WILLIAMSON
WATER & LAND ADVISORY

Muriwai Golf Project

Appendix B - Site Water Balance and Water Strategy Report

THE BEARS HOME PROJECT MANAGEMENT LIMITED

WWLA0321 | Rev. 5

8 December 2021

Muriwai Downs Golf Project

Project no:	WWLA0321
Document title:	Site Water Balance and Water Strategy Report
Revision:	5
Date:	8 December 2021
Client name:	The Bears Home Project Management Limited
Project manager:	Josh Mawer
Author(s):	Josh Mawer
File name:	G:\Shared drives\Projects\Bears Home Project Management Ltd\WWLA0321_Muriwai Downs Golf Project\Deliverables\Reports\6. Site Water Balance and Strategy Report\Report_Site Water Balance and Strategy Report - Rev 5.docx

Williamson Water & Land Advisory

P.O. Box 314
Kumeu
New Zealand
www.wwla.kiwi

Document history and status

Rev	Date	Description	By	Review	Approved
1	20 Aug 2021	First draft for review	Josh Mawer, Jon Williamson	Jon Williamson	Jon Williamson
2	8 Nov 2021	Updated to address project team comments	Josh Mawer, Jon Williamson	Jon Williamson	Jon Williamson
3	24 Nov 2021	Updated to address further comments	Josh Mawer, Jon Williamson	Jon Williamson	Jon Williamson
4	01 Dec 2021	Updated to address further comments	Josh Mawer, Jon Williamson	Jon Williamson	Jon Williamson
5	08 Dec 2021	Updated to address further comments	Josh Mawer, Jon Williamson	Jon Williamson	Jon Williamson

Distribution of copies

Rev	Date issued	Issued to	Comments
1	20 Aug 2021	Bears Home Project Management Limited, Mitchell Daysh	First draft issued for review
2	8 Nov 2021	Bears Home Project Management Limited, Mitchell Daysh, Buddle Findlay	Updated to address project team comments
3	24 Nov 2021	Bears Home Project Management Limited, Mitchell Daysh, Buddle Findlay	Updated to address further comments
4	01 Dec 2021	Bears Home Project Management Limited, Mitchell Daysh, Buddle Findlay	Updated to address further comments
5	08 Dec 2021	Bears Home Project Management Limited, Mitchell Daysh, Buddle Findlay	Updated to address further comments

Contents

1. Introduction

Williamson Water & Land Advisory (WWLA) was commissioned by The Bears Home Project Management Limited (Applicant) in January 2021 to undertake baseline water quality monitoring and to prepare a water effects assessment to support a resource consent application for the partial conversion of the Muriwai Downs property (Property) to a Golf Course, Clubhouse, Sports Academy and Lodge development (Project). WWLA's scope was later expanded to include an Electrical Resistivity Tomography (ERT) Survey, a Groundwater Effects Assessment, a Site Water Balance and Water Strategy Report, and Water Balance Assessment of Lake Ōkaihau.

This report details the Site Water Balance and Water Strategy. A site water balance assessment is the consideration of water supply (i.e. the provision of raw water supplies such as rainwater, surface water, and/or groundwater) balanced against site water demands (e.g. irrigation and potable use). The overall objective of this report was to demonstrate the water supply sources available and how they will be configured to meet the various site demands of the Project.

The scope of works commissioned to achieve these objectives included:

- the site water use requirements (irrigation demand assessment and potable use) (**Section 2**);
- an overview of water storage reservoir optioneering (**Section 3**);
- the proposed high-flow surface water take to fill the selected water storage reservoir (**Section 4**); and
- a site water balance assessment (**Section 5**).

1.1 Site Overview

The Applicant is proposing the establishment of a golf resort facility located on the Muriwai Downs Property. The existing site farm is approximately 507 hectares, and located approximately 3 kilometres north east of Muriwai Beach Township. The Property comprises of predominantly pastoral farmland (sheep and beef, and dairy), and pockets of significant ecological areas, outstanding natural features and a number of wetlands. An overview of the site is depicted in **Figure 1** below.

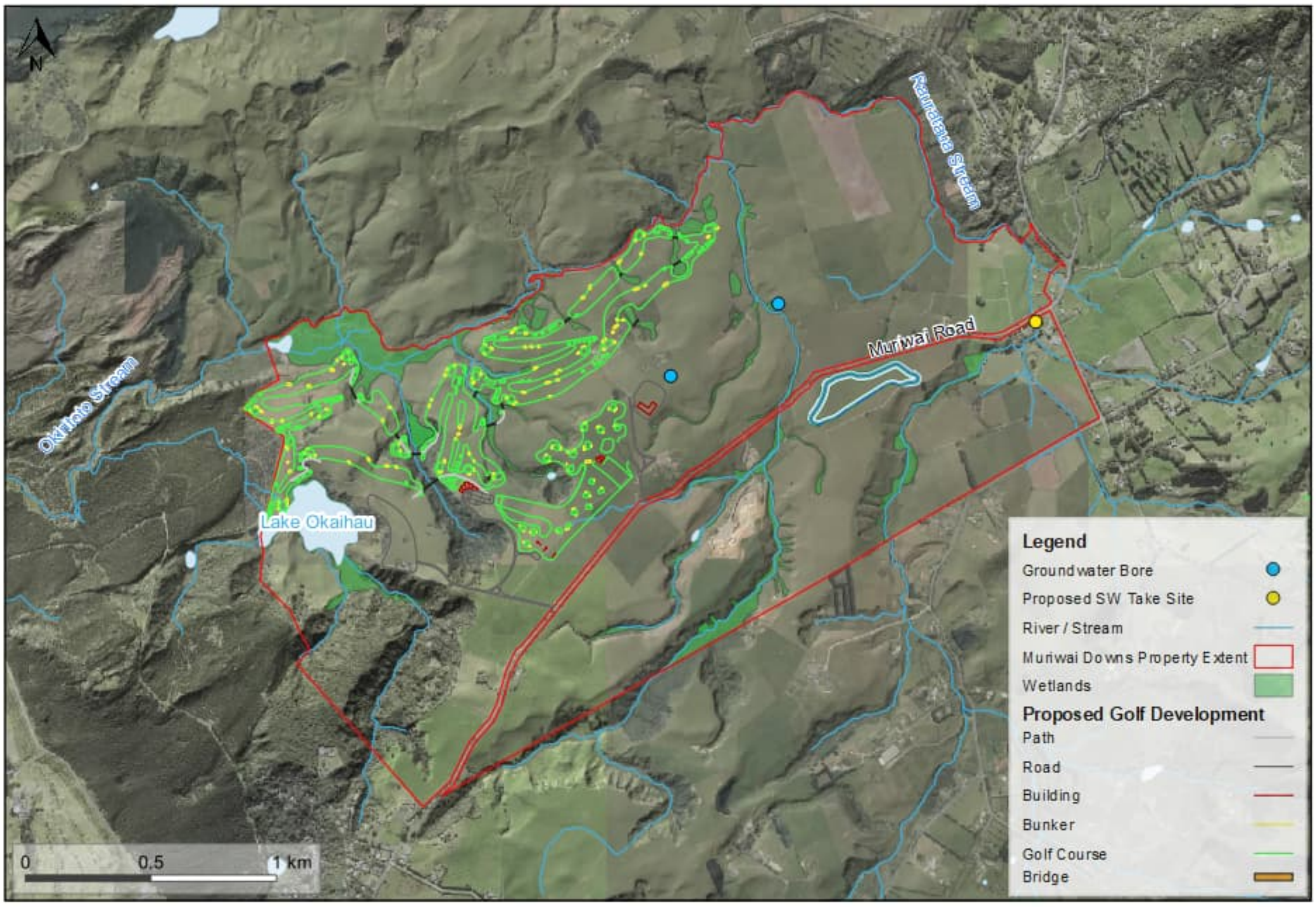

Figure 1. Site overview map.

2. Water Use Requirements

2.1 Irrigation Use

The Golf Strategy Group engaged irrigation expert Jeff Stamper of US consultancy firm Prevost Stamper Irrigation (PSI) to provide technical advice and assessment on golf course irrigation water use requirements. Consumptive Water Use Estimates (CUEs) were determined using the following parameters:

- representative climatic data (rainfall and evaporation) for Muriwai (based on published available rain gauge data for Kumeū, and Waimauku, and from National Institute of Water and Atmospheric Research's (NIWA) virtual climate station network);
- assumed irrigation infrastructure; and
- plant phenology of Creeping Bentgrass (Golf greens) and Windsor Green Couch grass (fairways, roughs and tees).

Based on historic climate data, estimated irrigation system efficiency, and monthly crop coefficients, monthly turf irrigation estimates were calculated, and as summarised in **Table 1**. The full calculation spreadsheet developed by Jeff Stamper is included in **Appendix A** to this report.

Table 1. PSI – Estimated average daily irrigation requirements per month.

Grass Species	Irrigation (mm/day)											
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Creeping Bentgrass (3.44 ha)	7.0	5.27	3.75	2.03	1.18	0.84	0.80	1.51	2.43	5.15	5.89	5.74
Windsor Green Couch (41.1 ha)	4.63	3.76	2.71	1.26	0.86	0.67	0.62	1.10	2.12	3.08	4.23	4.83

Based on the above, the total annual water requirement for the golfing area (44.5 ha) was estimated as 167,990 m^3, with 6,970 m^3/ha/year required for the golf greens (Creeping Bentgrass), and 3,515 m^3/ha/year required for the fairways, roughs and tees (Windsor Green Couch).

