COPPIN ROAD PRECINCT, MUNDARING

LOCAL WATER MANAGEMENT STRATEGY

Prepared for

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EXECUTIVE SUMMARY

Introduction

Maximum Sky Pty Ltd has prepared a Local Structure Plan (LSP) for nine lots in an area bounded by Great Eastern Highway, Coppin Rd, Thomas St and Grancey Ave, Mundaring. The LSP proposes the creation of 51 residential lots ranging in size from 2,000m^2 to 2,379m^2, along with 1.16ha of public open space. The lots will be supplied with scheme water and will employ on-site effluent disposal.

Environmental Features

The subject site is located on the Darling Plateau and is elevated and gently undulating, sloping gently to the south-west and east from a high point near the centre of the site. The proposed subdivision will generally follow and preserve the existing topography. The soils are gravelly, with areas of laterite outcrop and shallow subcrop.

There is no defined surface drainage on the site. The gravelly and sandy surface soils would absorb rainfall under normal conditions. Overland runoff to the east and west would occur under extreme rainfall conditions. Groundwater was detected at depths of 1.44-5m at two locations in the south-west in September 2021, and is probably present as seepage above laterite in other parts of the site during winter.

The vegetation of the project area consists of a mixture of Jarrah-Marri forest in varying condition and areas of cleared land. None of the vegetation is riparian or groundwater-dependent.

Effluent Disposal

Soil testing and other investigations have found that the subject land is suitable for on-site effluent disposal as proposed. Specifically:

- Risks of microbial contamination and water pollution due to shallow soils can be overcome by correct siting and design of effluent disposal systems.
- The soils have adequate permeability and phosphorus retention index for infiltration systems to operate efficiently.
- The site is not constrained by shallow groundwater.
- The slope of the site is suitable for effluent disposal.
- There are no watercourses within 100m of the site.

Stormwater Management

Stormwater will be managed by a series of interconnected infiltration basins located in the road reserves. The basins have been nominally sized at 4m x 5m, with 1:3 side slopes and a maximum water depth of 0.3m. The basins will be connected by either pipes (nominally 300mm diameter) or open swale drains. The basins will be spaced about every 40-100m along the road reserves, with the exact spacing to be determined by detailed design.

The basins will be sized to retain and infiltrate the road runoff from a 1-year ARI, 1-hour storm (about 16.8mm), and to detain and compensate the runoff from critical storms up to 100-year ARI. Excess runoff will overflow the basins and flow via either pipes or drains and/or pavement flow (in 100-year storms) to join the external drainage network. Some basins may include one or two soakwells to increase their capacity and minimise surface ponding.

The section of road directly east of the public open space reserve will not be fitted with drains or basins. Instead, runoff from this section of road will be allowed to flow directly into the vegetated POS, where it will infiltrate into the ground surface. The ground surface immediately adjacent to the road will be protected as necessary to prevent erosion.

Groundwater Management

Closer subdivision and development of the site will have little or no impact on groundwater levels.

Groundwater quality impacts will be minimised by measures to minimise nutrient inputs and exports in the development, including:

- disposing of all effluent in uplands with deep, adsorbent soils;
- regular street sweeping to remove accumulated contaminants;
- selection of native species with low water and fertiliser requirements for public open space and landscape areas;
- community education on waterwise gardening and fertiliser use; and
- community education on management of pet wastes.

Landscaping

Landscaping of the site will focus on the use of local native species with low water demand. Plantings will be limited to the POS.

The species selection and planting methods will be undertaken in accordance with the Shire of Mundaring's *Landscape and Revegetation* Guidelines (2015). No turf grass or street trees will be planted.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised. The plantings will not be irrigated after the establishment phase.

The irrigation requirements for landscape establishment may be met by existing private bores, by tanker or by scheme water. Because there will be no ongoing irrigation past the establishment phase, there will be no need for any bores to be operated or maintained by the Shire of Mundaring.

Implementation and Further Management Plans

Structure planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) is expected to be required as a condition of subdivision approval for each stage of subdivision. Each UWMP will contain a detailed design of the stormwater drainage system for the road(s) adjoining that stage.

The developer of each stage of subdivision will maintain the drainage system and landscape plantings within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for management will be handed over to the Shire of Mundaring, subject to the Shire's acceptance of the works.

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1.1 Proposed Development

Maximum Sky Pty Ltd, on behalf of a group of landowners, has prepared a Local Structure Plan (LSP) for Lots 22, 25, 26 and 72 Coppin Rd, Lots 100-101 Grancey Ave, Lots 4 & 91 Great Eastern Hwy and Lot 59 Gamgee Grove (the subject land). The LSP covers twelve existing lots with a total area of 14.17 hectares.

The LSP proposes the creation of 51 residential lots ranging in size from 2,000m^2 to 2,379m^2, along with 1.16ha of public open space. Figure 1 shows the proposed plan of subdivision. Figure 2 shows an aerial view of the site and surroundings.

The lots will be supplied with scheme water and will employ on-site effluent disposal.

1.2 Scope of the LWMS

The scope of this LWMS is to:

- Document the existing environment on the site, in relation to soils, drainage, erosion, watercourses, groundwater and water-dependent ecosystems.
- Briefly describe the proposed development in relation to water management.
- Examine the capability of the site for on-site effluent disposal.
- Address relevant regulatory requirements and design criteria for water harvesting, setbacks to watercourses, groundwater management and drainage.
- Describe the strategies to be implemented for water conservation, watercourse protection, groundwater management and stormwater drainage.
- Outline the proposed monitoring program.
- Outline what is to be addressed in the Urban Water Management Plans.

1.3 Relevant Guidelines and Policies

1.3.1 State Planning Policy 2.9

State Planning Policy 2.9: *Water Resources* (WAPC, 2006) lists the following key principles for total water cycle management:

- Consideration of all water sources (including wastewater) in water planning, maximising the value of water resources.
- Integration of water and land use planning.
- Sustainable and equitable use of all water sources, having consideration of the needs of all water users including the community, industry and the environment.
- Integration of water use and natural water processes.
- A whole-of-catchment integration of natural resource use and management.

SPP 2.9 also lists the following general objectives for water-sensitive urban design:

- to manage a water regime;
- to maintain and, where possible, enhance water quality;
- to encourage water conservation;
- to enhance water-related environmental values; and
- to enhance water-related recreational and cultural values.

Element 5 of *Liveable Neighbourhoods* Edition 3 (WAPC, 2004) identifies specific objectives and requirements for Urban Water Management. These are based on Best Planning Practices which are defined as the best practical approach for achieving water resource management objectives within an urban framework.

1.3.2 Better Urban Water Management

Better Urban Water Management (WAPC, 2008) sets out the following objectives for water sensitive urban design:

Water Conservation

- Consumption of 100kL/p/yr including less than 40-60 KL/p/yr scheme water.

Water Quantity

- Ecological Protection – Maintain pre-development flow rates and volumes for the 1 year ARI event. Maintain or restore desirable environmental flows and/or hydrological cycles.
- Flood Management – Maintain pre-development flow rates and volumes for the 100 year ARI event.

Water Quality

- Maintain pre-development nutrient outputs (if known) or meet relevant water quality guidelines (e.g. ANZECC & ARMCANZ, 2000).

- Treat all runoff in the drainage network prior to discharge consistent with the Stormwater Management Manual.

- As compared to a development that does not actively manage stormwater quality, achieve:

  - at least 80% reduction of Total Suspended Solids;
  - at least 60% reduction of Total Phosphorus;
  - at least 45% reduction of Total Nitrogen; and
  - at least 70% reduction of gross pollutants.

Mosquitoes and Midges

- Design detention structures so that, between the months of November and May, stormwater is fully infiltrated within 96 hours.

- Design permanent water bodies (where accepted by DoW) to maximise predation of mosquito larvae by native fauna.

1.3.3 Shire of Mundaring Town Planning Scheme No. 4

The Shire of Mundaring's Town Planning Scheme No. 4 sets out the following criteria for residential development that are directly relevant to this strategy:

Stormwater drainage

- Subdivision and development shall employ water sensitive urban design approaches to stormwater drainage. Any subdivision or development which increases the area of impermeable surfaces or which otherwise reduces stormwater recharge of groundwater systems, is to utilise best management practices to effect the retention of stormwater within the development area so as to:
  - minimise as far as practicable changes to both the rate and quantity of direct stormwater discharge from the site; and
  - prevent the export of water borne pollutants (including sediment load and nutrients).

- Subdivision and development shall be consistent with the relevant recommendations of Better Urban Water Management, published by the Commission, as applicable, and with any subsequent guideline or policy of the Commission relating to urban water management. Subdivision and development shall also be consistent with any guidelines and/or policy regarding stormwater drainage adopted by the Shire.

Effluent disposal

- Where access to a reticulated sewerage system is not available, on-site effluent disposal facilities are to be provided to treat and dispose of any effluent generated on the site. Soil permeability, nutrient retention characteristics, soil microbial purification ability, slope and distance to groundwater and surface water must be demonstrated to be appropriate for the proposed system.

- No on-site effluent disposal system (including any leach drain or soak well) is to be located nearer than the minimum setbacks specified to a watercourse, wetland, bore or underground water source used for human consumption in relative operational Western Australian environmental, water and health legislation. Where there is any conflict between the setbacks specified in different legislation, the greater setback shall apply.

- The Shire may require additional setbacks for on-site effluent disposal facilities and/or require the installation of specific types of facilities (including those involving the removal of nutrients) where it considers such requirements appropriate or necessary for the protection of water resources or other environmental values.

Management of construction sites

- In addition to any requirements which may be imposed as conditions of planning approval, construction sites are to be managed so as to minimise soil erosion, sedimentation and/or the degradation of any water resource due to the action of wind or water and protect as far as practicable, the natural resource values of the site and of the adjacent area.

1.3.4 Government Sewerage Policy 2019

The Government Sewerage Policy (2019) requires that all new residential development should be deep-sewered unless it is exempt for one of several reasons. For exempt developments, the policy establishes minimum site capability requirements and density limits. Provisions of the policy that are relevant in this case include:

- Large lot subdivision (minimum lot size 2,000m^2; density R5 equivalent or less) in the outer metropolitan area may be undertaken without deep sewerage provided the responsible authorities are satisfied that no significant environmental impact is likely and there is no further opportunity for subdivision without sewerage.

- Land used for on-site effluent disposal must meet the following requirements:
  - The slope must be less than 20% (1 in 5) and the land shall be engineered to prevent runoff.
  - The site should not be subject to inundation or flooding at a probability greater than once in 10 years.

- In loams and heavy soils, the discharge point of the effluent disposal system should be at least 0.6m above the highest groundwater level.
- The discharge point should not be within 100m of a waterway, significant wetland or a drain that discharges directly into a waterway or significant wetland without treatment. Smaller setbacks may be approved where the relevant agencies are satisfied that the reduced setback will not have significant impact on the environment or public health..

1.3.5 Water Quality Protection Note (WQPN) 70: *Wastewater treatment and disposal – domestic systems* (DWER, 2016)

WQPN 70 sets out the DWER's advice regarding domestic on-site effluent disposal in public drinking water source areas or near other sensitive water resources. The key recommendation relevant to this case is that effluent disposal systems should be located at least 100m from waterways and wetlands and outside the area subject to flooding by a 10-year ARI flood event.

The Note provides that smaller setbacks may be considered on a case-by-case basis in low-risk situations.

WQPN 70 is to be reviewed and updated following the release of the new Government Sewerage Policy (released September 2019).

1.3.6 DoW Interim Guideline: Developing a Local Water Management Strategy

The DoW LWMS guideline was published in 2008 and sets out the DoW's preferred format and content for LWMS documents. The guideline expands on the LWMS guidance provided in *Better Urban Water Management* (2008).

This LWMS has been prepared in accordance with the principles set out in the DoW guideline.

2.0 EXISTING ENVIRONMENT

2.1 Rainfall

Mundaring, like the rest of the Perth region, has a strongly seasonal rainfall, with most of the annual rain falling between May and September in association with winter cold fronts. Occasional heavy falls may occur from summer thunderstorms. The long-term average annual rainfall for Bickley (the closest Bureau of Meteorology weather station) is 1,088.8mm, of which 78% falls between the months of May and September.

Figure 3 shows a rainfall occurrence chart for Bickley. Table 2.1 shows rainfall intensity, frequency and duration for Mundaring.

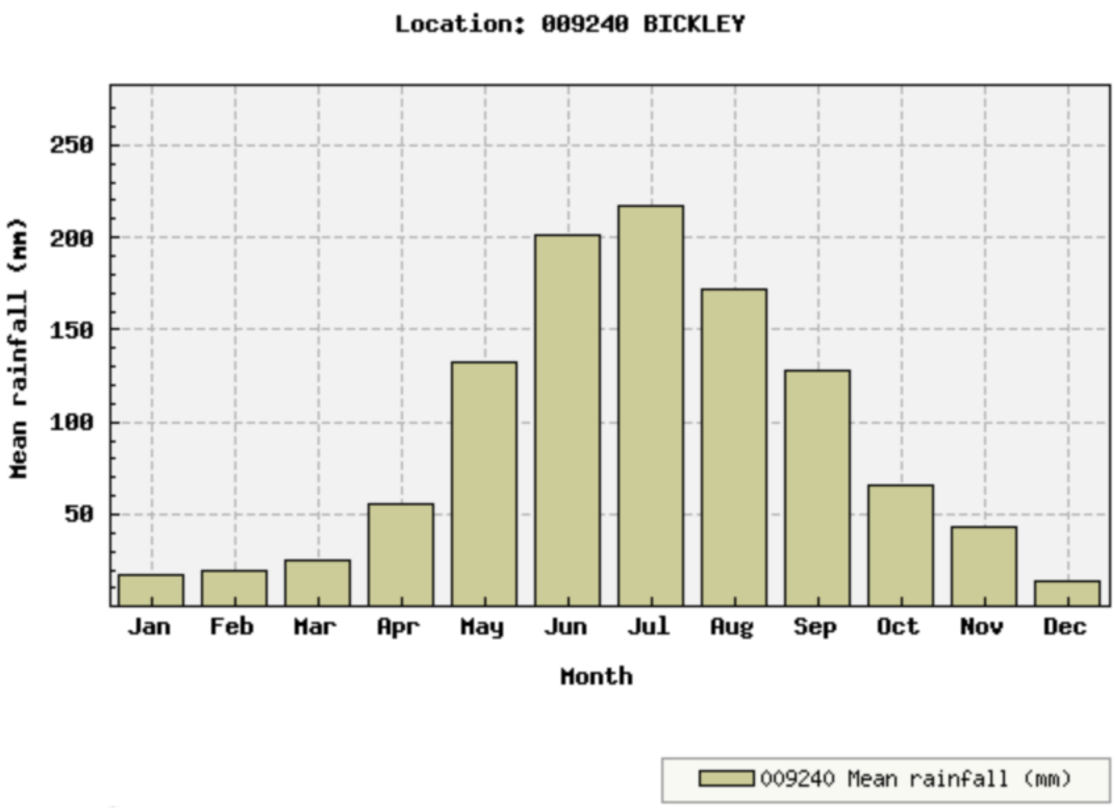

Figure 3 Bickley Mean Rainfall

Table 2.1 Rainfall Intensity for Mundaring

IFD Design Rainfall Depth (mm)

