Stormwater Disposal via Soakage in the Auckland Region

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Stormwater Disposal via Soakage in the Auckland Region

G Strayton
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Executive Summary

Soakage is a well-known method of disposal of stormwater in the basalt areas around the Auckland Region and within the Papakura peat.

The knowledge base with regard to the character of the majority of the Auckland Isthmus basalt aquifers has grown and the potential of the aquifers to accommodate soakage is now better understood. The state of knowledge of the Papakura peats is based on a 2006 review of the available soakage testing that has been carried out in the Papakura area based on property file records of applications for disposal of stormwater to ground.

There is potential for stormwater disposal to ground in other basalt and peat areas identified in this report. Maps setting out probable, potential and inferred soakage areas have been developed. These have also been provided to Auckland Council (AC) in GIS format. The criteria used to generate the maps given in Section 4 provide a useful guide to aid in the interpretation of site investigation data to determine the potential for soakage.

The design methodologies for private and commercial soakage devices are well documented and have been utilised within the legacy Auckland City Council and Papakura District Council areas over the last few decades.

The clogging of a soakage device is related to the land use of the catchment draining to the device. For average residential loadings the modelling undertaken indicates that pre-treatment in the form of a catchpit is adequate to prevent clogging for sediment from residential driveways. However for industrial, commercial and construction sites more comprehensive pre-treatment is required in order to ensure the effective ongoing functioning of the soakage device. In heavy sediment loading industrial areas, a sediment settlement tank or pond is recommended.

Soakage devices, with rockbores, discharge stormwater directly to the underlying aquifer. As the aquifer is considered to be the receiving environment, the stormwater needs to be treated to the relevant standard before entering the soakage devise.

Maintenance of the device is also an important element to minimise the effects of clogging by the entrained sediment within the stormwater.

The design approach for both basalt and peat follows the methodologies given in Appendices A and B. The most important factor in the design for the soakage devices located in the basalt is the site specific investigation to identify the area of most suitable soakage locating the device in the area of most fractured basalt. For the peat devices the site investigation is also important to identify the depth to the peat and the groundwater level within the peat.

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List of abbreviations

AC	Auckland Council
ACC	Auckland City Council
ARC	Auckland Regional Council
ARI	Annual Recurrence Interval
AT	Auckland Transport
CBR	Californian Bearing Ratio
COP	Code of Practice
FDC	Franklin District Council
GAS	Global Aquifer Study
GPR	Ground Penetrating Radar
ICS	Integrated Catchment Study
IDS	Infrastructure Design Standards
LRIS	Land Resource Information System
mBGL	metres below ground level
MCC	Manukau City Council
MW	Metrowater
NSCC	North Shore City Council
NZLRI	New Zealand Land Resources Inventory
OSSMM	On-Site Stormwater Management Manual
PDC	Papakura District Council
PDC DC	Papakura District Council Development Code
PDP	Pattle Delamore Partners Limited
SDM	Soakage Design Manual
TARS	Transport and Roading Services
TSS	Total Suspended Solids
WCC	Waitakere City Council

List of Definitions

Catchment	The area contributing flow to a given point on a drainage system
Catchpit	Small chamber incorporating a sediment trap that runoff flows through
Contours	Lines on a drawing that join points of equal elevation
Equivalent impervious area	The area of impervious surface that would contribute the same amount of runoff as an area made up of both pervious and impervious surfaces.
Filter-strip	Broad grassed surface conveying runoff
Flood frequency	Probability that a flood discharge rate will be equalled or exceeded in any year
Groundwater	Water stored and/or moving under the ground surface
Impermeable/impervious surface	A surface through which water cannot pass (eg roof, concrete)
Infiltration	The process by which water on the ground surface **enters** the soil or ground (also see Percolation)
Land Information Memorandum	A report detailing all information about a property that is known by the Council. This includes hazards, drainage plans and information on rates, permits and zones. The report is normally requested by people considering purchasing a property.
On-site stormwater management	The detention and/or retention of runoff on a site before discharging it to a disposal system
Orifice	Hole of a specified size designed to discharge flow at a pre-determined rate (it is normally machine-drilled in a plate and attached at the entry to a pipe)
OSM device	An on-site stormwater management system, designed to meet water quantity and/or quality goals, which utilises detention and/or retention of runoff before discharging it to a disposal system
Overland flow path	Route taken by flood runoff not able to be contained in the primary pipe or channel stormwater conveyance system
Paved area	Any impervious ground-level area, such as driveways or patios
Percolation	The movement of water **through** soils or fractured rock until it reaches the upper level of saturation or the water

	table (also see Infiltration). Design charts and worksheets, copied from legacy documents, use the term percolation. In these cases, no distinction between percolation and infiltration was made.
Pervious area	Any area covered in vegetation or garden.
Permeable surface	A surface through which water passes by infiltration
Porosity	Represents the proportion of water in a saturated gravel or soil. Multiply by the total volume of gravel/soil to give the volume of storage
Porous pavement	Paved surface through which water can infiltrate
Porous paved area	Any area covered in porous paving.
Project Information Memorandum	A report prepared by the Council for an owner considering a building project. The report contains information on hazards, public drainage systems and other services (e.g. electricity).
Rainwater tank	A tank that stores roof runoff (normally for re-use and flow attenuation purposes)
Rain garden	Device that receives and filters runoff and then disposes of the water by infiltration
Rockbore Soakholes	These are soakage devices with rockbores that deliver water many meter below ground into fractured rock.
Runoff	The flow of water across the ground or an artificial surface generated by rain falling on it
Soakage	The proses of water entering into the ground (see infiltration).
Soakholes	These can be existing natural chambers and tunnels in the basalt lava or engineered interconnected catch pits, manholes or chambers with boreholes.
Soakpits	These are soakage devices which are excavated into soil or rock and the capacity is dependent upon the extent of rock fissures or permeability of the pit base and walls.
Time of concentration	Time taken for rain falling at the head of the catchment to reach a designated point as runoff
Watercourse	Natural or artificial channel which conveys runoff

1.0 Introduction

The purpose of this report is to provide technical information regarding disposing of large quantities of stormwater into the ground. In this context a "large" quantity is so that soakage provides a primary drainage system level of service. This report focuses on disposing water to fractured basalt and to peat soils. Peat soils have been included due to their infiltrative capacity and the importance of maintaining ground water levels in peat soils to prevent shrinkage and settlement.

This report includes:

- Soakage maps - The analysis, interpretation and extrapolation of soakage rates, to form indicative soakage potential maps.
- Clogging – Analysis of soakage devices (based on Section 7.3) and recommendations for mitigation and allowance of blockage in device design.
- Soakage devices – the review and consolidation of two Legacy Auckland City Council documents (the Soakage Design Manual and the On-site Stormwater Management Manual) in relation to discharges to ground.

The soakage maps are the results of a desktop study based on a geological database held by Auckland Council (AC). They indicate areas in the Auckland region that have confirmed (through previous testing) soakage into basalt and peat soils. They also show areas where soakage is inferred (based on a comparison of soil/geological types) and give an indication of the relative level of soakage expected. The purpose of the maps is to inform designers at the concept stage regarding the likely availability of soakage. Site specific soakage tests will still be necessary for detail (and possibly preliminary) design. Areas of Auckland not included on the maps may have localised pockets of high infiltration capacity areas (eg sandy or peat areas on the west coast) however these have not been identified.

The soakage device clogging analysis considers clogging of both the fractures in basalt and of soakage devices in peat soils. The purpose of this analysis is to inform designers regarding appropriate safety factors to use to allow for clogging. It also demonstrates the need for pre-treatment.

The remainder of the report (including the appendixes) is dedicated to reproducing the pertinent messages relating to soakage in two legacy Auckland City Council (ACC) documents: the Soakage Design Manual (SDM) and the On-site Stormwater Management Manual (OSSMM). The purpose of this is to consolidate and update the information given in the legacy documents and to ensure the information remains readily available (as these legacy documents are not planned to be made available on the Auckland Council web site).

The inclusion of peat soils in this report is due to the legacy Papakura District Council (PDC) Development Code requirement to discharge a portion of stormwater runoff to ground in areas of peat soils (for the purposes of ground water recharge). This requirement is likely to be carried forward by the proposed Auckland Council Stormwater Code of Practice.

2.0 Background

Soakage is the process where a permeable substance receives a liquid. In the context of the Auckland region and elsewhere in the world, soakage has been generally defined as the process of disposal of stormwater into the ground.

Given an adequate period of time, stormwater can soak into even the clays and clayey silts of the region. However, the rate at which it can infiltrate is dependant of the type of soil and its character. Characteristics that determine permeability of the upper soils are soil structure, soil particle size and geomorphology. The flow rate of the soakage discharge is also dependent upon the soakage area available and the hydraulic head driving the water into the ground. Where the flow rate into the ground is slow, water must pond or be stored to allow sufficient time for the infiltration to occur. If the storage is full, the stormwater instead runs off the land as surface water runoff.

For this report, soakage is taken as the practice of disposal of stormwater into the ground to achieve the required level of service for primary drainage and reduce flooding. This report focuses on the basalt and peat areas within the Auckland region where soakage has historical been utilised for stormwater disposal.

The New Zealand Land Resources Inventory (NZLRI) divides the New Zealand landscape into land use capability units and provides a national database of physical land-resource information, based on two sets of data – an inventory of five physical factors and a land use capability rating of each unit based on an assessment of the ability of that soil type to provide sustained agricultural production.

The five physical factors used in the assessment of land resources are:

- rock type
- soil type
- slope
- erosion degree and type
- vegetation.

In addition, a range of land-use characteristics are contained within the inventory. These include characteristics such as permeability and soil infiltration. This data is useful at a regional level to help in the identification of areas that are more suitable to stormwater disposal by means of soakage. It must be remembered however that this data relates to the surface soils only and not the full geological profile.

From Figures 1, 2 and 3 it can be seen that the soil data applies only to the rural areas within the Auckland region. Therefore it could be a useful initial tool for assessing soakage potential of future development outside the main urban areas.

The information is available by means of the Land Resource Information Systems (LRIS) Portal. The LRIS is a repository of authoritative New Zealand physical land resource datasets and information (http://www.landcareresearch.co.nz/resources/data/s-maponline).

LRIS contains land resource data held specifically by Landcare Research for use in GIS and other applications that can handle geospatial data for mapping, querying and spatial analyses. There is strong focus on metadata and supporting documentation. The portal supports downloading data in many geospatial data formats.

Figures 1, 2 and 3 show the extent of the relevant data available for the following land characteristics:

1. Permeability
2. Soil Infiltration
3. Soil Type Classification

The majority of the previous work undertaken on the issue of soakage has been within the boundaries of the legacy Auckland City Council (ACC) area and has focussed on the basalt aquifers. These aquifers have a much higher hydraulic conductivity than the other groundwater systems within the Auckland Region and have therefore been used as a means of stormwater disposal. This method of disposal of stormwater is widely used and has been developed as the primary practice within certain basalt areas.

In the legacy documents from ACC such as the Soakage Design Manual (SDM) (ACC, 2003) soakage devices were required to be designed to accommodate the stormwater generated from the 10 year Annual Recurrence Interval (ARI) 24 hour rainfall event (ACC Consolidated Bylaw, 1998 (and amendments): Part 18 – Stormwater Management). This is also consistent with the requirements of the Building Code.

In 2003, the SDM (ACC, 2003) was updated and has been the main design tool for designing and developing private soakage into the basalts within the old ACC area. The SDM highlighted the interaction of the manual with a wider body of design manuals and policy documents.

In the period 2003-2005 as part of the Integrated Catchment Studies (ICS) conducted for ACC and Metrowater (MW), a separate study on the aquifers on the Isthmus was undertaken. This study was known as the Global Aquifer Study (GAS) Project (PDP, 2003, 2004, 2005a, 2005b, 2005c, 2005d). This project focused on the identification, characterisation and capacity modelling of the main basalt aquifers. In addition, issues associated with water quality were investigated and reported.

In 2005, a review of the discharge of stormwater to peat areas in Papakura was undertaken for Papakura District Council (PDC) (PDP, 2005e). This review focussed on the existing information on the soil characteristics in Papakura District in relation to disposal of stormwater via soakage devices to recharge groundwater levels. The objective of the review was to assess the extent of peat soils and to then prepare a standard design of a recharge device which could be incorporated into future developments to maintain the groundwater levels within these peat areas.

