean annual runoff (MAR) of 540 000 m^3/annum. This represents approximately 11.2 % of the MAP. While rain typically does fall throughout the year, results show that runoff is highly seasonal with the majority of occurring during spring from August up until November. January through to April represents the low flow period.

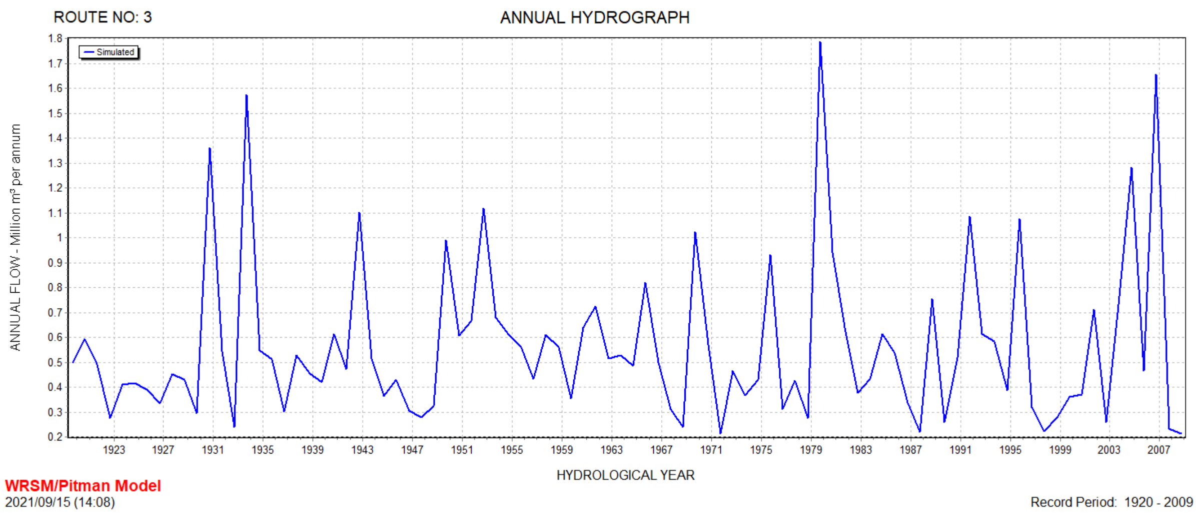

Figure 4: Annual hydrograph of the catchment area of the Rondesbosch furrow.

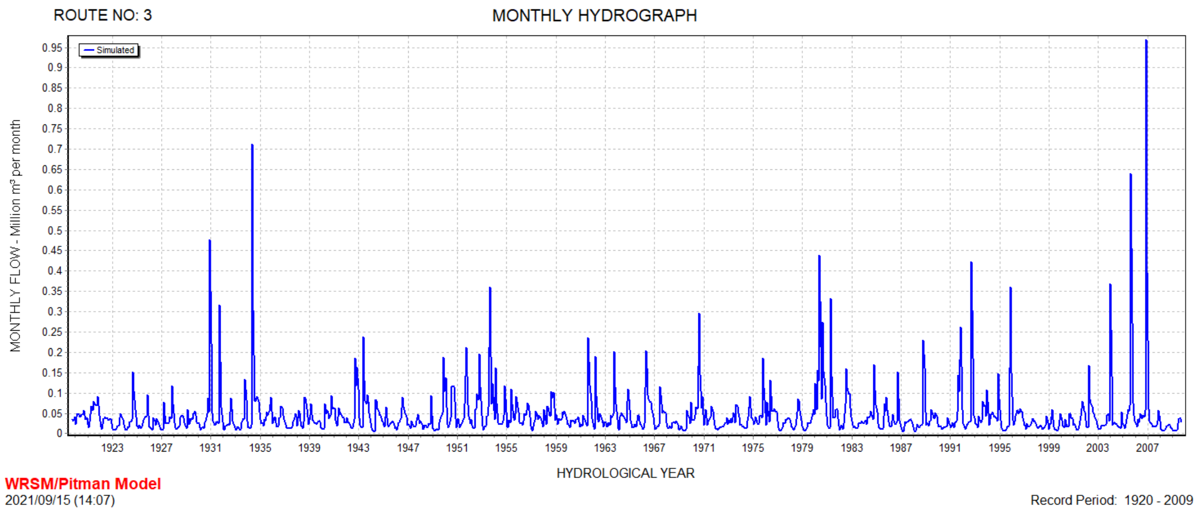

Figure 5: Monthly hydrograph of the catchment area of the Rondesbosch furrow.