Issued: 02 December 2022

Rainfall depth for Durations, Exceedance per Year (EY), and Annual Exceedance Probabilities (AEP).
FAQ for New ARR probability terminology

	Annual Exceedance Probability (AEP)						
Duration	**63.2%**	**50%#**	**20%***	**10%**	**5%**	**2%**	**1%**
1 min	1.68	1.85	2.41	2.81	3.23	3.81	4.28
2 min	2.96	3.22	4.09	4.72	5.38	6.32	7.10
3 min	3.97	4.33	5.53	6.40	7.32	8.62	9.69
4 min	4.79	5.25	6.75	7.84	8.98	10.6	11.9
5 min	5.50	6.03	7.79	9.08	10.4	12.3	13.8
10 min	7.97	8.79	11.5	13.4	15.4	18.2	20.4
15 min	9.62	10.6	13.9	16.2	18.6	21.9	24.6
20 min	10.9	12.0	15.7	18.3	21.0	24.7	27.7
25 min	11.9	13.1	17.1	19.9	22.9	26.9	30.2
30 min	12.8	14.1	18.3	21.3	24.5	28.8	32.3
45 min	15.0	16.5	21.2	24.7	28.3	33.4	37.6
1 hour	16.8	18.3	23.5	27.4	31.4	37.1	41.9
1.5 hour	19.6	21.3	27.2	31.7	36.4	43.3	49.1
2 hour	21.8	23.7	30.3	35.3	40.7	48.6	55.3
3 hour	25.6	27.7	35.3	41.3	47.8	57.5	66.0
4.5 hour	30.0	32.5	41.4	48.6	56.5	68.6	79.2
6 hour	33.6	36.4	46.5	54.7	63.7	77.7	90.1
9 hour	39.4	42.8	54.9	64.6	75.4	92.3	107
12 hour	44.1	47.9	61.6	72.5	84.5	104	120
18 hour	51.4	56.1	72.2	84.7	98.3	120	139

Note:
The 50% AEP IFD **does not** correspond to the 2 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 1.44 ARI.
* The 20% AEP IFD **does not** correspond to the 5 year Average Recurrence Interval (ARI) IFD. Rather it corresponds to the 4.48 ARI.

2.2 Physiography

2.2.1 Topography

The site is elevated and gently undulating, with elevations ranging from about 291m AHD in the south-west to 308m AHD in the south-east of the site. Most of the site slopes gently south-west except the eastern part, which slopes east. The gradient ranges from 2% to 12%, averaging less than 5%. Figure 4 shows the topography.

2.2.2 Geology, Landforms and Soils

The site is located on the Darling Plateau and the geology is predominantly lateritic, with shallow gravelly soils overlying laterite, clay and, at depth, granite. The Geological Survey of Western Australia (Smurthwaite, 1986) mapped the site as laterite (Czl) with soils of laterite (LA_1) and gravel (G_2), described as follows:

- LA_1 - Laterite: Massive, hard, vuggy and pisolitic; up to 4m thick, overlain by and associated with gravels (G_2 & G_3) of residual origin.

- G_2 - Gravel: Yellow-brown to red-brown, loose, fine to coarse, ferruginous pisolites, poorly sorted; variable amounts of sand and silt in matrix, minor recementation, of colluvial origin.

The Department of Agriculture (King & Wells, 1990) mapped the soil-landforms of the site as Dwellingup (D1, D2) and Murray (My3) units, described as follows:

Dwellingup
Gently undulating lateritic uplands on the western edge of the plateau.

D1 Crests and very gently inclined terrain dominated by lateritic duricrust and very shallow gravelly brownish sands, pale brown sands and earthy sands.

D2 Gently undulating terrain with well drained, shallow to moderately deep gravelly brownish sands, pale brown sands and earthy sands overlying lateritic duricrust.

Murray
Deeply incised river valleys with up to 120m relief occurring upstream from the Helena Valley system. Soils are similar to Darling Scarp units.

My3 Gently to moderately inclined sideslopes and lower slopes with very few areas of rock outcrop.

Test drilling at ten locations across the site generally confirmed these mapping units. Drilling in the higher areas (D1 & D2) found a predominantly gravelly loam to loamy gravel profile over laterite and/or loamy clay. Laterite occurred in most boreholes at 0.5-1.5m depth, and was mostly 1-2m thick.

In the lower areas (My3), the profile mostly consisted of gravelly or sandy loams to 2.5-4.5m depth over pale clays, with water occurring at 4-4.5m.

Soil logs from the drilling are attached in Appendix A. Figure 4 shows the drilling sites and the GSWA and DoA mapping.

2.2.3 Soil Permeability

The D1 and D2 soil units are generally permeable and well drained. Extensive shallow laterite may slow infiltration and produce localised lateral flow, but this can be overcome by excavation of the laterite and backfilling with porous soil. The My3 unit is generally less well drained with a higher clay content, but still has sufficient permeability for infiltration of effluent.

Constant-head permeability testing was carried out at nine locations in accordance with AS1547:2012 (Figure 4). The tests found saturated hydraulic conductivity (Ks) in the shallow profile (0.275-0.5m) ranging from 0.17m/day to 8m/day, averaging 3.6m/day. Tests in the deeper profile (1.05-1.15m) gave Ks of 0.35m/day to 5.5m/day, averaging 2.9m/day. The higher value was recorded in silty sand. Appendix B shows the test results.

All sites tested showed adequate permeability for on-site effluent disposal in accordance with AS1547:2012. Permeability is highly variable across the site, depending in part on the occurrence of laterite. Testing on individual lot building envelopes prior to development is recommended to inform effluent system location and sizing. A conservative permeability of 1m/day has been adopted for the preliminary design of bioretention swales.

2.2.4 Acid Sulphate Soils

The subject site is high in the landscape and is not likely to contain any acid sulphate soils. The DWER maps the site as low to nil risk of ASS.

2.2.5 Phosphorus Retention Index

No tests for PRI have been carried out on the site. The soil types present are known from experience elsewhere to have high PRI, making testing unnecessary.

PRI is a measure of the ability of a soil to adsorb and retain phosphorus from solution. A high PRI indicates that a soil is unlikely to leach phosphorus to the water table. Typical ranges for PRI values in soils are as follows:

PRI Range	*Rating*	*Typical soils*
0 – 0.5	Very Low	Bassendean Sand
2 – 4	Low – Moderate	Karrakatta Sands
5 – 12	Moderate – High	Cottesloe Sands
12 – 20	High	Crushed Limestone, Limesand
20 – 1000+	Very High	Clay

The site soils are expected to have PRI in the range of 50 or higher. The DWER recommends a minimum PRI of 15 for soils beneath infiltration basins.

2.3 Hydrology

2.3.1 Surface Drainage

There is no defined surface drainage on the site. The gravelly and sandy surface soils would absorb rainfall under normal conditions. Overland runoff to the east and west would occur under extreme rainfall conditions.

2.3.2 Groundwater

Shallow groundwater seepage (above the clay & laterite horizon) is likely to occur during wet winters. Groundwater was detected in only two boreholes (My3-B and My3-C), reaching minimum depths of 5m and 1.4m below ground level in early September 2021.

Groundwater is not a constraint to on-site effluent disposal on the site. Nevertheless, in areas with shallow laterite (less than 0.6m), upslope subsoil drainage may be advisable to intercept any seepage and prevent water ingress into leach drains.

The project area is not within a declared groundwater catchment and no licensing of bores is necessary.

2.4 Water Quality

No water quality information is available for the site. Groundwater was encountered in only two of the nine bores drilled to 5-6m, and neither held sufficient water to obtain a sample.

Given the lateritic soils present on the site, the groundwater quality is expected to be high.

2.5 Vegetation

The vegetation of the project area consists of a mixture of Jarrah-Marri forest in varying condition and areas of cleared land. Figure 4 shows the vegetation cover.

Heddle *et al.* (1980) mapped the vegetation of the site as Dwellingup Complex in Medium to High Rainfall, described as an open forest of Jarrah-Marri, restricted to areas receiving 900-1100mm average annual rainfall.

None of the vegetation on the site is riparian or groundwater-dependent.

2.6 Land Uses and Potential Contamination

Historical Landgate aerial photography shows that the project area has been partly cleared for agriculture since at least 1961. Photography from the 1960s to 1980s shows a number of small orchards, which are regarded by the DWER as potentially contaminating land uses due to the historic use of pesticides. In this case, given the small size of the orchards, the potential for significant contamination is considered low.

The DWER Contaminated Sites Database (https://dow.maps.arcgis.com/apps/webappviewer/index.html?id=c2ecb74291ae4da2ac32c441819c6d47) shows no record of any contaminated sites in or near the project area.

There is no visual evidence of significant contaminating activities such as piggeries, hydrocarbon storage or landfill.

3.0 WATER USE SUSTAINABILITY

3.1 Water Supply

The development will be serviced with potable water provided by the Water Corporation.

Due to the site's topography and geology, shallow groundwater for abstraction is unlikely to be available over most of the site. Site-specific exploratory drilling might find abstractable groundwater in some parts of the site. Large quantities of water for irrigation of large parks is unlikely to be available.

As the subject land is not within a proclaimed groundwater area, no licence is required to abstract groundwater.

3.2 Water Efficiency Measures

3.2.1 Public Open Space

Due to the limited availability of groundwater for irrigation, particularly over summer, all landscaping within the POS areas will employ waterwise local native plants that do not require irrigation. There will be no grass plantings within the POS. Further details of POS landscaping are provided in Section 7.0.

3.2.2 5 Star Plus Building Standards

In accordance with the amended *Building Regulations 1989*, new homes within the development will incorporate the following features:

- Minimum 4 stars WELS rated tap fittings, except bath outlets and garden taps.
- Minimum 3 stars WELS rated shower heads.
- Minimum 4 stars WELS rated dual-flush toilets.
- Covers on all private swimming pools.
- All internal hot water pipes installed and insulated in accordance with AS/NZS 3500:2003.
- Maximum run of pipe from hot water system to outlet will not exceed 20 metres length or 2 litres internal volume.

4.0 LAND CAPABILITY FOR ON-SITE EFFLUENT DISPOSAL

4.1 Published Land Capability Ratings

The proposed lots are located on land mapped by the Department of Agriculture (King & Wells, 1990) as Dwellingup 1, Dwellingup 2 and Murray 3. King & Wells (1990) rated the capability of these units for on-site effluent disposal as follows:

D1	Low
D2	Fair
My3	Fair

The D1 and D2 units are limited by microbiological purification ability due to their highly permeable gravelly surface soils and extensive laterite, which may promote rapid shallow seepage or lateral movement of effluent. This limitation can be overcome by excavation of the laterite to a depth of about 2m during the installation of leach drains and its replacement by a permeable soil such as sandy loam.

The My3 unit is limited by soil absorption ability and ease of excavation. However, the test drilling and infiltration testing carried out for this LWMS suggest that these limitations are not present on the My3 unit in the subject land.

4.2 Soil Permeability

Australian Standard AS1947:2012 recommends a minimum hydraulic conductivity of 0.06m/day for on-site effluent disposal without special design. The testing method set out in the *Health (Treatment of Sewage and Disposal of Effluent and Liquid Waste) Regulations 1974* implies a minimum conductivity of 0.11m/day without specific approval by the Director-General of Public Health. Permeabilities of this order are generally found in weakly structured or massive clays.

Infiltration testing at nine locations across the subject site indicated that all soil types present have adequate permeability for on-site effluent disposal.

4.3 Phosphorus Retention Index

Previous experience has shown that the gravelly, loamy and clayey soil types present at the site have high PRI. Therefore, provided that the effluent disposal systems are correctly sited and constructed so that infiltration through the soil profile occurs, there is not expected to be any significant export of phosphorus from these systems in the foreseeable future.

4.4 Depth to Groundwater

The 2019 Government Sewerage Policy requires that the discharge point of an on-site effluent disposal system on loamy or heavy soils must be at least 0.6m above the highest seasonal or permanent water table.

Test drilling across the site found no groundwater less than 1.44m below ground level. It is concluded that all parts of the site have adequate depth to groundwater for on-site effluent disposal.

4.5 Slope

The Government Sewerage Policy prohibits on-site effluent disposal on land with a slope of more than 1 in 5 (20%), in order to prevent runoff of effluent.

The subject land is mostly sloping but nowhere does the gradient exceed 20% (Figure 4). Therefore effluent disposal on the site is not constrained by slope.

4.6 Watercourse Setbacks

There are no watercourses within 100m of the site. The nearest watercourse is a minor creekline located about 550m to the east. Most of the site is outside the catchment of this creek.

4.7 System Selection and Location

All effluent generated within the subdivision will be treated and disposed by means of individual on-site effluent disposal systems. On most or all lots, the disposal system may be either conventional septic systems, modified leach drain systems or ATUs.

4.8 Subsoil Drainage

Subsoil drainage is not expected to be required on most lots within the subdivision. In some areas with shallow laterite, the use of subsoil drainage upslope of the effluent disposal system may be prudent to eliminate upslope seepage.

4.9 Conclusion

This analysis has found that the subject land is suitable for on-site effluent disposal as proposed. Specifically:

- The risks of microbial contamination and water pollution identified by King & Wells (1990) can be overcome by correct siting and design of effluent disposal systems.
- The soils have adequate permeability and phosphorus retention index for infiltration systems to operate efficiently.
- The site is not constrained by shallow groundwater.
- The slope of the site is suitable for effluent disposal.
- There are no watercourses within 100m of the site.

5.0 STORMWATER MANAGEMENT STRATEGY

5.1 Principles and Objectives

The stormwater management strategy aims to comply with the principles and objectives for stormwater management identified in the *Stormwater Management Manual for WA* (DoW, 2004) and *Better Urban Water Management* (WAPC, 2008).

Nutrient concentrations and loads in water leaving the site will be managed to comply with the targets of the draft *Swan Canning Water Quality Improvement Plan* (SRT, 2009), as follows:

- Winter median TP concentration: 0.1 mg/L
- Winter median TN concentration: 1.0 mg/L
- Annual TP yield: 0.013 kg/ha
- Annual TN yield: 0.2 kg/ha.

