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Our Ref: 3324_Peer Review Letter_001

13 September 2022

Peer review of Wastewater Management Assessment for proposed Commercial Development at Catherine Field, NSW 2557

This document forms a review of the Wastewater Management Assessment report (the "Martens report" or "WMA"), prepared by Martens Consulting Engineers for the proposed Minarah College (the "College") development at 268 – 278 Catherine Fields Road, Catherine Field NSW (the "Site"), along with response submissions from Camden Council ("Council") and Sydney Water.

This review has been undertaken by Connor Morton and Mark Saunders of Whitehead and Associates Environmental Consultants Pty Ltd ("W&A"). The review was limited to a desktop study only; no Site investigation has been completed.

The following documents have been considered as part of the review:

- Preliminary and Detailed Site Investigation – 268-278 Catherine Fields Road, Catherine Fields, NSW, Report No 14892/2-AA; prepared by Geotechnique Pty Ltd, dated 30 April 2021, 425 pages;
- Civil Works Plan - Minarah College - Catherine Field, Project No P2108320; prepared by Martens Consulting Engineers Pty Ltd, dated 17 March 2022, 31 sheets;
- Wastewater Management Assessment – Minarah College, 268-278 Catherine Fields Road, Catherine Fields, NSW; prepared by Martens Consulting Engineers Pty Ltd, dated 18 May 2022, 55 pages;
- Architectural Plans - Minarah College 268-278 Catherine Fields Road, Catherine Fields, NSW; prepare by Tonkin Zulaikha Greer Architects, dated 31 March 2022, 32 pages; and
- Environmental Impact Statement – Minarah College Catherine Field; prepared by Urbis, dated 2 June 2022, 146 pages.

This document presents the key findings of the review, with relevant observations and recommendations highlighted in grey. Sections of the Martens report and the response submissions are referred to by numbered section and addressed in the order they appear in the relevant documents.

Any mention to 'Appendix' refers to supporting information appended to this document; 'Attachments' refer to information provided with the Martens report.

Wastewater Management Assessment – Minarah College, 268-278 Catherine Fields Road, Catherine Fields, NSW; prepared by Martens Consulting Engineers Pty Ltd, dated 18 May 2022.

1. Introduction

1.1 – Overview

The overview confirms that the development will accommodate up to 1,580 students by Stage 5, consisting of; 840 primary students; 660 high school students; 60 early learning centre (ELC) students; and 20 school for specific purpose (SSP) students.

The information presented in this section is consistent with information provided in the Environmental Impact Statement (EIS).

1.3 – Relevant Standards and Guidelines

The Martens report has been prepared with reference to the following:

- Camden Council (2006) *Sewage Management Strategy* [Council SMS, 2006];
- NSW Department of Environment and Conservation (2004) *Use of Effluent by Irrigation* [DEC, 2004];
- NSW Department of Local Government *et al*. (1998) *On-site Sewage Management for Single Households* [NSW DLG, 1998];
- The NSW Ministry of Health (2001) *Septic Tank and Collection Well Accreditation Guideline* [NSW Health, 2001]; and
- Standards Australia (2012) *Australian / New Zealand Standard 1547: On-site domestic wastewater management* [*AS/NZS 1547:2012*].

As per Section 15 of Council SMS (2006), all requirements of Appendix 8 must be included in the WMA when a commercial treatment system is to be installed.

It is noted that, subsequent to this application, Camden Council have adopted a new 'Sewage Management Policy', dated June 2022 [Council SMP, 2022].

Whilst the majority of Council requirements for OSSM remain unchanged between the Council SMS (2006) and SMP (2022), some variation exists and may have bearing on the advice provided in this review. Where appropriate, additional comment is provided in the relevant section.

2. Site Description

Site summary details are described in Table 1 of the WMA and identify the Site as being located on the Blacktown ('bt') Soil Landscape. Soil chemistry data has been inferred from another site located on the same soil landscape and is supplied as Attachment E of the WMA.

W&A have confirmed the location of the reference soil site using the NSW Office of Environment and Heritage's (OEH) information system (eSPADE). This approach is supported by W&A.

2.2 – Climate Data

Rainfall data from Bringelly (Maryland) (Station 068192, 1867 - 2021) and evaporation data from Prospect Reservoir (Station 067019, 1987 - 2021) have been used in the WMA.

Appendix 8 of Council SMS (2006) also requires information regarding 'storm intensity' and 'prevailing wind' to be provided in the climate description for commercial OSSM applications.

This minor omission can easily be rectified by the designer in the WMA.

Table 2 of the WMA presents Class A pan evaporation as a 'median monthly' dataset.

This is mislabelled and should read 'mean monthly' based on the quoted Bureau of Meteorology (BoM) station report. W&A have confirmed that the data presented in the table is accurate.

2.3 – Hydrogeological Assessment

Groundwater inflow was detected at 500mm within one (1) borehole (BH107) during the soil survey described in the Martens report.

The WMA provides a probable explanation for the groundwater detection and notes that it is isolated to one (1) borehole only. The recorded location is outside of the proposed effluent management areas (EMAs) for Stages 1 & 2 of the development and is therefore not considered to be of substantial concern.

3. Wastewater Management Assessment

3.1 – Soil Profile and Effluent Application Rates

The Civil Works Plan proposes up to 2.25m of soil disturbance (cut/fill) works across the Site, disturbing the natural topography and soil profile.

As per the Civil Works Plan (Appendix Q of the EIS) it is assumed that cutting and filling works will occur in stages, consisting of initial earthworks in the west and south of the Site to facilitate Stage 1 development, followed by additional works to allow for the remaining Stages (refer Sheets 9 and 10 of the Civil Works Plan).

The proposed (Stage 1) EMA will be located on the natural soil profile in the northeast of the Site. Plans indicate that 'no filling' of the EMA will occur during Stage 1 works; however, fill material will be added to the already established Stage 1 EMA location during later earthworks. Natural topsoils in the vicinity of this location consist of clay loam (Cat 4) to a depth of 0.1m (BH109) and 0.3m (BH113). W&A recommend that the Stage 1 fill plan is modified to include the provision of a (minimum) 0.3m topsoil depth throughout the EMA. Care should be taken to ensure that only native topsoil material is added to this area (no subsoil).

The proposed (Stage 2) EMA includes areas of variable cut (-0.15m to -0.75m) and fill (0.15m to 1.5m) in the centre of the Site. While filling may increase the available topsoil depth, excavation (cut) will expose the underlying (Cat 5) light clay subsoil material.

The WMA recommends the addition of 0.3m (minimum) of 'suitable' topsoil in proposed EMAs where cutting or filling works have exceeded 1m. W&A recommend that this procedure is expanded to include all areas where effluent application is proposed to ensure that satisfactory soil depth is available for irrigation installation and effluent assimilation. This approach is consistent with *AS/NZS 1547:2012*, requiring a minimum 150mm-250mm of "in-situ or imported good quality topsoil" for irrigation lines installed over Category 5 soils to slow seepage and assist with nutrient uptake. Further, it is recommended that 'in-situ' topsoil from cutting works is stockpiled from the Site and used for improvement of EMA locations prior to installation.

It is noted that Section 8.9 of Council SMP (2022) now requires that effluent is only to be applied to natural soil profiles, with EMAs on cut or filled land no longer supported.

Care must be taken to ensure that adequate topsoil depth is achievable throughout all proposed EMA's during each Stage of the development.

BH108 – BH114 are considered accurate representations of the soil profile within the EMA, consisting of 0.1m – 0.3m of moderately structured clay loam (Category 4) topsoil underlain by moderately structured light clay (Category 5) subsoils to 0.9m – 1.7m.

There are sufficient boreholes distributed across the Site on different landform elements and elevations to adequately characterise the soil profile within the preferred EMA locations (refer Figures 1 and 2, Appendix A).

Based on the limiting Category 5 subsoil, a design irrigation rate (DIR) of 3mm/day has been adopted, as per Table M1 of *AS/NZS 1547:2012* and Table 4 of Council SMS (2006).

The adopted (maximum) DIR for EMA design is supported.

A preferred OSSM design comprising 'secondary treatment of wastewater (with disinfection)' and onsite reuse via 'subsurface irrigation' has been selected for the Site.

Subsurface irrigation of secondary effluent is considered a best practicable option (BPO) for Sites with limiting Category 5 soils (Table M1, *AS/NZS 1547:2012*); assuming that the recommended (minimum) topsoil depth described can be reliably achieved.