Soakage has also been used in volcanic aquifers of the former district and city councils such as Franklin District Council (FDC) (for example in Pukekohe and Waiuku), Manukau City Council (MCC) (Wiri) and North Shore City Council (NSCC) (Devonport). Other legacy documents such as the FDC Development Code allows discharge to soakage where the system can soak away the 20yr ARI 10 minute storm within 24 hours. The NSCC Infrastructure Design Standards (IDS) allowed soakage subject to detailed site investigations with drawings SW2 and SW3 of the IDS showing the indicative areas that are suitable. Soakage was, however, required to meet Building Code levels of service (i.e. the 10 year ARI storm).

In 2010 and 2012 an assessment of the soakage potential of the main Auckland Isthmus basalt aquifers was undertaken (PDP, 2010 and PDP, 2012). This assessment was theoretical in nature using the knowledge of the existing character and extent of the two main aquifers on the Auckland Isthmus to determine the soakage potential of the aquifers.

All these documents and reports have been utilised in the development of this report in the following sections. The methods from the legacy SDM and the PDC Development Code have been reviewed and text from those documents used here where the design methods are considered still appropriate.

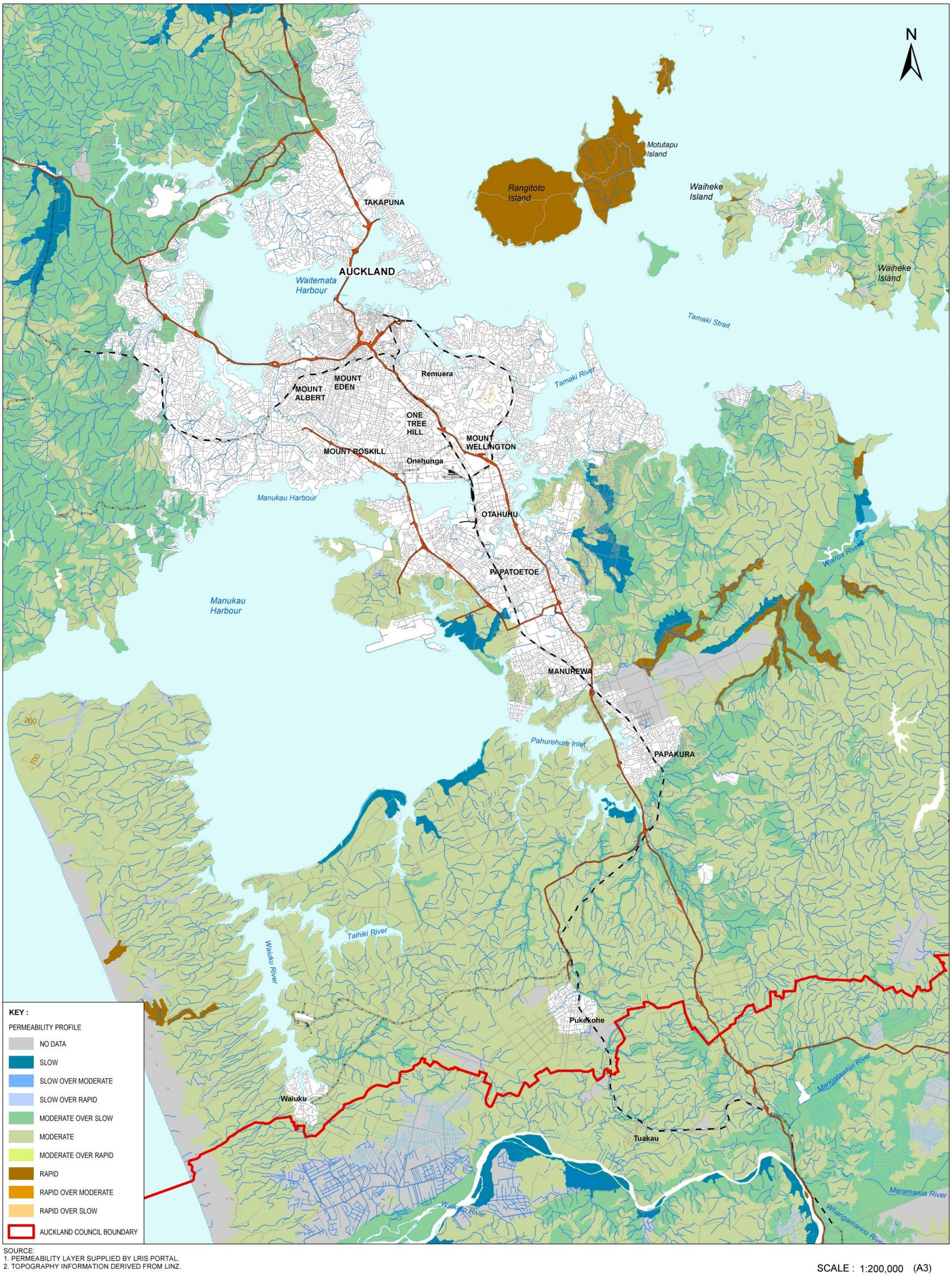

Figure 1: Permeability of the Soils in the Auckland Central and South Areas

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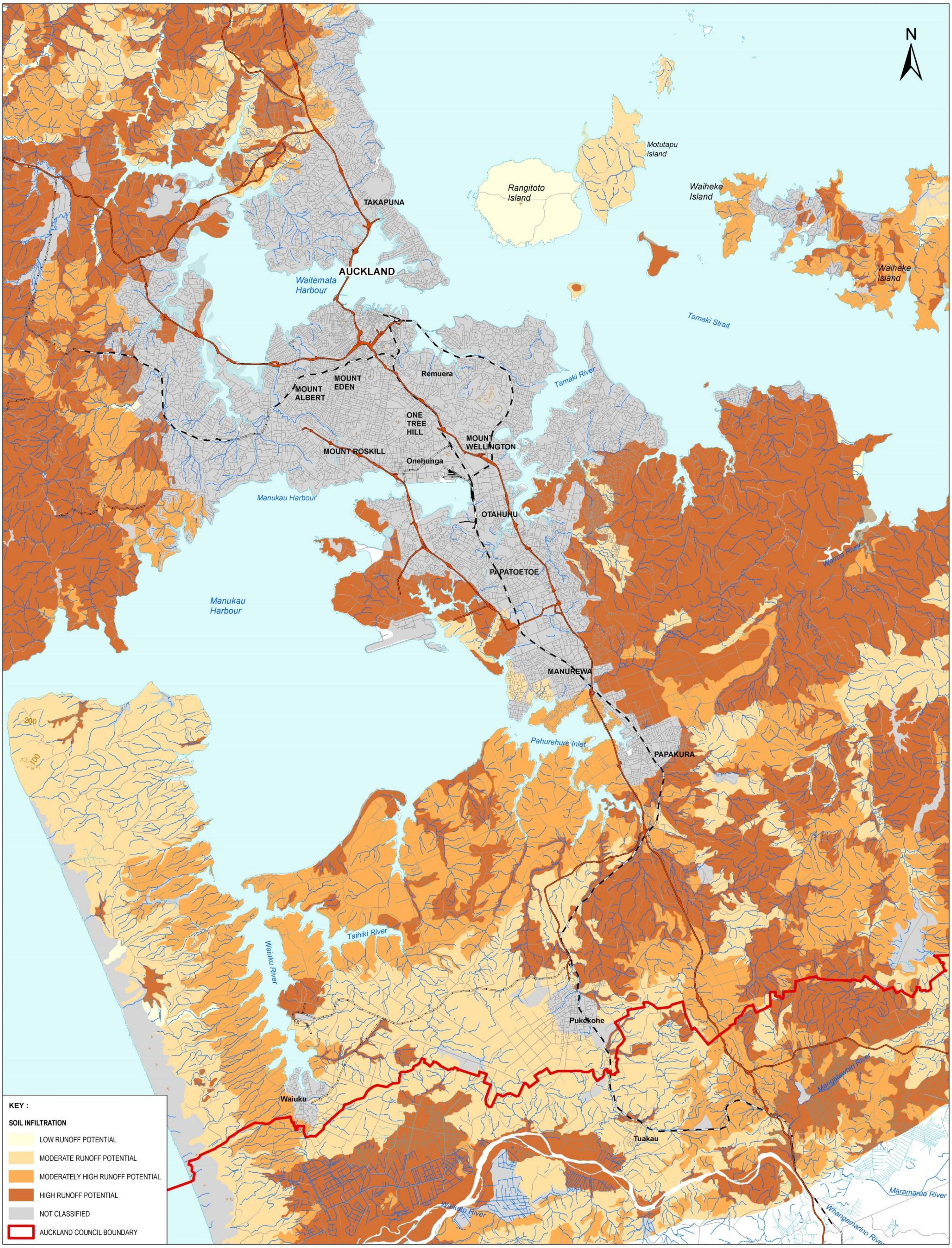

SOURCE:
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2. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

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KILOMETRES

Figure 2: Soil Infiltration of the Soils in the Auckland Central and South Areas

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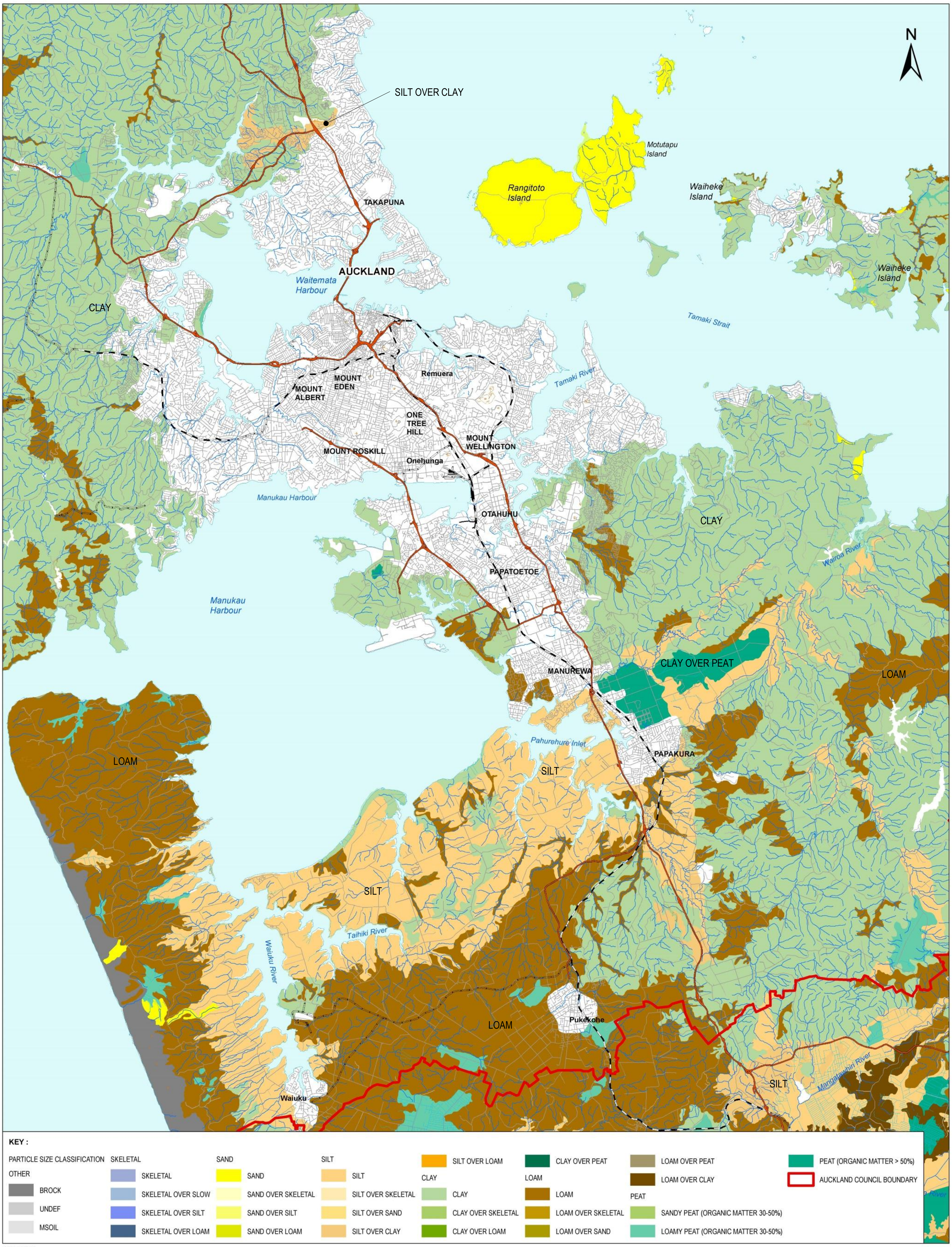

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Figure 3: Particle Size Classification of the soils in the Auckland Central and South Areas

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3.0 Relationship to other relevant Manuals and Documents

This section of the report illustrates the links between the various documents (legacy and current) relating to soakage and the different objectives they promulgate.