The drainage system will be designed to maintain surface flow rates and volumes within and from the developed site at or below their predevelopment levels. The drainage design presented here is conceptual and will be refined in the detailed subdivision design.

The priorities for managing the various sizes of storm event will be as follows:

- 1 year ARI — Retain and infiltrate all flows as close to source as possible. Maintain pre-development flow rates and volumes. Minimise export of nutrients and sediments.

- 5 year ARI — Detain water prior to discharge. Maintain pre-development flow rates and volumes. Maintain amenity and serviceability. Prevent scouring and damage.

- 100 year ARI — Maintain pre-development flow rates and volumes. Prevent flooding and damage.

5.2 Drainage Management System

Runoff will be generated from road surfaces, road verges, private lots and open space. Runoff from private lots will be increased by the partial replacement of vegetated surfaces with roofs and paved areas. This will be mitigated by the capture of roof runoff in rainwater tanks or soak wells and the interception of runoff from driveways and other paved areas by lawns and gardens.

Storms up to 1-year ARI, 1-hour duration (about 16.8mm) are not expected to generate any significant runoff from private lots, vegetated road verges or open space. Runoff from larger storms will flow into the road drainage system or bushland areas along existing flow paths. The development of the project area will not alter the major drainage paths of the site.

All roads within the project area will be kerbed. These will generally be semi-mountable kerbs except for the road abutting the eastern boundary of the POS, which will be flush-kerbed to allow runoff to flow directly into the POS.

Road runoff from storms up to 1-year, 1-hour will be captured and infiltrated in a series of small, linked infiltration basins located at 40-100m intervals along the road reserves, with the spacing dependent on the slope of the road reserve and the area of catchment being drained. Figure 5 shows the conceptual layout of the drainage network. Figure 6 shows conceptual plans and profiles of the basins

The basins will nominally be sized with base dimensions of 1m x 2m and top dimensions of 4m x 5m, with a total depth of 0.5m and a maximum water depth of 0.3m. The basins will also capture and detain the excess flow from critical storms up to 100-year ARI, releasing it at no more than the pre-development rate. Some basins may incorporate one or more soakwells to increase the volume of storage and ensure that prolonged ponding does not occur. The need for soakwells will be determined on the basis of detailed flow calculations and permeability testing.

The section of road adjacent to the POS will not be fitted with basins. Instead, runoff from this section of road will be allowed to flow directly into the vegetated POS, where it will infiltrate into the ground surface. The ground surface immediately adjacent to the road will be protected as necessary to prevent erosion.

Runoff from larger and longer-duration storms will progressively overflow the basins and flow via pipes, open drains and/or pavement flow along the road reserves to join the external drainage system. The peak flows in storms up to 100-year ARI will be no greater than the pre-development flow rates. There will therefore be no requirement for dedicated compensating basins to attenuate the flows prior to it leaving the site. The peak flow rates in the road drainage system downstream of the site (Coppin Rd and Thomas Rd) will be unchanged by the subdivision.

Preliminary calculations using the Rational Method (Engineers Australia, 1987) suggest that pipes up to 300mm diameter will be sufficient to carry the 5-year overflows from the basins. Overflows from storms greater than 5-year ARI will be carried by a combination of pipe and pavement flow.

Table 5.1 summarises the parameters adopted in the preliminary drainage calculations and the overall runoff and retention/detention volumes. The detailed flow calculations are set out in Appendix C.

Table 5.1 Drainage Summary

1 yr 1 hr rainfall	16.8mm				
<u>Basins</u>					
Base dimensions (m)	1 x 2				
Top dimensions (m)	4 x 5				
Depth (m)	0.5				
Maximum water depth	0.3				
Side slopes	1:3				
<u>Runoff coefficients</u>	*1 yr*	*5 yr*		*100 yr*	
		Pre Dev	*Post Dev*	*Pre Dev*	*Post Dev*
Road pavement	0.9	0.2	1	0.25	1
Road verge	0	0.2	0.25	0.25	0.35
Lots	0	0.2	0.25	0.25	0.35
Basins	1	0.2	1	0.25	1
Open space	0	0.2	0.2	0.25	0.25
Effective Impervious Area	7931	22812	34500	28516	44557
<u>Flows</u>					
Peak flow (L/sec)	37	501.5	597.3	1114.2	1390.2
Total flow (m^3)	22.2		330.3		745.9
Storage required (m^3)	22.2		18.3		43.5
Effective storage (m^3)	65		61.4		61.4

Detailed design, including selection, sizing and location of retention structures, will be undertaken as part of each subdivision design and reported in the UWMP for that stage of subdivision.

5.3 Water Quality Management

The drainage system will be designed to maximise on-site retention of nitrogen and phosphorus. This will be achieved by:

- Retaining and infiltrating all lot runoff from storms up to 1-year ARI within the lots.
- Infiltrating all road runoff from storms up to 1-year ARI 1-hour duration (estimated by the DWER to carry more than 99% of total flows and nutrients) in vegetated bioretention swales and soak wells with a minimum soil PRI of 15.
- Detaining runoff from storms between 1-year and 100-year ARI in rock-pitched drains and creekline pools to allow suspended particles to settle.

5.4 Maintenance

The drainage system has been designed to require minimal maintenance. The following will be required to ensure that the system continues to function as designed:

- Regular (possibly annual) cleaning of side entry pits, inlet pits and soak wells. More frequent cleaning may be required during the construction phase.

- Tending and maintenance of POS areas, swales and other vegetated drainage features to remove litter, control weeds and encourage the growth of native species.

- Pruning, mulching or removal of vegetation in infiltration swales as necessary to maintain ground fuel loads below 8 tonnes/ha.

6.0 GROUNDWATER MANAGEMENT STRATEGY

6.1 Groundwater Levels

Groundwater was encountered only in the lower south-west part of the project area, although some shallow seepage is likely to occur above laterite layers during wet winters. Closer subdivision and development of the site will have little or no impact on groundwater levels.

6.2 Groundwater Quality

The relationship between nutrient inputs and exports is complex, especially in the case of phosphorus, which travels through the soil profile as a "front" in a complex series of adsorption and desorption reactions. Nitrogen is subject to denitrification and mineralisation in the soil and groundwater. As a result, nutrient exports from the site at present will be a reflection of nutrient inputs over the last several decades, modified by soil hydrology and nutrient retention capacity.

The aim of nutrient management will be to limit nutrient inputs to the site so that nutrient outputs are minimised. The primary source of groundwater-borne nutrients will be soluble garden fertilisers. With low-phosphorus garden fertilisers being strongly promoted under the State government's Fertiliser Action Plan, most garden fertilisers for sale in hardware and garden stores contain little or no phosphorus.

Measures available to minimise nutrient inputs and exports in the development will include:

- disposing of all effluent in uplands with deep, adsorbent soils;
- regular street sweeping to remove accumulated contaminants;
- selection of native species with low water and fertiliser requirements for public open space and landscape areas;
- community education on waterwise gardening and fertiliser use; and
- community education on management of pet wastes.

7.0 LANDSCAPING STRATEGY

Landscaping of the site will focus on the use of local native species with low water demand. Plantings will be limited to the POS and the bioretention basins.

The species selection and planting methods will be undertaken in accordance with the Shire of Mundaring's *Landscape and Revegetation* Guidelines (2015). No turf grass or street trees will be planted.

Fertiliser use will be minimal. New tube stock plantings will be fertilised with slow-release nitrogen and phosphorus tablets on establishment and thereafter will be unfertilised. The plantings will not be irrigated after the establishment phase.

The POS will be designed as passive open space, with landscaping focussed on native sedges, low shrubs and scattered trees interspersed with open areas. Trees will be spaced at least 15m apart so as to maintain a 10m canopy separation.

The total area to be planted in the will be approximately 1.25 hectares. If all of this area were irrigated simultaneously at the DWER's recommended rate for POS (4,750 KL/ha/yr) during the establishment phase, approximately 5.9 ML of water would be required to irrigate the new plantings for one year. As the project area is expected to be developed in a number of stages, the requirement for irrigation water is likely to be spread out over a number of years, with only a part of the total demand being required in any one year.

The irrigation requirements for landscape establishment may be met by existing private bores, by tanker or by scheme water. Because there will be no ongoing irrigation past the establishment phase, there will be no need for any bores to be operated or maintained by the Shire of Mundaring.

The density of planting will be controlled to keep flammable ground fuel loads below 8 tonnes/ha, in accordance with the Bushfire Management Plan (Bushfire Prone Planning, 2022).

It is expected that a Landscape Management Plan will be required as a condition of subdivision for lots abutting the POS.

8.0 IMPLEMENTATION AND FURTHER MANAGEMENT PLANS

Structure planning and subdivision of the subject land will be carried out in accordance with the general water management principles set out in this LWMS. Subdivision of lots in the structure plan area may be carried out by individual owners as they see fit, in accordance with the framework of the LWMS.

An Urban Water Management Plan (UWMP) is expected to be required as a condition of subdivision approval for each stage of subdivision. Each UWMP will contain a detailed design of the stormwater drainage system for the road(s) within that stage.

The developer of each stage of subdivision will maintain the drainage system and landscape plantings within that stage until two years after that stage of subdivision is completed. At the end of that time the responsibility for management will be handed over to the Shire of Mundaring, subject to the Shire's acceptance of the works.

9.0 REFERENCES

Bushfire Prone Planning (2022). *Structure Plan BMP – Coppin Road, Mundaring.* Unpublished report prepared for Statewest Planning, Midland.

DoW (2004). *Stormwater Management Manual for WA*. WA Department of Water, Perth.

DWER (2016). *Water Quality Protection Note 70: Wastewater treatment and disposal – domestic systems*. DWER, Perth.

Institution of Engineers Australia (1987). *Australian Rainfall and Runoff: A Guide to Flood Estimation.* Institute of Engineers, Australia, Barton, ACT.

King P.D. & Wells M.R. (1990). *Darling Range Rural Land Capability Study.* Land Resources Series No. 3, Department of Agriculture, Perth.

Shire of Mundaring (2015). *Landscape and Revegetation Guidelines*. Shire of Mundaring, Mundaring.

Smurthwaite A.J. (1986). *1:50,000 Environmental Geology Series: Mundaring Part Sheets 2134 II & 2134 III.* Geological Survey of Western Australia, Perth.

Standards Australia (2012). *Australian/New Zealand Standard 1547:2012 – On-site Domestic Wastewater Management.*

Summers R. & Weaver D. (2008). *Agricultural Nutrients: Presentation to the CSIRO Urban Drainage Workshop*. CSIRO, Perth.

Swan River Trust (2009). *Swan Canning Water Quality Improvement Plan.* Swan River Trust, Perth.

WAPC (2004). *Liveable Neighbourhoods Edition 3.* WAPC, Perth.

WAPC (2006). State Planning Policy 2.9: Water Resources. WAPC, Perth.

WAPC (2008). *Better Urban Water Management.* WAPC, Perth.

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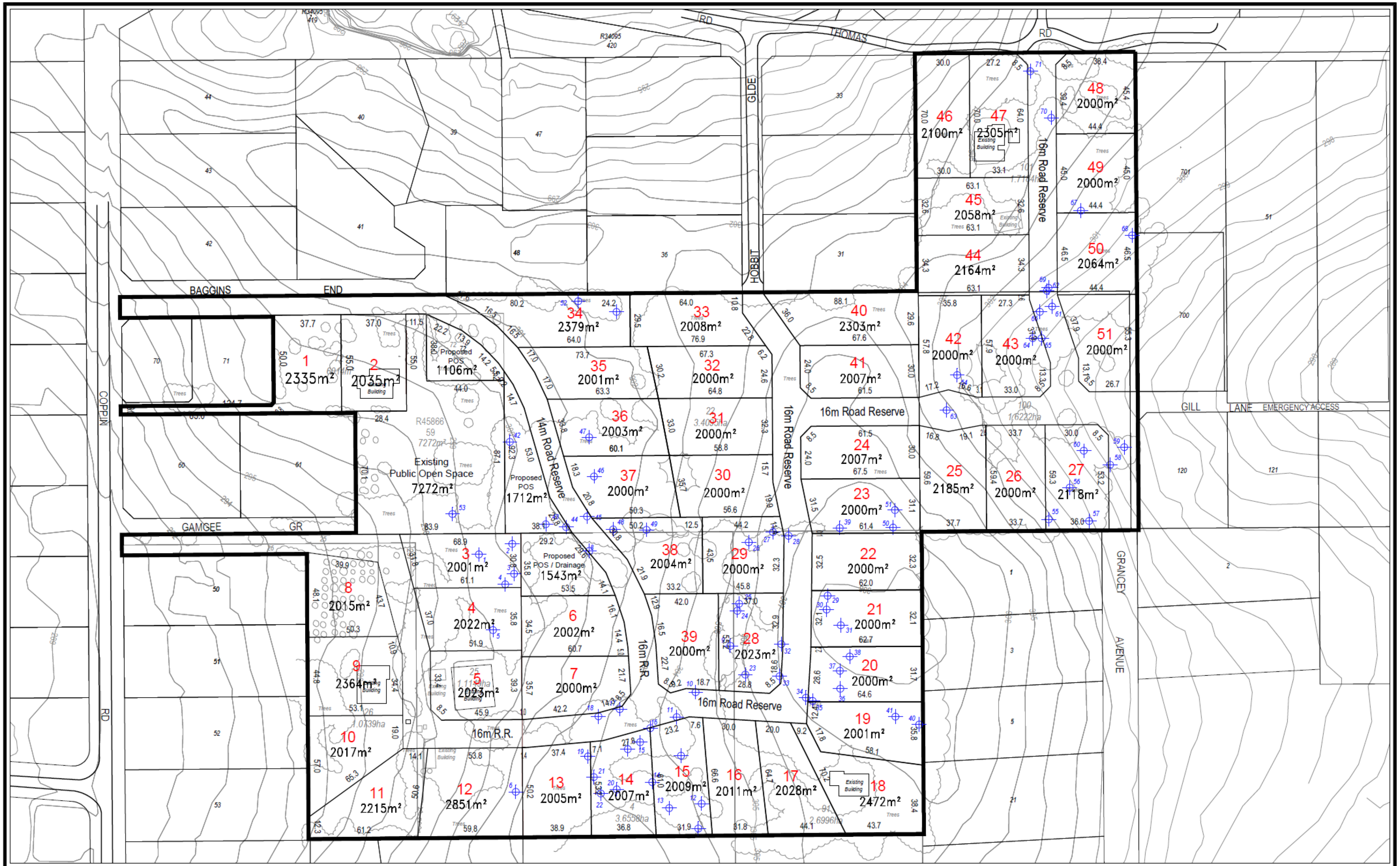
Figures



0 20 40 60 80m
SCALE 1:2000
ORIGINAL PLAN SIZE: A3

STATEWEST PLANNING

NORTH

Statewest Planning
Midland House
69 Great Northern Highway, Midland
PO Box 1377, Midland WA 6936
t. 9274 1363 m. 0418 932 792
e. simon.ohara@statewestplanning.com.au

LEGEND:
Subject Land.............
Habitat Trees............