The WMA states that no reserve irrigation area is required, based on the provision of an 'improved wastewater treatment and land application system'.

The reserve area waiver provision in *AS/NZS 1547:2012* (C5.5.3.4) is subject to the discretion of the regulatory authority.

Section 17.5 of Council SMS (2006) requires the provision of a 50% reserve area for aerated wastewater (secondary) treatment systems with irrigation. Based on detail provided in Table 10 of the WMA, provision of a 50% reserve area is only achievable for Stage 1 development at the Site.

A 'reserve area' is set aside to allow for the replacement or extension of the EMA in the case of failure. The anticipated timeframe for operational delivery of the Stage 2 development is 9 years (EIS Section 3.2.4; Urbis, 2022); therefore, W&A do not anticipate a requirement for the reserve area as the expected serviceable life of a properly installed and maintained subsurface irrigation system is typically >15 years (*AS/NZS 1547:2012*).

3.2 – Landform and Soil Constraints Assessment

Table 4 of the WMA presents the results of a site and soil assessment, as per NSW DLG (1998), and provides information on: flood potential; exposure; slope; landform; surface waters; fill; rock outcrops; geology; depth to bedrock and water table; coarse fragments and electrical conductivity. The limitations associated with these Site attributes are mostly minor, with the impact of fill and depth to bedrock presenting moderate limitations.

Boreholes within proximity of the proposed EMA locations indicate available soil depths of 0.9m – 1.7m. *AS/NZS 1547:2012* recommends a minimum separation of 0.5m between the point of effluent application and the most limiting (bedrock) constraint. This requirement can be achieved with the proposed design, as irrigation lines will be installed 0.1m – 0.15m below the finished surface.

The presence of fill has been assigned a moderate limitation, and was observed in BH107 only.

This was the only borehole with fill detected during the Site investigation. The location is outside of the proposed EMA and therefore is not of concern.

Section 21.8(c) of the Council SMS (2006) also describes a number of other site and soil parameters that have not been assessed within the WMA: run-on and up-slope seepage; erosion potential; sodicity (ESP); fertility (CEC), and stability (Emerson Aggregate Test).

> Whilst not described in the WMA, Emerson Aggregate Test and soil sodicity (ESP) results for Site soils is presented in Attachment E. Soil stability is described as a minor limitation (EAT Class 5); however, ESP results indicate that sodic conditions (>6% ESP) may occur in subsoils (>0.5m) on the 'bt' soil landscape.
>
> Soil fertility analysis is presented in the Preliminary and Detailed Site Investigation (Geotechnique, 2021), with results ranging from 5.7cmol/kg to 18cmol/kg.
>
> These parameters may present limitations to OSSM and may require soil amelioration works to ensure sustainable land application of effluent. Further discussion of this requirement should be addressed in the WMA.

3.3 – Buffers and Setbacks to Effluent Management Areas

All recommended setback distances presented in Table 3 of Council SMS (2006) have been applied to the proposed Stage 1 and 2 EMAs, including a discretionary 3m/1.5m setback to downslope and upslope stormwater works respectively.

> It is noted that the required 40m setback to 'other waters' is not practically achieved for the identified Stage 1 EMA, with a partial encroachment in the north-east corner of the Site (refer Figures 1 and 2, Appendix A).
>
> This can be rectified with a minor modification to the proposed Stage 1 EMA in the WMA report.

The WMA does not mention the required setbacks to treatment and holdings tanks.

> As per Section 21.2(b) of Council SMS (2006), 5m and 2.5m setbacks are required between tanks and property boundaries and buildings (dwelling, habitable building, and other structures), respectively.
>
> Compliance with this requirements should be confirmed in the WMA, and identified on the associated Site Plans.

3.4 – Site Wastewater Generation Rates

The property is currently serviced by on-site (tank) water supply. Reticulated (town) water service is available at the Site.

> Wastewater flow allowances should be based on the assumed availability of reticulated (town) potable water supply to the College, as described in the EIS (Urbis, 2022).

The WMA proposes 'balancing' of the wastewater effluent load to the EMA, with Site use limited to 5 days per week (Mon-Fri) only during Stages 1-3 of the development, as described in the EIS (Urbis, 2022).

> Flow balancing is an acceptable method of managing variable inflows to an OSSM system, whereby, the cumulative (5-day) weekly wastewater generation is treated and stored before being proportionally dispersed to the available EMA over the entire (7-day) week.
>
> The limited use of College facilities during Stage 1 and 2 development operations is clearly outlined in the 'Hours of Operation' as described in the EIS (Urbis, 2022).
>
> W&A support effluent flow balancing as an appropriate strategy for a 'school-based' OSSM design.

The assumed wastewater flow allowance for staff/students at the College is based on (potable) water usage and effluent pump-out invoices from comparably sized schools in the Sydney region. A design value of 20L/person/day is presented in the WMA.

It should be noted that a flow allowance describes 'typical' wastewater generation values, and wastewater is generated as a proportion of total potable water usage (typically ~80%); therefore, potable water use records are a reliable indicator of average wastewater generation.

Sydney Water[1] advice suggests a typical 'water-efficient' primary school would use <9L/day of potable water per student, increasing to 18L/day for a 'medium' intensity (primary school) user.

The WMA anecdotally cites a number of school examples used to develop the design flow allowances.

No further supporting evidence for the 'school' design values is provided in the WMA.

W&A experience with similarly-sized educational facilities in the Central Coast and Hunter regions is consistent with the analysis provided for this study. The proposed (per person) flow allowance is comparable to the mid-range guidance in Table H4 *AS/NZS 1547:2012* and the (no-shower / no-cooking) values presented in Annexure 3 of NSW Health (2001).

It is understood the College will predominantly cater to the Islamic community, where it is further assumed that a proportion of students and staff will participate in prayer activities throughout the school day.

The Architectural Plans (Tonkin Zulaikha Greer, 2022) show multiple 'ablutions' areas within the Stage 2 floor plan. Whilst not explicitly stated or shown, it could be assumed that additional washing might also be expected as part of ritual observance before prayer.

The degree to which 'additional' wastewater associated with this activity may influence the selection of an appropriate flow allowance is unknown; however, we believe it is not insignificant.

W&A are satisfied that the proposed 'design' flow allowance of 20L/day for future students/staff at the College includes sufficient cushion to account for ablution usage and is acceptable for the Stage 1 and 2 proposal.

Site occupancy (attendance) and wastewater generation (flow) estimates for each development stage is presented in Table 6 of the WMA.

Minor inconsistencies exist between the WMA flow estimates and 'potential' occupancy data presented in the EIS (Urbis, 2022) and Section 1.1 of the WMA; however, the greater of these values is used in the WMA design and is therefore more conservative.

Appendix 8 of Council SMS (2006) requires both 'average' and 'peak' flow rates are provided.

Balanced average dry weather flow (ADWF) rates for each development stage are presented in Table 6 of the WMA.

Analysis of 'peak' flows is not provided. Peak flows can introduce problems to the collection, transfer and treatment systems in response to surge loads during high-usage periods (e.g. breaks). The duration and extent of peak loading on the OSSM system is usually addressed during detailed design.

Further discussion regarding the scale and impact of 'peak' flows should be included in the WMA.

[1] https://www.sydneywater.com.au/education/programs-resources/high-school/water-audit.html

4. Wastewater Option Assessment

The WMA presents three (3) potential wastewater servicing options for the College: pump to sewer; effluent pump-out, and onsite treatment and irrigation. Pump to sewer was discounted due to initial feedback from Sydney Water. Effluent pump-out and onsite treatment and irrigation were considered the most suitable options and are assessed further in the WMA.

5. On Site Wastewater Management

5.1 – Overview

Onsite wastewater management has only been assessed for Stages 1 and 2 as the increased development footprint of Stage 3 will reduce the potential area for effluent reuse. The WMA assumes Sydney Water reticulated sewer services will become available before commencement of Stage 3 developments as the Site is located in a designated growth area (Urbis, 2022).

It is understood that a Feasibility Study for wastewater servicing is in preparation and will be submitted to Sydney Water for consideration.

The WMA further highlights that accrued flow data from the preliminary development (Stages 1 and 2) may be used to inform wastewater flow estimates for the forward stages and, if appropriate, the capacity of the proposed EMA's could be extended to accommodate Stage 3 development.