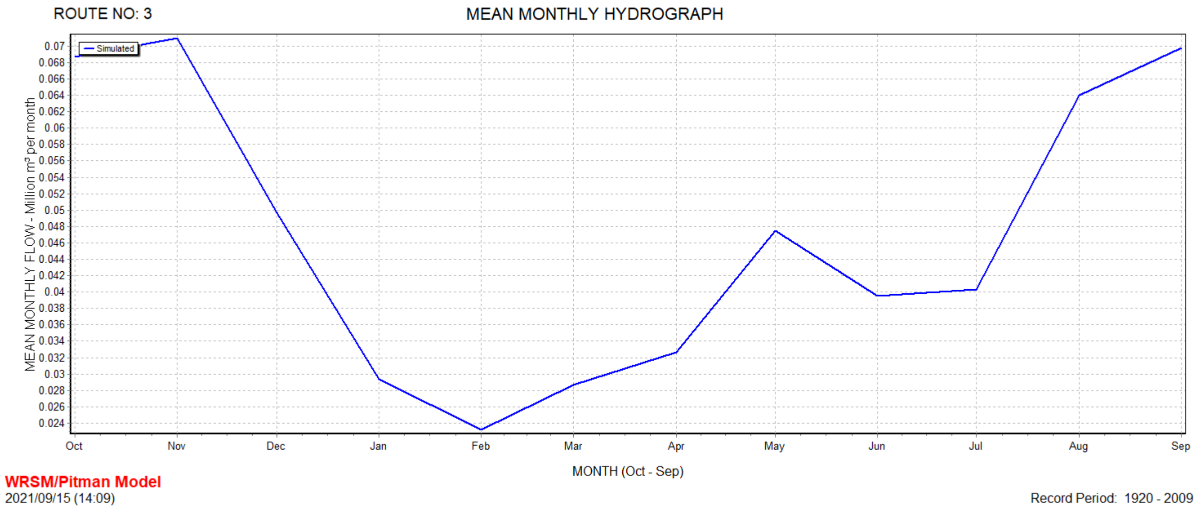

Figure 6: Mean monthly hydrograph of the catchment area of the Rondebsoch furrow.

4.2 Water Source Analysis – Furrow

The dimensions of the aqueduct are presented in Table 1. Based on these parameters the maximum conveyance was calculated as 0.078 m^3/s (or approximately 200 000 m^3/month). The monthly time series generated by the WRSM Model was then reconfigured for the furrow diversion, ensuring that for every month of the time-series, no more than 200 000 m^3 was diverted out of the river. Based on this analysis, the mean annual volume of water diverted out of the river was estimated at approximately 520 000 m^3, which represents 93 % of the mean annual runoff of the furrow catchment area. The furrow therefore does divert the majority of flow out of the river.

Table 1: Dimensions of aqueduct diverting water out of the Rondebosch River.

Parameter	Dimensions
Length	10.4 m
Width	0.6 m
Maximum height	0.13 m
Slope	0.014
Manning coefficient	0.023
Maximum Conveyance	0.078 m^3/s

Mean monthly flow volumes diverted into the furrow system are presented in Table 2. Based on this analysis, the mean annual allocation volume per property is approximately 16 792 m^3/annum. Assuming the dam on Portion 17 of Farm 232 Redford will store allocations for three properties, the mean annual volume allocation for storage would be approximately 50 377 m^3/annum. This volume does not take transmission losses that are likely to occur along the length of the furrow system into account.

Table 2: Estimated mean monthly flow volumes diverted out of the Rondebosch River and into the furrow.

Month	Furrow	Furrow Allocation per Property (m^3)	Furrow Allocation to Portion 17 of Farm 232 (m^3)
Oct	67 689	2 184	6 551
Nov	60 633	1 956	5 868
Dec	42 533	1 372	4 116
Jan	29 144	940	2 820
Feb	23 189	748	2 244
Mar	28 678	925	2 775
Apr	31 144	1 005	3 014
May	38 767	1 251	3 752
Jun	38 289	1 235	3 705
Jul	40 378	1 303	3 908
Aug	55 022	1 775	5 325
Sep	65 100	2 100	6 300
TOTAL	**520 567**	**16 792**	**50 377**

4.2.1 Measured Flows

According to measurements taken by a landowner on the furrow system, the following flows are typical of the furrow system:

- Normal baseflow: Approximately 18 000 litres per day.
- 30 mm rain: Approximately 30 000 litres per day.
- 70 mm rain: Approximately 80 000 litres per day.