2.1.1 Irrigation Demand Model

While the PSI report provides detailed insight into the anticipated average monthly CUEs, an historic daily irrigation demand profile was required to undertake the Site Water Balance Assessment as it is calculated based on daily timestep interval. Therefore, an irrigation demand assessment was undertaken using the irrigation module of WWLA's Soil Moisture Water Balance Model (SMWBM_Irr).

An irrigation demand time series representing general landscaping irrigation was also required. Therefore, a generic third grass type was simulated in addition to the Creeping Bentgrass and Windsor Green Couch types presented above. It was estimated that up to 10.5 ha of general landscaping irrigation may be required.

This model was configured to site conditions as part of the Surface Water Effects Assessment (WWLA, 2021 – Appendix C). A schematic overview of the SMWBM_Irr is provided in **Appendix B**. The turf crop coefficient and turf species adjustment factors used in Jeff Stamper's calculations were included in the monthly Crop Coefficient parameter within the SMWBM_Irr, and the irrigation system efficiency, scheduling and contingency coefficients from Jeff Stamper's calculations combined and included within the SWMBM_Irr Efficiency Factor.

The SMWBM_Irr used the historic climate record in order to simulate soil moisture levels to determine days when irrigation was required in order to maintain soil moisture levels where plant growth is uninhibited. The model was configured with the calculated Peak Application Rates as provided by Jeff Stamper (**Table 1**).

An example of the irrigation model interface is presented in **Figure 2**, and the resulting irrigation demand time series presented in **Figure 3**.

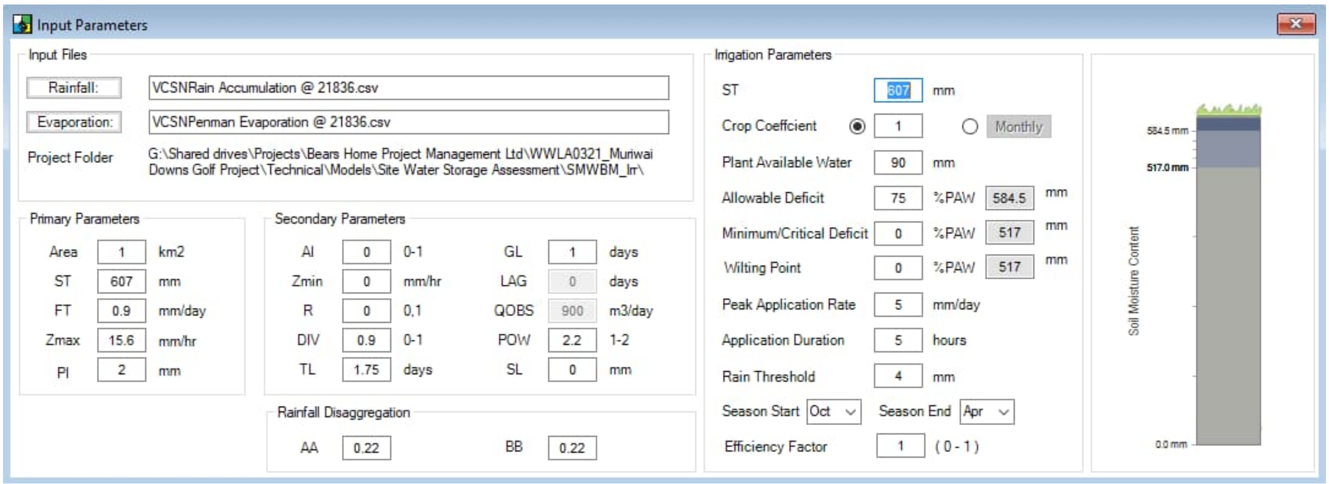

Figure 2. Irrigation model interface.

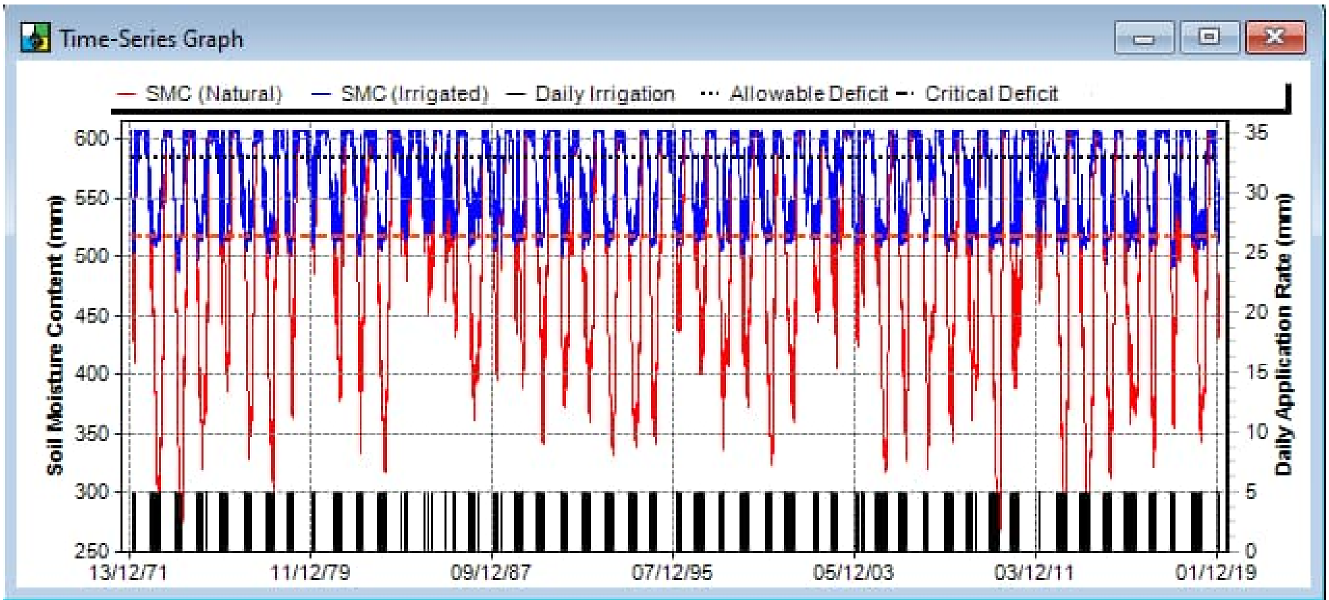

Figure 3. Irrigation demand time series output.

A summary of simulated irrigation demand is provided in **Section 2.1.3** below.

2.1.2 Climate Data

Evaporation and rainfall data were obtained from the NIWA virtual climate station network (VCSN). The VCSN data provides estimates of climate variables on a 5 km regular grid, covering all of New Zealand. Estimates of climate parameters are produced for each VCSN point on a daily time-step based on spatial and temporal interpolation of recorded observation data at the nearest reliable meteorological sites.

VCSN Station ID 21836 is located approximately 2 km south of the Property and was utilised for this assessment. Annual rainfall and evaporation totals for the period 1972 through to 2020 are presented in **Figure 4**, and median monthly rainfall and evaporation totals presented in **Figure 5**.

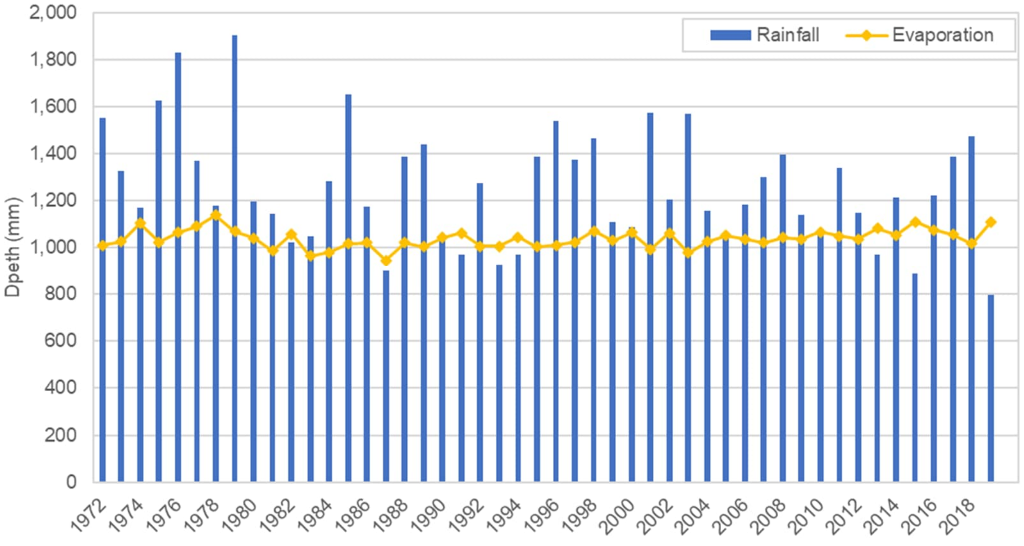

Figure 4. Annual rainfall and evaporation (1972-2020) – VSCN ID 21836.