Section 7.4 of the WMA makes recommendation for collection of detailed Site occupancy and flow monitoring records for the Site during the implementation of the first two development stages.

This information will provide a useful dataset for supporting approval or developing appropriate conditions to the consent for future development of the Site (Stages 3+).

5.2 – Wastewater Collection and Transfer System

The WMA proposes gravity drainage of all wastewater generated from the Stage 1 and 2 development to a 14.4kL collection well nominally located in the northwest of the Site. The collection well will be fitted with a dual-pump assembly, odour controls and access/inspection openings (as required).

The design capacity of the proposed collection well is equal to the 24-hour ADWF for the maximum (Stage 2) development. Accepted design practice would typically provide a multiple of the ADWF volume to accommodate inflows during wet-weather.

In this instance, the integrity of the new sewer reticulation system should be such that wet-weather inflows are largely prevented; therefore, when combined with the proposed overflow storage (see below), the size of the collection well may be adequate.

A separate 'overflow storage tank' of 43kL is also recommended in case of potential pump failure in the collection well. The overflow tank is sized based on three (3) days of storage for the Stage 2 ADWF.

A minimum 8 hours of storage (at ADWF) is typically required for sewage pumping stations in sensitive locations. Preference is usually for the provision of an 'emergency' storage volume in the collection well; however, an off-line overflow storage volume can also be considered if appropriate management procedures are in place.

W&A believe the capacity of the proposed overflow storage tank is sufficiently conservative to prevent adverse outcomes associated with collection well inoperability (i.e. pump failure). Three (3) days storage is sufficient time to undertake maintenance or repair activities on infrastructure or, if necessary, organise a pump-out Contractor to safely empty the storage if longer-term repairs are necessary.

Monitoring and maintenance of the wastewater transfer and emergency storage systems is a critical component of the proposed OSSM design. Procedures must be clearly documented in an Operational Management Plan as part of the detailed design for the proposal.

Raw wastewater from the collection well is to be transferred to the proposed sewage treatment plant (STP) via dedicated rising main.

The WMA proposes a dual-pump assembly in the collection well. It is assumed the pumps will operate in a redundant (duty/standby) configuration which offers the best defence to individual pump failure. Pump type is not provided; however, vortex-impeller or macerating pumps are common.

No mention of pump control and alarm systems is provided in the WMA. This can be addressed during detailed design and specification for the wastewater transfer and collection system. Procedures must be clearly documented in an Operational Management Plan as part of the detailed design for the proposal.

5.3 – Treatment and Effluent Management

5.3.1 – Wastewater Treatment System

There is no mention of the expected wastewater quality from the development in the WMA. Appendix 8 of Council SMS (2006) requires that a list of wastewater generating processes is also provided.

Based on the Architectural and Staging Plans (Tonkin Zulaikha Greer, 2022), it appears that generated wastewater from Stages 1 and 2 of the development will predominantly result from the use of bathroom facilities (WCs, urinals and basins); kitchenettes; and showers.

No commercial kitchen, food-technology, or other high-strength (e.g. laboratory) wastewater generating components are included in the Stage 1 and 2 development plan. A small laundry facility is noted on the Stage 1 Staging Plan; however, use would be expected to be minimal/intermittent and adequately accounted for in existing flow assumptions.

The expected quality of ‘influent’ wastewater from the Stage 1 and 2 development should be included in the WMA and should address all parameters described in Appendix 8 of Council SMS (2006).

Appendix 8 of Council SMS (2006) requires that an estimate of the expected organic loading (g/day as BOD_5) is provided.

The anticipated organic load from the Stage 1 and 2 development can be derived from the influent wastewater characteristics and flow data, and should be included in the WMA.

The WMA indicates that wastewater will be transferred from the collection well directly to the STP (via rising main). The proposed STP will be capable of treating up to the Stage 2 ADWF of 14.4kL/day to a secondary effluent quality standard with disinfection.

Appendix 8 of Council SMS (2006) requires that a system selection rationale, treatment process description and influent loading (staging) profile are provided for any proposed commercial STP application. Appendix 8 also requires schematic flow diagrams and details of major components (aerators, sprays, pumps etc.) be provided.

System selection, process design and influent flow analysis are typically prepared at detailed design stage. W&A are satisfied that all required information can be provided during detailed design and specification for the wastewater collection, transfer and treatment system prior to the commencement of Site construction activities.

The proposed STP design assumes that all wastewater generated at the Site, up to the completion of the Stage 2 development, will be treated to a secondary effluent standard without the need for flow management. Post-treatment, effluent will be directed to an ‘effluent storage system’ capable of balancing the design hydraulic load to the EMA.

The WMA recommendation for an STP capacity ‘up to’ 14.4kL/day provides little redundancy and relies on the accuracy of the wastewater generation estimates presented.

Whilst it is accepted that commercial STP designs include provision for ‘surge’ loading conditions, they are not typically designed to be operated at maximum rated capacity indefinitely. Given the uncertainty associated with ‘design’ load estimates for the proposal, and no provision for upfront (influent) flow moderation in the design, W&A support the inclusion of additional capacity in the STP sizing.

W&A suggest the design capacity of the proposed commercial STP be increased to 110% of the anticipated ADWF in the WMA, and subsequent planning documents. On present estimates, this would increase the STP capacity from 14.4kL/day to 15.84kL/day (≤16kL/day).

5.3.2 – Effluent Storage System

Secondary disinfected effluent will be transferred from the STP to a 70kL effluent storage tank. The proposed volume comprises 20.5kL of ‘effluent balancing’ capacity and 35kL of ‘wet weather storage’ capacity; with a further 25% volume increase for conservatism.

W&A have confirmed the required 20.5kL ‘effluent balancing’ volume using an in-house model (copy attached at Appendix B). The model assumes the seven (7) day flow characteristics based on completion of Stage 2 development works and the proposed EMA loading, as described in Table 6 of the WMA.

The water balance model presented as Attachment D of the WMA is reviewed separately in this document (refer Section 8). Whilst inconsistencies are identified, W&A are satisfied that the required 35kL ‘wet weather’ storage volume is appropriate.

The WMA proposes that the effluent storage tank will be fitted with level alarms at 50% and 80% of total tank capacity, with pump-out for off-site disposal via a licensed contractor to occur when the tank reaches 80% capacity.

The ‘additional’ effluent storage capacity appears to be related to typically available tank sizes; however, beneficially it is noted that based on design flow estimates more than two (2) days of additional storage is available.

The intention behind the proposed ‘pump-out’ trigger is unclear, but appears to address inherent uncertainty at the concept design stage.

Details regarding the final sizing, design and operation of the effluent storage system can be provided during detailed design and specification for the OSSM system prior to the commencement of Site construction activities.

5.3.3 – Effluent Quality

Table 7 of the WMA states that the final STP design must achieve the following (secondary) effluent standard: BOD_5 <20mg/L; suspended solids <30mg/L; E. coli <1,000cfu/100mL; total phosphorus <10mg/L, and total nitrogen <30mg/L.

Table 6 of Council SMS (2006) specifies a minimum acceptable pathogen standard as <30cfu/100mL for disinfected secondary effluent. This value <u>must</u> be included in the effluent performance specification for the proposed STP design.

As per Appendix 8 of Council SMS (2006), discussion of the following effluent quality parameters should also be included in the WMA for commercial systems: temperature; pH; radioactivity; oil, grease or floating solids; infectious or contagious materials, and restricted substances.

Whilst not described, it is assumed that the majority of these effluent parameters will not be of concern due to the nature of the development. This omission can easily be rectified by the designer in the WMA.

5.4 – Effluent Application Assessment

5.4.1 – Soil Hydraulic Design

The WMA presents preliminary assessment of the required EMA necessary to accommodate the balanced hydraulic load from the Stage 2 development. The approach uses the *AS/NZS 1547:2012* 'areal' sizing method to calculate a minimum hydraulic area of 3,435m^2 (rounded).

The *AS/NZS 1547:2012* method does not take into account climate factors. Further analysis using water balance modelling is presented in Section 5.4.3 of the WMA.

5.4.2 – Nutrient Modelling

The WMA also presents nutrient modelling to determine the minimum EMA required to ensure that key nutrients (nitrogen and phosphorus) can be safely assimilated on Site, reducing the risk of off-site export.