Minimum flows would therefore result in inflows of approximately 6 480 m^3 per property per year or almost 20 000 m^3 per year for Portion 17 (assuming it receives the allocation for three properties). Measured baseflows are approximately half of the modelled baseflow volumes and would suggest that the volume of water that bypasses the furrow together with transmission losses are significantly greater than assumed by the modelling approach adopted in this study. Based on these measurements, WRSM/Pitman estimates were calibrated to resulting in mean monthly flows as presented in Table 3.

Table 3: Mean monthly flows estimated from the furrow allocation (calibrated to measured flows).

Month	Furrow Allocation (m^3)
Oct	3 275
Nov	2 934
Dec	2 058
Jan	1 410
Feb	1 122
Mar	1 388
Apr	1 507
May	1 876
Jun	1 853
Jul	1 954
Aug	2 662
Sep	3 150
TOTAL	**25 189**

4.3 Water Source Analysis – Dam Catchment Area

Based on a catchment area of 0.14 km^2 and a MAR of 11.2 % (as estimated by the WRSM/Pitman model for the broader catchment area) the mean annual runoff contributed from the direct catchment area of the dam is approximately 12 200 m^3 per annum. Mean monthly flows as estimated by the WRSM/Pitman model are presented in Table 4.

Table 4: Mean monthly surface flows from the catchment area of the dam

Month	Surface Runoff from Catchment (m^3)
Oct	1 587
Nov	1 421
Dec	996
Jan	683
Feb	543
Mar	672
Apr	730
May	909
Jun	897
Jul	946
Aug	1 289
Sep	1 526
TOTAL	**12 200**

4.4 Water Requirements Analysis

Estimated annual irrigation requirements over a 50-year simulation period (taking rainfall and other weather data for the catchment into account) are presented in Table 5 and Figure 7.

Average irrigation demand per annum is approximately 80 500 m^3 per annum, with maximum demand increasing up to 116 000 m^3 during below average rainfall periods.

The total average annual irrigation requirements cannot be met by surface water volumes derived from the furrow and the immediate catchment area of the dam. Supplemental irrigation from a borehole will therefore be required. According to the geohydrological report the sustainable yield of the borehole drilled for this purpose is 69 000 m^3/annum or approximately 5 750 m^3/month (Stroebel, 2021). The borehole is limited by this yield and no more than 5 750 m^3 can be abstracted from the borehole on a monthly basis. The borehole, together with surface flows from the catchment and furrow (total of approximately 106 000 m^3) is therefore capable of providing sufficient water required to meet the mean annual irrigation requirements and up to a 5 % exceedance probability (i.e. only 5 % of the years had an irrigation requirement higher than 106 000 m^3) (see Table 5). Irrigation demand frequently exceeds the quantity of water that can be supplied by the surface and groundwater resources and storage is therefore required to ensure assurance of supply during deficit months. This is particularly relevant in drought conditions when irrigation requirements are higher while water availability is lower.

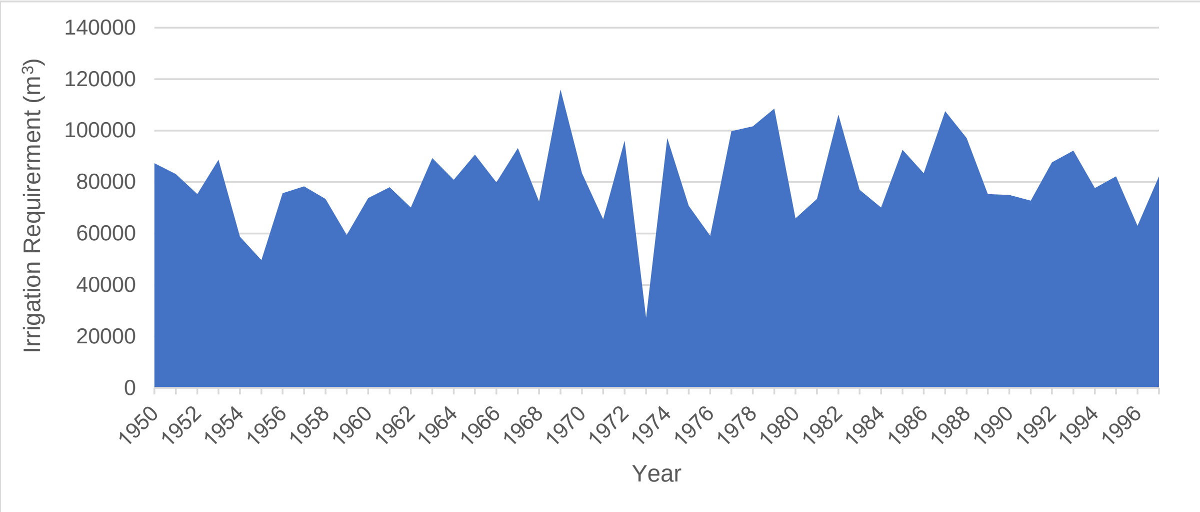

Figure 7: Graph showing annual irrigation requirements over a 50-year period.