NOTE:
1. Areas and dimensions are subject to survey.

DATE: 01.12.2022

Figure 1

PROPOSED PLAN OF SUBDIVISION

Figure 2

THE SITE AND SURROUNDINGS

bayley environmental services

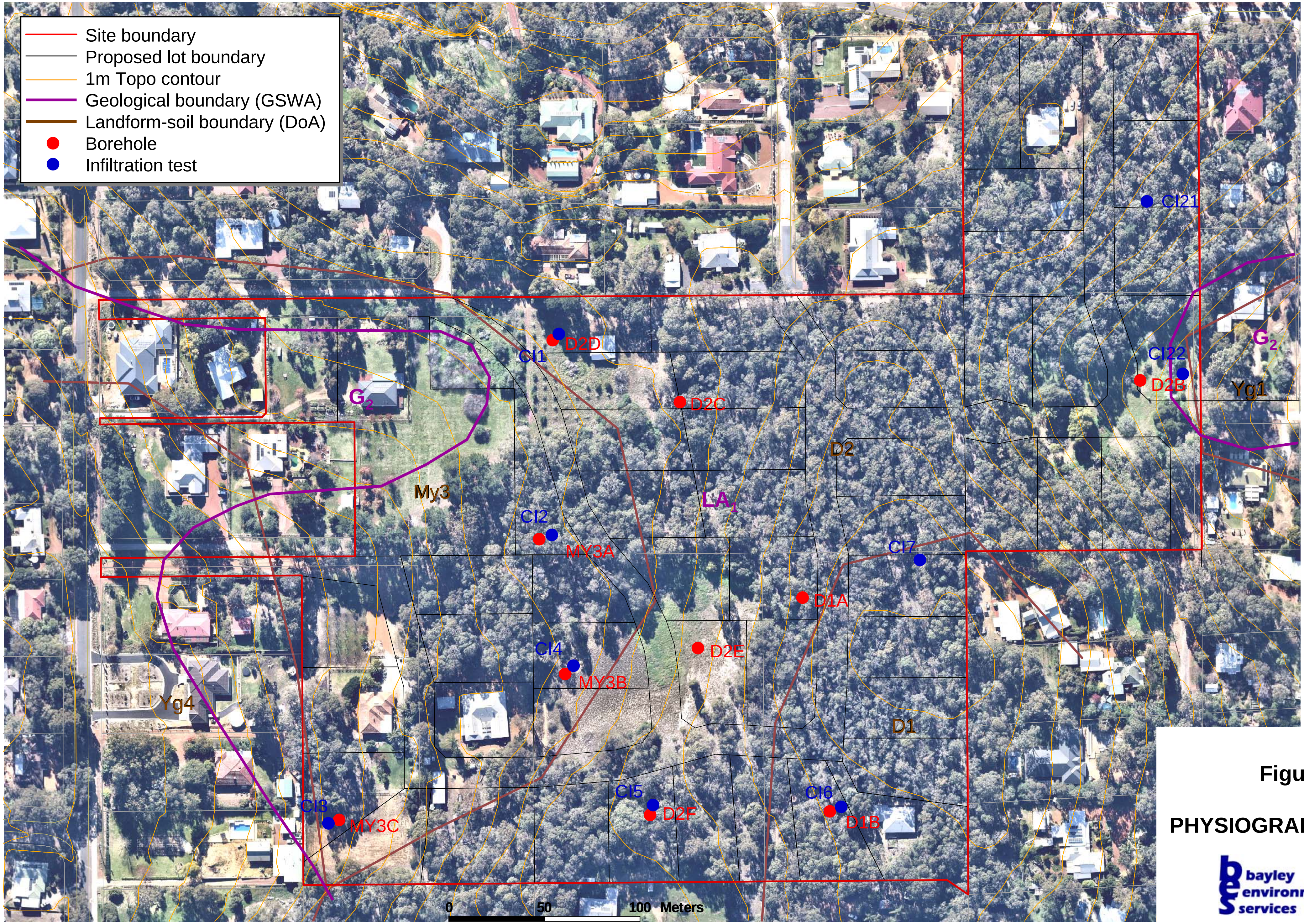


Figure 4

PHYSIOGRAPHY

bayley environmental services

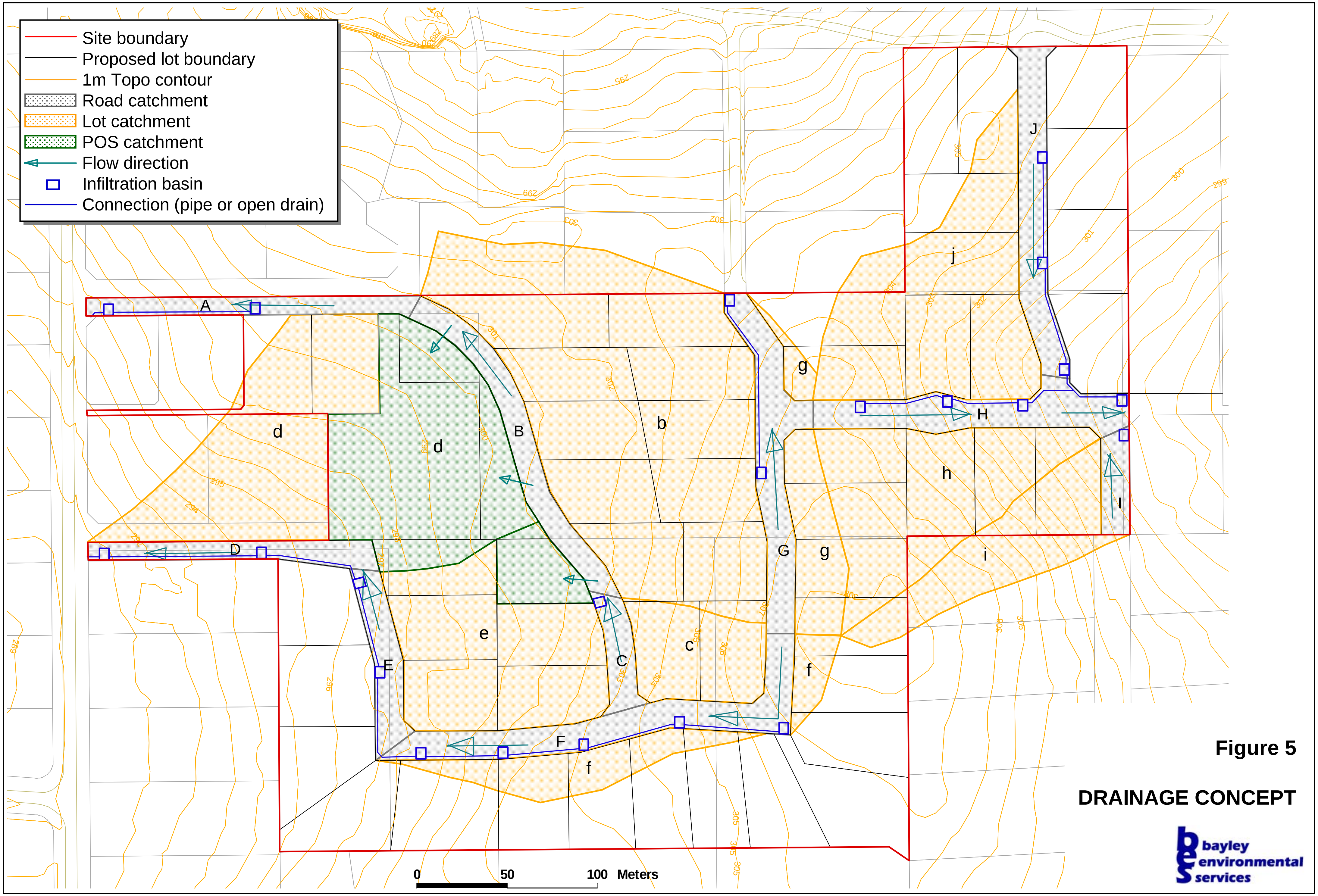


Figure 5

DRAINAGE CONCEPT

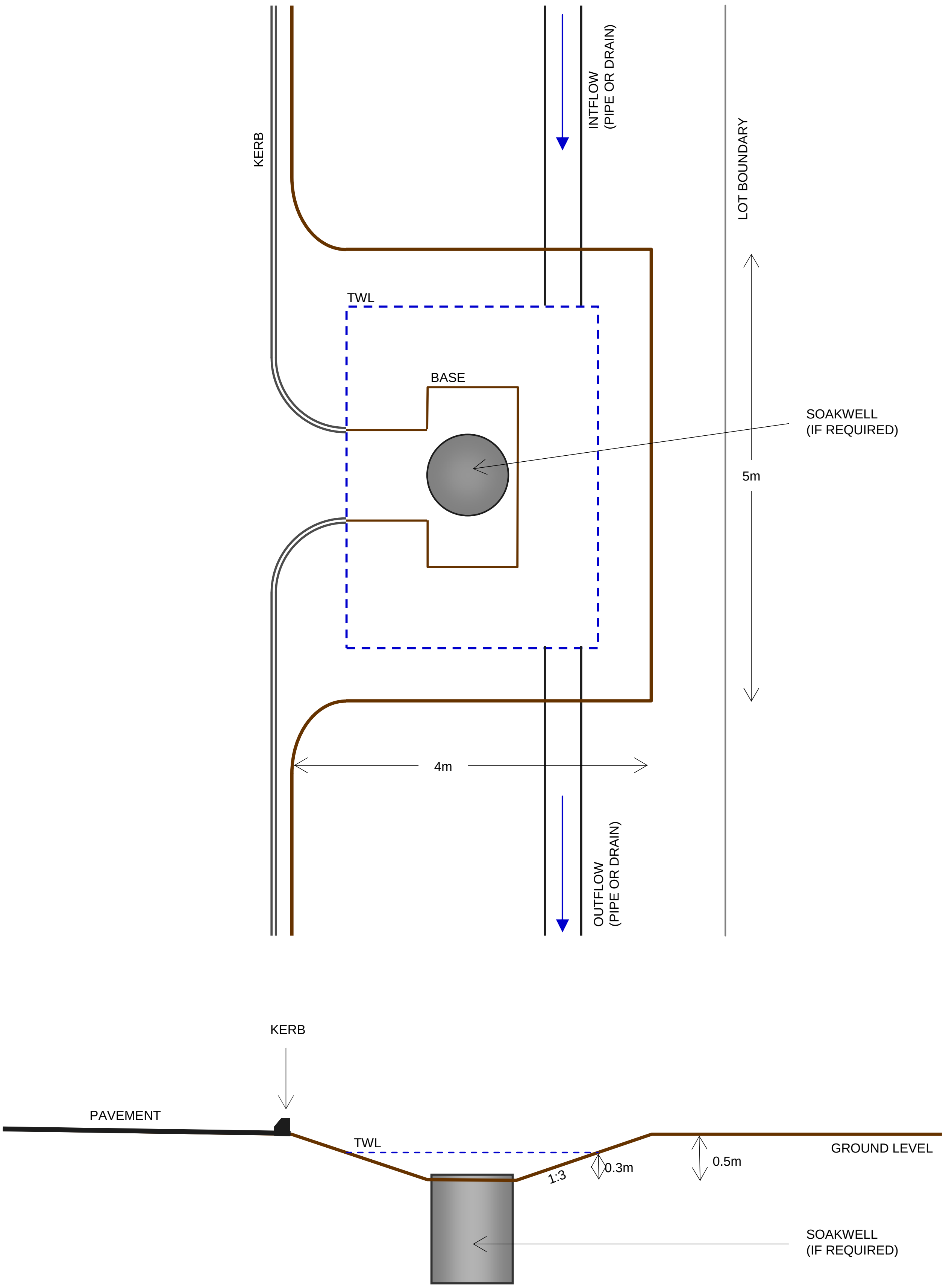


Figure 6

BASIN CONCEPT

bayley environmental services

Appendix A

Soil Logs

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D1-A
EASTING:	420148
NORTHING:	6470536
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Jarrah-marri woodland, elevated, gently sloping to south-west, ground surface dark brown sandy loam with frequent laterite outctops & boulders

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Orange gravelly laterite		
1 - 2	Orange laterite		
2.5 - 5	Orange clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D1-B
EASTING:	420164
NORTHING:	6470423
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Marri-Jarrah woodland, elevated, flat, brown gravelly loam

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Dark brown gravelly loam		
1	Brown loamy gravel		
1.5	Orange loamy gravel		
2	Orange gravelly clay-loam		
2.5	Yellow-orange gravelly loamy clay		
3 - 3.5	Pale yellow-brown gritty gravelly clay, damp		
4	Pale orange-brown clay		
4.5	Pale yellow-brown clay		
5	Orange-yellow clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D2-B
EASTING:	420325
NORTHING:	6470649
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	6.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Clearing in orchard among marri woodland, converging contours, gently sloping to east, brown gravelly loam surface

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Dark brown topsoil		
1	Brown gravelly loam		
1.5	Brown gravelly clay-loam		
2	Red loamy gravel		
2.5	Red laterite		
3	Pale red-brown clay		
3.5	Red-brown clay		
4	Pale brown clay		
4.5	White clay with occasional red mottles		
5	Red/white mottled clay, damp		
5.5	Pale red/white mottled clay		
6	White kaolin clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D2-C
EASTING:	420084
NORTHING:	6470638
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Marri woodland, gravelly loam surface with occasional laterite rocks, no outcrop

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5 - 1.5	Yellow-brown gravelly loam		
2	Orange-brown loamy gravel		
2.5 - 3.5	Red-brown loamy gravel		
4	Red-brown clayey gravelly loam		
4.5	Brown gravelly clay-loam		
5	Red-brown gravelly loamy clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D2-D
EASTING:	420018
NORTHING:	6470670
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	6.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Yellow-brown gravelly loam		
1	Orange-brown loamy gravel		
1.5 - 2.5	Laterite		
3 - 3.5	Yellow-brown clay		
4 - 5.5	Red/white mottled clay		
5.5 - 6	Red/white mottled gravelly clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D2-E
EASTING:	420094
NORTHING:	6470509
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Cleared marri woodland, gentle slope to south-west, brown silty sand surface with gravel and laterite outcrop