The legacy ACC SDM and the OSSMM detail the links between these two documents and the relevant legacy Auckland Regional Council (ARC), ACC and MW standards and plans and other documents. In summary the following documents are related to soakage.

Statutory Documents

- Building Act 2004.
- New Zealand Building Code, Part E1: Surface Water.
- Auckland Council draft Unitary Plan.
- *ARC – Proposed Regional Plan – Air, Land and Water (PRP-ALW).*
- *ACC District Plan – Isthmus Section.*
- *ACC Consolidated Bylaw, 1998 (and amendments): Part 18 – Stormwater Management.*
- *Papakura District Plan.*

Standards

- *ACC/MW Development and Connection Standards.*
- *PDC Development Code*
- *NSCC IDS*
- New Zealand Standard: Subdivision Standard.

Guideline Documents

- *ARC – Stormwater Treatment Devices – Design Guideline Manual (TP10).*
- *ARC – Guidelines for Stormwater Runoff Modelling in the Auckland Region (TP108).*
- *ARC – Erosion & Sediment Control – Guidelines for Land Disturbing Activities (TP90).*

NB: Legacy documents are italicised.

Auckland Council (AC) is producing a Stormwater Code of Practice (SWCoP) for use across the Auckland region. It is expected that this document will provide the required standards and levels of service to which the soakage devices must be designed.

The discharge and diversion of stormwater from impervious areas needs to be authorised by a permitted activity or a resource consent in accordance with the regional plan. The construction of a soakage system is a means of drainage to meet Building Code performance standards and therefore it will require a building consent. A resource consent application to council would be separate to a building consent application.

The interaction of soakage with the various documents and manuals is illustrated in Figure 4.

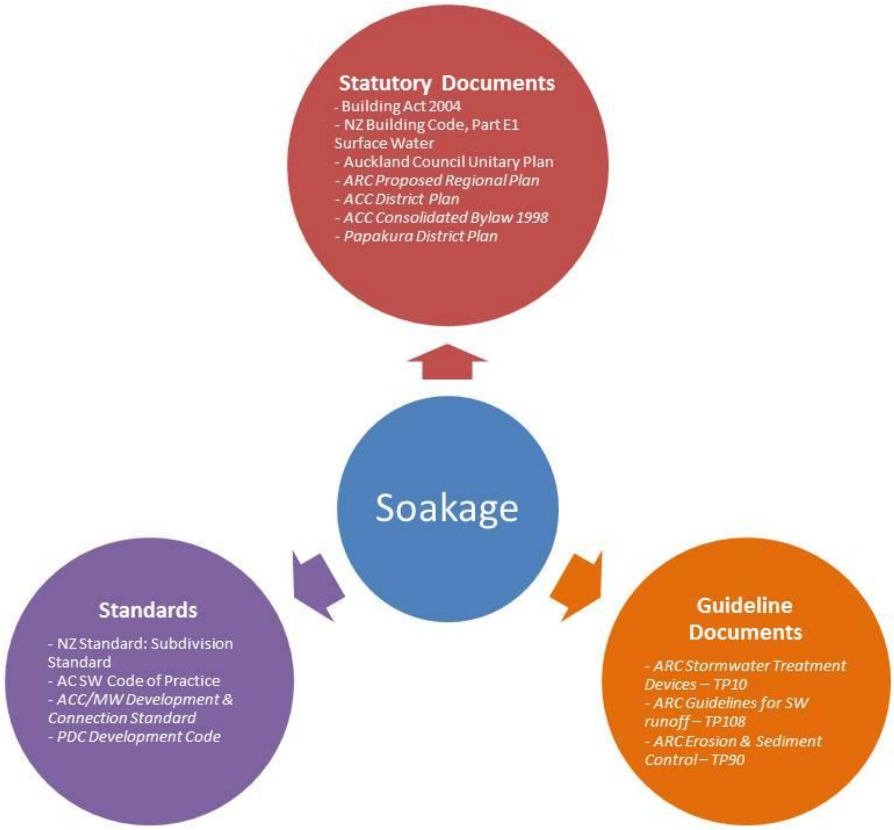


Figure 4: Relationship between Soakage and Manuals & Documents

This information has been tabulated in Table 1 below to provide a greater level of detail of the relationship of soakage to the manuals and documents.

Table 1: Relationships to Statutory Documents

Statutory Document	Aspect	Description
Building Act	Statutory Requirements	All building work is governed by the Building Act, including stormwater systems. Section 36 outlines policy relating to building on land subject to flooding.
NZ Building Code	Stormwater Objectives	The Building Code sets out the objectives that buildings must be designed to achieve. Clause E1 sets out performance standards and acceptable solutions relating to stormwater.
AC Unitary Plan	Consenting	This document provides the rules and policies relating to natural hazards, residential and business activity with respect to consenting requirements for stormwater discharges to ground.
	Water Quality & Use of Soakage	Groundwater - stormwater quality – Requires land use and development in areas underlain by shallow or highly permeable aquifers to use stormwater discharge to ground soakage provided that: • ground soakage is available • any risk to people and property from land instability or flooding is avoided • stormwater quality treatment is implemented to avoid degrading the capacity and water quality of the underlying aquifer system. Peat soils - Requires land use and development and drainage systems within areas underlain by peat soils to provide for stormwater discharge to ground soakage that maintains underlying aquifer water levels and the geotechnical stability of the peat soils.
ACC DP	Consenting	This document provides the rules and policies relating to natural hazards, residential and business activity with respect to District Plan consenting requirements.
ARC PRP-ALW	Consenting	This document provides the rules and policies relating to stormwater discharges with respect to Regional Plan consenting requirements.
ACC – Bylaw – Legacy Document	Design Flows	This document prescribes requirements to be met with respect to the functioning operation and maintenance of private soakage devices to accommodate the 10% AEP storm.

Table 2: Relationships to Standards

Standard	Aspect	Description
ACC Soakage Design Manual – Legacy Document	Testing	The SDM in section 3 describes infiltration test methods for estimating the rate at which stormwater will soak into the ground. Sub-sections cover: • An overview of the procedures. • Boreholes/test pits. • Preparation of boreholes/test pits for infiltration tests. • Falling-head infiltration tests. • Constant head infiltration tests. • Minimum soakage rate for soil areas.
	Design	The SDM in section 5 describes procedures for sizing the devices. Sub-sections cover: • Design standards for soakage devices. • Design standards for pre-treatment devices. • Design areas for sizing. • Ratios used for sizing (soakage device area ratio, catchment soakage ratio, storage ratio, orifice area ratio). • Sizing of soakage devices. • Sizing of pre-treatment devices. • Sizing of rainwater tanks and on-site storage. • Standard details. • Innovative designs.
	Device Selection	The SDM in section 4 provides descriptions of the different devices, and suggestions for selecting the most appropriate system. Sub-sections cover: • Descriptions of the approved soakage devices. • Descriptions of the approved pre-treatment devices. • Pre-treatment requirements. • Cost of Devices. • Difficult Sites. • Descriptions of rainwater tanks and on-site storage. • Rainwater tanks and network charges.
ACC On-site Stormwater Management Manual – Legacy Document	Water Quality	The OSMM explains the general water quality control performance standards to be met by OSM devices.
	Consenting	The OSMM identifies the submittal requirements for the consents required to implement OSM devices. It covers: • General submittals process. • Resource Consents. • Building Consent (including the OSM O&M Plan). • Certifications. • Submittal Forms.
FDC CoP for Subdivision & Development – Legacy Document	Design	The Code of Practice in section 401.1.1 states the design standard for the design of soakage devices. Further detail is provided in the District Plan via the Pukekohe North Structure Plan.
North Shore City Council IDS – Legacy Document	Design	The IDS in section 4.5.1 describes the design approach for the design of soakage devices.
Papakura District Council DC – Legacy Document	Design	The Development Code in section 4.6 describes the design approach and methodology for the design of soakage devices in peat.
	Testing	The Development Code in section 4.6 describes testing methodologies for the infiltration testing of the ground.

Table 3: Relationships to Guideline Documents

Guideline Document	Aspect	Description
ARC TP 10 – Legacy Document	Design & Water Quality	TP 10 provides guidelines for the design, construction and operation of stormwater management devices that minimise the environmental effects of stormwater discharges
ARC TP 108 – Legacy Document	Design Flows	TP 108 describes recommended method for the calculation of rainfall runoff based on the US Soil Conservation Service model.
ARC TP90 – Legacy Document	Sediment Control	TP90 provides the guidelines that need to be met with regard to the erosion and sediment control requirements around the carrying out earthworks.

4.0 Soakage Areas

4.1 Introduction

In this section the geology of the Auckland region has been considered with a focus on the parts of the region with potential soakage to basalt and peat. Maps are presented to provide guidance in assessing the soakage potential of the various areas in the Auckland region that are likely to provide stormwater disposal to soakage. There may be small areas of soakage that lie outside the area shown on these maps; however they have not been identified in this study.

The basalt and peat soakage areas are divided based on level of knowledge. Within each area the degree of soakage potential is determined based on various criteria. The divisions between soakage areas and degrees of soakage in the following sections are summarised in Table 4 below.

Table 4: Soakage Zones

Relative Degree of Soakage	**Soakage Areas (based on knowledge & information)**		
	Probable	**Possible**	**Inferred**
Good	Soakage potential calculated between 10^5 to 10^7 m^3/day per ha	Areas where: i) unsaturated depth of basalt > 5m and total depth of basalt >14m ii) Cover <8m and unsaturated depth >5m iii) Papakura Peat	Remainder of basalt and peat areas
Medium	Soakage potential calculated between 10^3 to 10^4 m^3/day per ha	Areas where: i) unsaturated depth of basalt < 5m and total depth of basalt >14m ii) Cover <8m and unsaturated depth <5m	
Poor	Soakage potential calculated between 0 to 10^3 m^3/day per ha	Not defined	
None	Areas where groundwater is within 2m of surface		