Table 5: Long-term estimated irrigation requirements for 28 hectares of macadamias.

	Irrigation Requirements								Mean Monthly Water Supply (m^3)			
Month	**Max**	**95 %**	**75 %**	**Median**	**25 %**	**5 %**	**Min**	**Average**	**Furrow Allocation**	**Runoff from Catchment**	**Borehole**	**Total**
October	16240	16240	8120	8120	0	0	0	6259	3 275	1 587	5 750	13 888
November	24360	16240	16240	8120	8120	0	0	9304	2 934	1 421	5 750	13 039
December	32480	24360	16240	16240	8120	8120	0	13364	2 058	996	5 750	10 862
January	32480	24360	16240	16240	8120	8120	0	15394	1 410	683	5 750	9 253
February	24360	21518	16240	8120	6090	0	0	9473	1 122	543	5 750	8 573
March	16240	16240	8120	8120	0	0	0	6598	1 388	672	5 750	9 197
April	16240	13398	8120	4060	0	0	0	4568	1 507	730	5 750	9 494
May	18514	12976	10150	7795	4385	763	325	7267	1 876	909	5 750	10 411
June	8120	0	0	0	0	0	0	338	1 853	897	5 750	10 352
July	8120	8120	0	0	0	0	0	1523	1 954	946	5 750	10 604
August	16240	8120	8120	0	0	0	0	3045	2 662	1 289	5 750	12 364
September	16240	16240	8120	0	0	0	0	3383	3 150	1 526	5 750	13 576
Annual	**115953**	**107054**	**91025**	**79088**	**72764**	**58902**	**62600**	**80516**	**25 189**	**12 200**	**69 000**	**106 389**

4.5 Water Balance & Dam Sizing

Establishment of macadamia orchards represents a significant financial investment. Establishment costs of the orchards are approximately R 200 000/ha. At 10-12 years age, the orchards are expected to yield 3 tonnes/ha at a return of R 300 000/ha. As such security of water supply, particularly during below average rainfall conditions is critical for protection of the investment.

A detailed monthly time series water balance was therefore compiled to determine the volume of storage that is required to ensure assurance of supply covering the full range of expected climatic conditions over a 50-year period. The SAPWAT model was used to produce monthly irrigation requirements using weather data (supplied with the model) covering the period from 1950 to 2000 (i.e. a 50-year period). The water balance estimated the dam volume at the end of each month taking the following into consideration:

- Four different maximum storage volumes were simulated (40 000, 50 000, 60 000 and 70 000 m^3). The maximum storage volume was defined such that the stored volume at the end of each month could not exceed this volume;
- The starting balance at each month comprised of the volume of stored water from the preceding month, and incoming monthly surface water flows (i.e. from the furrow and the immediate catchment area of the dam) and the monthly supply from the borehole (which is also stored in the dam);
- The monthly time series of furrow allocation and surface runoff from the catchment was derived using the output of WRSM/Pitman model (calibrated according to measured flows);
- As a proportion of the water supply will need to be abstracted from a borehole it was important to run scenarios that included storage of borehole water. *The water balance assumed that borehole water could only be abstracted up to the recommended maximum monthly yield as indicated in the geohydrological report (i.e. 5 750 m^3/month). Storage of borehole water is therefore justified in that the monthly irrigation demands of the macadamias will frequently exceed the sum of surface inflows (from the catchment and furrow) and the maximum monthly volume that can be sustainably abstracted from the borehole. Storage of borehole is therefore required to ensure that there is sufficient water available during high irrigation demand periods*;
- The balance at the end of each month was calculated by subtracting the evaporative loss from the dam and the irrigation requirement for the month from the starting balance;
- The evaporative loss for each month was estimated based on the monthly evaporation and the surface area of the dam. The surface area was estimated for each month according to the following equation (Murray, 2004):

$$A = A_{max}(V/V_{max})^{0.6}$$

Where:

A = surface area (m^2) to be determined a volume V;

A_{max} = surface area (m^2) at maximum capacity (10 000 m^3)

V = volume (m^3) for which A is to be determined

V_{max} = volume (m^3) at maximum capacity (70 000 m^3)

The objective of the monthly time series water balance is therefore to ensure that there is sufficient storage so as to ensure assurance of supply (i.e. zero deficit) over the entire period of the time series. Negative monthly balances imply that irrigation demands for the month exceed the total volume of water available for the month (i.e. combined volume of water stored in the dam together with incoming surface water flows and borehole allocation for the month).