Model results are presented in Attachment D of the WMA, indicating EMAs of 5,600m^2 and 2,440m^2 are required for nitrogen and phosphorus assimilation respectively, based on the anticipated Stage 2 development load. Nutrient concentration values of total nitrogen (TN) = 30mg/L and total phosphorus (TP) = 10mg/L were used in the WMA analysis.

W&A have confirmed the nutrient balance results presented in the WMA and find them to be sustainably conservative and based on best-practice science, as described in *Designing and Installing On-Site Wastewater Systems: A WaterNSW Current Recommended Practice* (WaterNSW, 2019) and demonstrated in Appendix 2 of the *Victorian Land Capability Assessment Framework* (MAV and DSE, 2014). Copies of the (W&A) confirmation nutrient balances for both development stages are provided at Appendix C.

Section 21.8(f) of Council SMS (2006) requires a total phosphorus concentration of 12mg/L be adopted for design, unless extensive testing of system produced by the same manufacturer is carried out within the Camden Local Government Area (LGA).

Camden Council takes a more precautionary approach to achievable phosphorus (TP) concentrations in secondary effluent from commercial STPs. The required 12mg/L value is consistent with performance values reported for many domestic secondary treatment systems. Updated modelling using the required TP concentration was completed using the confirmed W&A nutrient balance, resulting in revised nutrient EMA requirements of: Stage 1 - 2,738m^2 for nitrogen and 1,431m^2 for phosphorus; and Stage 2 - 5,600m^2 for nitrogen and 2,928m^2 for phosphorus. As shown, the required nitrogen (TN) area is the limiting criteria for each development Stage. Therefore, the conservative Council SMS (2006) phosphorus loading value can readily be accommodated within the EMA design presented in the WMA. Copies of the updated nutrient balances for both development stages are provided at Appendix C.

5.4.3 – Water Balance Assessment

The WMA presents a water balance assessment for the purpose of optimising the required wet weather storage volume for the Stage 2 development load. The water balance model is referred to as Attachment E of the WMA.

The relevant WMA summary table is referred to incorrectly as Table 9 in the text and the associated water balance can be found as Attachment D of the WMA.

WMA Table 8 presents the results of the Stage 2 wet weather storage assessment, with a 35kL volume selected and resulting in a minimum EMA requirement of 6,138m^2 to accommodate the Stage 2 development load.

W&A have confirmed the water balance model presented in the WMA and find it be sustainably conservative and based on best-practice science, as described in Appendix Q of *AS/NZS 1547:2012* and demonstrated in Appendix 1 of the *Victorian Land Capability Assessment Framework* (MAV and DSE, 2014).

5.4.4 – Irrigation Field Design Summary

WMA Table 9 presents a summary of the soil (effluent) loading rates used to determine the appropriate size of the required EMA for each development stage. The analysis states that a design value of 1.8mm/day has been adopted, based on the most-limiting (nitrogen) balance.

When reviewing the WMA water balance (Attachment D), it is noted that the 'design percolation rate' (DPR) used = 1.429mm/day. It is unclear why this value has been used rather than the 3mm/day value obtained from the soil analysis (WMA Table 3).

The applied DPR may have been included by omission or error during WMA preparation. Regardless, the value used is significantly more conservative than the (maximum) acceptable rate based on *AS/NZS 1547:2012;* therefore presenting no material impact to the final design.

This confusion can easily be rectified by the designer in the WMA.

The WMA (Table 10) summarises the minimum EMA requirements for each development stage based on the most-limiting design criteria.

Stage 1 requires an EMA of 2,738m^2, based on the limiting nitrogen balance.

The Stage 1 nutrient balance is confirmed by W&A. Copy attached in Appendix C.

The Stage 1 water balance is confirmed by W&A. Based on a conservative assumption of 20% run-off, an 'effective' soil loading rate of 2mm/day is expected, with zero wet-weather storage requirement. A copy of the updated (W&A) water balance is attached in Appendix D.

Stage 2 requires an EMA of 6,138m^2, with 35kL wet weather storage, based on the limiting hydraulic balance.

The Stage 2 nutrient balance is confirmed by W&A. Copy attached in Appendix C.

The Stage 2 water balance is confirmed by W&A. Based on a conservative assumption of 20% run-off, an 'effective' soil loading rate of 1.83mm/day is expected, with zero wet-weather storage requirement. A copy of the updated (W&A) water balance is attached in Appendix D.

5.4.5 – Effluent Reuse Management Requirements

The WMA proposes the use of a 'rain sensor' controller (or similar) to indicate when weather conditions are not conducive to irrigation. The sensor should be arranged such that it overrides the irrigation timer-control and stores treated effluent until the next irrigation cycle is triggered or conditions are favourable.

The use of a 'rainfall' irrigation override is an effective measure to ensure that the EMA does not become overloaded during extended periods of wet weather. Providing the proposed 35kL wet weather storage volume, greater than 3.4 days of storage is available based on the Stage 2 ADWF.

5.4.6 – Effluent Management Area Requirements

The WMA summarises standard requirements for the effective installation and operation of the proposed Stage 1 and Stage 2 subsurface irrigation (SSI) EMA's, consistent with the guidance in *AS/NZS 1547:2012*.

Section 21.4(4) of Council SMS (2006) requires that stormwater diversion drains are to be implemented upslope of the EMA to divert surface water away.

The implementation of upslope stormwater diversion devices for EMA's is considered best-practice as their performance can be adversely affected if stormwater is allowed to run on to the EMA.

Stormwater diversion devices should be designed and constructed to collect, divert and dissipate collected run-on away from the EMA. The structure should be installed by a suitably qualified professional and be compliant with relevant guidelines and standards.

The WMA (and Site Plans) should be amended to show the location and construction of any proposed stormwater diversion structures associated with Stage 1 and Stage 2 development works.

6. Pump Out Wastewater Management

6.2 – Proposed Wastewater Treatment and Storage

The WMA recommends a septic tank designed to treat 14.5kL/day.

Annexure 3; Section 6 of NSW Health (2001), provides a formula for the required septic tank volumes for commercial developments. Septic tanks are to be sized on a minimum sludge allowance (1,550L), plus the expected ADWF (14,320L).

Therefore, a minimum septic tank size of 16kL (rounded) is recommended to service all development up to Stage 2.

The WMA recommends an 86kL collection well to store primary treated effluent prior to collection for off-site disposal. The required volume is based on a minimum five (5) days of effluent storage (71.6kL) plus 20% freeboard.

Annexure 3; Section 6 of NSW Health (2001) provides a formula to size the required collection well volume for commercial developments.

Based on the expected daily flow (14,320L) and an assumed weekly pump-out frequency (5-days generation), the proposed collection well volume is appropriate, providing additional storage in the case of pump-out tanker delays.

The collection well will be fitted with level monitoring equipment, alarms and communication equipment to advise when 80% and 100% of the available tank capacity is reached, as well as the top water level.

It is assumed that the collection well will be pumped out by a licensed Contractor for off-site disposal once the 80% alarm (~69kL) has been triggered. No mention of the type of alarm system (audible, visual, telemetric) is provided in the WMA. Procedures must be clearly documented in an Operational Management Plan as part of the detailed design for the proposal.

7. Recommendations and Conclusion

7.5 – Conclusion

The WMA finds that the development is capable of managing wastewater via either (i) onsite treatment and irrigation; or (ii) pump-out for all proposed development up to and including Stage 2 works.

The WMA anticipates that Sydney Water will be in a position to extend the reticulated sewer service to the area prior to Stage 3.

W&A agree that the Site is capable of managing wastewater for Stages 1 and 2 if the matters raised in this review are addressed.

8. Attachments

Attachment A

No locality plans are provided.

As per Appendix 8 of Council SMS (2006), a locality plan must be provided showing the Site location in relation to public roads or places; and any natural or artificial waters and proposed buffer zones. A plan should also be provided showing facilities within 100m of the proposed sewage management facility. This omission can easily be rectified by the designer in the WMA.

Attachment D

Water Balance Modelling

Inconsistency occurs between the water balance model and the input variables described in the WMA, as shown in the following table.

Input	WMA (Section 5)	Attachment D
Daily Effluent Load (L/day)	**10,229**	**10,229**
Effluent Disposal Area (m^2)	**6,138**	5,573
Wet Weather Storage (kL)	**35**	60
Design Irrigation / Percolation Rate (DIR/DPR) (mm/day)	3.0	**1.429**

By iteration, W&A confirm the input variables shown **in bold** have been used in the 'design' water balance modelling.