4.2 Geology of the Auckland Region

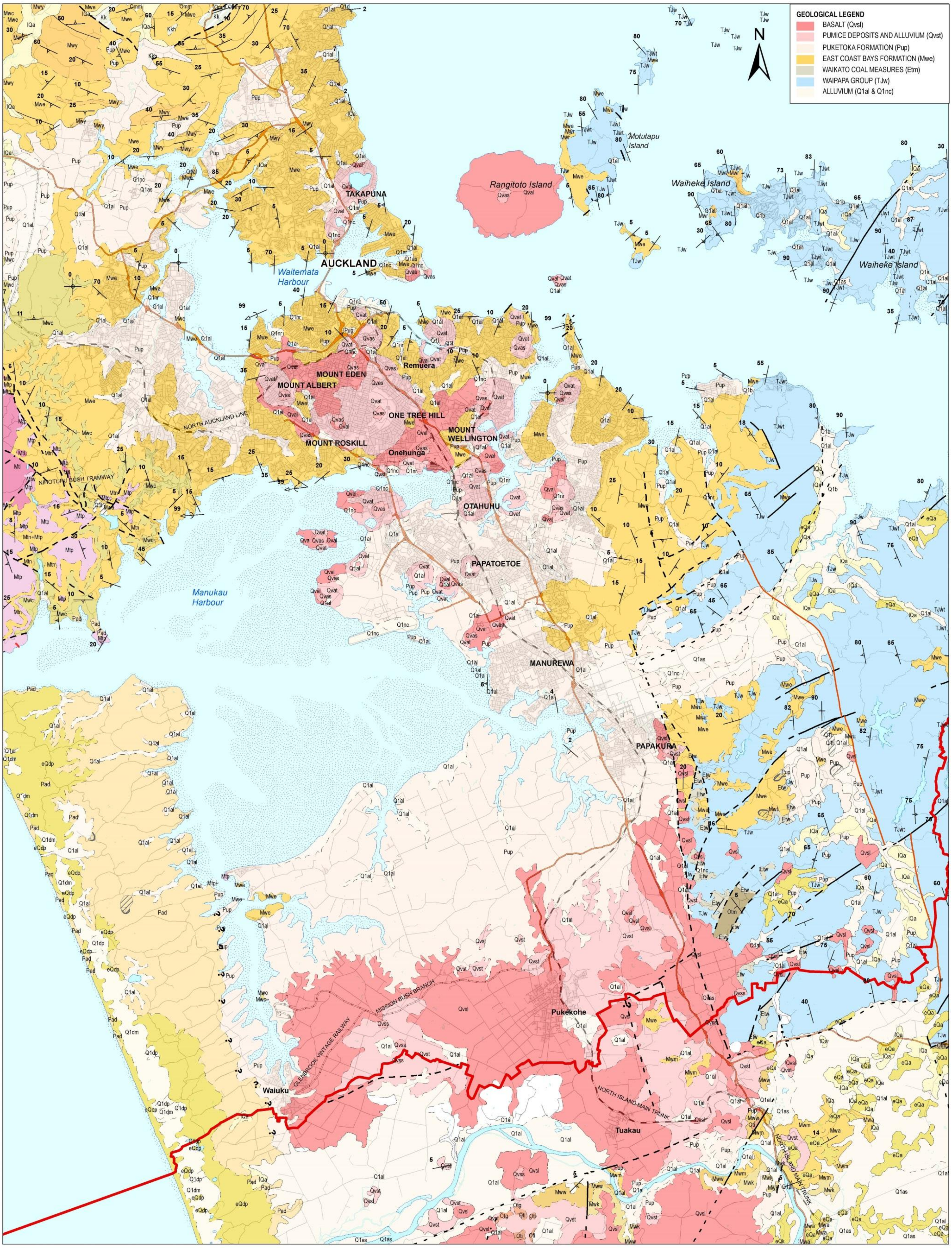
Auckland is underlain by a variety of different geological formations. Many of these, such as the Waitemata group, contain high quantities of clay and silt creating low permeability soils. Overlying parts of the Waitemata Group there are also a number of areas with basalt layers throughout the region. This basalt contains lava tunnels and in some places is highly fractured. The resulting voids and fractures act as conduits within the basalt allowing the geological unit to act as an aquifer. Prior to development of these areas the basalt aquifer was recharged by natural infiltration of stormwater into the fractured basalt. Where the basalt is not completely saturated, there is potential to dispose of stormwater by releasing it into the aquifer.

In the areas where soil is found above the basalt, most of the soil consists of low permeability clays, silts and volcanic ashes which will not allow the rapid infiltration of water. Therefore, boreholes need to be drilled through this layer in order to access the basalt aquifer to dispose of the stormwater. This soil cover, particularly in the basalt areas of South Auckland is reflected in Figures 1, 2 and 3 based on the LRIS data. The depth of the soil is not known other than from geological logs from boreholes documented by AC.

In some cases on the Auckland isthmus especially areas of basalt are covered by up to 15m of tuff (volcanic ash). Tuff can include in its profile layers of scoria which may serve as soakage lenses however the general nature of tuff is such that it is not particularly permeable. Soakage devices in these areas can be constructed within the tuff layer but the underlying basalt should be accessed by means of boreholes to ensure adequate soakage. Within the central isthmus there are also areas of tuff underlain by the Waitemata Series and these areas are known to have poor to no soakage. It is therefore important in such areas to identify the underlying geology and test the underlying basalt using site specific investigations to determine if soakage is a feasible solution.

Within the legacy Papakura district there is an area of peat which acts as an aquifer. This layer is prone to subsidence if the water level within the peat drops, so the main impetus behind using soakage in Papakura is to maintain the groundwater levels in the peat and reduce the potential for subsidence within the developed areas.

The geology of the Auckland soakage region is shown in Figure 5.



KEY :

AUCKLAND COUNCIL BOUNDARY

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SOURCE:
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2. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

Figure 5: Geology of the Auckland Central and South Areas

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4.3 Soakage Areas

Basalt covers significant areas of the Auckland Isthmus and the area around Pukekohe. These areas are developed and developing areas that generate increased stormwater runoff due to the creation of impermeable surfaces. The potential for soakage has been evaluated based on the available information and knowledge of the characteristics of the areas.

The potential of soakage in the Auckland region is illustrated in Figure 7. Figures 8 & 9 are a larger scale of the northern and southern soakage areas. Note that soakage is not found in all of the Auckland regional area.

Soakage areas have been divided into three main areas viz. probable, possible and inferred soakage areas. Within these categories, soakage is defined in terms of *relative degrees of soakage*. For probable soakage the basalt areas are divided into good, medium, poor and none soakage zones and for the possible soakage the areas are divided into good and medium. All other basalt areas are defined as having inferred soakage. The peat area in Papakura is regarded as a possible good soakage area as discussed below.

These areas are defined as follows:

4.3.1 Probable

The basalt aquifers that have been well investigated with numerous in situ tests that characterise the properties of the various portions of the aquifers form the basis for the probable category. Although the peat area around Papakura has been relatively well defined and investigated, the range of the methodologies used in these investigations preclude it from being considered under this soakage area. As more data on the peat is gathered using the methodologies in this report this additional data may result in a re-categorisation of the peat area.

There are a number of recent reports that detail the characteristics and soakage potential of the basalt aquifers on the Auckland Isthmus. The most recent reports have calculated the potential of the aquifer based on a theoretical estimate of soakage capacity (PDP, 2010 & 2012). The analysis used the basalt thickness and the available volume of unsaturated basalt at points throughout the city to calculate the maximum flow capacity of individual soakage boreholes. A 100m by 100m grid was used to contour the result and produce a soakage potential map.

While it provides a good foundation, this method has its limitations. Primarily, it assumes the soakage devices act independently, when in practice they are a network of devices concurrently providing soakage for the catchment. In a network there is commonly hydraulic interference between boreholes in the aquifer which serves to reduce the capacity of individual devices. The interference between these rockbore soakholes is, therefore, a significant factor which needs to be included in estimating soakage network potential for a catchment.

These studies also determined that the permeability of the aquifer is an important parameter in the estimation of the soakage potential with Figure 6 illustrating the relationship between transmissivity (permeability multiplied by basalt thickness) and inflow rate for a 100mm diameter borehole in a 4m thick aquifer with an 8% porosity. The average transmissivity and inflow rates are plotted below using the maximum and minimum permeability values for the Auckland area of 2×10^{-5} m/s and 2×10^{-1} m/s (PDP, 2010 & 2012).

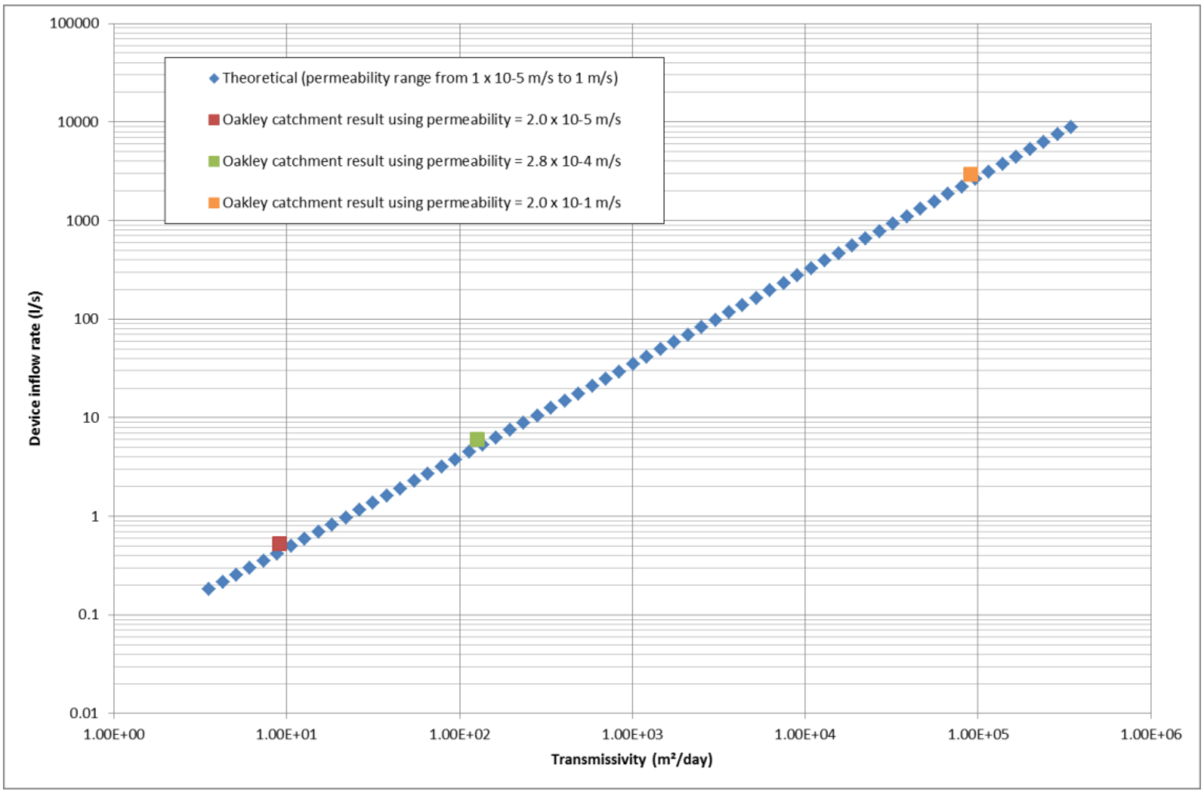


Figure 6: Transmissivity vs Inflow Rate

The calculated potential soakage of Auckland Isthmus basalt aquifers were divided into relative degrees of high, medium and low soakage as well as those areas defined as none due to a lack of unsaturated basalt. The criteria for each of these degrees is given in Table 3 below.

Table 5: Probable Soakage Zones – Degree of Probable Soakage

High	Medium	Low	None
Soakage potential calculated between 10^5 to 10^7 m^3/day per ha	Soakage potential calculated between 10^3 to 10^4 m^3/day per ha	Soakage potential calculated between 0 to 10^3 m^3/day per ha	Areas where groundwater is within 2m of surface

4.3.2 Possible

4.3.2.1 Basalt Areas

These areas are located on the volcanic basalt geology in the Auckland region for which there are borehole logs that describe the extent of the profile. The data for various boreholes varies significantly in content, format and quality, and this reduces the reliability in identifying suitable soakage areas. This lack of conformity of the data has highlighted the need to limit the identification of possible soakage to only two areas.

For categorisation of this area 70 boreholes were identified in potentially key locations - of which only 13 provided adequate data to fully categorise the area whilst another 22 had partial data. The information from the selected borehole logs was used to establish criteria to divide the basalt aquifer into different degrees of soakage.

The relative degrees of soakage for these areas have been estimated based on the following factors:

- The extent of the basalt layer indicated on the Auckland Geological Map.
- The non-basalt soil cover to the top of the basalt.
- The total depth of the basalt.
- The unsaturated depth of the basalt.

The last three factors were established using the acquired borehole log data and based on the results of this data, areas with degrees of good and medium potential soakage were defined.

The depth of basalt is an indication of the extent of possible aquifer which could be used for soakage, the unsaturated depth of the basalt is an indication of the volume of the aquifer that is available for possible soakage and the depth of non-basalt soil cover is an indication of the ease of access to the underlying basalt aquifer.

The degree of fracturing was also initially considered to provide a good indicator of possible soakage however the level of detail on the descriptions of the borehole logs reviewed precluded this as a factor in determining soakage potential. There were also no documented pump test data available as part of the borehole survey.

The possible soakage of those areas of the Auckland regional basalt aquifers for which there is some data were divided into areas with degrees of high and medium potential soakage. The criteria for each of these areas based on the factors listed above is given in Table 5 below.