Simulations show that a dam storage volume of 70 000 m^3 in combination with an annual borehole abstraction of 69 000 m^3 (i.e. approximately 5 750 m^3 per month), will be sufficient to ensure assurance of supply over the simulation period, even under extreme dry conditions (Figure 8). Lower dam volumes would result in some months going into an irrigation deficit (Figure 9 to Figure 11). While the number of months in deficit is relatively low (e.g. up to 5 % of the months over a 50-year simulation period for a 40 000 m^3 dam), the maximum irrigation deficit for a given month is relatively high (e.g. 48 % and 61 % for a 50 000 m^3 and 40 000 m^3 dam, respectively) (Table 6), which presents a risk to high value crops such as macadamia trees. Given the constraints on borehole abstraction, a 70 000 m^3 dam is the only size that would guarantee 100 % assurance of supply over the simulation period.

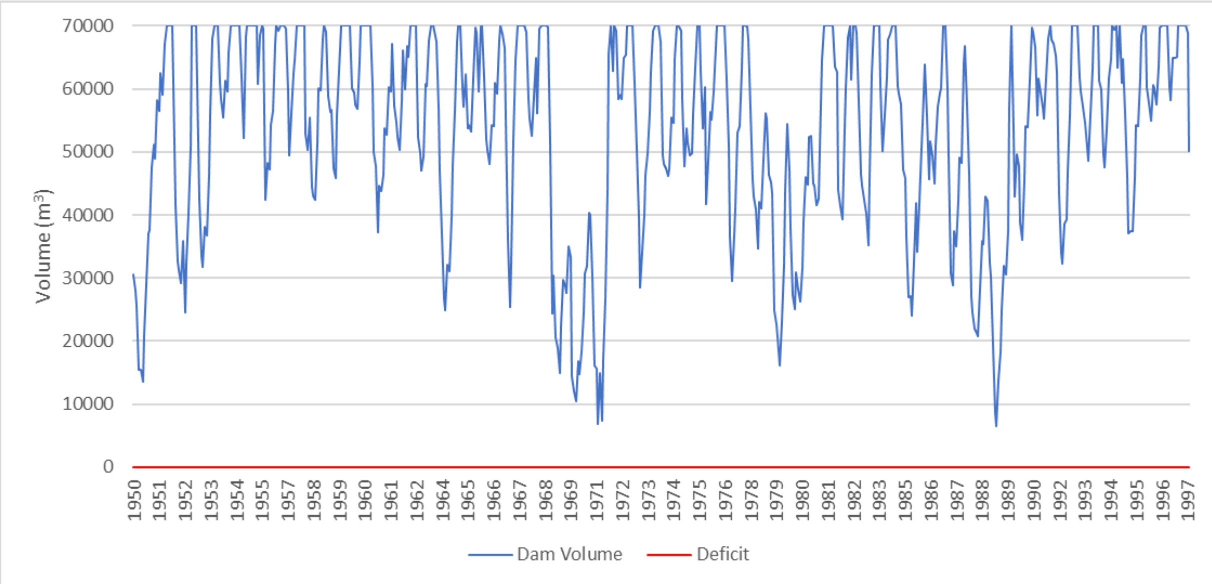

Figure 8: 50-year simulation with a 70 000 m^3 dam and 5 750 m^3/month borehole abstraction.