Comparison with the (W&A) review model confirms that the (WMA) water balance model (Attachment D) is validated, with inconsistencies most likely due to documentation error.

It is recommended that the WMA water balance model is reviewed and clarified, as necessary.

A design percolation rate of 1.429mm/day has been used, rather than the 3mm/day value presented in the WMA.

As discussed, it is unclear why the design value presented in Section 3.1 of the WMA (3mm/day) has not been used. This should be clarified by the designer.

A run-off factor of 35% has been used in the water balance model.

> This value describes the proportion of incident rainfall that would be expected to run-off due to the inability to infiltrate EMA soils. It is typically influenced by slope and ground condition (topsoil permeability and cover).
>
> Run-off values >30% are considered high, particularly for the Site where natural and constructed slopes are <10%. W&A consider a value of 20% to be more applicable and this value has been used in our water balance model assessment.

Nutrient Balance Modelling

A soil P-sorption value of 403mg/kg has been used, as 50% of the weighted average P-sorption value (assumed to be 806mg/kg).

> This approach is considered sufficiently conservative.

The bulk density of the soil is not provided, and is necessary to calculate the P-sorption capacity.

> By iteration, W&A have confirmed the assumed bulk density value to be 1.65g/cm^3. This value is more indicative of a 'sandy' soil profile. No laboratory data or analysis supporting this value is provided.

Camden Council Submission

1. Planning

1.7 – Sewer / Pump-out System

Council do not support pump-out systems due to the potential for failure and reliance on transport vehicles with a lack of flood free access roads.

> W&A concur with the Council view; however, it is expected that, in the event of flood or local road inundation Site attendance would be significantly reduced or ceased. Subsequently, expected wastewater generation during that period would not occur.

1.8 – Sewer / Onsite Disposal

The capacity of the system and planned redundancies in the event of failure are to be carefully considered.

> W&A believe the capacity of the proposed overflow storage tank is sufficiently conservative to prevent adverse outcomes associated with collection well inoperability (i.e. pump failure), allowing sufficient time to undertake maintenance or repair activities on infrastructure or, if necessary, organise a pump-out Contractor to safely empty the storage if longer-term repairs are necessary.
>
> The proposed treatment system design is based on the Stage 2 ADWF. As described in this review, W&A recommend the STP capacity is increased from 14.4kL/day to 15.84kL/day (≤16kL/day) to address variability in wastewater generation from the proposal.

Strict measures are to be put in place to prevent future users coming into contact with effluent.

> Wastewater will be treated to a secondary standard with disinfection, with effluent disposed at 0.1m – 0.15m below the ground surface in dedicated EMA's located away from Stage 1 and Stage 2 development areas. Both the STP and EMA's will be fenced to limit public access.

Sydney Water Submission

Sydney Water states that the Site is located within the Leppington Water Supply Zone, which has limited capacity to service growth. Hydraulic modelling will be carried out to assess the infrastructure requirements to service growth in the area, and a commercial agreement may be required to upgrade or amplify water supply to service the College.

The Site has access to a potable water main at Catherine Fields Road; however, hydraulic modelling will be necessary to assess the possibility of connection of these mains.

Sydney Water states that the ‘South West Growth Area Catherine Field Precinct’ is yet to be released or rezoned for development; hence, there is no plan to deliver reticulated sewer services to the locality within the next five (5) years.

Sydney Water do not provide any indication that the expansion of the sewer network will be available to the Site by the expected Stage 3 development timeframe (2035). Sydney Water request that the proponent maintain contact throughout the development stages to assess the future likelihood of this connection.

9. W&A Concluding Remarks

This concludes our review of the WMA and associated submissions for the proposed (Minarah) College development at 268 – 278 Catherine Fields Road, Catherine Field NSW.

It is our view that the College **can** sustainably manage expected wastewater generation from the College via onsite wastewater treatment and irrigation until the end of Stage 2, transitioning to reticulated sewer when made available, subject to confirmation by Sydney Water.

Whilst the effluent pump-out proposal is considered achievable (following the recommendations in this Letter Report), W&A believe it not to be the most-appropriate solution for the Site. Further, Section 8.13.1 of Council SMP (2022) states that "any new development that relies on the use of pump-out systems are not supported by Council". This consideration, along with the significant ongoing costs associated with a pump-out system, make onsite treatment and subsurface irrigation the preferred approach to wastewater management for the College.

The summary results of our review are as follows:

For completeness of the WMA:

- Information regarding expected 'storm intensities' and 'prevailing wind' should be included in the WMA;
- The cut/fill plans (and notes) should be modified to include the provision of a (minimum) 0.3m topsoil depth throughout the EMA, ensuring that satisfactory soil depth is available for irrigation installation and effluent assimilation;
- Remove the (1m) cut/fill threshold for the required addition of 0.3m of suitable topsoil to effluent application areas;
- Recommend topsoil materials from cutting works is stockpiled and used for the improvement of the proposed EMA prior to installation;
- Address potential soil amelioration works required to ensure sustainable application of effluent;
- Ensure the 40m setback from the EMA to 'other waters' is achieved, along with 5m and 2.5m setbacks from tanks to property boundaries and buildings, respectively;
- Further discussion regarding the scale and impact of 'peak' flows should be included;
- Further detail regarding wastewater generating processes at the Site, along with the anticipated quality and organic load of the 'influent' wastewater for Stages 1 and 2 should be included;
- Consider increasing the design capacity of the proposed STP to (minimum) 16kL/day;
- Clarify the 'design percolation rate' used for the water balance modelling;
- If required, show the location and construction of stormwater diversion structures associated with the Stage 1 and 2 development works, along with one (1) metre contours, on the Site Plans; and
- Review and update the attached water balance modelling (as required).

To comply with *AS/NZS 1547:2012*:

- Ensure irrigation lines are installed in 0.15 – 0.25m of good quality topsoil (Table M1, Note 1).

To comply with Council SMS (2006):

- Provide a minimum 50% reserve effluent management area for each development stage (Section 17.5);

- Reduce the minimum acceptable pathogen concentration of effluent to <30cfu/100mL (Section 21.10);
- Address the effluent quality parameters outlined in Appendix 8 of Council SMS (2006); and
- Provide a locality plan, showing the location of the Site in relation to public roads / places, waters and proposed buffer zones (Appendix 8).

Prior to Approval to Install the OSSM system:

- An Operational Management Plan addressing the design, sizing and operational monitoring of collection, emergency storage and flow-balancing systems should be prepared and submitted to the approval authority, along with appropriate procedures for response and reporting.

If you have any questions or require any further information, please do not hesitate to contact the undersigned.