4.3.2.2 Peat Areas

This soakage area comprises the peats in the legacy Papakura District which have been previously identified (PDP, 2005e). Soakage to peat is different to soakage to basalt as the purpose is to maintain the groundwater level to prevent consolidation and subsidence. Therefore the peat has not been divided into areas of high, medium and low soakage.

In 2005, an estimate of the peat area boundary was made based on information from PDC council officers. The reports obtained from the PDC subdivision files were reviewed by PDP, and the following information was retrieved from each report (where available) (PDP, 2005e):

- Site Location.
- Predominant Soil Type. The categories were 'Peat' for areas where a definite peat layer were noted, 'Organic' for areas where only minor peat inclusions were noted, and 'Neither' where no organic inclusions were recorded.
- Depth to, and thickness of, peat layer (if any). Where there were a number of boreholes across the site, depths were averaged to produce an estimate for the entire site.
- Groundwater level. Where there were a number of boreholes across the site, depths were averaged to produce an estimate for the entire site.
- Soakage Rate. Where there were a series of soakage tests undertaken, the lowest result was taken to provide a conservative estimate of the soakage rate. This is standard practice in accordance with the SDM (ACC 2003).

- The month that the borehole was drilled in. This was to provide an assessment of the groundwater level fluctuation across the different seasons.

The extent of the peat area was derived from the borelogs in the geotechnical and soakage reports, and the edges of this area were refined using the Californian Bearing Ratio (CBR) strength map produced by Bartley Consultants (Bartley, 2003), and the knowledge of long serving PDC staff (PDP, 2005e).

A GIS map showing the location of the peat areas across the district, and the spatial distribution of soakage test results and their assumed soakage category, is shown in Figure 10.

The primary information with regard to soil type was firstly the presence of peat, and secondly the depth of the peat below ground level.

Table 4 shows the average, maximum and minimum depths below ground level (BGL) to the peat layer in the catchments identified within the Peat Area Extents (Figure 10). The average depth to peat across the entire peat area was found to be 1.46m BGL.

Table 6: Depth to Peat Layers Across legacy PDC Catchments

Catchment	Depth to Peat Layer (m BGL)			Number of data points
	Average	Minimum	Maximum	
Ardmore	0.8	0.5	1.5	5
Croskery	1.7	1.0	2.3	15
Elliot Street	1.5	1.5	1.5	2
Old Wairoa Road	1.6	0.9	2.8	19
Porchester	1.2	1.0	1.5	2
Takanini North	0.8	0.2	1.5	6

NB: catchments are as plan SW-1 from the legacy PDC DC

Soakage Rates

Of the 120 reports that were obtained from the subdivision files, 44 contained information of soakage tests that had been undertaken at the sites. Generally, these were falling head infiltration tests carried out using boreholes drilled with hand augers to depths around 2m or 3m BGL. These results have been separated into four different categories based on soakage rate measured in L/m^2/min, and mapped to produce Figure 10 (PDP, 2005e).

It is important to note that these tests were undertaken by a range of different consultants who may have used a range of different preparation and measurement methods. Therefore, the results presented on the map are only indicative of the potential soakage rates in those areas. The results varied within these areas and suggest that soakage could vary greatly from site to site depending on a range of factors.

4.3.2.3 Degrees of Possible Soakage

Table 5 below defines the degrees of possible soakage for the basalt and peat areas that are within this area.

Table 7: Possible Soakage Zones – Degrees of Potential Soakage

High	Medium
Areas where: i) unsaturated depth of basalt > 5m and total depth of basalt >14m ii) Cover <8m and unsaturated depth >5m iii) Papakura Peat	Areas where: i) unsaturated depth of basalt < 5m and total depth of basalt >14m ii) Cover <8m and unsaturated depth <5m

Due to the lack of focused soakage investigations in the areas identified in Figures 7 and 9, it is not possible to establish areas of low soakage and therefore this possible soakage area has not been delineated. Note that the definition of "high" and "medium" used in Table 5 above is not equivalent to the soakage disposal rates in the volcanic areas as given in Table 2.

There will also be areas of the basalt aquifers where no soakage will be available due to the high groundwater level conditions. Currently these areas are not able to be well defined except in the Auckland Isthmus.

4.3.3 Inferred

Inferred soakage is defined as the remaining areas of basalt as indicated by the geological map. These are areas for which the borehole logs are incomplete, unavailable or non-existent but the geological map indicates the presence of basalt. Therefore there will be some degree of soakage available.

Inferred soakage will include areas of good, medium, low or no potential soakage. The degree of soakage potential will only be determined by investigation and testing of the areas.

4.4 Maps

The soakage areas as categorised in the previous sections are shown on Figures 8, 9 and 10.

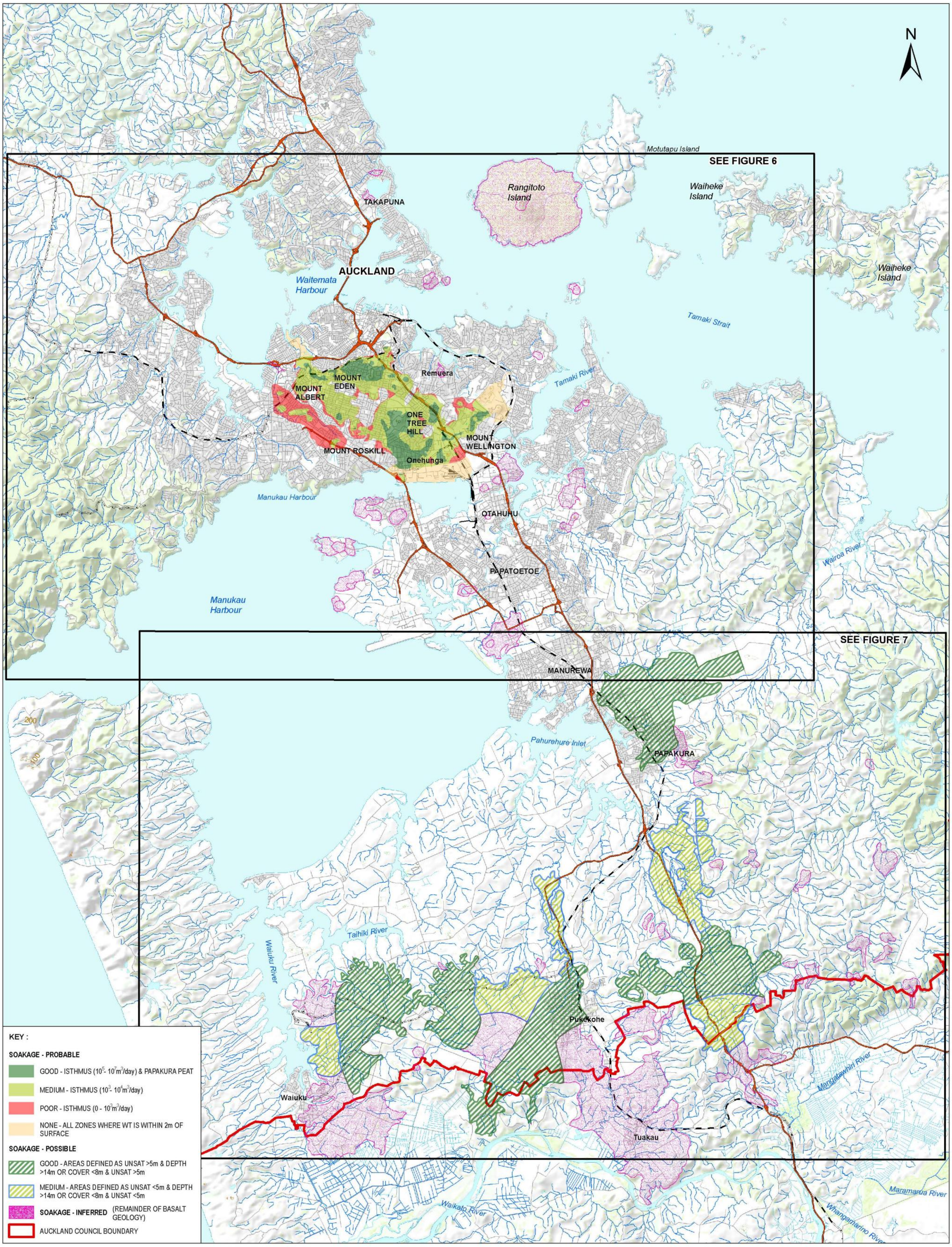
While these maps give a good indication of where soakage could be utilised, any areas to be utilised for soakage will need to be investigated. The future investigations on the basalt and peat geology in these areas should be documented so that a database could be established in which to record all future soakage tests. Over time this database could be used to produce a more accurate representation of soakage rates across the region.

A similar database system has been set up in the Canterbury Region to collect and collate all geotechnical data gathered from site investigations. The information is provided to professional engineering companies involved with the Canterbury Recovery, the Government, the Councils and the Earthquake Commission.

Apart from the regions of probable soakage located in and around the Auckland Isthmus there are areas of possible soakage in the legacy Franklin District. There are also a few areas on the North

Shore and Manukau which may be useful for soakage (in the basalts). The peat soakage area is limited to part of the legacy Papakura District. The test data is insufficient to accurately determine more than one zone of possible soakage and therefore the whole area has been designated as good possible soakage zone.

These maps can be utilised to provide guidance for future development within the Auckland region with respect to soakage. In all cases however prior to the design and development of any soakage disposal system, soakage must be confirmed by field investigations at the actual locations where it is desired.



SOURCE:
1. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

SCALE : 1:200,000 (A3)

0 1.5 3 6
KILOMETRES

Figure 7: Overview of Soakage in the Central and South Areas

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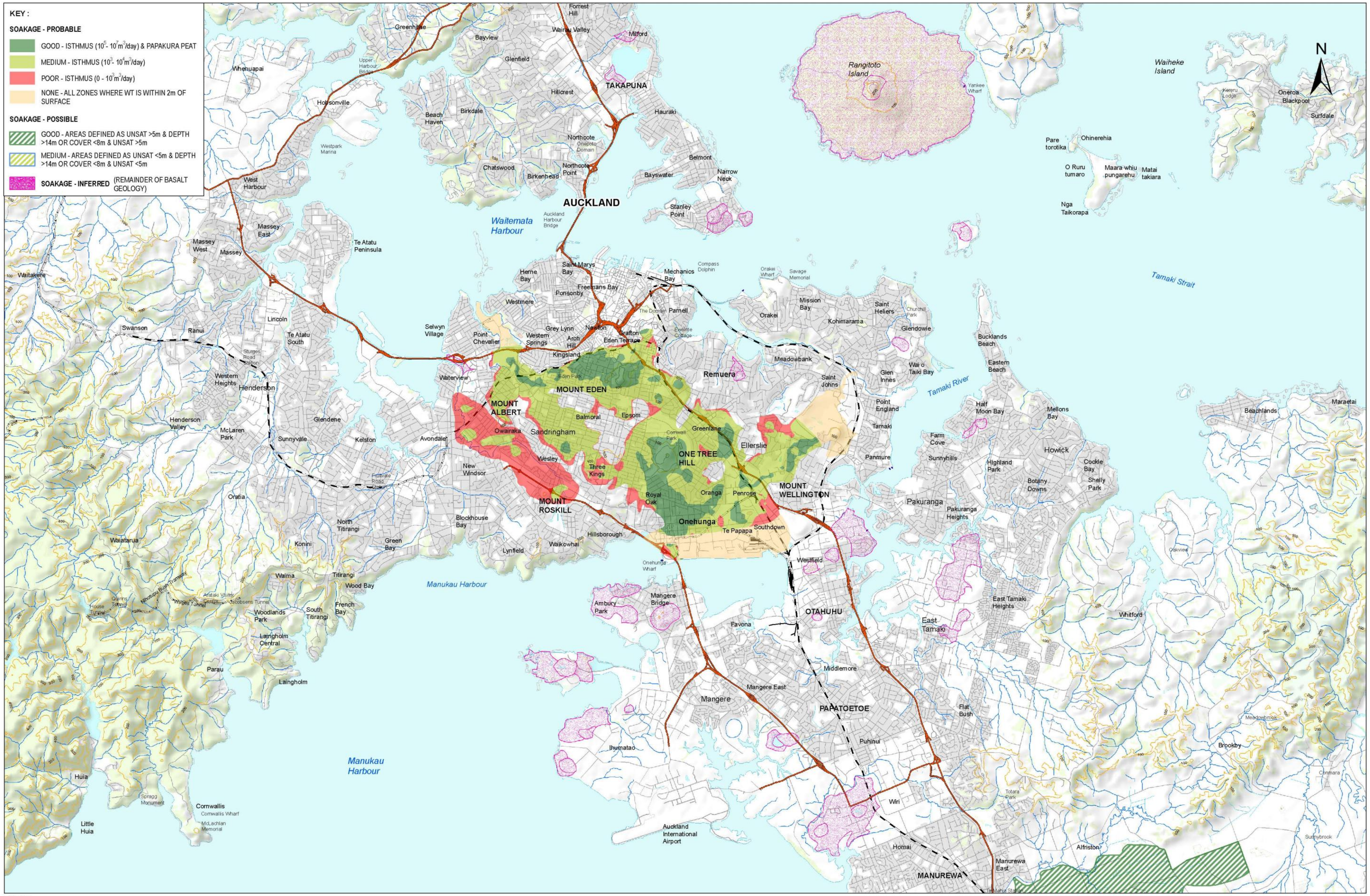