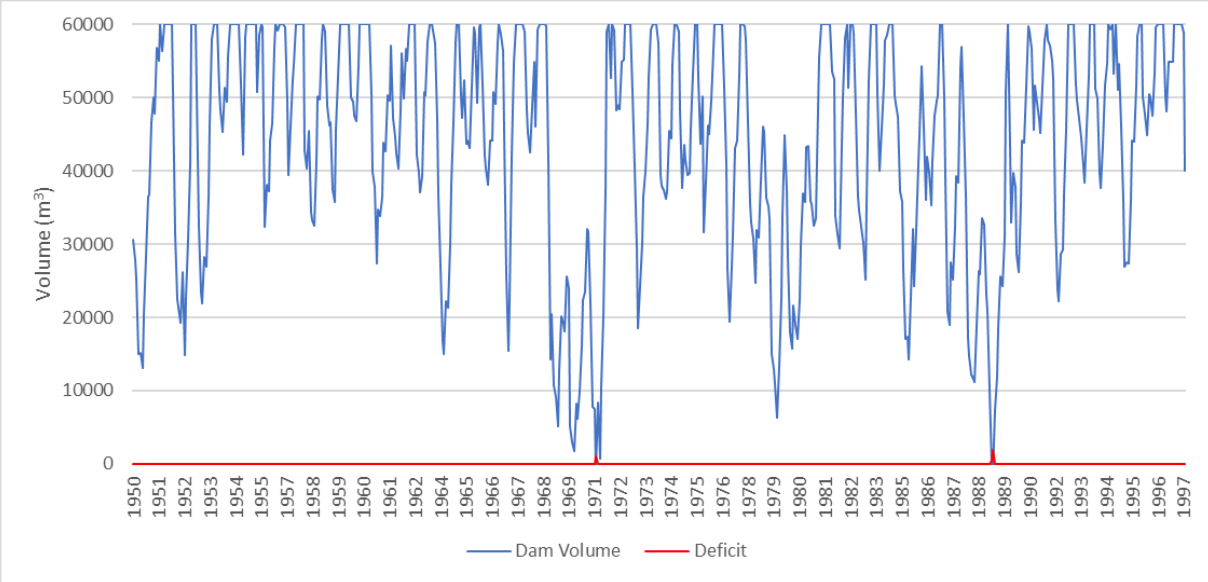

Figure 9: 50-year simulation with a 60 000 m³ dam and 5 750 m³/month borehole abstraction.

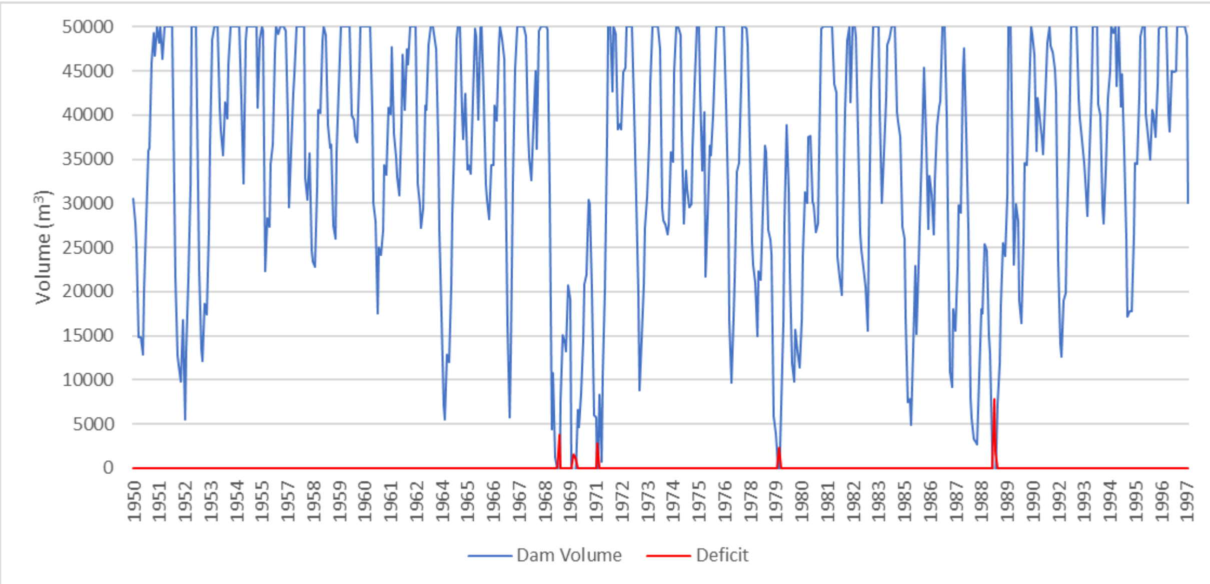

Figure 10: 50-year simulation with a 50 000 m³ dam and 5 750 m³/month borehole abstraction.