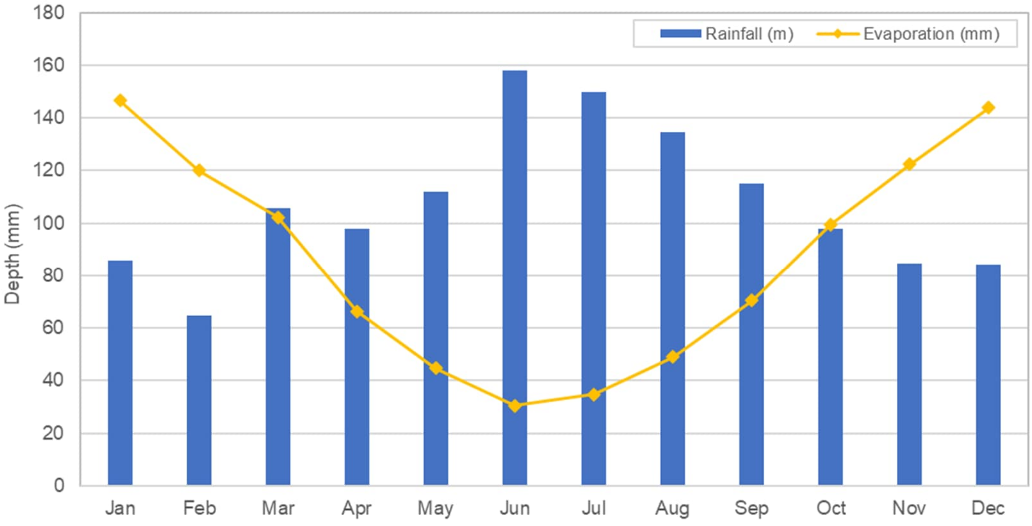

Figure 5. Median monthly rainfall and evaporation (1972-2020) – VCSN ID 21836.

The assessment of irrigation demand was based on historical climate data. The future climate projections available from NIWA show that the study area is likely to experience a small change in annual precipitation. The maximum emission scenario (RCP8.5) shows a change ranging from 0% (unchanged) to a 5% increase in annual rainfall in the study area predicted for 2046-2065[1], a period that extends beyond the length of the proposed consent. For this reason, the range of conditions within the historic data set used in model development were considered sufficient to account for climate change in this region.

[1] https://ofcnz.niwa.co.nz/#/nationalMaps

2.1.3 Summary of Irrigation Demand

The key outputs from the SMWBM_Irr for this assessment was an irrigation scheduling time-series, which is a hind-cast estimate from 1972 to present of all the days where irrigation would have been required to maintain soil moisture levels that avoid plant stress).

During a 1 in 10-year drought, irrigation is required 83-92 days per season based on the proposed grass types. This required 4,150 to 5,950 m^3/ha/year of water. On average, 48-55 days of irrigation were required per year (**Table 2**). The monthly average irrigation return period is presented in **Figure 6**, for the three grass types. For example, this shows that on average, irrigation was required approximately every 2-3 days during January, every 2 days during February, and every 4-6 days during November and December. Of the three grass types, general landscaping is anticipated to require irrigation less frequently than the golfing grasses (i.e. a greater recurrence interval) during the shoulder months (November – December, and March – April). During the peak of summer (January – February), all three grasses are anticipated to require similar frequency of irrigation.

In reality, the golf course irrigation system will operate based on an array of sophisticated soil moisture sensors (AEE – Appendix 3, Section 10), allowing finer control over daily irrigation depths i.e. smaller applications more frequently. We anticipate the annual depth and volumes would be similar to those simulated by the SWMBM_Irr and presented in **Table 2**.

The 1-in-10-year annual irrigation water estimate for the golfing area (i.e. excluding general landscaping), was approximately 9% greater than that calculated by PSI. This difference is considered within the general level of uncertainty of both assessments.

Table 2. Annual irrigation demand summary statistics.

Statistic	Creeping Bentgrass (3.44 ha)		Windsor Green Couch (41.4 ha)		Landscaping (10.5 ha)	
	No. Days Per Year	Volume (m^3/ha/year)	No. Days Per Year	Volume (m^3/ha/year)	No. Days Per Year	Volume (m^3/ha/year)
Minimum	11	781	0	0	10	500
Median	52	3,692	40	1,852	52	2,600
Mean	55	3,886	48	2,213	54	2,717
90^{th} Percentile	84	5,950	92	4,241	83	4,150
Maximum	117	8,307	135	6,251	116	5,800

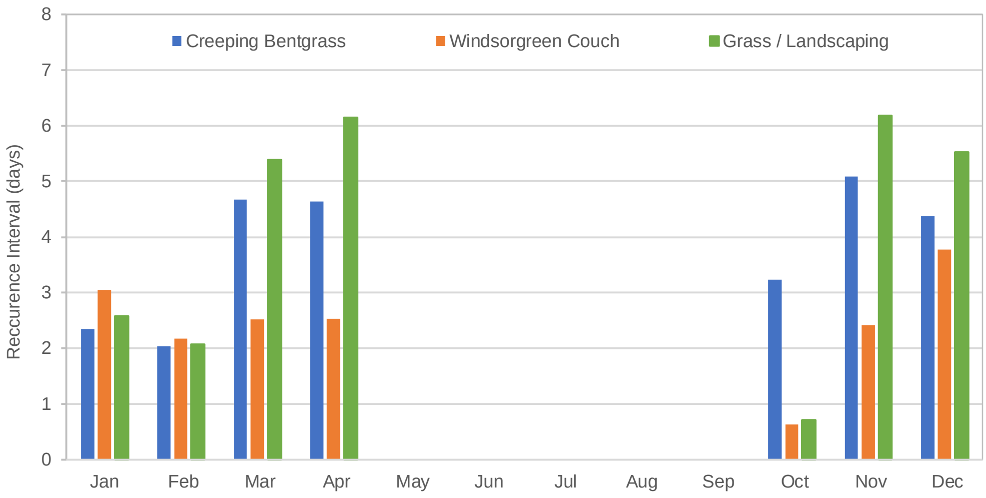

Figure 6. Monthly average return period for irrigation days.

2.2 Potable Water Use Requirements

In addition to irrigation, water is also required for potable supply and on-site facilities maintenance. Potable and facilities maintenance water use requirements were estimated by McKenzie and Co as part of their Engineering Infrastructure report (AEE – Appendix 5). Total potable and maintenance water use requirements are summarised in **Table 3**.

Table 3. Potable and facilities maintenance water use requirements.

Statistic	Lodge, Wellness Centre & Golf Clubhouse	Sports Academy & Maintenance Complex
Average Daily Demand (L/s)	0.30	0.13
Peak Daily Demand (L/s)	0.59	0.26
Peak Hourly Demand (L/s)	1.47	0.64
Daily Demand Volume (m^3/day)	25.9	11.0
Total Annual Volume (m^3/year)	9,453.5	4,015

Lodge, Wellness Centre & Clubhouse

The Lodge, Wellness Centre & Clubhouse may be supplied directly from a secondary production bore (Figure 1 – western groundwater bore). The water supply will be distributed via a pump and pressurised water reticulation main.

Sports Academy and Golf and Property Maintenance Complex

Roof runoff from the Sports Academy and Golf and Property Maintenance Complex (Maintenance Complex) will be collected in dedicated rainwater harvesting tanks and provide the primary potable and non-potable water supply to the Sports Academy and Maintenance Complex.

A supplementary reticulated supply from the water storage reservoir will provide redundancy to the Sports Academy and Maintenance Complex for use if the rain harvesting tanks run dry. Reservoir water would be treated at the Maintenance Complex to ensure water quality meet potable water standards.

2.3 Summary of Water Use Requirements

The total site water use requirement comprises the total irrigation demands (golfing area plus landscaping), potable water use, and on-site facilities maintenance. Irrigation will typically only occur during the spring/summer period (i.e. typically October to April, inclusive), however, small volumes may be required from time to time outside of the spring/summer period. Potable supply and maintenance use are required year-round. Therefore, summer water use requirements are significantly larger than during winter.

A summary of estimated total annual water use requirements for the Project are presented in **Table 4**.

Table 4. Summary of annual water use requirements.

	Median (m^3/year)	**Mean (m^3/year)**	**1-in-10-year (m^3/year)**	**Maximum (m^3/year)**
Creeping Bentgrass [3.4 ha]	12,700	13,212	20,230	28,244
Windsor Green Couch [41.1 ha]	76,117	90,954	174,305	256,916
General Landscaping [10.5 ha]	27,196	28,529	43,575	60,916
Lodge, Wellness Centre & Golf Clubhouse [365 days]	9,454	9,454	9,454	9,4548
Golf Academy & Maintenance Facilities [365 days]	4,015	4,015	4,015	4,015
Total	**129,956**	**146,638**	**252,053**	**360,003**

3. Review of Water Storage Options

3.1 Reservoir Optioneering

Water is a considered an essential resource for the Project. Water is required for irrigation to maintain optimum grass conditions for safe bounce and roll of the golf balls, general landscaping, and to provide water to the associated facilities (e.g. club rooms, accommodation, and facilities maintenance sheds, etc).

A core allocation take from the Ōkiritoto Stream would be insufficient in volume, and would not provide the level of reliability required for the Project. Therefore, a high-flow surface water take (**Section 4**), and potentially a supplementary groundwater take (**Section 5**) may be required to fill the water storage reservoir to reliably meet Project demands.

An extensive water storage optioneering assessment was undertaken by consultants of the core project team[2], which identified and considered a wide range of potential reservoir locations. Each of these are briefly described below, and full details on the development of the Project, including reservoir optioneering are provided in the Project AEE (Mitchel Daysh, 2021).