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5 - 1	Red laterite		
1.5 - 2.5	Orange laterite		
3	Orange-brown gravelly clay		
3.5 - 5	Yellow-brown clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	D2-F
EASTING:	420069
NORTHING:	6470424
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Marri/Jarrah woodland, elevated, shallow loamy topsoil, very gentle slope to south-west, laterite outcrops

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5 - 1.5	Orange laterite		
2 - 2.5	Orange lateritic clay		
3	Yellow-orange lateritic clay		
4 - 5	Yellow-brown clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	My3-A
EASTING:	420011
NORTHING:	6470565
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	-

Marri woodland, gently sloping, grey-brown gravelly loam surface with laterite boulders

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Grey-brown gravelly loam		
1 - 1.5	Brown loamy gravel		
2 - 2.5	Brown clayey gravel		
2.5	Brown gravelly clay		
3	Brown loamy clay	Damp to 3m, dry below	
3.5 - 4	Yellow-brown clay		
4.5 - 5	Red/white mottled clay		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	My3-B
EASTING:	420025
NORTHING:	6470496
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	6.0
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	4.5

Cleared marri woodland, brown silty sand surface, slight depression sloping gently west

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5 - 2	Orange-brown silty sand, slightly gravelly		
2.5 - 3	Red/brown gravelly silty sand		
3.5 - 4	Red gravelly silty sand		
4.5 - 5	Pale yellow-brown sandy clay, wet		
5.5	Red/white mottled clay, wet		
6	Red/white mottled clay, damp		

SOIL PROFILE LOG

PROJECT NUMBER:	J21021
SITE ID:	My3-C
EASTING:	419900
NORTHING:	6470420
METHOD:	Auger rig
TOTAL DEPTH (mbgl):	5.5
REFUSAL (Y/N):	N
DATE:	27/08/2021
DEPTH TO WATER (mbgl)	4.0

Cleared marri woodland, dark brown gravelly loam surface, gentle slope to south

SOIL PROFILE		SAMPLE DATA	
DEPTH (m)	SOIL DESCRIPTION	SAMPLE ID	INTERVAL (m)
0.5	Dark brown loam		
1 - 2	Brown gravelly sandy loam		
2.5	Yellow-brown gravelly sandy clay, becoming paler & wetter		
4 - 4.5	Pale brown clay, saturated		
5	Pale grey sandy clay, saturated		
5.5	Pale pink-brown sandy clay, damp		

Appendix B

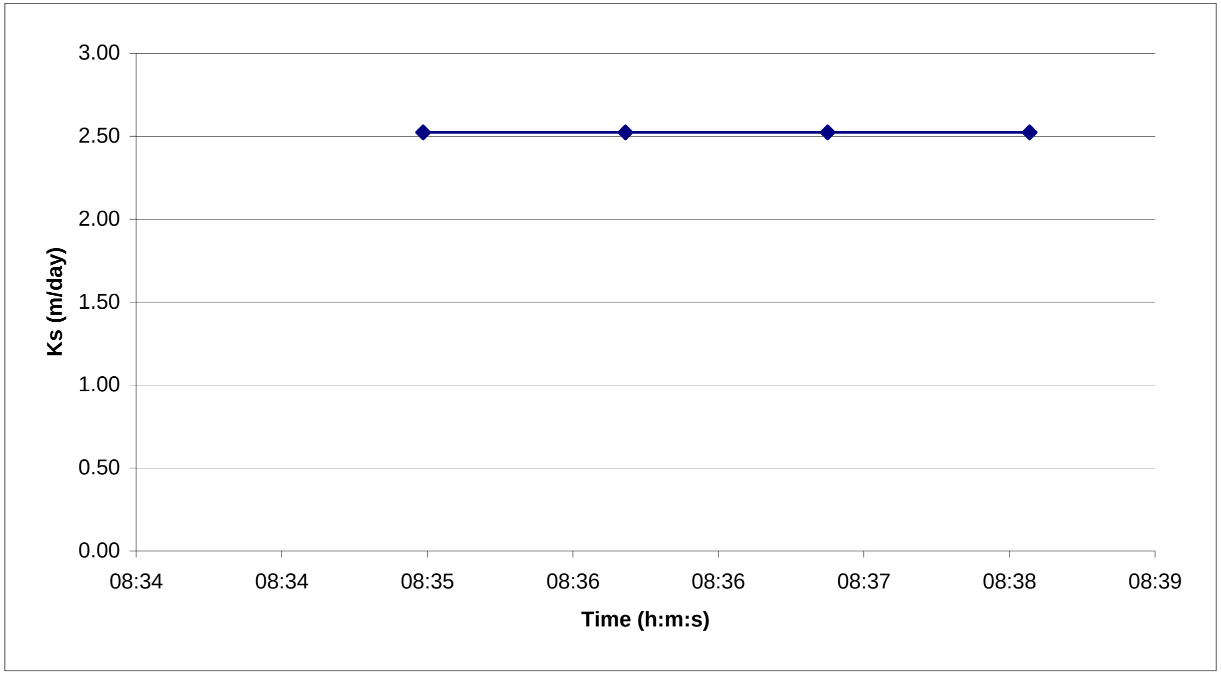
Infiltration Test Results

SOIL PERMEABILITY TEST

Site No.	CI1
Date	3/09/21
Easting	420021
Northing	6470673
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
08:34:30	39.4		
08:35:30	39.1	0.3	**2.52**
08:36:30	38.8	0.3	**2.52**
08:37:30	38.5	0.3	**2.52**
08:38:30	38.2	0.3	**2.52**
		38.2	

H =	25
r =	**4.5**



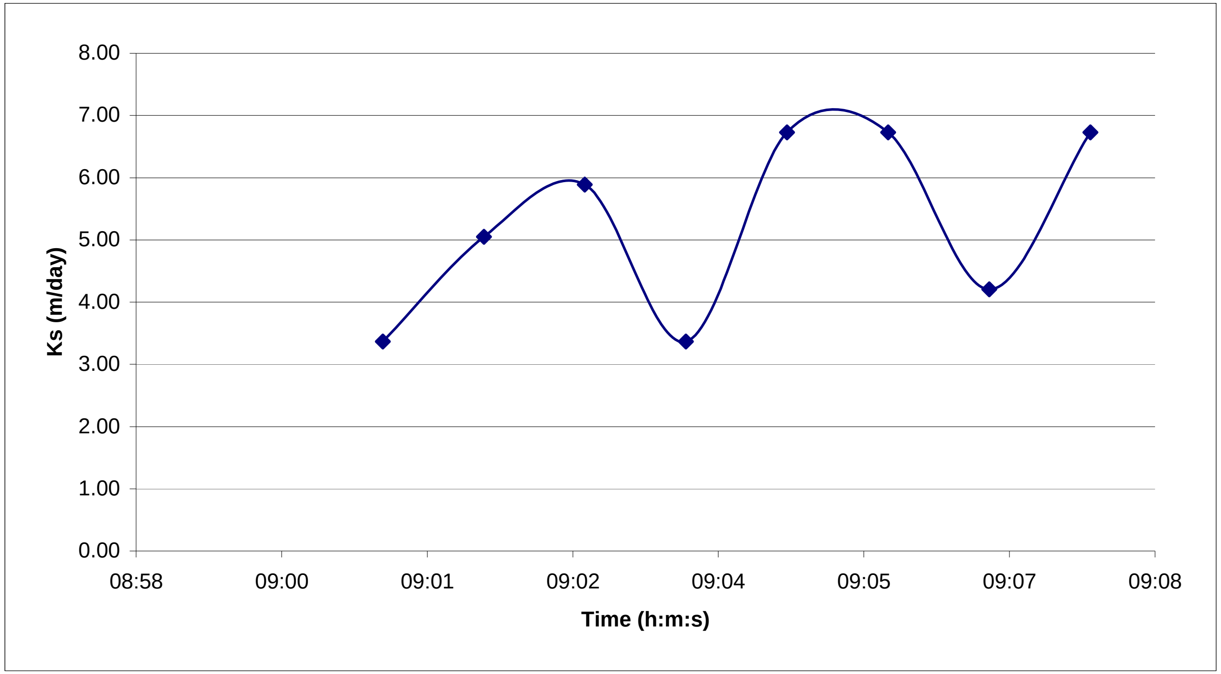
Ks = 2.5 m/day

SOIL PERMEABILITY TEST

Site No.	CI2s
Date	3/09/21
Easting	420019
Northing	6470586
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
09:00:00	30.5		
09:01:00	30.1	0.4	**3.37**
09:02:00	29.5	0.6	**5.05**
09:03:00	28.8	0.7	**5.89**
09:04:00	28.4	0.4	**3.37**
09:05:00	27.6	0.8	**6.73**
09:06:00	26.8	0.8	**6.73**
09:07:00	26.3	0.5	**4.21**
09:08:00	25.5	0.8	**6.73**
		25.5	

H =	25
r =	**4.5**



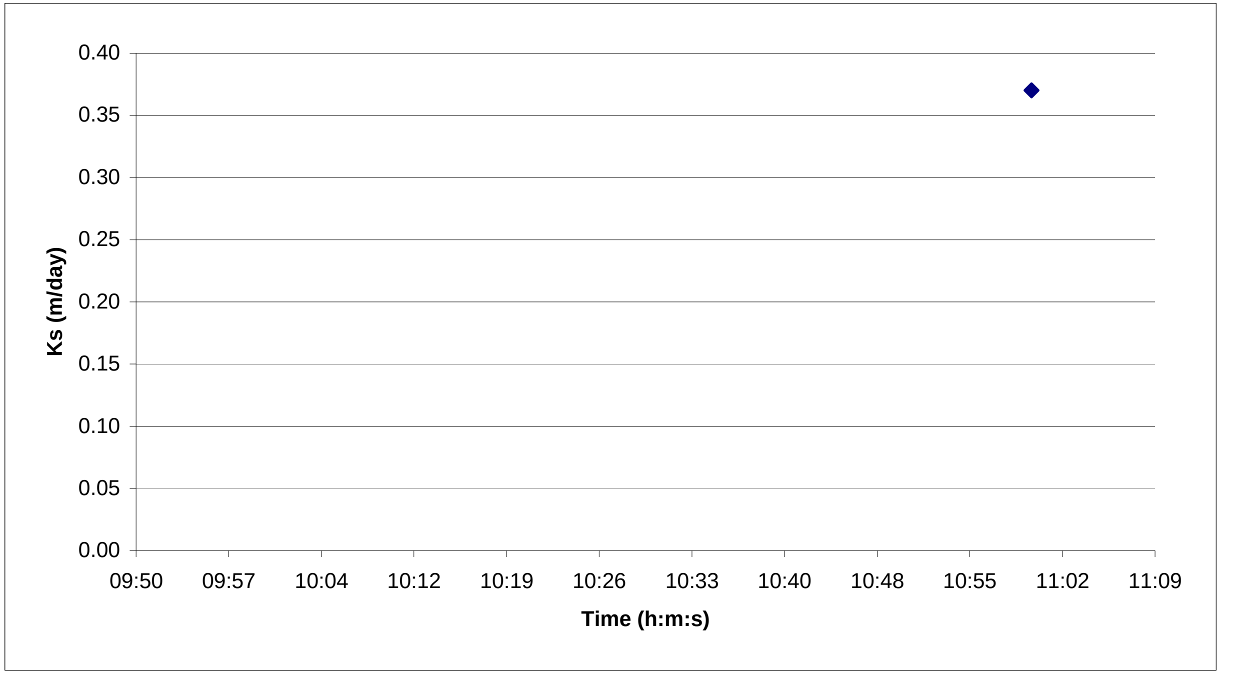
Ks = 5 m/day

SOIL PERMEABILITY TEST

Site No.	CI2d
Date	3/09/21
Easting	420019
Northing	6470586
Depth	1.15

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
10:00:00	42.54		
11:00:00	39.9	2.64	0.37
		39.9	

H =	25
r =	4.5



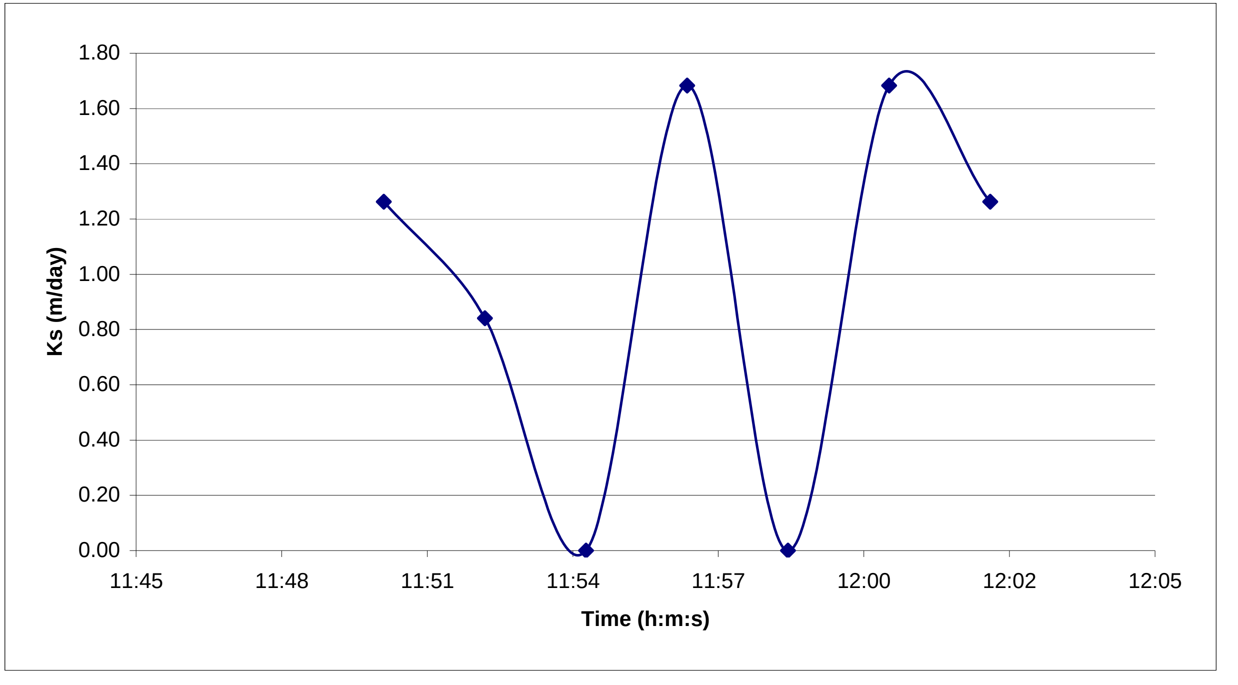
Ks = 0.35 m/day

SOIL PERMEABILITY TEST

Site No.	CI3
Date	3/09/21
Easting	419901
Northing	6470419
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
11:48:30	20		
11:50:30	19.7	0.3	**1.26**
11:52:30	19.5	0.2	**0.84**
11:54:30	19.5		
11:56:30	19.1	0.4	**1.68**
11:58:30	19.1		
12:00:30	18.7	0.4	**1.68**
12:02:30	18.4	0.3	**1.26**
		18.4	