Yours sincerely,

Cmorton

Connor Morton
Environmental Consultant
Whitehead & Associates

Mark Saunders
Senior Environmental Consultant
Whitehead & Associates

Appendix A

Figures

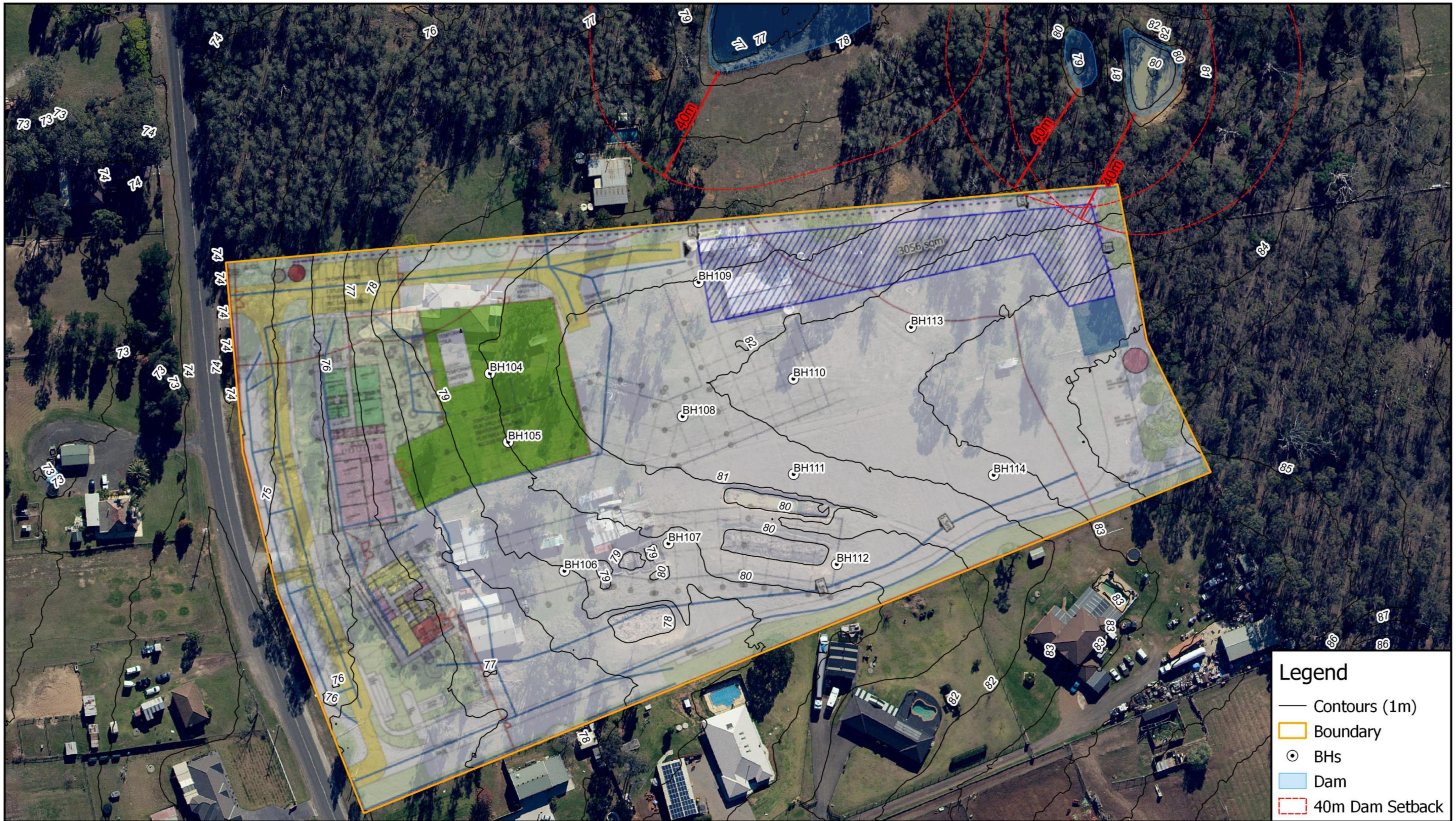

Figure 1: Site Plan Showing Proposed On-site Wastewater Management (Stage 1)

3324: Minarah College - Third Party Peer Review

Whitehead & Associates
Environmental Consultants

0 50 100 150 200 250 300 m

(Approx Scale)

Revision	001
Drawn	CM
Approved	MS

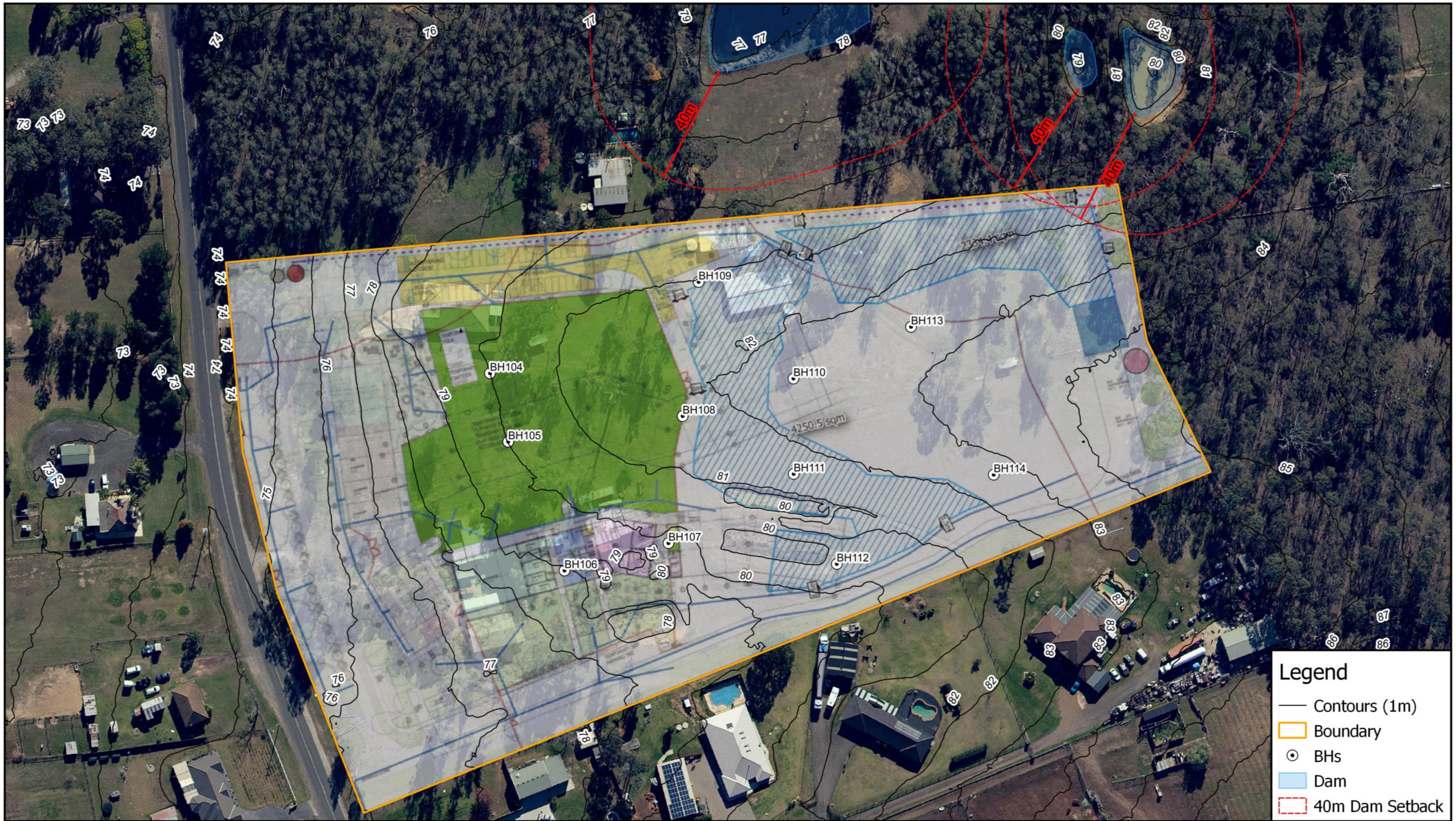

Figure 2: Site Plan Showing Proposed On-site Wastewater Management (Stage 2)

3324: Minarah College - Third Party Peer Review

Whitehead & Associates
Environmental Consultants

0 50 100 150 200 250 300 m

(Approx Scale)

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Revision	001
Drawn	CM
Approved	MS

Appendix B

Effluent Balance Modelling

Effluent Storage Balancing Assessment

Day	Day	Treated Water Input (L/day)	Recycled Water to Irrigation (L/day)	Excess Wastewater (L/day)	Stored Wastewater from Previous Day (L)		Cumulative Wastewater Storage (L)	Balancing Storage Volume Required (L)
Monday, 31 January 2022	Monday	14,320	10,229	4,091	0		4,091	20,457
Tuesday, 1 February 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	Balancing Storage Volume Required (m^3)
Wednesday, 2 February 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 3 February 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 4 February 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	20.5
Saturday, 5 February 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 6 February 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 7 February 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 8 February 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 9 February 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 10 February 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 11 February 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 12 February 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 13 February 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 14 February 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 15 February 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 16 February 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 17 February 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 18 February 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 19 February 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 20 February 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 21 February 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 22 February 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 23 February 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 24 February 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 25 February 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 26 February 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 27 February 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 28 February 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 1 March 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 2 March 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 3 March 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 4 March 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 5 March 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 6 March 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 7 March 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 8 March 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 9 March 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 10 March 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 11 March 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 12 March 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 13 March 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 14 March 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 15 March 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 16 March 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 17 March 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 18 March 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 19 March 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 20 March 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 21 March 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 22 March 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 23 March 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 24 March 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 25 March 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 26 March 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 27 March 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 28 March 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 29 March 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 30 March 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 31 March 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 1 April 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 2 April 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 3 April 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 4 April 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 5 April 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 6 April 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 7 April 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 8 April 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 9 April 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 10 April 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 11 April 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 12 April 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 13 April 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 14 April 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 15 April 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 16 April 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 17 April 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 18 April 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 19 April 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 20 April 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 21 April 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 22 April 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 23 April 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 24 April 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 25 April 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 26 April 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 27 April 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 28 April 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 29 April 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 30 April 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 1 May 2022	Sunday	0	10,229	-10,229	10,229	0	0	
Monday, 2 May 2022	Monday	14,320	10,229	4,091	0	4,091	4,091	
Tuesday, 3 May 2022	Tuesday	14,320	10,229	4,091	4,091	8,183	8,183	
Wednesday, 4 May 2022	Wednesday	14,320	10,229	4,091	8,183	12,274	12,274	
Thursday, 5 May 2022	Thursday	14,320	10,229	4,091	12,274	16,366	16,366	
Friday, 6 May 2022	Friday	14,320	10,229	4,091	16,366	20,457	20,457	
Saturday, 7 May 2022	Saturday	0	10,229	-10,229	20,457	10,229	10,229	
Sunday, 8 May 2022	Sunday	0	10,229	-10,229	10,229	0	0	