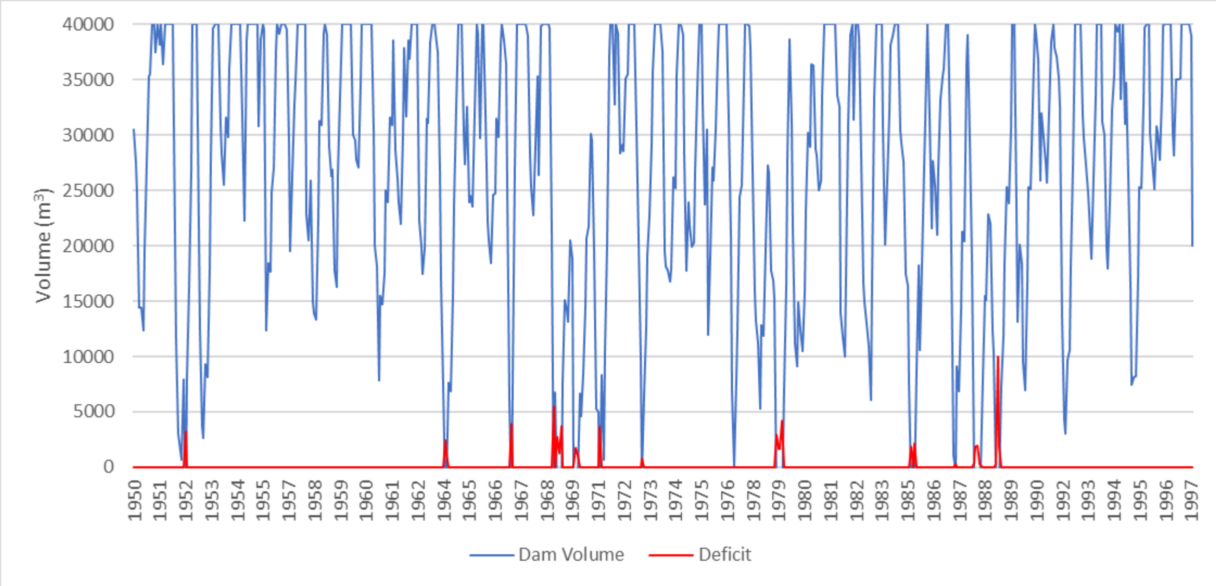

Figure 11: 50-year simulation with a 40 000 m^3 dam and 5 750 m^3/month borehole abstraction.

Table 6: Summary of irrigation deficit for different dam sizes.

Dam Size	No. of Deficit Months	No. of Deficit Months (% of total)	Average Monthly Deficit (% of irrigation demand)	Maximum Monthly Deficit (% of irrigation demand)
40 000	28	4.9	17	61
50 000	8	1.4	22	48
60 000	3	0.5	10	22
70 000	0	0	0	0

5 IMPACT OF DAM ON DOWNSTREAM FLOWS

The immediate catchment area of the dam covers approximately 25 % of the total catchment area of the drainage line on which the dam will be located (Figure 12). Assuming all instream flows are captured by the dam, flows to the catchment immediately downstream of the dam would therefore be reduced by approximately 25 %. The actual flow reduction is likely to be less than 25 % as the dam balance does indicate that the dam will overflow periodically during larger flood events. The impact on the reserve of the stream reach immediately below the dam is considered to be negligible as it is a non-perennial river that receives intermittent flow following rainfall events. The stream reach is not anticipated to host diverse aquatic biota that are dependent on regular instream flows. The primary function of the stream reach is to therefore deliver flows to more seasonal and perennial watercourses downstream.

The impact on the reserve of the larger catchment area immediately below the dam is expected to be low as 75 % of the catchment area remains un-impounded and can therefore still generate runoff to the larger stream network.

No abstractive water users (e.g. irrigated farms) are located downstream of the dam.