H =	25
r =	**4.5**



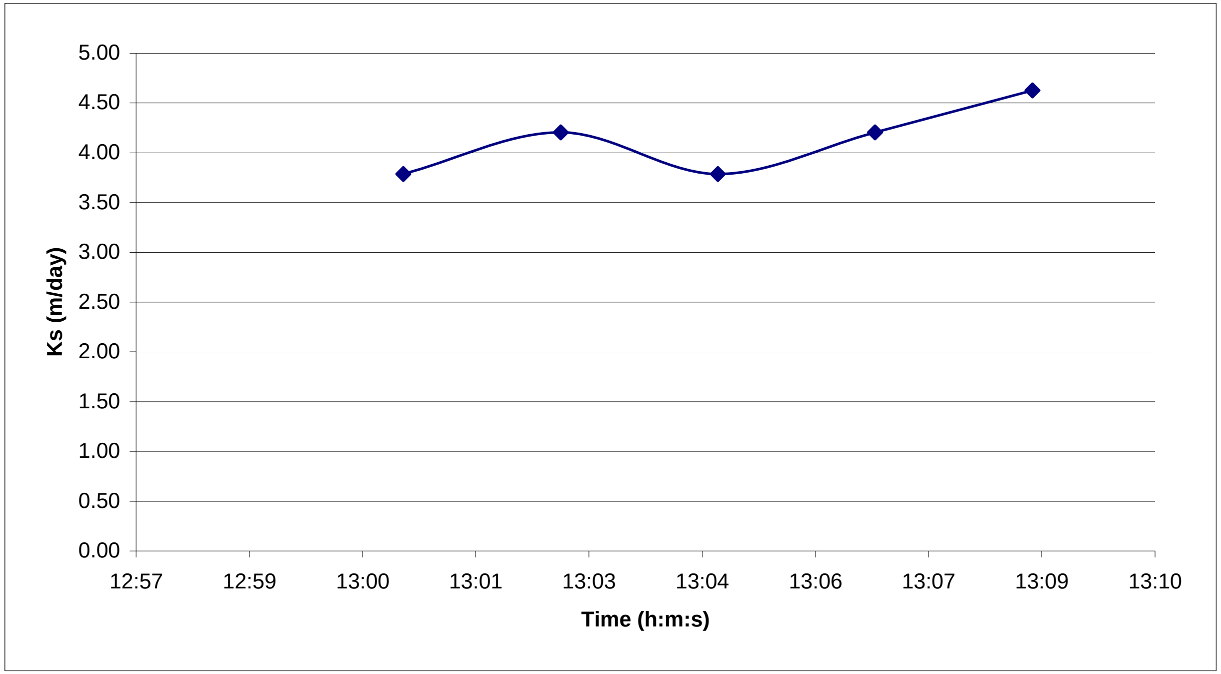
Ks = 1 m/day

SOIL PERMEABILITY TEST

Site No.	CI4s
Date	3/09/21
Easting	420027
Northing	6470503
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
12:59:00	41.6		
13:01:00	40.7	0.9	**3.79**
13:03:00	39.7	1	**4.21**
13:05:00	38.8	0.9	**3.79**
13:07:00	37.8	1	**4.21**
13:09:00	36.7	1.1	**4.63**
		36.7	

H =	25
r =	**4.5**



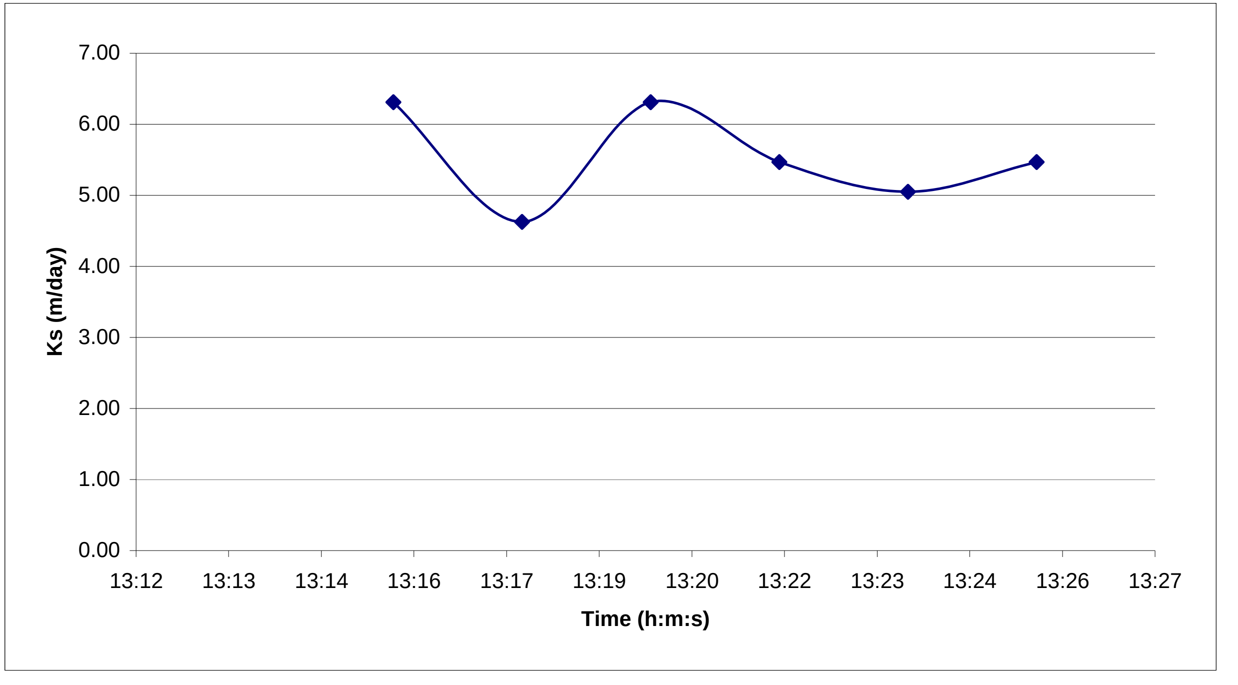
Ks = 4 m/day

SOIL PERMEABILITY TEST

Site No.	Cl4d
Date	3/09/21
Easting	420027
Northing	6470503
Depth	1.05

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
13:14:00	32.8		
13:16:00	31.3	1.5	**6.31**
13:18:00	30.2	1.1	**4.63**
13:20:00	28.7	1.5	**6.31**
13:22:00	27.4	1.3	**5.47**
13:24:00	26.2	1.2	**5.05**
13:26:00	24.9	1.3	**5.47**
		24.9	

H =	25
r =	**4.5**



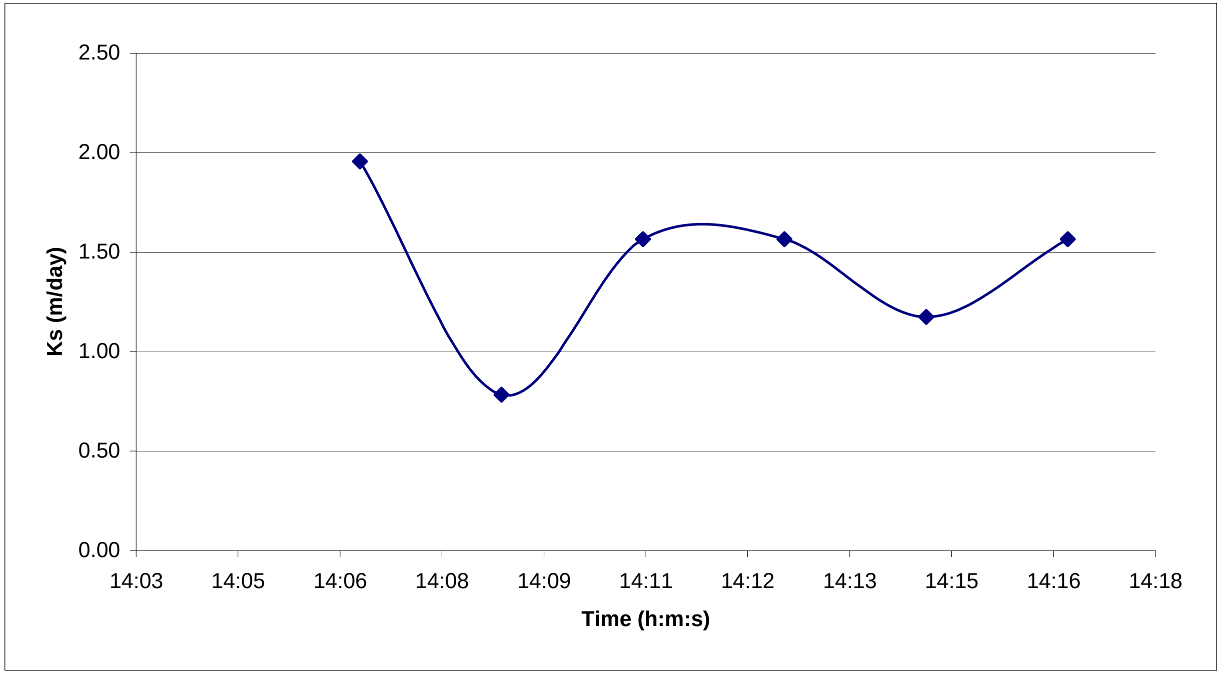
Ks = 5.5 m/day

SOIL PERMEABILITY TEST

Site No.	CI5
Date	3/09/21
Easting	420069
Northing	6470424
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
14:05:00	36.2		
14:07:00	35.7	0.5	**1.96**
14:09:00	35.5	0.2	**0.78**
14:11:00	35.1	0.4	**1.57**
14:13:00	34.7	0.4	**1.57**
14:15:00	34.4	0.3	**1.17**
14:17:00	34	0.4	**1.57**
		34	

H =	25
r =	**5**



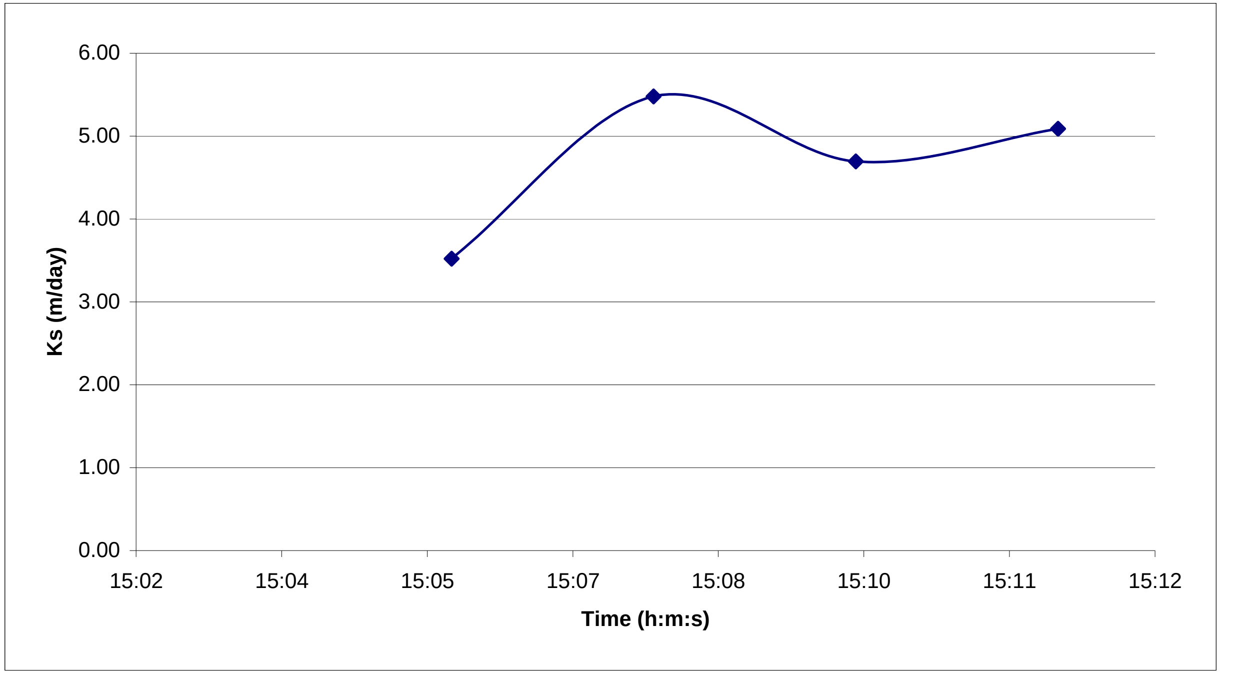
Ks = 1.4 m/day

SOIL PERMEABILITY TEST

Site No.	CI6
Date	3/09/21
Easting	420171
Northing	6470422
Depth	0.275

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
15:04:00	42.5		
15:06:00	41.6	0.9	**3.52**
15:08:00	40.2	1.4	**5.48**
15:10:00	39	1.2	**4.70**
15:12:00	37.7	1.3	**5.09**
		37.7	