Appendix C

Nutrient Balance Modelling Review

Confirmed (WMA) Nutrient Balance - Stage 1

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Project 3324: Minarah College Third Party Review (Stage 1)

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 2,738 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	5,000	L/day	Crop N Uptake	200	kg/ha/yr	which equals	54.79	mg/m^2/day
Effluent N Concentration	30	mg/L	Crop P Uptake	20	kg/ha/yr	which equals	5.48	mg/m^2/day
% Lost to Soil Processes (Geary & Gardner 1996)	0	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	0	mg/day	P-sorption result	806	mg/kg	which equals	13,299	kg/ha
Remaining N Load after soil loss	150,000	mg/day	Bulk Density	1.65	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	1	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	2,738	m^2	Nominated LAA Size	2,738	m^2
Phosphorus	1,193	m^2	Predicted N Export from LAA	-0.01	kg/year
			Predicted P Export from LAA	-23.64	kg/year
			Phosphorus Longevity for LAA	143	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	**2,738**	m^2			
Daily P Load	0.05	kg/day	→ Phosphorus generated over life of system	912.5	kg
Daily Uptake	0.0150027	kg/day	→ Phosphorus vegetative uptake for life of system	0.100	kg/m^2
Measured p-sorption capacity	1.3299	kg/m^2			
Assumed p-sorption capacity	0.665	kg/m^2	→ Phosphorus adsorbed in 50 years	0.665	kg/m^2
Site P-sorption capacity	1820.63	kg	→ Desired Annual P Application Rate	41.889	kg/year
			which equals	0.11476	kg/day
P-load to be sorbed	12.77	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Confirmed (WMA) Nutrient Balance - Stage 2

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Project 3324: Minarah College Third Party Review (Stage 2)

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 5,600 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	10,229	L/day	Crop N Uptake	200	kg/ha/yr	which equals	54.79	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	20	kg/ha/yr	which equals	5.48	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	0	mg/day	P-sorption result	806	mg/kg	which equals	13,299	kg/ha
Remaining N Load after soil loss	306,857	mg/day	Bulk Density	1.65	g/cm^3			
Effluent P Concentration	10	mg/L	Depth of Soil	1	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer		
Nitrogen	5,600	m^2
Phosphorus	2,440	m^2

Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nominated LAA Size	5,600	m^2
Predicted N Export from LAA	0.00	kg/year
Predicted P Export from LAA	-48.34	kg/year
Phosphorus Longevity for LAA	142	Years
Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE
STEP 1: Using the nominated LAA Size

Nominated LAA Size	5,600	m^2				
Daily P Load	0.1022857	kg/day	→	Phosphorus generated over life of system	1866.714286	kg
Daily Uptake	0.0306849	kg/day	→	Phosphorus vegetative uptake for life of system	0.100	kg/m^2
Measured p-sorption capacity	1.3299	kg/m^2				
Assumed p-sorption capacity	0.665	kg/m^2	→	Phosphorus adsorbed in 50 years	0.665	kg/m^2
Site P-sorption capacity	3723.72	kg	→	Desired Annual P Application Rate	85.674	kg/year
				which equals	0.23472	kg/day
P-load to be sorbed	26.13	kg/year				

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Updated (W&A) Nutrient Balance - Stage 1

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Project 3324: Minarah College Third Party Review (Stage 1)

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 2,738 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	5,000	L/day	Crop N Uptake	200	kg/ha/yr	which equals	54.79	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	20	kg/ha/yr	which equals	5.48	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	0	mg/day	P-sorption result	806	mg/kg	which equals	13,299	kg/ha
Remaining N Load after soil loss	150,000	mg/day	Bulk Density	1.65	g/cm^3			
Effluent P Concentration	12	mg/L	Depth of Soil	1	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	2,738	m^2	Nominated LAA Size	2,738	m^2
Phosphorus	1,431	m^2	Predicted N Export from LAA	-0.01	kg/year
			Predicted P Export from LAA	-19.99	kg/year
			Phosphorus Longevity for LAA	111	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**2,738**	m^2			
Daily P Load	0.06	kg/day	→ Phosphorus generated over life of system	1095	kg
Daily Uptake	0.0150027	kg/day	→ Phosphorus vegetative uptake for life of system	0.100	kg/m^2
Measured p-sorption capacity	1.3299	kg/m^2			
Assumed p-sorption capacity	0.665	kg/m^2	→ Phosphorus adsorbed in 50 years	0.665	kg/m^2
Site P-sorption capacity	1820.63	kg	→ Desired Annual P Application Rate	41.889	kg/year
			which equals	0.11476	kg/day
P-load to be sorbed	16.42	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Updated (W&A) Nutrient Balance - Stage 2

Nutrient Balance

Whitehead & Associates
Environmental Consultants

Project 3324: Minarah College Third Party Review (Stage 2)

Please read the attached notes before using this spreadsheet.

SUMMARY - LAND APPLICATION AREA REQUIRED BASED ON THE MOST LIMITING BALANCE = 5,600 m^2

INPUT DATA [1]

Wastewater Loading			Nutrient Crop Uptake					
Hydraulic Load	10,229	L/day	Crop N Uptake	200	kg/ha/yr	which equals	54.79	$mg/m^2/day$
Effluent N Concentration	30	mg/L	Crop P Uptake	20	kg/ha/yr	which equals	5.48	$mg/m^2/day$
% Lost to Soil Processes (Geary & Gardner 1996)	0	Decimal	**Phosphorus Sorption**					
Total N Loss to Soil	0	mg/day	P-sorption result	806	mg/kg	which equals	13,299	kg/ha
Remaining N Load after soil loss	306,857	mg/day	Bulk Density	1.65	g/cm^3			
Effluent P Concentration	12	mg/L	Depth of Soil	1	m			
Design Life of System	50	yrs	% of Predicted P-sorp. [2]	0.5	Decimal			

METHOD 1: NUTRIENT BALANCE BASED ON ANNUAL CROP UPTAKE RATES

Minimum Area required with zero buffer			Determination of Buffer Zone Size for a Nominated Land Application Area (LAA)		
Nitrogen	5,600	m^2	Nominated LAA Size	5,600	m^2
Phosphorus	2,928	m^2	Predicted N Export from LAA	0.00	kg/year
			Predicted P Export from LAA	-40.87	kg/year
			Phosphorus Longevity for LAA	111	Years
			Minimum Buffer Required for excess nutrient	0	m^2

PHOSPHORUS BALANCE

STEP 1: Using the nominated LAA Size

Nominated LAA Size	**5,600**	m^2			
Daily P Load	0.1227429	kg/day	Phosphorus generated over life of system	2240.057143	kg
Daily Uptake	0.0306849	kg/day	Phosphorus vegetative uptake for life of system	0.100	kg/m^2
Measured p-sorption capacity	1.3299	kg/m^2			
Assumed p-sorption capacity	0.665	kg/m^2	Phosphorus adsorbed in 50 years	0.665	kg/m^2
Site P-sorption capacity	3723.72	kg	Desired Annual P Application Rate	85.674	kg/year
			which equals	0.23472	kg/day
P-load to be sorbed	33.60	kg/year			

NOTES

[1]. Model sensitivity to input parameters will affect the accuracy of the result obtained. Where possible site specific data should be used. Otherwise data should be obtained from a reliable source such as,

- *Environment and Health Protection Guidelines: Onsite Sewage Management for Single Households*
- *Appropriate Peer Reviewed Papers*
- *EPA Guidelines for Effluent Irrigation*
- *USEPA Onsite Systems Manual.*

[2]. A multiplier, normally between 0.25 and 0.75, is used to estimate actual P-sorption under field conditions which is assumed to be less than laboratory estimates.