3.1.1 PDP Water Supply Options Assessment

Pattle Delamore Partners Ltd (PDP) were engaged by the Applicant to carry out an options assessment of securing reliable water supply and storage locations for the Project. This exercise identified twelve potential water storage locations across the Property (the potential options are labelled A to L in **Figure 7**).

Following further review of the twelve options, all sites - with the exception of Option J - were not feasible due to a combination of insufficient storage volumes, limited catchment inflows, and the presence of wetlands or significant ecological areas.

Accordingly, Option J was progressed for further consideration by the core project team.

[2] The core project team consisted of The Golf Strategy Group, Buddle Findlay, Mitchel Daysh, McKenzie and Co., WWLA , and PDP.

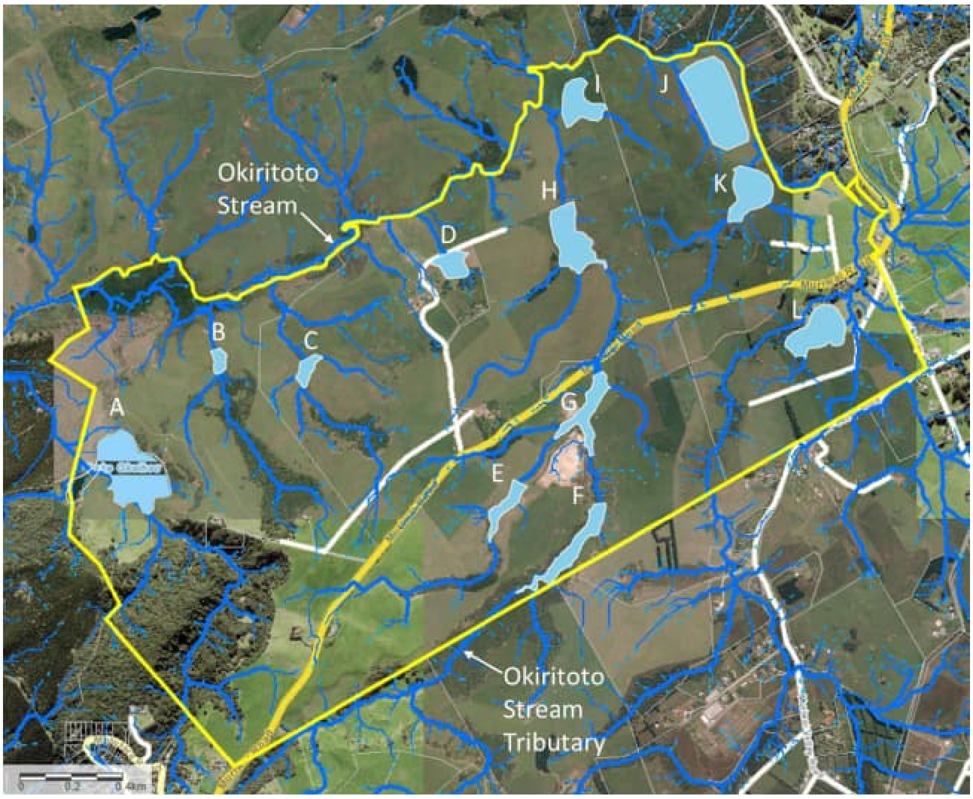

Figure 7. Potential storage locations (PDP, 2020).

3.1.2 WWLA Proposed Quarry Reservoir

During a site visit in March 2021, WWLA raised the idea of constructing a water storage reservoir within the existing sandstone quarry located on the southern section of the Property. Three configurations were proposed for the quarry reservoir location, ranging in storage volumes from 70,000 to 130,000 m^3, with an example of one option shown in **Figure 8** (a 100,000 m^3 reservoir). The quarry provided a potentially novel solution in that it would be constructed in a site of already disturbed land, and material excavated from the quarry to form the reservoir could be used as part of the Project and/or sold offsite to local contractors.

Following initial feasibility analysis, the quarry reservoir location was considered in detail, with a number of configurations being identified and investigated further by McKenzie and Co. as detailed in **Section 3.1.3**.

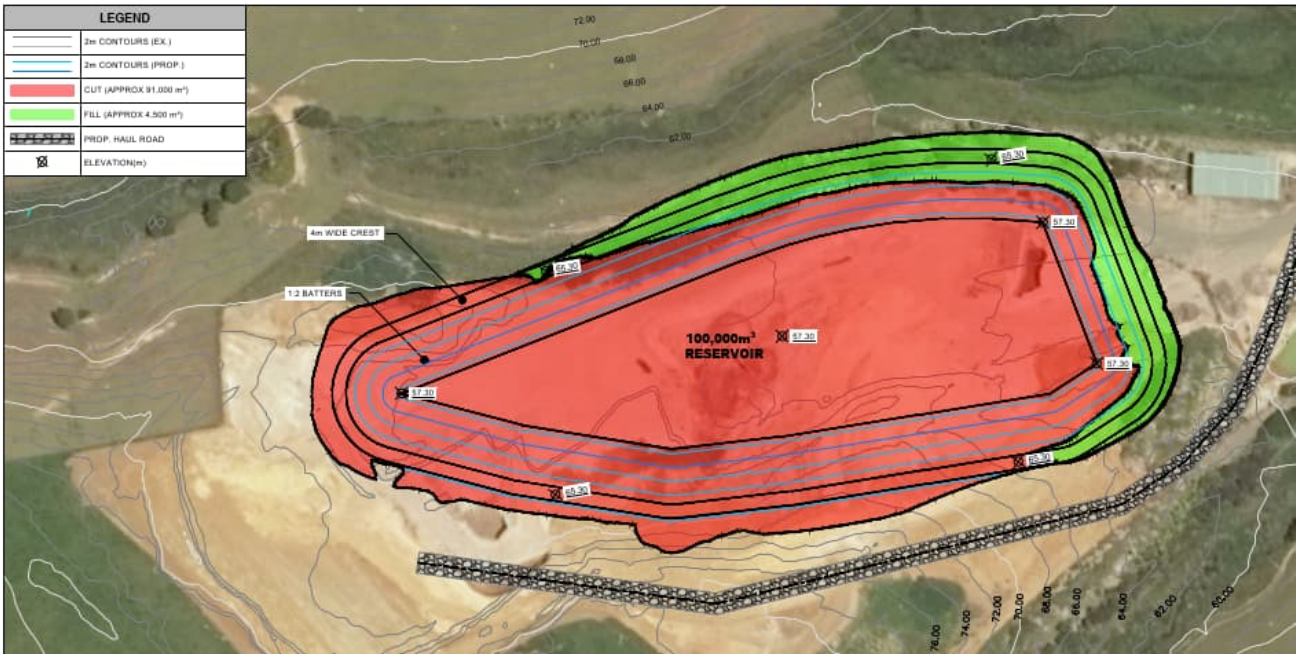

Figure 8. Example quarry reservoir concept.

3.1.3 McKenzie and Co. Preliminary Reservoir Designs

McKenzie and Co. were engaged to undertake a feasibility review of three reservoir options shortlisted by the core project team. These were:

- Option J;
- Quarry reservoir; and
- An additional reservoir to the east of the quarry, referred to as the Southern Reservoir (due to its location on the southern section of the Property).

Upon further consideration, Option J was not progressed further following this analysis due to its close proximity to a flood hazard zone, the disruption and operational inefficiencies it creates for ongoing farming activities and its visual prominence when viewed from adjacent dwellings located to the east of the Property.

The construction of the Quarry reservoir option was considered cost prohibitive at this time. A smaller option was considered at this location by McKenzie and Co., but it was not sufficient to meet the water needs of the Project.

The Southern Reservoir is a “turkeys’ nest” style reservoir located to the east of the quarry (**Figure 9**). The reservoir in its preliminary configuration could store approximately 140,000 m^3 of water and is approximately four metres in depth.

The core project team has confirmed the Southern Reservoir has been selected for the Project due to (amongst other things) its capacity, generally low visibility, and location away from any potential floodplain and the absence of ecological constraints (e.g., wetlands and significant ecological areas).