H =	25
r =	**5**



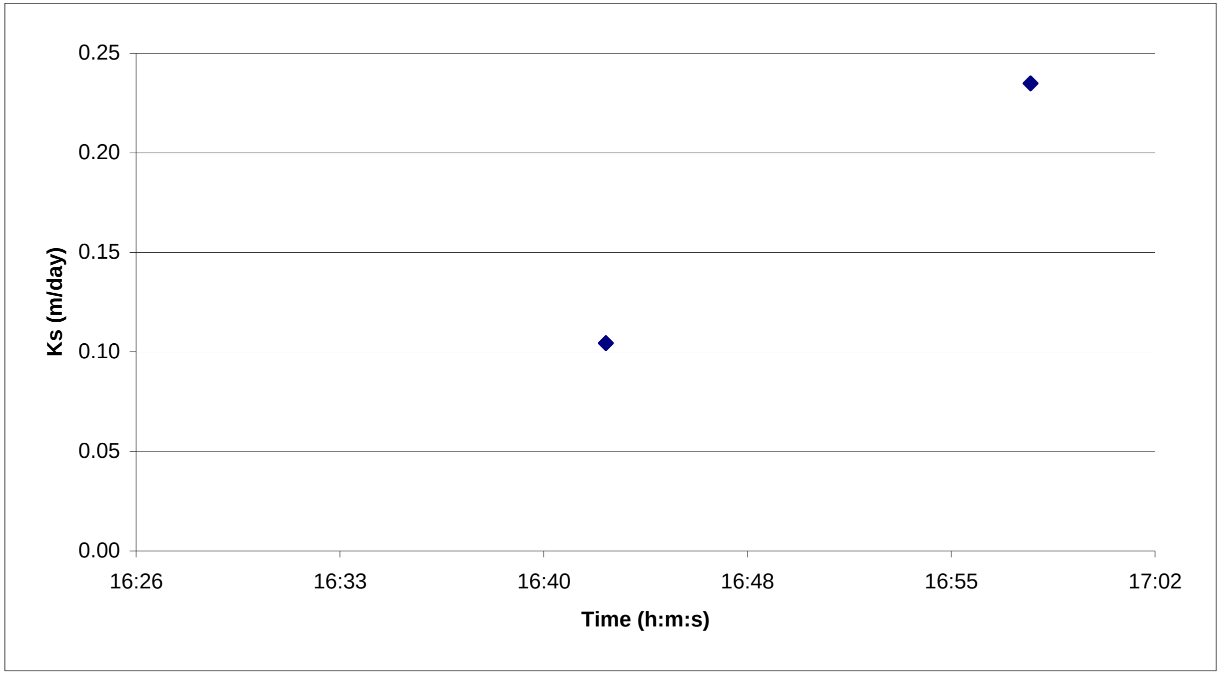
Ks = 5 m/day

SOIL PERMEABILITY TEST

Site No.	CI7
Date	3/09/21
Easting	420217
Northing	6470564
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
16:28:00	41		
16:43:00	40.8	0.2	**0.10**
16:48:00	41.6		
16:58:00	41.3	0.3	**0.23**

H =	25
r =	**5**



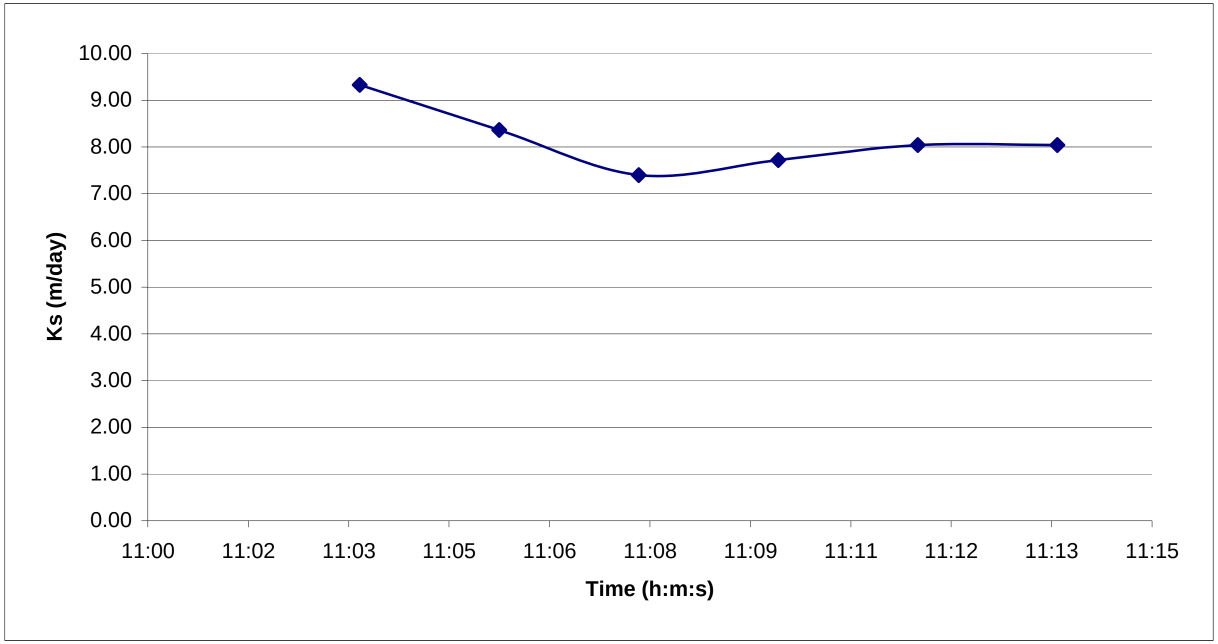
Ks = 0.17 m/day

SOIL PERMEABILITY TEST

Site No.	CI21
Date	16/11/22
Easting	420328
Northing	6470741
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
11:02:00	37.4		
11:04:00	34.5	2.9	**9.33**
11:06:00	31.9	2.6	**8.37**
11:08:00	29.6	2.3	**7.40**
11:10:00	27.2	2.4	**7.72**
11:12:00	24.7	2.5	**8.04**
11:14:00	22.2	2.5	**8.04**
		22.2	

H =	29
r =	**5**



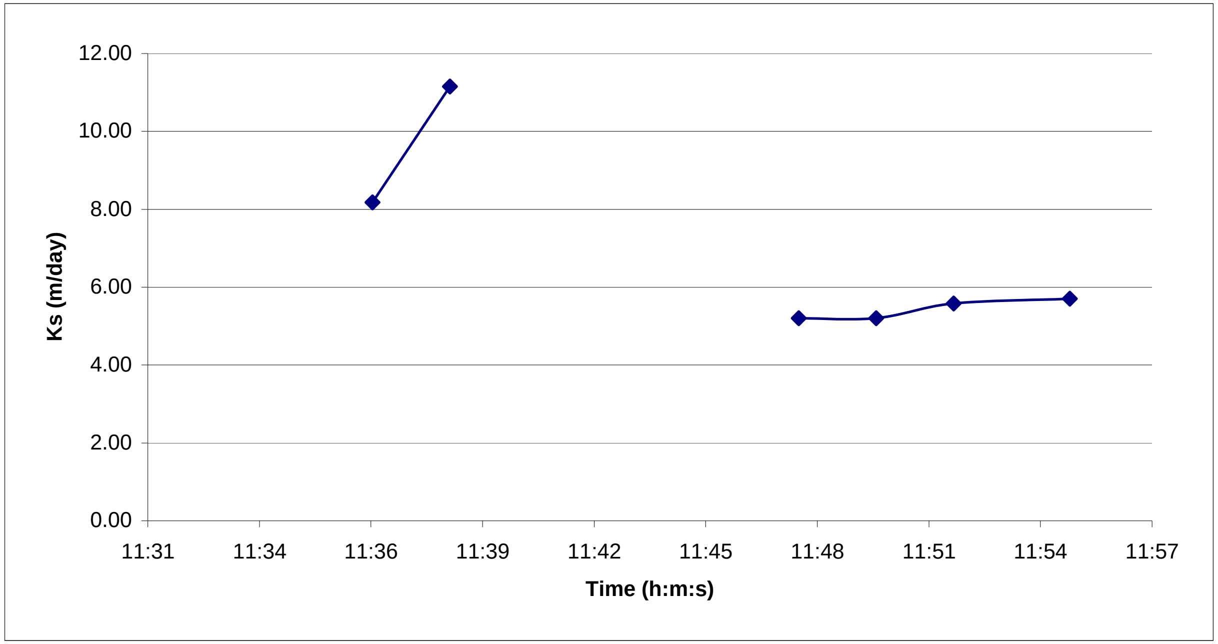
Ks = 8 m/day

SOIL PERMEABILITY TEST

Site No.	CI22
Date	16/11/22
Easting	420347
Northing	6470651
Depth	0.5

Time (h:m:s)	Weight (kg)	Change in Weight (kg)	Ks (m/d)
11:35:00	13.7		
11:37:00	11.5	2.2	**8.18**
11:39:00	8.5	3	**11.15**
11:46:00	37.6		
11:48:00	36.2	1.4	**5.21**
11:50:00	34.8	1.4	**5.21**
11:52:00	33.3	1.5	**5.58**
11:55:00	31	2.3	**5.70**
		31	

H =	26
r =	**5**



Ks = 5.5 m/day

Appendix C

Runoff Calculations

1 YEAR ARI 1 HOUR FLOWS - POST DEVELOPMENT

Rainfall Intensity i (mm/h)	16.8	(1yr, 1hr Storm)
Cr Road pavement	0.9	
Cr Road verge	0	
Cr Lots	0	
Cr Basin	1	
Cr OS	0	
Permeability k (m/hr)	0.0417	

Catchment	Road Pavement	Road Verge	Lots	Basin	OS	Total	Effective Area	Flow (L/s)	Inflow (m3)
A	528	1228	0	21	0	1777	496	2.32	1.4
B	1188	1591	24362	0	0	27141	1069	4.99	3.0
C	390	679	3634	11	0	4714	362	1.69	1.0
D	480	1313	10115	21	10738	22667	453	2.12	1.3
E	600	1028	9169	21	0	10818	561	2.62	1.6
F	1560	2579	3921	53	0	8113	1457	6.81	4.1
G	1308	2054	2748	21	0	6131	1198	5.60	3.4
H	1050	2216	8907	43	0	12216	988	4.61	2.8
I	342	545	5232	21	0	6140	329	1.54	0.9
J	1074	1754	11485	32	0	14345	999	4.66	2.8

Basin Sizing

	Storm Event	Water Depth	Side Slopes (1:x)	No. Basins	No. Soakwells	Base Width	Base Length	Top Width (m)	Top Length (m)	Volume	Effective Volume	Surface Area (m2)	1yr Vol chk	5yr vol chk	100yr vol chk
A	1	0.3	3	2	2	1	2	2.8	3.8	5	6	21	ok	ok	ok
B	1	0	0	0	0	0	0	0.0	0.0	0	0	0	ok	ok	ok
C	1	0.3	3	1	1	1	2	2.8	3.8	3	3	11	ok	ok	ok
D	1	0.3	3	2	0	1	2	2.8	3.8	3	4	21	ok	ok	ok
E	1	0.3	3	2	2	1	2	2.8	3.8	5	6	21	ok	ok	ok
F	1	0.3	3	5	0	1	2	2.8	3.8	9	9	53	ok	ok	ok
G	1	0.3	3	2	0	1	2	2.8	3.8	3	4	21	ok	ok	ok
H	1	0.3	3	4	8	1	2	2.8	3.8	15	16	43	ok	ok	ok
I	1	0.3	3	2	4	1	2	2.8	3.8	7	8	21	ok	ok	ok
J	1	0.3	3	3	0	1	2	2.8	3.8	5	6	32	ok	ok	ok

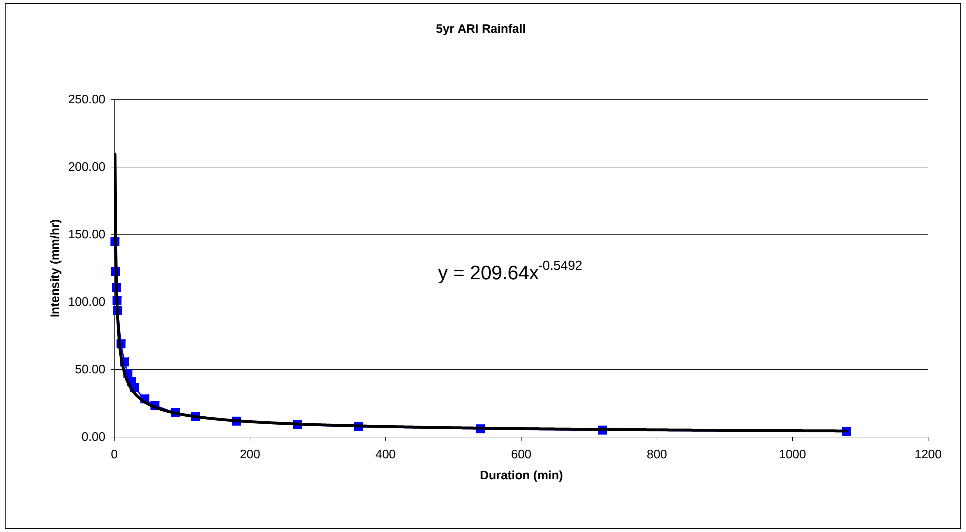
5 YEAR ARI CRITICAL FLOWS - PRE & POST DEVELOPMENT

CATCHMENT	AREAS (m2) Road Pavement (m2)	Road Verge (m2)	Lots (m2)	Basin	OS (m2)	Total	EFFECTIVE AREAS (m2) Pre	Post	TIME OF CONCENTRATION PRE DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	TIME OF CONCENTRATION POST-DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	CRITICAL STORM INTENSITY (mm/h) Pre-Dev	Post-Dev	FLOW Pre Dev	Post Dev	Total Flow (m3)	Storage Req (m3)	STORAGE Effective Storage (m3)	Volume Check
A	528	1228	0	21	0	1777	355	851	175	301	295	34.29	11.1	175	301	295	34.29	10.1	56.0	58.7	5.52	13.88	8.45	3.06	5.51	ok
B	1188	1591	24362	0	0	27141	5428	7676	144	305.5	300.5	34.72	6.9	144	305.5	300.5	34.72	6.7	72.4	73.8	109.24	157.45	63.16	0.00	0.00	ok
C	390	679	3634	11	0	4714	943	1476	101	307	302	49.50	5.4	128	307	302	39.06	6.8	83.1	72.9	21.77	29.89	12.28	0.91	2.75	ok
D	480	1313	10115	21	10738	22667	4533	5500	205	300.5	290.5	48.78	9.4	255	300.5	290.5	39.22	11.9	61.3	53.7	77.24	82.03	58.80	0.20	3.51	ok
E	600	1028	9169	21	0	10818	2164	3165	144	303	296.5	45.14	7.2	181	303	296	38.67	9.0	70.9	62.8	42.61	55.19	29.76	1.55	5.50	ok
F	1560	2579	3921	53	0	8113	1623	3225	154	308.5	303	35.71	8.3	286	308.5	296	43.71	13.8	65.5	49.5	29.54	44.37	36.82	4.11	8.81	ok
G	1308	2054	2748	21	0	6131	1226	2524	70	308.5	306.5	28.57	4.1	219	308.5	296	57.08	10.3	97.1	58.3	33.08	40.86	25.23	0.92	3.50	ok
H	1050	2216	8907	43	0	12216	2443	3863	218	308.5	296	57.34	10.3	218	308.5	296	57.34	9.8	58.3	59.8	39.60	64.20	37.77	5.55	15.03	ok
I	342	545	5232	21	0	6140	1228	1802	200	308.5	296	62.50	9.9	200	308.5	296	62.50	9.5	59.5	60.7	20.28	30.40	17.41	1.93	7.51	ok
J	1074	1754	11485	32	0	14345	2869	4408	40	301	298	75.00	1.8	179	304.5	297.5	39.11	8.6	153.8	64.4	122.61	78.84	40.58	0.00	5.24	ok