Appendix D

Water Balance Modelling Review

Irrigation Area Water Balance & Storage Calculations

Project 3324: Minarah College Third Party Review (Stage 1)

Whitehead & Associates
Environmental Consultants

INPUT DATA

Design Wastewater Flow	Q	5,000	L/day	Balanced wastewater load with 20.5kL effluent balancing
Design Irrigation Rate	DIR	2.000	mm/day	Litres/m^2/day - based on Table M1 AS/NZS 1547:2012 for secondary effluent
Available Land Application Area	L	2,738	m^2	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.6 - 0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.80	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data		Bringelly (Maryland) [067015]		Median Monthly data (~154 years)
Evaporation Data		Prospect Reservoir [067019]		Mean Daily data (~44 years)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	**365**
Rainfall	R		mm/month	66.0	63.4	63.0	47.1	37.3	42.1	28.6	24.1	36.0	44.6	55.4	49.3	66.0	63.4	63.0	47.1	37.3	42.1	**556.9**
Evaporation			mm/day	5.5	4.7	3.9	2.9	2.0	1.6	1.7	2.5	3.6	4.4	5.0	5.6							
Evaporation	E		mm/month	170.5	131.6	120.9	87.0	62.0	48.0	52.7	77.5	108.0	136.4	150.0	173.6	170.5	131.6	120.9	87.0	62.0	48.0	**1,318.2**
Crop Factor	C			0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.6	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	136.4	105.3	96.7	69.6	43.4	28.8	31.6	46.5	75.6	109.1	120.0	138.9	136.4	105.3	96.7	69.6	43.4	28.8	**1,001.9**
Percolation	B	DIRxD	mm/month	62.0	56.0	62.0	60.0	62.0	60.0	62.0	62.0	60.0	62.0	60.0	62.0	62.0	56.0	62.0	60.0	62.0	60.0	**730.0**
Outputs		ET+B	mm/month	198.4	161.3	158.7	129.6	105.4	88.8	93.6	108.5	135.6	171.1	180.0	200.9	198.4	161.3	158.7	129.6	105.4	88.8	**1,731.9**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	52.8	50.7	50.4	37.7	29.8	33.7	22.9	19.3	28.8	35.7	44.3	39.4	52.8	50.7	50.4	37.7	29.8	33.7	**445.5**
Effluent Irrigation	W	(QxD)/L	mm/month	56.6	51.1	56.6	54.8	56.6	54.8	56.6	56.6	54.8	56.6	54.8	56.6	56.6	51.1	56.6	54.8	56.6	54.8	**666.5**
Inputs		RR+W	mm/month	109.4	101.9	107.0	92.5	86.5	88.5	79.5	75.9	83.6	92.3	99.1	96.1	109.4	101.9	107.0	92.5	86.5	88.5	**1,112.1**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-89.0	-59.4	-51.7	-37.1	-18.9	-0.3	-14.1	-32.6	-52.0	-78.8	-80.9	-104.8	-89.0	-59.4	-51.7	-37.1	-18.9	-0.3	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m^3	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	1065	1266	1431	1632	2051	2721	2191	1737	1404	1144	1106	960	1065	1266	1431	1632	2051	2721	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 2,721 m^2

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months

Irrigation Area Water Balance & Storage Calculations

Whitehead & Associates
Environmental Consultants

Project 3324: Minarah College Third Party Review (Stage 2)

INPUT DATA

Design Wastewater Flow	Q	10,229	L/day	Balanced wastewater load with influent balance
Design Irrigation Rate	DIR	1.830	mm/day	ITERATED VALUE
Available Land Application Area	L	6,138	m^2	Used for iterative purposes to determine storage requirements for nominated areas
Crop Factor	C	0.6 - 0.8	unitless	Estimates evapotranspiration as a fraction of pan evaporation; varies with season and crop type
Runoff Coefficient	RC	0.80	unitless	Proportion of rainfall that remains onsite and infiltrates; function of slope/cover, allowing for any runoff
Rainfall Data	Bringelly (Maryland) [067015]			Median Monthly data (~154 years)
Evaporation Data	Prospect Reservoir [067019]			Mean Daily data (~44 years)

Soil Category (AS1547:2012)	DIR	Units
Gravels and Sands (1)	5	mm/day
Sandy Loams (2)	5	mm/day
Loams (3)	4	mm/day
Clay Loams (4)	3.5	mm/day
Light Clays (5)	3	mm/day
Medium to Heavy Clays (6)	2	mm/day

Parameter	Symbol	Formula	Units	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Days in Month	D		days	31	28	31	30	31	30	31	31	30	31	30	31	31	28	31	30	31	30	**365**
Rainfall	R		mm/month	66.0	63.4	63.0	47.1	37.3	42.1	28.6	24.1	36.0	44.6	55.4	49.3	66.0	63.4	63.0	47.1	37.3	42.1	**727.7**
Evaporation			mm/day	5.5	4.7	3.9	2.9	2.0	1.6	1.7	2.5	3.6	4.4	5.0	5.6							
Evaporation	E		mm/month	170.5	131.6	120.9	87.0	62.0	48.0	52.7	77.5	108.0	136.4	150.0	173.6	170.5	131.6	120.9	87.0	62.0	48.0	**1,318.2**
Crop Factor	C			0.8	0.8	0.8	0.8	0.7	0.6	0.6	0.6	0.7	0.8	0.8	0.8	0.8	0.8	0.8	0.8	0.7	0.6	
OUTPUTS (LOSSES)																						
Evapotranspiration	ET	ExC	mm/month	136.4	105.3	96.7	69.6	43.4	28.8	31.6	46.5	75.6	109.1	120.0	138.9	136.4	105.3	96.7	69.6	43.4	28.8	**1,001.9**
Percolation	B	DIRxD	mm/month	56.7	51.2	56.7	54.9	56.7	54.9	56.7	56.7	54.9	56.7	54.9	56.7	56.7	51.2	56.7	54.9	56.7	54.9	**668.0**
Outputs		ET+B	mm/month	193.1	156.5	153.5	124.5	100.1	83.7	88.4	103.2	130.5	165.9	174.9	195.6	193.1	156.5	153.5	124.5	100.1	83.7	**1,669.9**
INPUTS (GAINS)																						
Retained Rainfall	RR	RxRC	mm/month	52.8	50.7	50.4	37.7	29.8	33.7	22.9	19.3	28.8	35.7	44.3	39.4	52.8	50.7	50.4	37.7	29.8	33.7	**445.5**
Effluent Irrigation	W	(QxD)/L	mm/month	51.7	46.7	51.7	50.0	51.7	50.0	51.7	51.7	50.0	51.7	50.0	51.7	51.7	46.7	51.7	50.0	51.7	50.0	**608.2**
Inputs		RR+W	mm/month	104.5	97.4	102.1	87.7	81.5	83.7	74.5	70.9	78.8	87.3	94.3	91.1	104.5	97.4	102.1	87.7	81.5	83.7	**1,053.8**
STORAGE CALCULATION (Δ)																						
Storage Remaining from Previous Month			mm/month	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Storage for the Month	S	(RR+W)-(ET+B)	mm/month	-88.7	-59.1	-51.4	-36.8	-18.6	0.0	-13.8	-32.3	-51.7	-78.5	-80.6	-104.5	-88.7	-59.1	-51.4	-36.8	-18.6	0.0	
Cumulative Storage	M		mm	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	
Maximum Storage for Nominated Area	N		mm	0.0																		
Storage Volume required	V	(NxL)/1000	m^3	0.0																		
LAND AREA REQUIRED FOR ZERO STORAGE			m^2	2260	2707	3077	3534	4511	6135	4843	3777	3017	2436	2350	2030	2260	2707	3077	3534	4511	6135	

MINIMUM AREA REQUIRED FOR ZERO STORAGE: 6,135 m^2

This value is based on the worst month of the year, so the balance overestimates the area/storage requirements and is therefore conservative for all other months