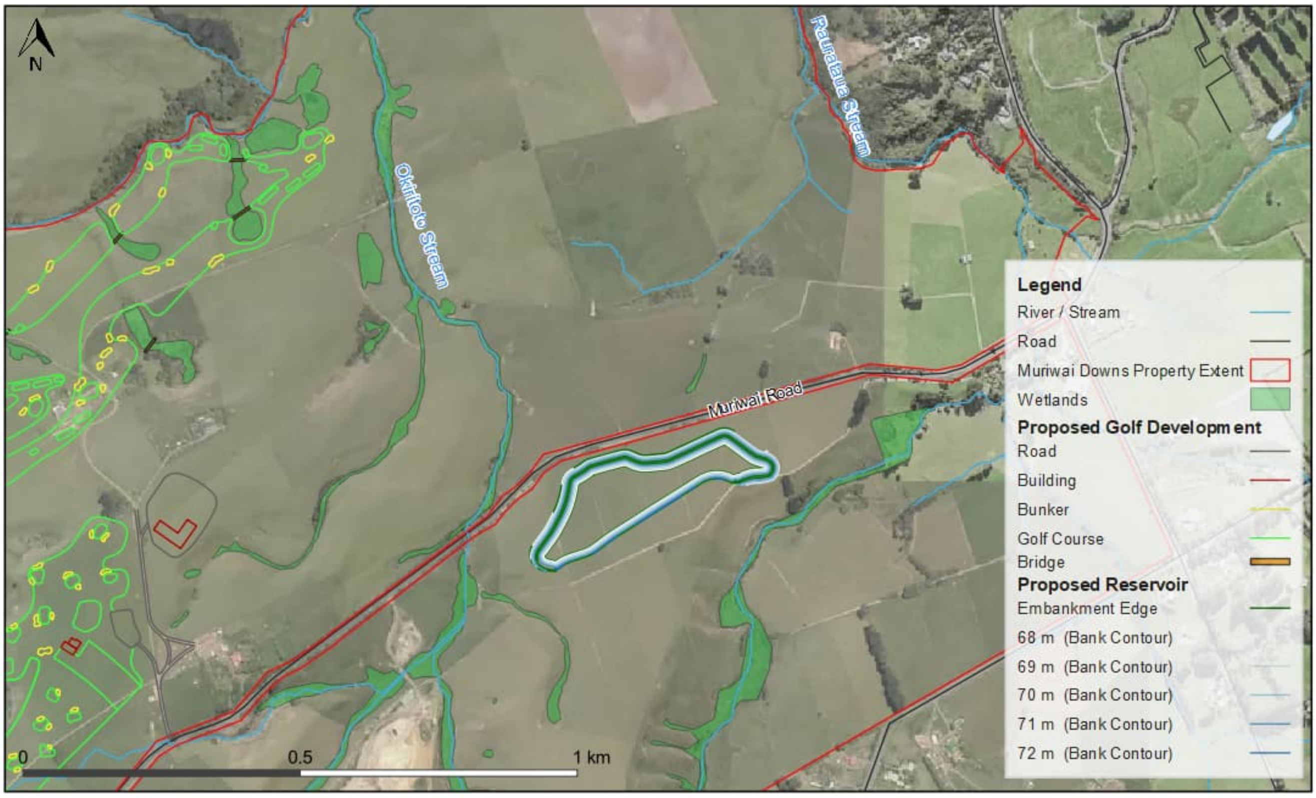

Figure 9. Proposed Southern Reservoir – conceptual design by McKenzie and Co.

4. Surface Water Take

4.1 Overview

A surface water take is proposed from the Raurataua Stream (which is a tributary of the Ōkiritoto Stream, with its confluence approximately 2 km downstream). Abstracted water will be pumped to the proposed water storage reservoir and subsequently used for golf course irrigation, landscape irrigation and other non-potable water requirements.

The location of the proposed surface water take is presented in **Figure 10** (see yellow dot in the far-right corner of the Property, close to Muriwai Road).

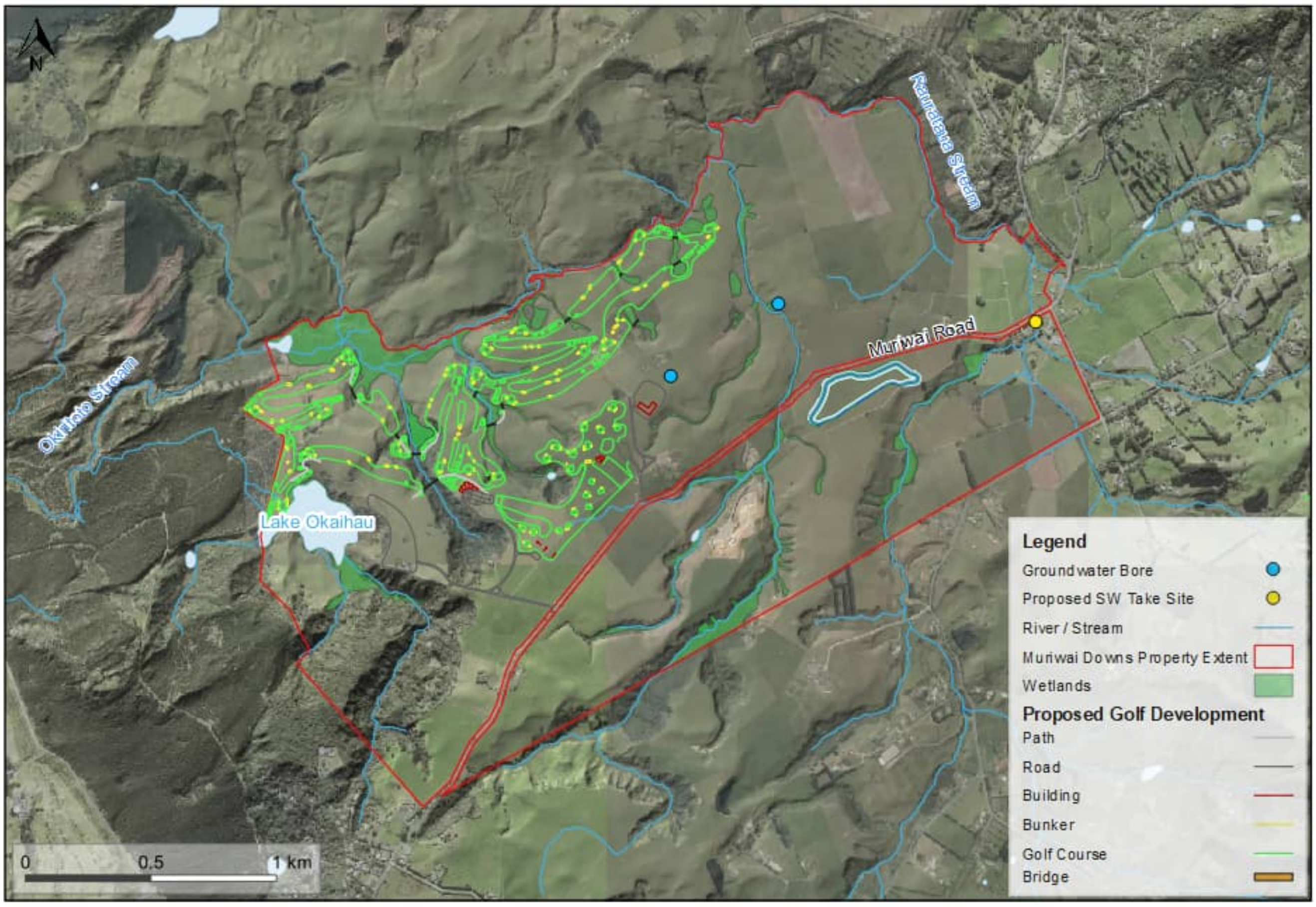

Figure 10. Location of the proposed surface water take.

The following sub-sections detail the relevant water take regulations of the Auckland Unitary Plan Operative in Part (AUP), describe the historic streamflow regime at the proposed take location and outline the proposed surface water take regime.

4.2 Auckland Unitary Plan

The AUP, provides for the taking and use of water under Chapter E2.

The abstraction of water during "normal" conditions is referred to as a core allocation take. Core allocation takes consist of a defined available allocation, and a minimum flow requirement. Under the AUP, the available core allocation for the Raurataua Stream is defined as 30% of its Mean Annual Low Flow (MALF), and the minimum flow is equivalent to 75% of its MALF.

A take from a river or stream during flood conditions is referred to as a high-flow take. Significantly greater volumes of water are available for harvesting during high-flow. However, given their occurrence is limited to periods of flood or during freshes (i.e. periods of high flow in response to rainfall), high-flow takes require the water to be stored in a reservoir in order to provide a reliable water source. Under the AUP, high-flow takes can occur when the river or stream flow is greater than the median flow, provided the total take does not exceed 10% of the flow in the river or stream at the time of abstraction.

In regards to water take infrastructure, Chapter E2.3 Policy (6)(d) states intake structures must be designed, constructed, operated and maintained to avoid adverse effects on biota, including the entrainment and impingement of fish.

4.3 Historic Streamflow Regime

The historic streamflow regime at the proposed point of take was simulated using WWLA's SOURCE catchment flow model developed as part of the Surface Water Effects Assessment (WWLA, 2021 – Appendix C). The catchment flow model was calibrated to three Project specific stream flow monitoring sites operated by WWLA and a range of historic spot gauge data provided by Auckland Council. Full details of the model development and calibration are provided in WWLA (2021 – Appendix C). The model demonstrated good agreement to available stream flow monitoring data, and is considered appropriate for the purposes of undertaking surface water resources assessment and water quality effects assessment.

Historic streamflow was simulated for the period 1972 to present. The simulated flow hydrograph and flow duration curves are presented in **Figure 11**, and **Figure 12**, respectively, and summary statistics outlined in **Table 5**.