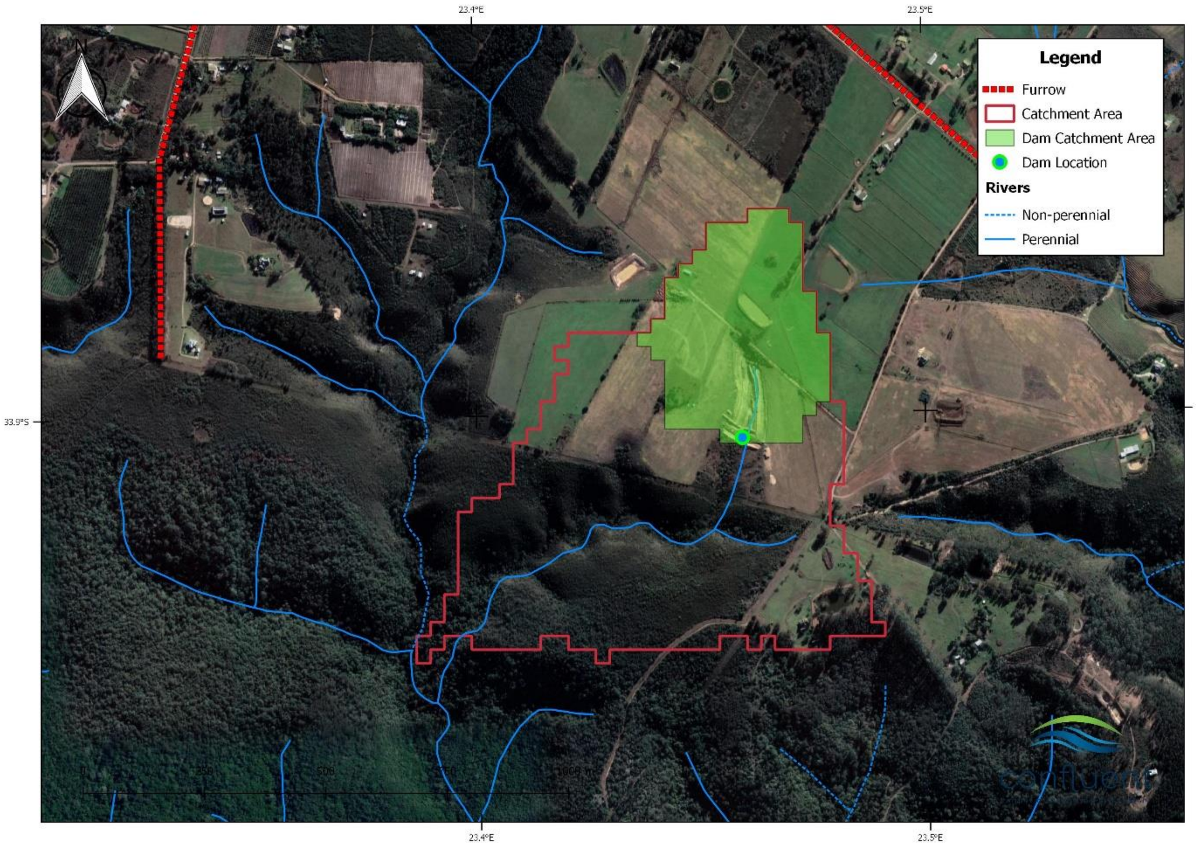

Figure 12: Map indicating the immediate catchment area of the dam within its larger catchment area.

6 CONCLUSION

This report summarises the hydrological yields to a dam located on Portion 17 of Farm 232 Redford for the purposes of a WULA. The dam will be constructed to store water for the irrigation of 28 ha of macadamia trees under drip irrigation on Portions 12, 15 and 17 of Farm 232. The main findings can be summarised as follows:

- The mean estimated irrigation requirements for 28 ha of macadamia trees under drip irrigation is approximately 81 000 m^3 per annum, with maximum demand reaching up to 116 000 m^3.
- A catchment modelling exercise indicates that the furrow system (50 000 m^3 per annum) and surface runoff from the immediate catchment area (12 200 m^3 per annum) of the dam is expected to yield a combined average of 62 200 m^3 per annum. This estimate assumes that all flow from the river below 0.078 m^3/s is directed into the furrow and also does not consider transmission losses along the furrow system. This scenario is therefore likely to over-predict flows from the furrow into the dam.
- Flows measured by a user on the furrow suggest that actual flows produced by the furrow are as much as 50 % lower than predicted by the modelling approach adopted in this study (i.e. a mean annual flow of approximately 25 000 m^3). This implies that more of the instream flow volumes bypass the furrow than estimated by the modelling approach adopted in this study. Transmission losses along the pipeline and furrow system are also likely to be significant. The WRSM/Pitman flow output values were therefore decreased by 50 % to approximate actual measured flow volumes.

- The combined furrow allocations and surface runoff from the catchment area will be insufficient to meet the irrigation requirements for 28 ha of macadamia trees and the deficit in mean annual irrigation requirements will need to be supplied by a borehole.
- An annual average abstraction of 69 000 m^3 from the borehole in addition to the estimated 12 200 m^3 from the catchment area of the dam and the furrow allocation will be sufficient to meet the mean annual irrigation demands of the trees such that irrigation requirements will be met 95 % of the time.
- Based on a detailed monthly water balance based on weather data covering a 50-year period, a dam size of 70 000 m^3 is expected to be sufficient to ensure security of supply over the long term, even under drought conditions. Lower dam volumes will result in monthly irrigation deficits occurring for a limited number of drier months, resulting in maximum irrigation deficits of up to 22, 48 and 61 % for a 60 000 m^3, 50 000 m^3 and 40 000 m^3 dam, respectively.
- Assuming all instream flows are captured by the dam, flows to the catchment immediately downstream of the dam would be reduced by approximately **25 %**. The impact on the reserve of the stream reach immediately below the dam is considered to be negligible as it is a non-perennial river that receives intermittent flow following rainfall events. The stream reach is not anticipated to host diverse aquatic biota that are dependent on regular instream flows. The primary function of the stream reach is to therefore deliver flows to more seasonal and perennial watercourses downstream. The impact on the reserve of the larger catchment area immediately below the dam is expected to be low, as **75 %** of the catchment area remains un-impounded and can therefore still generate runoff to the larger stream network.

7 REFERENCES

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