SOURCE:
1. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

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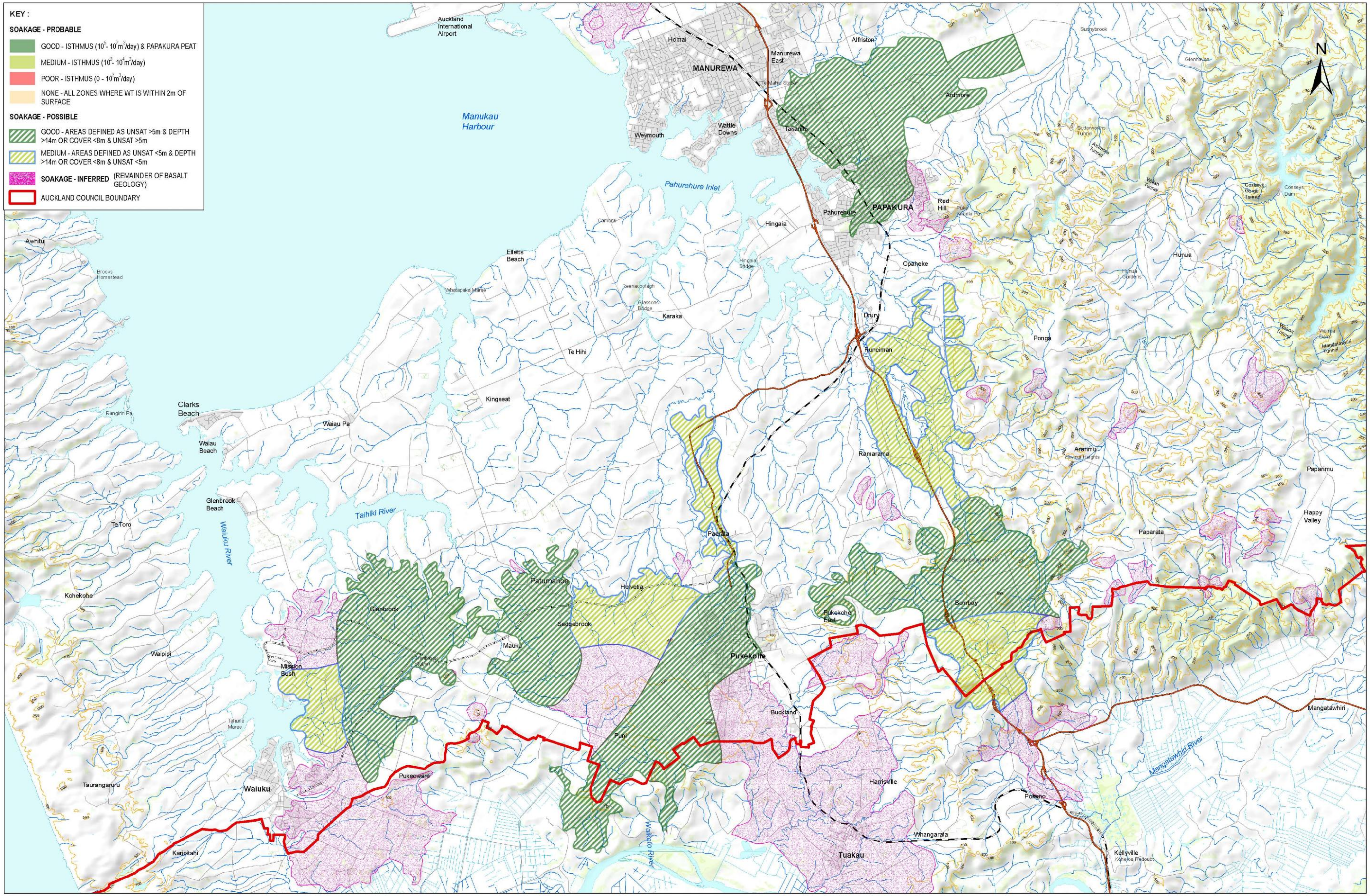
0 1.25 2.5 5
KILOMETRES

Figure 8: Soakage in the Central Area



SOURCE:
1. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

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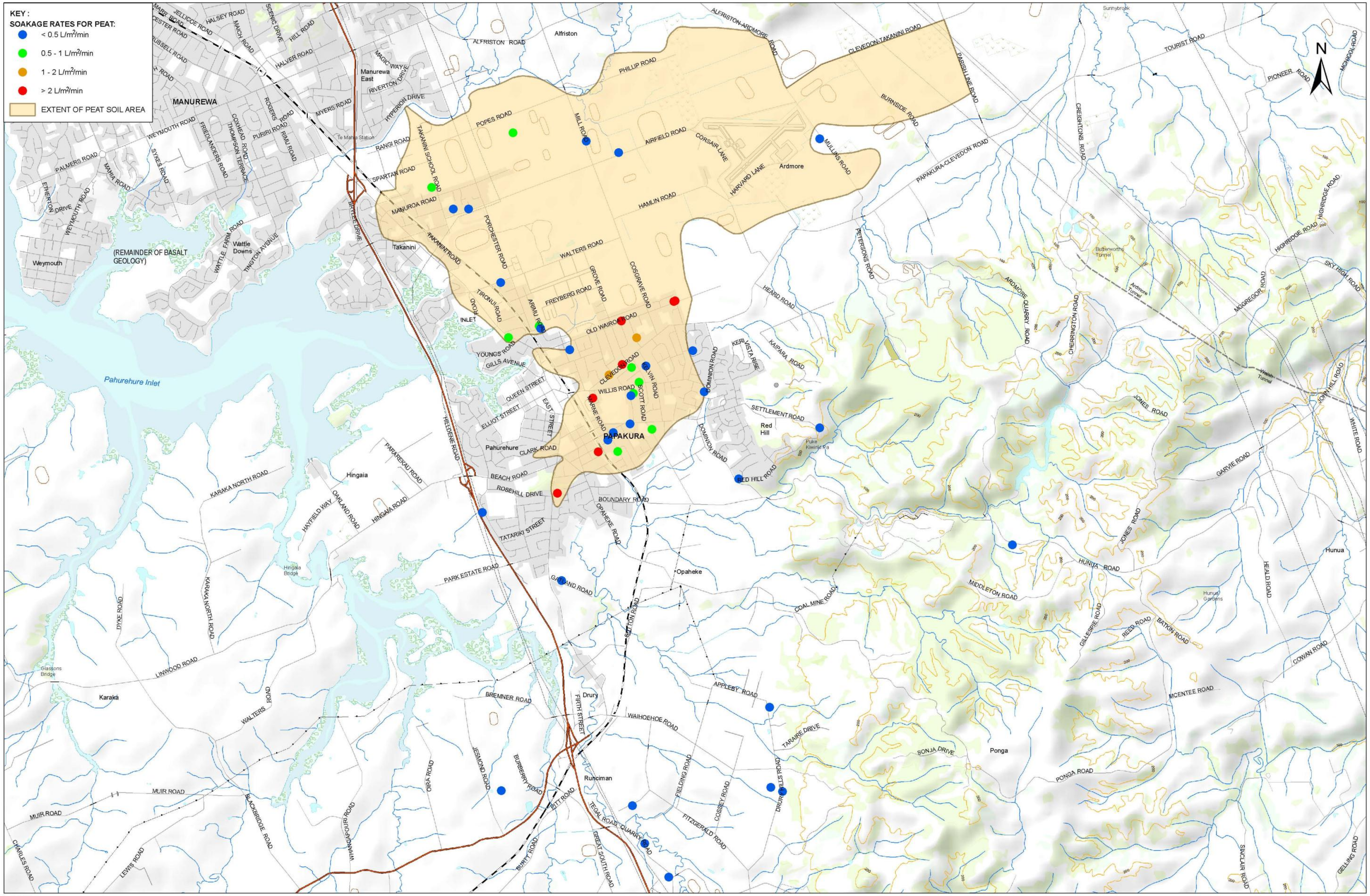
0 1.25 2.5 5 KILOMETRES

Figure 9: Soakage in the South Area



SOURCE:
1. EXTENT OF PEAT AREA ASSESSED FROM DISCUSSIONS WITH PAPAKURA DISTRICT COUNCIL STAFF, NZ GEOLOGICAL MAP, AND REVIEW OF SITE INVESTIGATION REPORTS HELD IN COUNCIL SITE FILES AND BARTLEY CONSULTANTS' SOIL CBR STRENGTH RATING MAP.
2. SOAKAGE RATE RESULTS OBTAINED FROM REVIEW OF SITE INVESTIGATIONS REPORTS HELD IN COUNCIL SITE FILES. THESE TESTS WERE UNDERTAKEN ACROSS A RANGE OF INCONSISTENT CONDITIONS AND ARE THEREFORE INDICATIVE ONLY, AND SHOULD NOT BE USED IN ANY OTHER MANNER.
3. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

Figure 10: Indicative Soakage Rates for Peat

SCALE: 1:50,000 (A3)

0 0.5 1 2
KILOMETRES

5.0 Soakage Concepts

5.1 Introduction

This section discusses the effects of stormwater discharges and the types of devices used to dispose of stormwater to soakage. The various effects are described in relation to soakage and the need to dispose of stormwater to ground as well as to minimise the effects.

5.2 General

In Auckland two kinds of aquifer suitable for soakage predominate: basalt and peat. For those areas underlain with volcanic basalt the purpose of soakage devices is to manage stormwater runoff and recharge the aquifer. In the peat areas, recharge to the peat and the maintenance of the groundwater levels is the main purpose.

Soakage devices are stormwater management devices designed to dispose of stormwater runoff by releasing it to groundwater through rockbore soakholes and soakpits.

Soakholes in basalt take many forms, from existing natural chambers and tunnels in the basalt lava to engineered interconnected catch pits, manholes or chambers with boreholes. Soakage takes place on public (roads and parks) and private property throughout those areas of the region that are underlain by basalt.

Rockbore Soakholes are soakage devices with rockbores that deliver water many meters below ground into fractured rock. These typically have no significant storage component with the capacity of the device is reliant on the extent of fissures in the rock.

Soakpits are soakage devices which are excavated into soil or rock and the capacity is dependent upon the extent of rock fissures or permeability of the pit base and walls as well as the storage volume within the device.

5.3 Stormwater Effects

5.3.1 Flooding and Drainage

For the purposes of this report this effect is discussed in relation to the flooded areas underlain by basalt within the Auckland region. Significant damage from flooding is likely to occur when excess runoff collects to an extent that the ponded water levels exceed allowable freeboards to buildings, structures or properties. This can occur either in connection with permanent streams and water courses or overland flow paths and particularly within hollows in the basalt surface. Flood management methods may involve; avoiding development in flood plains, building structures above flood levels, flow attenuation of post development discharges, and flood defences (such as stopbanks). To manage flooding, soakage devices, as receptors for stormwater discharges, need to have sufficient capacity to receive flood flows.

A soakage device receives stormwater from an area via pipes, overland flow or interflow through soil. The water is released into the aquifer, often via a borehole specifically drilled for that purpose. The device may also have storage or quality treatment properties. Under the legacy documents soakage devices discharging to fractured basalt aquifers were required to accommodate the stormwater generated from the 10% AEP 24 hour rainfall event (ACC Consolidated Bylaw, 1998 (and amendments): Part 18 – Stormwater Management). Other stormwater management devices may be used in series with soakage devices in order to meet this goal, or to meet water quality requirements.