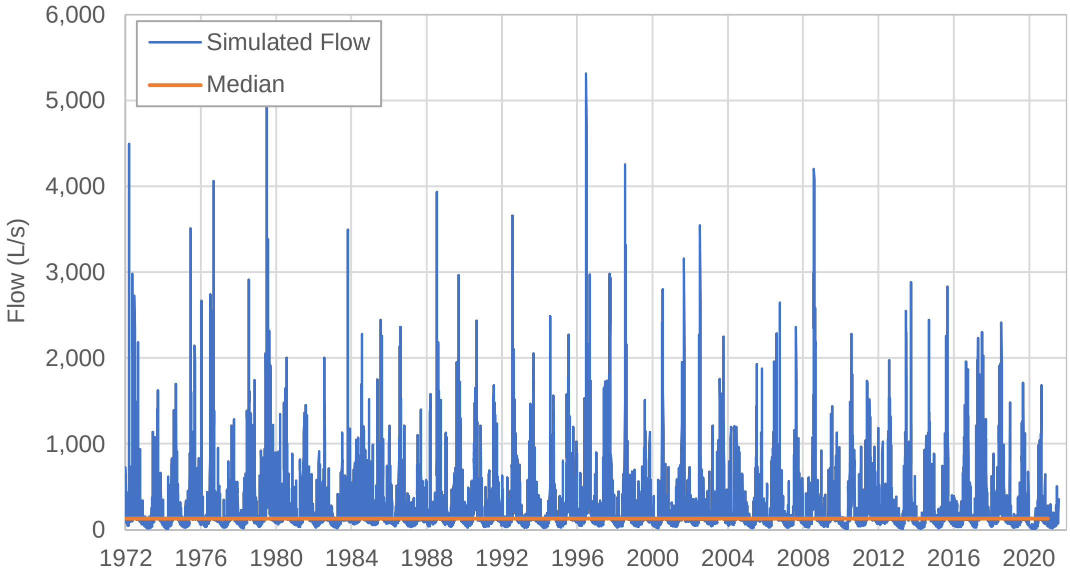

Figure 11. Proposed take site – simulated flow hydrograph.

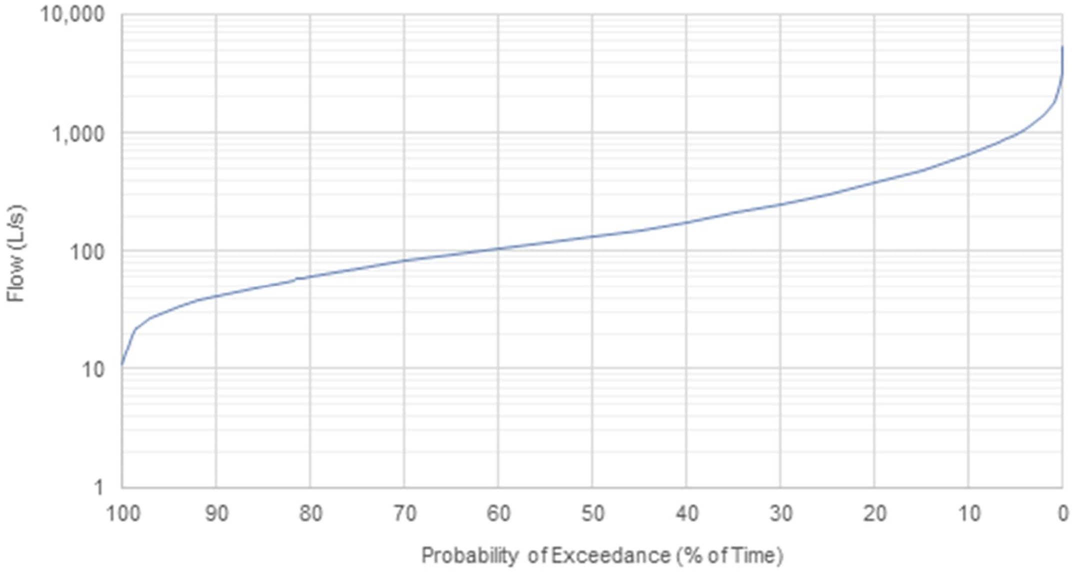

Figure 12. Proposed take site – simulated flow duration curve.

Table 5. Proposed take site – simulated flow statistics

Statistic	Flow (L/s)
Minimum	11
Mean annual 7-day low flow (MALF)	34
25th percentile	74
Median	131
Mean	274
75th percentile	310
90th percentile	669
Maximum	5,210

4.4 Proposed High-Flow Take

As described in **Section 4.2**, under the AUP a high-flow take can occur when the river or stream flow is greater than the median flow, provided the total take does not exceed 10% of the flow in the river or stream at the time of abstraction.

The Applicant proposes to abstract up to 30 L/s during periods of above median flow. When flows are at or above 161 L/s (i.e. median flow of 131 L/s + 30 L/s), the abstraction would occur at the full take rate of 30 L/s. When flows are above median flow, but less than 161 L/s, the take rate would be proportionally decreased to ensure no more than 10% of the total flow is abstracted.

The proposed take regime is summarised in **Table 6** below.

Table 6. Proposed high-flow water take regime.

Condition	Flow (L/s)
Minimum high-flow take criterion	131
Maximum take rate	30

An Assessment of Effects of the proposed high-flow take on downstream flows is presented in the Summary Water Effects Report (WWLA, 2021 – Appendix C).

4.5 Intake Structure and Management of the High-Flow take

The exact design of the intake structure has not yet been confirmed. It is recommended that the intake structure is designed to avoid adverse effects on biota, including the entrainment and impingement of fish through inclusion of appropriately sized mesh screen (e.g., < 1.5 mm), and intake velocities less 0.3 m/s (AUP E7.6.1.1).

Examples of potential intake structure types are presented in **Table 7**.

Table 7. Example potential intake structures.

Structure type	Example
Stream Intake (Fixed).	
Screen Intake on Swivelled Winch (Removeable).	

Stream Bank Chamber and Pump. Consists of a pump chamber formed alongside the river with a simple overflow weir or small intake gates to allow above the median flow level into the chamber.	

In terms of management of the take, two options exist. These are:

1. Converting the existing Flow Site 1 (as detailed in WWLA 2021 – Appendix C) to a permanent monitoring site for management of the proposed high flow take; or
2. Installing a new water level sensor at the proposed take site, and undertake flow gaugings to develop a site rating curve.

Both options are considered appropriate to manage the take to comply with the take regime (which will be detailed in draft consent conditions to be prepared for the Project). The ultimate solution to manage the high-flow take will be determined as part of the detailed design of the intake structure and discussions between the applicant, planners and Auckland Council compliance team.

5. Groundwater Take

5.1 Overview

As described in **Section 2.1.3**, annual site irrigation water use requirements were estimated at an average of 132,695 m^3/year, with a maximum of 344,076 m^3/year. Annual water usage will exceed the total capacity of the reservoir (140,000 m^3 – **Section 3.1.3**) during particularly dry years, hence an additional supply of water is required. Supplementary groundwater is proposed to fulfill the shortfall.

A reservoir storage water balance assessment was undertaken (**Section 6**) to determine the maximum daily and annual volumes of supplementary groundwater required in addition to the surface water take to reliably meet site water use requirements.

While groundwater can be pumped directly from a bore to irrigation, pumping it to the reservoir as a supplementary source generally provides advantages in that:

1. Less groundwater is required than if it was the sole water source, as the reservoir will also be filled via a surface water take; and
2. Groundwater can be abstracted at a lower rate (over a longer period) if pumped to a reservoir first, thus reducing potential groundwater drawdown effects.

A groundwater production bore is located near the middle of the Property (**Figure 10**). A pilot bore was drilled and tested at yields of 10 L/s. Construction of a 200 mm diameter production bore has been completed and once pump testing is completed it is anticipated to supply an instantaneous peak rate of up to 30 L/s. Test pumping and analysis is planned to verify the peak yield of 30 L/s and to understand the limits of the aquifer. Test pumping will likely include a stepped discharge test, a constant discharge test and groundwater monitoring.

A secondary production bore is proposed approximately 500 metres to the southwest of the existing production bore, near the Maintenance Complex. The proposed bore will access the same deep aquifer as the existing production bore.

A global groundwater take consent is being sought for two bores from the same deep confined aquifer. The production bore will supply supplementary groundwater to the reservoir. The secondary smaller bore is proposed to primarily provide potable supply. Ultimately, the reticulation network from both bores will be designed to allow maximum flexibility as to where the water is conveyed and how it is used.

6. Reservoir Storage Water Balance Assessment

6.1 Overview

WWLA's Reservoir Storage Model (RSM) was used to determine the volume of supplementary groundwater supply required in addition to flow harvested from the high-flow take, to provide a reliable source of water from the storage reservoir for irrigation and site water use.

The RSM balances catchment inflows and direct rainfall inputs with water demand and evaporation losses to simulate the change in reservoir storage volume on a daily timestep. The model was simulated for the period 1972 through to 2020.

The following assumptions were made as part of the reservoir storage water balance modelling assessment:

- Maximum reservoir storage volume of 140,000 m^3;
- Direct gains (rainfall) and losses (evaporation) were calculated from the reservoir surface on daily basis;
- A pumped high-flow take of up to 30 L/s, from the Raurataua Stream;
- Irrigation demand as per **Section 2.1.3**, with the two golfing grass types plus the generic landscaping demand;
- A volume vs. surface area curve was calculated from the preliminary reservoir design prepared by McKenzie and Co.;
- No seepage will occur from the reservoir because it will be HDPE lined; and
- Water supplies to the following project elements would be provided directly from the groundwater bore, and thus not included in the reservoir storage water balance:
  - Lodge;
  - Golf Clubhouse; and
  - Wellness Centre.
- The Sports Academy and Maintenance Complex will be supplied entirely through rain harvesting.

It is noted the Sports Academy and Maintenance Complex rain harvesting tanks may require top-up if they run dry (**Section 2.2**). This was not specifically accounted for in the reservoir storage water balance assessment, as it would be a temporary supply on an as needed basis only. The reason for this is that the temporary peak demand is only 0.26 L/s (**Table 3**), which in comparison to the average daily irrigation demand for the total irrigation area (30 L/s for 55 ha) is 0.9% of the daily demand in peak periods. A temporary supply of this magnitude would not impact on reservoir supply reliability.