Runoff Coefficients	Pre-Dev	Post-Dev
Road Pavement	0.2	1
Road Verge	0.2	0.25
Lots	0.2	0.25
Basins	0.2	1
OS	0.2	0.2

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)	Event Rainfall (mm)
1 min	1	144.60	2.41
2 min	2	122.70	4.09
3 min	3	110.60	5.53
4 min	4	101.25	6.75
5 min	5	93.48	7.79
10 min	10	69.00	11.5
15 min	15	55.60	13.9
20 min	20	47.10	15.7
25 min	25	41.04	17.1
30 min	30	36.60	18.3
45 min	45	28.27	21.2
1 hr	60	23.50	23.5
1.5 hr	90	18.13	27.2
2 hr	120	15.15	30.3
3 hr	180	11.77	35.3
4.5 hr	270	9.20	41.4
6 hr	360	7.75	46.5
9 hr	540	6.10	54.9
12 hr	720	5.13	61.6
18 hr	1080	4.01	72.2



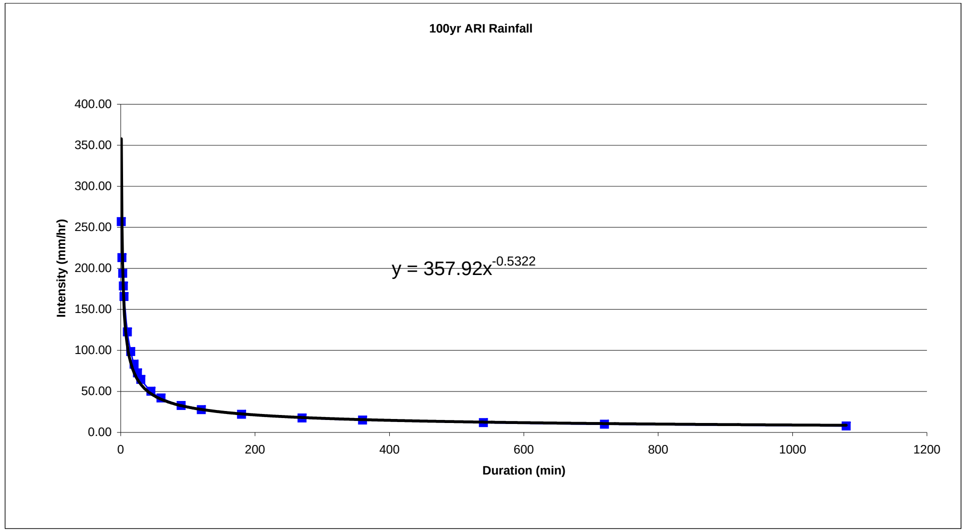
100 YEAR ARI CRITICAL FLOWS - PRE & POST DEVELOPMENT

CATCHMENT	AREAS (m2) Road Pavement (m2)	Road Verge (m2)	Lots (m2)	Basin	OS (m2)	Total	EFFECTIVE AREAS (m2) Pre	Post	TIME OF CONCENTRATION PRE DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	TIME OF CONCENTRATION POST-DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	CRITICAL STORM INTENSITY (mm/h) Pre-Dev	Post-Dev	FLOW Pre Dev	Post Dev	Total Flow (m3)	Storage Req (m3)	STORAGE Effective Storage (m3)	Volume Check
A	528	1228	0	21	0	1777	444	979	175	301	295	34.29	10.8	175	301	295	34.29	10.0	100.7	105.0	12.43	28.57	17.15	5.47	5.51	ok
B	1188	1591	24362	0	0	27141	6785	10272	144	305.5	300.5	34.72	6.8	144	305.5	300.5	34.72	6.5	129.4	132.2	243.81	377.32	147.01	0.00	0.00	ok
C	390	679	3634	11	0	4714	1179	1910	101	307	302	49.50	5.3	128	307	302	39.06	6.7	147.8	130.4	48.39	69.18	27.69	2.50	2.74	ok
D	480	1313	10115	21	10738	22667	5667	7185	205	300.5	290.5	48.78	9.2	255	300.5	290.5	39.22	11.6	110.1	97.0	173.27	193.56	135.08	1.48	3.51	ok
E	600	1028	9169	21	0	10818	2705	4190	144	303	296.5	45.14	7.0	181	303	296	38.67	8.7	126.7	112.9	95.16	131.43	68.90	5.25	5.50	ok
F	1560	2579	3921	53	0	8113	2028	3888	154	308.5	303	35.71	8.1	286	308.5	296	43.71	13.6	117.4	89.3	66.14	96.47	78.57	7.77	8.80	ok
G	1308	2054	2748	21	0	6131	1533	3010	70	308.5	306.5	28.57	4.0	219	308.5	296	57.08	10.1	171.8	104.5	73.16	87.36	52.99	1.40	3.50	ok
H	1050	2216	8907	43	0	12216	3054	4986	218	308.5	296	57.34	10.0	218	308.5	296	57.34	9.6	104.9	107.6	88.97	149.09	85.51	13.90	15.02	ok
I	342	545	5232	21	0	6140	1535	2385	200	308.5	296	62.50	9.7	200	308.5	296	62.50	9.3	106.8	109.4	45.55	72.46	40.34	5.56	7.51	ok
J	1074	1754	11485	32	0	14345	3586	5740	40	301	298	75.00	1.7	179	304.5	297.5	39.11	8.4	268.4	115.6	267.33	184.38	92.43	0.00	5.24	ok

Runoff Coefficients	Pre-Dev	Post-Dev
Road Pavement	0.25	1
Road Verge	0.25	0.35
Lots	0.25	0.35
Basins	0.25	1
OS	0.25	0.25

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)	Event Rainfall (mm)
1 min	1	256.80	4.28
2 min	2	213.00	7.1
3 min	3	193.80	9.69
4 min	4	178.50	11.9
5 min	5	165.60	13.8
10 min	10	122.40	20.4
15 min	15	98.40	24.6
20 min	20	83.10	27.7
25 min	25	72.48	30.2
30 min	30	64.60	32.3
45 min	45	50.13	37.6
1 hr	60	41.90	41.9
1.5 hr	90	32.73	49.1
2 hr	120	27.65	55.3
3 hr	180	22.00	66
4.5 hr	270	17.60	79.2
6 hr	360	15.02	90.1
9 hr	540	11.89	107
12 hr	720	10.00	120
18 hr	1080	7.72	139



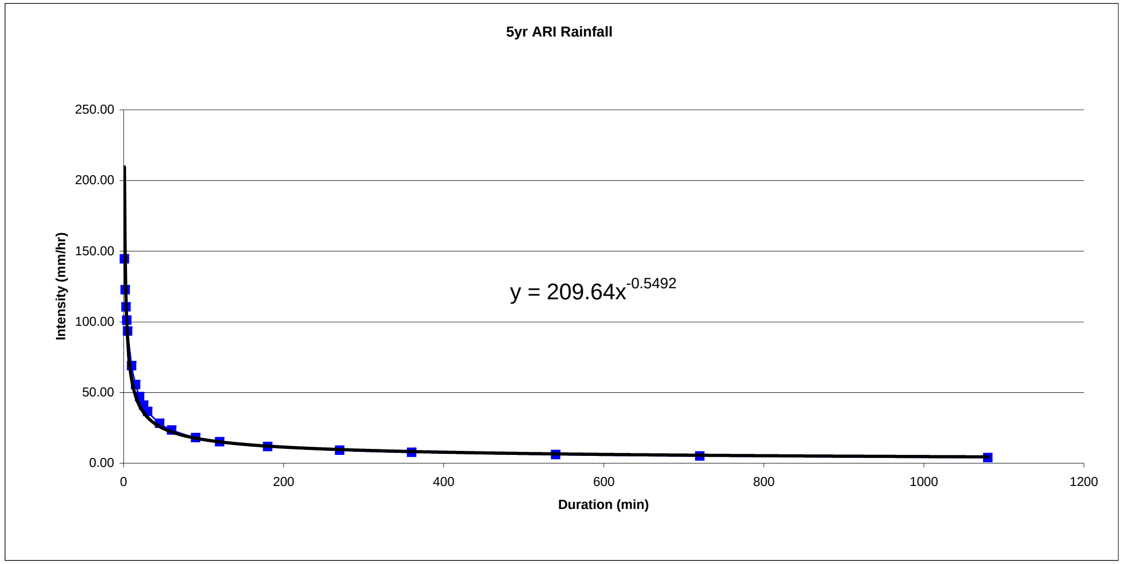
5 YEAR ARI CUMULATIVE FLOWS - PRE & POST DEVELOPMENT

CATCHMENT	Contributing Catchments	AREAS (m2) Road Pavement (m2)	Road Verge (m2)	Lots (m2)	Basin	OS (m2)	Total	EFFECTIVE AREA (m2) Post	TIME OF CONCENTRATION POST-DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/km)	TC (mIn)	CRITICAL STORM INTENSITY (mm/h) Post-Dev	FLOW Peak Flow (L/s)	Total Flow (m3)	Long Slope	Overflow Depth in 300mm Pipe	Pipe Velocity (m/s)
A		528	1228	0	21	0	1777	851	175	301	295	34.29	10.1	58.7	0.01	0.01	0.0320	0.05	1.56
B		1188	1591	24362	0	0	27141	7676	144	305.5	300.5	34.72	6.7	73.8					
C		390	679	3634	11	0	4714	1476	128	307	302	39.06	6.8	72.9	29.89	12.28	0.0231	0.09	1.87
D	E,F	2640	6470	27126	149	10738	47123	13298	548	308.5	290.7	32.48	24.4	36.3	133.95	196.16	0.0380	0.17	3.31
E	F	600	2579	13090	74	0	16343	4573	390	308.5	296	32.05	19.4	41.2	52.29	60.79	0.0100	0.15	1.6
F		1560	2579	3921	53	0	8113	3225	297	308.5	297	38.72	14.7	47.9	42.89	37.87	0.0385	0.09	2.51
G		1308	2054	2748	21	0	6131	2524	226	308.5	303.5	22.12	12.8	51.6	36.19	27.87	0.0207	0.1	1.89
H	I,J	2466	2299	16717	53	0	21535	7260	245	308.5	297	46.94	10.8	56.8	114.61	74.06	0.0718	0.13	4.08
I		342	545	5232	21	0	6140	1802	220	308.5	296.5	54.55	10.8	56.8	28.42	18.40	0.0268	0.08	1.97
J		1074	1754	11485	32	0	14345	4408	179	305.5	297.5	44.69	8.4	65.3	80.01	40.09	0.0365	0.13	2.86

Runoff Coefficients	Pre-Dev	Post-Dev
Road Pavement	0.2	1
Road Verge	0.2	0.25
Lots	0.2	0.25
Basins	0.2	1
OS	0.2	0.2

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)	Event Rainfall (mm)
1 min	1	144.60	2.41
2 min	2	122.70	4.09
3 min	3	110.60	5.53
4 min	4	101.25	6.75
5 min	5	93.48	7.79
10 min	10	69.00	11.5
15 min	15	55.60	13.9
20 min	20	47.10	15.7
25 min	25	41.04	17.1
30 min	30	36.60	18.3
45 min	45	28.27	21.2
1 hr	60	23.50	23.5
1.5 hr	90	18.13	27.2
2 hr	120	15.15	30.3
3 hr	180	11.77	35.3
4.5 hr	270	9.20	41.4
6 hr	360	7.75	46.5
9 hr	540	6.10	54.9
12 hr	720	5.13	61.6
18 hr	1080	4.01	72.2



100 YEAR ARI CUMULATIVE FLOWS - POST DEVELOPMENT

CATCHMENT	Contributing Catchments	AREAS (m2) Road Pavement (m2)	Road Verge (m2)	Lots (m2)	Basin	OS (m2)	Total	EFFECTIVE AREA (m2) Post	TIME OF CONCENTRATION POST-DEVELOPMENT Longest Path (m)	RL Top (mAHD)	RL Bottom (mAHD)	Slope (m/m)	TC (mIn)	CRITICAL STORM INTENSITY (mm/h) Post-Dev	FLOW Peak Flow (L/s)	Total Flow (m3)
A		528	1228	0	21	0	1777	918	508	307	295	23.62	31.5	57.1	14.54	27.49
B		1188	1591	24362	0	0	27141	8974	333	307	300.5	19.52	17.1	79.0		
C		390	679	3634	11	0	4714	1695	146	307	302	34.25	7.9	119.1	56.06	26.59
D	E,F	2640	6470	27126	149	10738	47123	15015	548	308.5	290.7	32.48	24.1	65.8	274.41	396.99
E	F	600	2579	13090	74	0	16343	5375	390	308.5	296	32.05	19.1	74.5	111.30	127.33
F		1560	2579	3921	53	0	8113	3563	297	308.5	297	38.72	14.6	86.0	85.14	74.42
G		1308	2054	2748	21	0	6131	2770	226	308.5	303.5	22.12	12.7	92.5	71.16	54.29
H	I,J	2466	2299	16717	53	0	21535	8224	245	308.5	297	46.94	10.6	101.7	232.33	148.27
I		342	545	5232	21	0	6140	2096	220	308.5	296.5	54.55	10.6	101.8	59.25	37.78
J		1074	1754	11485	32	0	14345	5078	179	305.5	297.5	44.69	8.2	116.5	164.37	81.22

Runoff Coefficients	Pre-Dev	Post-Dev
Road Pavement	0.2	1
Road Verge	0.2	0.3
Lots	0.2	0.3
Basins	0.2	1
OS	0.2	0.2

Rainfall IFD

Event	Duration (mins)	Intensity (mm/hr)	Event Rainfall (mm)
1 min	1	256.80	4.28
2 min	2	213.00	7.1
3 min	3	193.80	9.69
4 min	4	178.50	11.9
5 min	5	165.60	13.8
10 min	10	122.40	20.4
15 min	15	98.40	24.6
20 min	20	83.10	27.7
25 min	25	72.48	30.2
30 min	30	64.60	32.3
45 min	45	50.13	37.6
1 hr	60	41.90	41.9
1.5 hr	90	32.73	49.1
2 hr	120	27.65	55.3
3 hr	180	22.00	66
4.5 hr	270	17.60	79.2
6 hr	360	15.02	90.1
9 hr	540	11.89	107
12 hr	720	10.00	120
18 hr	1080	7.72	139