Soakage only functions as a stormwater disposal method when the underlying aquifer has the capacity to receive water. The soakage device itself can be a restriction to flow entering the aquifer. Smaller catchments generally do not have this constraint, but flow from larger catchments may require storage or large inlets to allow water to enter the aquifer.

A key benefit of using soakage for stormwater drainage is that reticulation systems may not need to be constructed to collect and dispose of stormwater. Soakage devices can be installed at dispersed locations across a catchment to address individual flooding problems. This can be useful in basalt catchments where surface topography often consists of uneven surfaces and humps and hollows without natural drainage channels. Soakage capacity needs to be assessed for the group of devices discharging concurrently to ensure overall capacity to the design flood level of service is available.

Sediment clogging over time may affect the hydraulic capacity of soakage and this needs to be considered in the design of the overall soakage system. Therefore, either: maintenance needs to proactively occur to maintain soakage hydraulic capacity, or an overland flow path or secondary outlet needs to be provided in the event the soakage system fails.

5.3.2 Stormwater Quality

Devices which discharge water via infiltration through soil provide a stormwater quality benefit to the receiving environment. The in situ soil acts as a filter media which can remove particulate contaminants and provide adsorption sites for dissolved contaminants. TP10 recognises this benefit and provides for infiltration devices to be used as stormwater quality treatment devices. Infiltration into rock may also provide some form of treatment, depending upon the extent and size of the fractures and fissures and soil present. The extent of basalt fractures and fissures are typically unknown and the extent of water quality treatment provided in rock devices is therefore also unknown, but is expected to be small. However, if the unsaturated rock or soil around the discharge point was considered as part of the receiving environment, any required treatment would need to be carried out prior to the soakpit or rockbore soakhole

Suspended sediment in stormwater typically consists of particles smaller than 250µm. Coarser particles (larger than 63µm) are relatively easily removed by sedimentation processes. The extent to which sediment particles may be transported into basalt fissures is expected to be variable and is currently unknown. From a maintenance perspective, treatment of the sediment in stormwater may be required prior to a soakpit or rockbore soakhole. Although the surrounding soil provides treatment, this treatment in advance of the soakage device reduces the likelihood of clogging and the frequency with which the device would need to be maintained. The circumstances which need pre-treatment are assessed in Section 7 of this report.

5.3.3 Groundwater Recharge

Soakage devices provide a means of maintaining infiltration to underlying aquifers and hence stream baseflows following urbanisation. The rate at which infiltration occurs through underlying soils needs to be assessed when considering whether to use soakage to recharge groundwater. Where low permeability soils are present, infiltration may be very slow and significant storage required.

When groundwater levels in the peat recede, peat consolidates and shrinks and this has the potential to cause damage to buildings, underground services and roads that overlie the peat.

Groundwater levels in the lower catchment depend upon the extent of recharge and aquifer permeability characteristics. Where the aquifer hydraulic capacity is lower downstream than upstream, groundwater breakout and flooding may occur. In these cases, the seasonal variability in groundwater levels needs to be carefully assessed before soakage is promulgated, particularly to rates greater than the pre-development case.

5.4 Soakage Infiltration Devices

5.4.1 Descriptions of the Soakage Devices

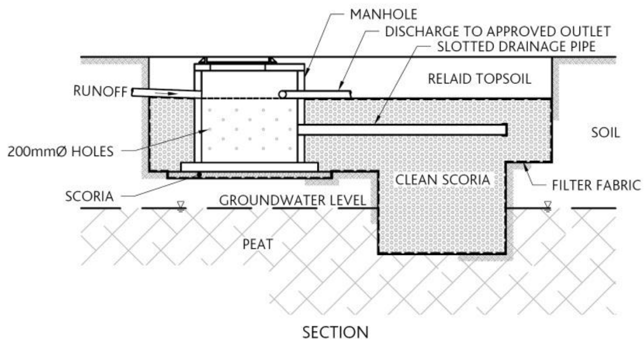
In the SDM and PDC DC six main types of soakage devices are described, and each of these is described below (refer to drawings in Appendix A).

Soakage devices in peat areas are highly standardised and their design mostly depends on the size of impermeable area they are treating (refer to the drawings in Appendix B).

These are typical designs and the physical design for a particular site may use a number of devices or variations on these typical examples.

5.4.1.1 Peat Soakpits

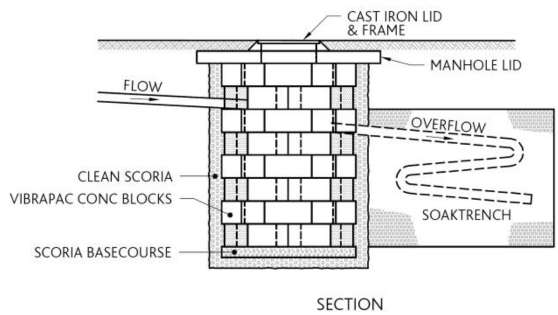
Because of the uniformity of soakage rate within the peats there is a more standardised design procedure for soakage devices above peat aquifers. The Auckland Council (legacy PDC Development Code) requires landowners in areas with peat who are increasing the impermeable area on their property to provide soakage to make up for the lost groundwater recharge. The main factors in deciding the appropriateness and size of the device are:



1. Underlying ground conditions.
2. Size of the property being treated.
3. Change in impermeable area.

5.4.1.2 Onehunga Soakpit

Historically called the “Onehunga Soakhole” the Onehunga Soakpit is a soakpit with a central chamber (constructed from either concrete or brick) and scoria backfill around the circumference. The central chamber (soakpit) increases the void volume and hence the storage capacity and provides a space for sediments to

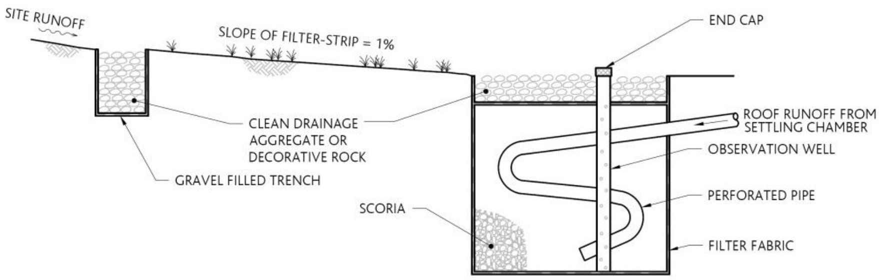


settle out. The scoria filled part is normally covered with around 300 mm of soil, but the main chamber normally extends to the surface with a cast iron lid to allow access for maintenance. Rainwater enters the main chamber through pipes.

Provided the infiltration rate is above 0.7 L/m^2/min, a reduction in the size of the soakpit is allowed (due to there being sufficient storage in the chamber versus the available outflow rate). The reduction in size is normally only significant if the soakpit chamber takes up more than 50% of the soakpit volume. The chambers get more expensive above 1.0m diameter, so it is often more economical to increase the wall and base area in the device by extending the trench section (and hence increase the soakage rate) rather than increase the size of the chamber.

5.4.1.3 Filter-strip Soakpits

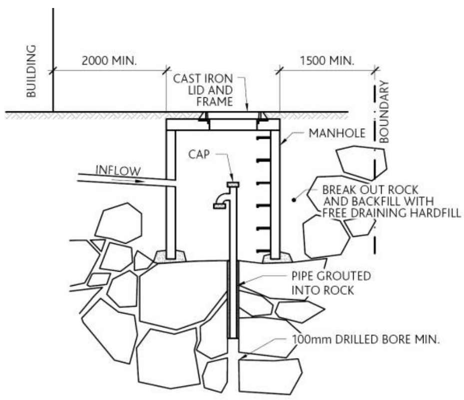
A filter strip soakpit consists of a scoria filled trench from which water enters a scoria filled soakpit. A rockbore soakhole may be added to improve the soakage capacity. The pit may provide some soakage but is predominately for water storage and attenuation. Filter-strip soakpits are for use when a filter-strip is used as a pre-treatment device for site and yard runoff. This design does not have a chamber, and the scoria layer is covered with cobbles or shingle rather than soil. Runoff from the filter-strip enters the soakpit through the cobbles. Runoff from roofed areas may enter the pit directly.



SECTION

5.4.1.4 Rockbore Soakholes

Rockbore soakholes are chambers with bores drilled into fractured rock. Site runoff enters the chamber via catchpits while roof runoff enters the chamber directly. Some settling may occur in the chamber. Water enters the basalt aquifer directly through the base of the chamber if it is unsealed or builds up and enters through a pipe upstand directly to the unsaturated zone of the underlying basalt aquifer. This type of device is commonly used for public soakage devices and drainage of roads.

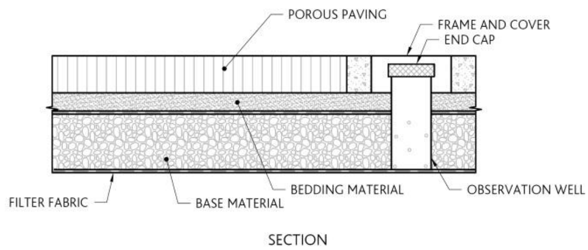


SECTION

The rockbores aspect of this soakage device means that stormwater is discharged directly to the underlying aquifer. As the aquifer is considered to be the receiving environment, the stormwater needs to be treated to the relevant standard before entering the soakage devise.

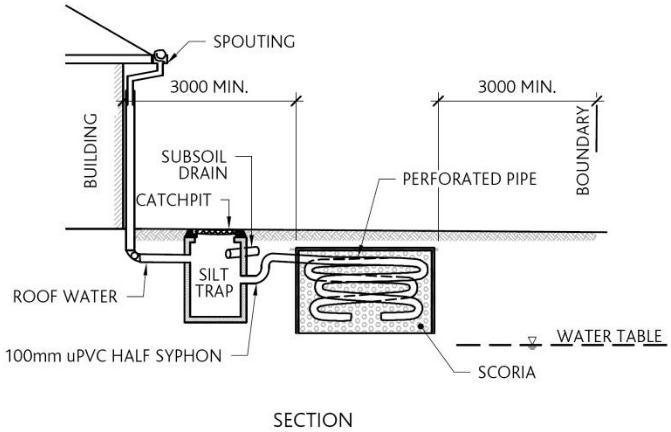
5.4.1.5 Porous Paving

Porous paving consists of layers of gravel and sand overlain by permeable paving (such as modular paving or porous concrete pavers). Stormwater normally percolates directly through the pavement layer and into the ground. The underlying ground soakage rate and the paving itself may limit the catchment of the porous paving. Typically the catchment is no more than double the area of the porous paving. Porous paving can be used on both residential and commercial properties, provided there are relatively low sediment loadings and traffic volumes. It assumes that the percolating water is able to soak into the underlying aquifer at a rate greater than the rate of flow through the paving.



5.4.1.6 Nominal Soakpits

Nominal soakpits are scoria filled pits, normally covered with around 300 mm of soil. They do not have a chamber, and are only intended for use in small catchments less than 20 m^2. Nominal soakpits were approved at the discretion of the legacy ACC in the past, and have the advantage that infiltration tests do not need to be carried out. For nominal designs to be used, the owner may be required to demonstrate that the property currently has adequate stormwater disposal to prevent adverse effects in up to a 10yr ARI storm.



5.5 Applicability of Soakage Devices

This section summarises factors which need to be considered when determining which (if any) soakage device is most applicable to a given site. These criteria have generally been previously identified in the SDM and have been reviewed and considered here in the light of current practice.

1. Soakage potential of the location. When looking at soakage rates to determine the discharge rate, two things need to be considered - both of which can limit the maximum soakage discharge rate achievable:

    a. the capacity of the aquifer to accept water.

    b. the capacity of the device to collect and deliver the water to aquifer (i.e. the hydraulic design of the device).

    To achieve a primary drainage level of service consistent with the Building Code, it is required that no off-site surface runoff from site occurs in storms up to the 10 year ARI (other devices may be used to provide additional storage on site to help achieve this). Any runoff from paved surfaces in a non-residential area into a soakage device should be treated first. Refer to Section 7 of this report for further discussion on treatment.