The RSM was utilised to determine the additional supplementary water that would be required (i.e. from the primary groundwater production bore) to achieve adequate irrigation supply reliability.

6.2 Water Balance Assessment

Two scenarios were simulated to provide insight into the site water balance. The two scenarios were defined as follows:

- **Scenario 1** – 30 L/s high-flow take from the Raurataua Stream; and
- **Scenario 2 –** 30 L/s high-flow take from the Raurataua Stream + 20 L/s from the groundwater bore whenever the reservoir storage volume falls between 40% (56,000 m^3) and 65% (91,000 m^3) and ceasing once it reaches between 40% to 65%.

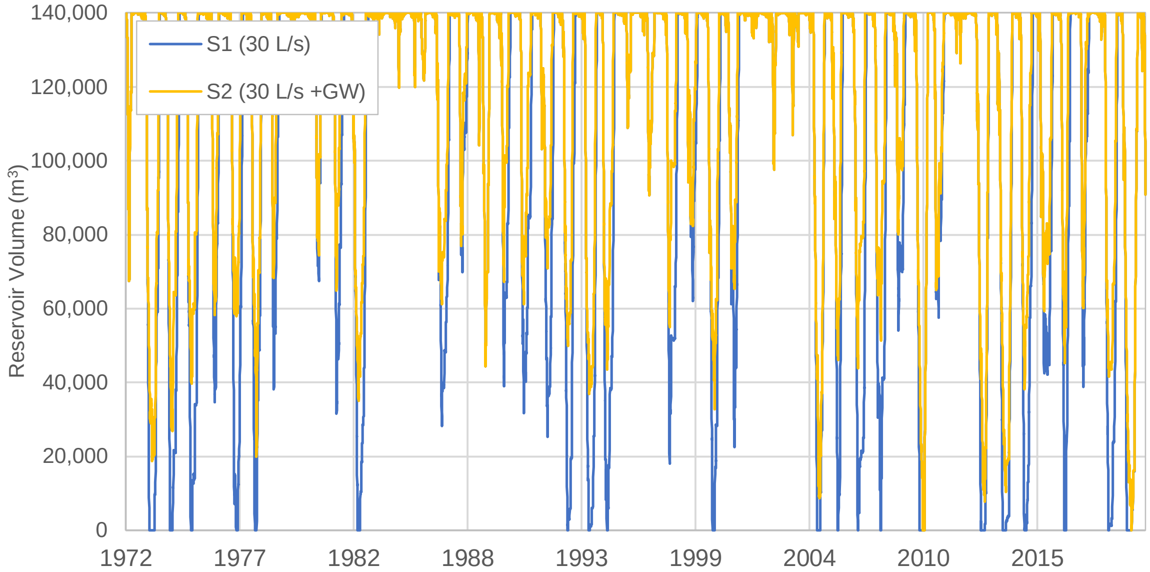

Figure 13. Reservoir storage time series plots.

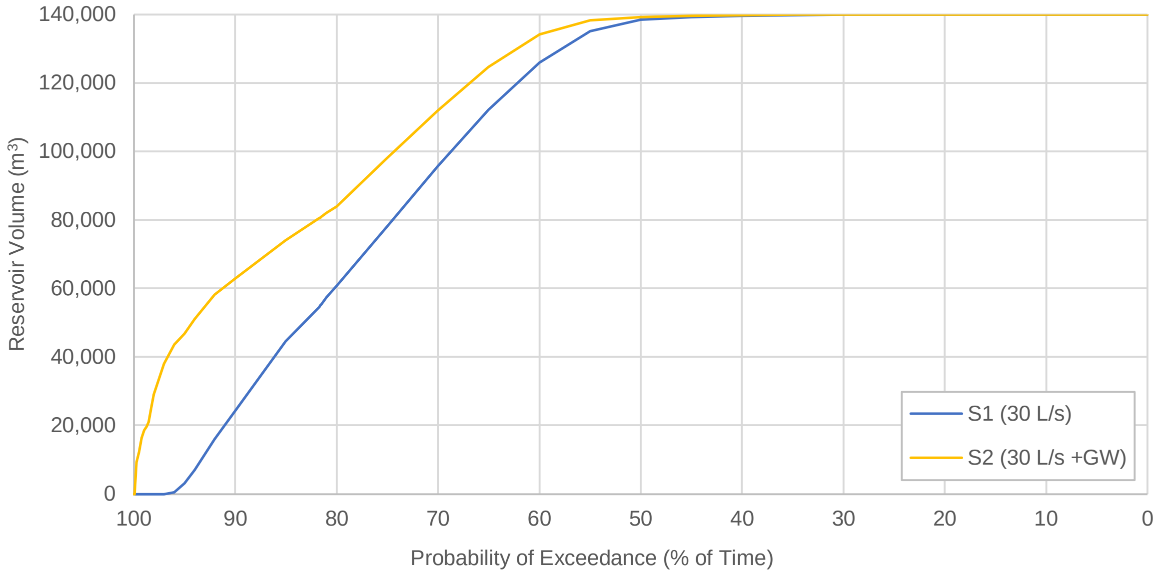

Figure 14. Reservoir storage volume exceedance curve.

This water balance analysis has demonstrated that a 30 L/s high-flow surface water take from the proposed high-flow take location would be insufficient to meet site water use requirements reliably every year. A range of scenarios with high take rates (up to 80 L/s), were also tested, but they were also insufficient to provide a reliable irrigation supply on their own. This is because the size of the reservoir is the limiting factor on reliability (i.e. the reservoir has a smaller volume than maximum estimated annual irrigation requirements), rather than harvestable surface water volumes. For the sake of clarity and simplicity, these additional scenarios are not presented in this report.

While under the AUP high-flow take regulations, water could be harvested immediately once the median flow is exceeded (**Section 4.1**), the rate at which this could occur, up to the maximum take rate, will ultimately depend on the configuration of pumps installed (i.e. number of pumps and variable speed drives). Therefore, this analysis made the conservative assumption that the take could not operate until flows had reached the median + 30 L/s (i.e., 161 L/s).

Scenario 2 demonstrated the incorporation of supplementary groundwater at a rate of 20 L/s, during times when reservoir storage is between 40% to 65% capacity, would reliably meet site water use requirements 48- out of 49-years, based on the historic climate record. Similar to the surface water take, a range of groundwater abstraction scenarios were assessed in order to determine the maximum daily and annual maximum abstraction volumes required to meet the Project's water use requirements. For the sake of clarity and simplicity, these additional scenarios are not presented in this report.

The conjunctive use of stored high-flow water and groundwater as a supplementary source will safeguard the development from potential water shortages and increased demand associated with climate change.

6.2.1 Take Statistics

The range in surface water and groundwater take volumes for Scenario 2 over the 49-year simulation period are summarised in **Table 8** and **Table 9**, and **Figure 15** and **Figure 16**, respectively. This data demonstrates the following:

- The surface water take will be typically greatest during spring and early summer (prior to New Year) and very small in mid-late summer months (due to lack of floods);
- The groundwater take will typically only be needed during January to March and occasionally in December and April.

Table 8. Monthly surface water take volume statistics (m^3/month) from 49-year simulation.

Month	Minimum	Mean	Maximum
July	0	6,962	32,436
August	0	6,296	41,277
September	0	8,605	36,484
October	0	10,968	36,143
November	0	16,157	59,506
December	109	19,343	54,962
January	197	7,589	48,049
February	117	1,010	15,431
March	262	991	1,725
April	576	1,588	4,793
May	637	5,129	23,278
June	0	8,599	22,011

Table 9. Monthly groundwater take volume statistics (m^3/month) from 49-year simulation.

Month	Min	Mean	Maximum
July	0	0	0
August	0	0	0
September	0	0	0
October	0	0	0
November	0	0	0
December	0	510	16,632
January	0	6,877	46,656
February	0	19,699	50,112
March	0	20,857	53,568
April	0	3,944	42,580
May	0	4	117
June	0	0	0

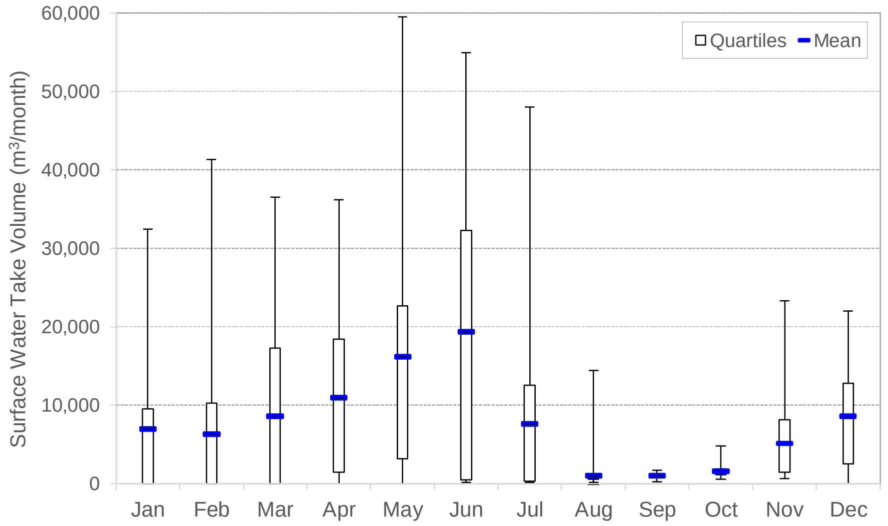

Figure 15. Range in monthly surface water take volumes.

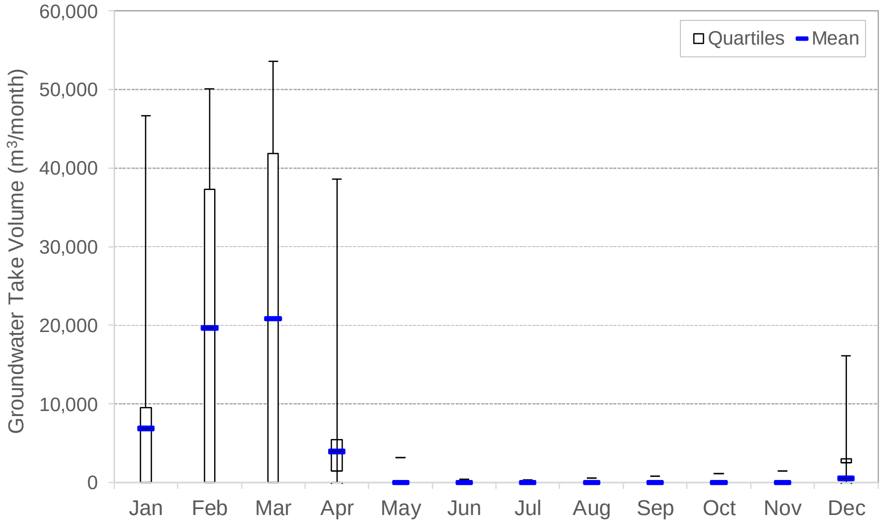

Figure 16. Range in monthly groundwater take volumes.

7. Water Management Strategy

Water is required on the site for potable, domestic and irrigation purposes. Water for potable and domestic purposes will be sourced from groundwater from the deep confined basalt aquifer. Water for irrigation purposes will be sourced from a take from Raurataua Stream when it is in flood flow conditions, and supplementary groundwater from the deep confined basalt aquifer.

Irrigation demand will be primarily supplied via the storage reservoir, with an option to source directly from the groundwater production bore if required. Potable supply for the Lodge, Clubhouse and Wellness Centre will be supplied directly from a groundwater bore to maintain supply of high water quality. The Sports Academy and Maintenance Complex will be supplied through rain harvesting and topped up from the reservoir when required.

The conjunctive use of stored high-flow water and groundwater as a supplementary source will safeguard the development from potential water shortages and likely increased future demand associated with climate change.

The metrics associated with the Water Management Strategy are summarised in **Table 10**.

Table 10. Water Management Strategy metrics.

	Parameter		**Value**
Demand	Irrigation area		55 ha
	Irrigation seasonal volume	Average	132,695 m^3
		(1 in 10-year drought)	237,110 m^3
		Maximum	346,076 m^3
Storage	Reservoir volume		140,000 m^3
Supply	Raurataua Stream median flow		131 L/s
	Surface water high-flow harvesting take rate		Up to a maximum of 30 L/s (at stream flows above the median)
	Deep groundwater for irrigation	Pump rate	20 L/s
		Average seasonal volume	50,000 m^3
		Max seasonal volume	170,546 m^3
	Deep groundwater for potable supply (Lodge, Clubhouse and Wellness Centre)	Annual volume	9,454 m^3
	Rain harvesting (Golf academy and maintenance facility)	Annual volume	4,015 m^3

8. References

McKenzie and Co. 2021. Muriwai Golf Course – Reservoir Feasibility Report. Report Prepared for The Bears Home Project Management Limited. June 2021. Project 1676.

McKenzie and Co. 20.1. Muriwai Downs Golf Course – Engineering Infrastructure Report. Report prepared for the Bears Home Project Management Limited. October 2021.

PDP. 2021. Muriwai Downs Golf Course: Water Supply Options Assessment. Letter to David Moore (Golf Strategy Group Ltd) dated 21 September 2020.

Stamper, Jeff. 2021. Muriwai Downs Golf Course Irrigation Calculations.

WWLA. 2021. Surface Water Effects Report. Report prepared for the Bears Home Project Management Limited.

Appendix A. Irrigation Calculations – Jeff Stamper

Overall Development - Creeping Bentgrass Greens

Turf Area (hectares)	3.44

Turf Requirements	January	February	March	April	May	June	July	August	September	October	November	December
ETo per day (mm)	4.67	3.79	3.13	1.67	1.06	0.87	0.81	1.46	2	3.06	3.83	4.03
Cool Season Turf Crop Coefficient	0.94	0.86	0.74	0.75	0.69	0.6	0.61	0.64	0.75	1.04	0.95	0.88
Creeping Bentgrass Adjustment	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1	1.1
Efficiency of Irrigation System	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Scheduling Coefficient and Contingency	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Adjusted Water Required for Turf (mm)	7.10	5.27	3.75	2.03	1.18	0.84	0.80	1.51	2.43	5.15	5.89	5.74
Total Daily Water Requirement for Turf (liters)	244,279	181,376	128,890	69,698	40,700	29,048	27,495	51,997	83,471	177,091	202,472	197,347
Total Monthly Water Requirement for Turf w/o Rain (liters)	7,572,663	5,078,529	3,995,581	2,090,938	1,261,708	871,433	852,352	1,611,895	2,504,118	5,489,827	6,074,155	6,117,749

Rainfall

50% Probability Monthly Rainfall (mm)	76	68	74	86	111	121	134	124	106	89	82	99
Total Rainfall (liters)	2,614,400	2,339,200	2,545,600	2,958,400	3,818,400	4,162,400	4,609,600	4,265,600	3,646,400	3,061,600	2,820,800	3,405,600
Usable Monthly Rainfall (66%) (liters)	1,725,504	1,543,872	1,680,096	1,952,544	2,520,144	2,747,184	3,042,336	2,815,296	2,406,624	2,020,656	1,861,728	2,247,696
Total Monthly Water Requirement for all Turf including Rain (liters)	5,847,159	3,534,657	2,315,485	138,394	0	0	0	0	97,494	3,469,171	4,212,427	3,870,053

Flow and Storage Requirements

Nightly Water Window (hours)	8	8	8	8	8	8	8	8	8	8	8	8
Flow Required (LPM)	509	378	269	145	85	61	57	108	174	369	422	411
Annual Water Requirement w/o rain (liters)	43,520,947											
Annual Water Requirement with rain (liters)	23,484,840											
Minimum Size Pump Required for normal peak demand (LPM)	509											
One Month storage capacity for Peak Demand (liters)	7,572,663											

Overall Development - Windsorgreen Couch Fairways, Roughs and Tees

Turf Area (hectares)	41.083

Turf Requirements	January	February	March	April	May	June	July	August	September	October	November	December
ETo per day (mm)	4.67	3.79	3.13	1.67	1.06	0.87	0.81	1.46	2	3.06	3.83	4.03
Warm Season Turf Crop Coefficient	0.71	0.71	0.62	0.54	0.58	0.55	0.55	0.54	0.76	0.72	0.79	0.68
Windsorgreen Couch Adjustment	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95	0.95
Efficiency of Irrigation System	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85	0.85
Scheduling Coefficient and Contingency	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80
Adjusted Water Required for Turf (mm)	4.63	3.76	2.71	1.26	0.86	0.67	0.62	1.10	2.12	3.08	4.23	3.83
Total Daily Water Requirement for Turf (liters)	1,903,058	1,544,452	1,113,815	517,591	352,867	274,637	255,696	452,505	872,410	1,264,535	1,736,612	1,572,863
Total Monthly Water Requirement for Turf w/o Rain (liters)	58,994,804	43,244,655	34,528,250	15,527,743	10,938,868	8,239,105	7,926,587	14,027,657	26,172,288	39,200,577	52,098,349	48,758,742

Rainfall

50% Probability Monthly Rainfall (mm)	76	68	74	86	111	121	134	124	106	89	82	99
Total Rainfall (liters)	31,223,080	27,936,440	30,401,420	35,331,380	45,602,130	49,710,430	55,051,220	50,942,920	43,547,980	36,563,870	33,688,060	40,672,170
Usable Monthly Rainfall (66%) (liters)	20,607,233	18,438,050	20,064,937	23,318,711	30,097,406	32,808,884	36,333,805	33,622,327	28,741,667	24,132,154	22,234,120	26,843,632
Total Monthly Water Requirement for all Turf including Rain (liters)	38,387,572	24,806,604	14,463,312	0	0	0	0	0	0	15,068,423	29,864,230	21,915,110

Flow and Storage Requirements

Nightly Water Window (hours)	8	8	8	8	8	8	8	8	8	8	8	8
Flow Required (LPM)	3,965	3,218	2,320	1,078	735	572	533	943	1,818	2,634	3,618	3,277
Annual Water Requirement w/o rain (liters)	359,657,625											
Annual Water Requirement with rain (liters)	144,505,251											
Minimum Size Pump Required for normal peak demand (LPM)	3,965											
One Month storage capacity for Peak Demand (liters)	58,994,804											

Appendix B. Soil Moisture Water Balance Model – Irrigation Module