2. Rainfall rate, area being serviced and land hydrological characteristics (curve number, impermeable/permeable).
3. Access Requirements. Effective maintenance relies on ready access to the soakage or pre-treatment device. The following points should be considered:
    a. Onehunga Soakpits and Rockbore Soakholes (soakage devices with chambers) are cleaned most effectively using vacuum-type systems. These systems are generally mounted on trucks and can only be used if the vacuum pipes are able to reach from the truck to the soakage or pre-treatment device. Smaller trucks normally need to be within 20 to 30m of the soakage device. Large street-cleaning trucks may have pipes that can stretch 75m or more, but will be more expensive to hire.
    b. All soakpit type devices may eventually require excavation of soil or scoria/gravel layers, so that sediment can be removed and aggregate replaced. An access way at least 2m wide should be allowed for, so that at least a small excavator can gain entry.
    c. Re-drilling Rockbore Soakholes normally requires an access way that is around 3m wide. This is not a regular maintenance procedure, but may be required eventually.
4. Available area for the device. The device needs clearance to buildings and site boundaries to avoid water affecting the adjacent structures and property.
5. Pre-treatment of stormwater may be required before it enters the main soakage device (refer Section 7 for further discussion). Such treatment is to account for:
    a. Mitigating any adverse impacts on water quality from the intensified development on aquifer quality.
    b. Compliance with the water quality control requirements of the relevant Council Plans or Standards
    c. Prevent premature clogging of the device – particularly where yard runoff or high sediment loading catchments are being drained.
    d. The need for attenuation storage so that there is no runoff in the 10 year ARI rainfall event.
6. Aesthetics. The rockbore soakhole or soakpit should not intrude on the amenity value of the property. This is a subjective issue and will be determined by the property owner.
7. If a reticulated stormwater system is available within reasonable proximity of the site and the cost of using this deemed reasonable then this should be used as part of the drainage system for the site.

6.0 Soakage Design Methodology

6.1 Introduction

This methodology is based on a review of the legacy Auckland Council Soakage Design Manual (SDM) (ACC, 2003) and on the legacy Papakura District Council Development Code – Stormwater Section 4.6 Stormwater Recharge in Peat Areas.

For the sake of uniformity, the terminology used in the legacy PDC Development Code viz recharge pit, has been changed to "soakpit device" in line with the terminology used for the devices in the basalt aquifers. There is very limited discussion of soakage design in the legacy FDC COP and legacy NSCC IDS and no mention in the legacy MCC EQS. The legacy ACC SDM method is the most detailed local method available.

This section details the regional methodology adopted for the design of both basalt and peat soakage devices.

6.2 Regional Methodology:

The regional soakage design methodology is covered in this section.

The Auckland region has varied geology. Some of the city is underlain by the Waitemata Group and other rock formations which are generally unsuitable for soakage. Of the areas suitable for soakage, two kinds of geology predominate; fractured basalt and peat. These two different types of geology have different approaches to design and will be dealt with separately in this section.

6.3 Soakage to Basalt

The SDM provides a flowchart that summarises the design approach for soakage systems for private and commercial properties. This flowchart has been reviewed and is considered appropriate for all basalt and tuff covered basalt areas in the Auckland Council area and is given below in Figure 11.

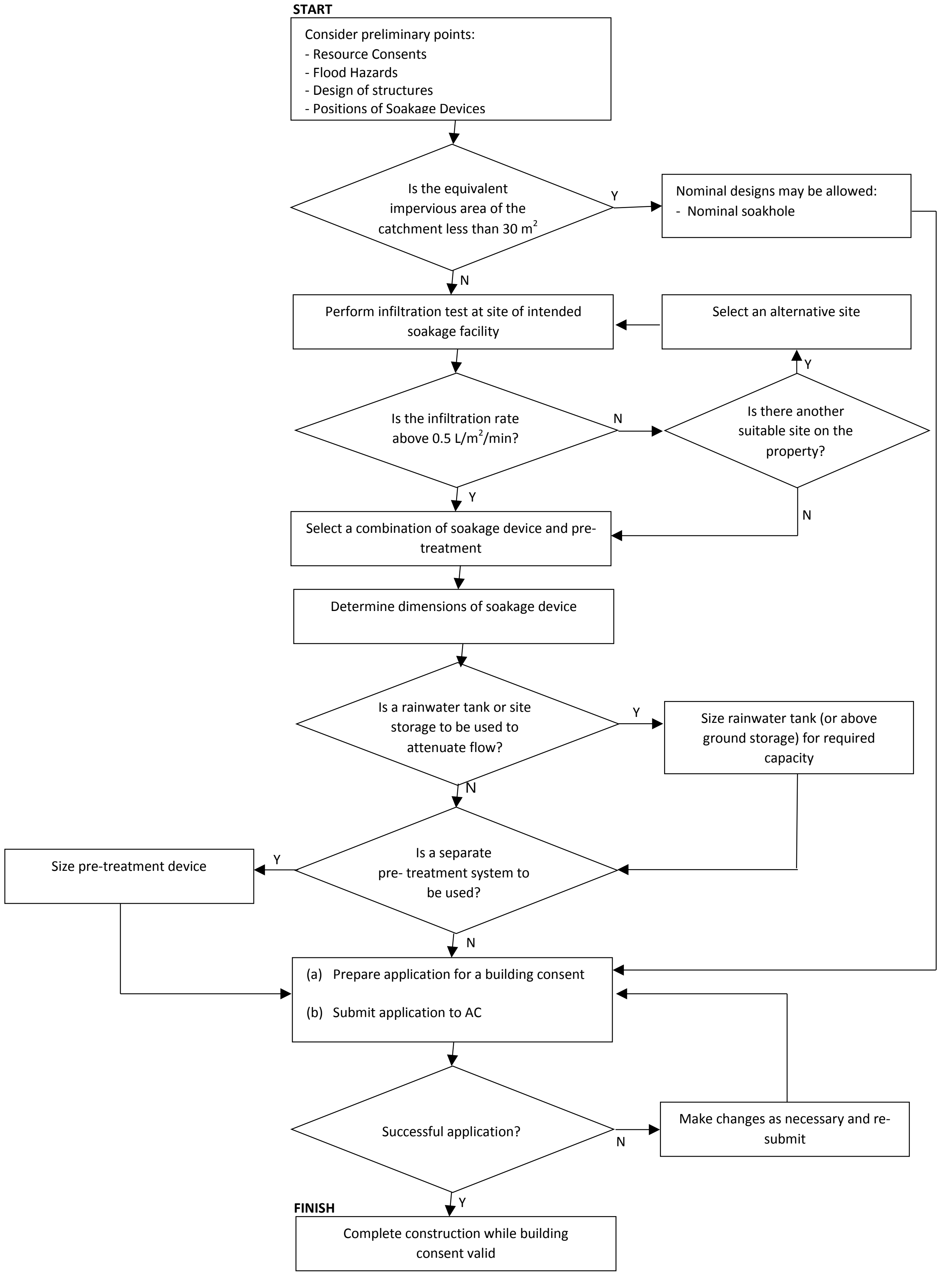


Figure 11: Flowchart for Soakage System Design

6.3.1 Private Soakage

Private soakage devices typically service small catchments such as residential properties. The success of private soakage is integral to the management of stormwater within the basalt areas. Failure of, or inefficient private soakage devices will result in additional loading for the public systems that serve the road reserve and parklands.

These devices are privately owned and maintained. The maintenance required in the past has been in accordance with the legacy ACC SDM document.

6.3.2 Public Soakage

Public soakage devices serve public land - which is mainly the road reserve and park/reserve land which are usually larger catchments that those served by private soakage devices. The devices are generally larger than private soakage devices and in many instances utilise natural features of the basalt such as lava caves and lava tubes. These devices are maintained and operated by Council.

The need for high flow, high volume stormwater discharge points for public areas such as roadways can be provided by the use of soakage devices. These are best located in or close to the overland flow paths within the public area being serviced.

6.3.3 Site Investigation

The success of an efficient soakage device is wholly dependent on the ability of the aquifer to receive and accommodate the stormwater being discharge. This ability is defined by the presence of fracturing and fissuring within the basalt rock as well as the depth of unsaturated basalt. Devices therefore have to be located such that they access these fractured zones.

The design of the soakage devices for private and public use remains the same and is dependent on the characteristics of the basalt aquifer which must be investigated. At the smaller catchment scale (generally on private property), investigation and testing the soakage capacity is typically done by a trial and error type method with a rockbore soakhole drilled in a preferred location and the test carried out in the proposed final rockbore soakhole. Hand auger holes are used to check the soakage of soils and machine investigation boreholes are used to check the soakage of the basalt.

At the larger scale the investigation approach may be more structured and use a greater number of stages and level of detail as the investigation progresses.

A suggested approach to investigations for identifying areas of potential soakage is:

- Review soakage potential maps in this document to identify general soakage characteristics.
- Review nearby information on soakage tests and any geotechnical investigations to identify local characteristics – if available.
- Review flood hazard maps for any nearby ponding areas.
- Use ground penetrating radar to identify rock cavities and major fracture zones.
- Bore drilling and testing.

It must be noted that prior to any design the proposed sites must be investigated and tested to provide the required design criteria. The investigation can include the use of GPR and as a minimum, the drilling of investigation boreholes.

6.3.3.1 Ground Penetrating Radar

Ground Penetrating Radar (GPR) is a non-destructive geophysical investigation method that produces a continuous, cross-sectional profile or record of subsurface features, without probing or digging. GPR operates by transmitting pulses of ultra-high frequency radio waves down into the ground via a transducer or antenna. The transmitted energy is reflected from the various buried objects or distinct contrasts between various geological horizons. The transmitted signal contacts objects or subsurface strata with differing electrical conductivities as it enters the ground. The antenna then receives the reflected waves and stores them in a digital control unit that registers the reflections and then amplifies the signals, resulting in output signal voltage peaks that are plotted on the GPR output profile as bands of contrasting intensity or hyperbolic reflections. The GPR output is in depth unlike seismic reflection surveys where the output is in time.

Underground services can generally be distinguished by reverberation (multiple signal return) and a very regular shaped diffraction hyperbola. Services are identified on the interpreted data, and are often also associated with a region of increased porosity, where a trench has been backfilled.

Deeper zones of higher reflection intensity indicate increased porosity within the basalt. This may be from cavities formed as lava tubes / caves or fractured and broken basalt. The GPR is able to identify these features due to the very strong contrast in dielectric permittivity between the basalt and the air, which results in a very strong reflection coefficient. The result is a very high amplitude (intense) signal return, shown on the GPR image as a brighter colour (red / purple). Signal attenuation by clay, often in thick tuff layers, has proved to be a problem as the GPR signal cannot penetrate through the thickness of the layer.

GPR has been used extensively in archaeology to detect the presence of caverns and tunnels and has proved to be successful in this application. Basalt lava tubes on Hawaii have been detected and mapped using GPR (Olhoeft et al., 2000). However, these lava tubes were within 1.5 m of the surface and Olhoeft notes that penetration of up to 6 m was observed - which is similar to the results of the GPR surveys undertaken across the Auckland Isthmus.

Whilst this method does not identify fissures and fractures zones at depths greater than approximately 6 m it does, and has, identified zones or depths greater than 6m that yield acceptable soakage rates when tested. Testing of the identified zones is usually undertaken by drilling an investigation borehole and testing the aquifer by means of a flow test. The investigation borehole can also be retained and used as part of a soakage device or system if required.

6.3.3.2 Infiltration Testing

The infiltration testing methods and tests are given in Appendix A. The various tests and preparation for testing are discussed and the methodology is presented. Both Falling Head and Constant Head test methods and the calculation of the results are described.

6.3.4 Design Methodology

A flow chart illustrating the steps involved in designing a soakage device is shown in Figure 11 above. In addition, a summary of the main design steps is given below:

Preliminary considerations involve considering flooding risks, stability issues, ownership issues and planning suitable locations to carry out infiltration tests and identify soakage devices.

Infiltration tests assess the rate at which stormwater will soak into the ground, called the infiltration rate (or soakage rate).

Selecting soakage systems involves selecting a soakage system that will meet Council standards, fit in the available space and provide the best long-term performance at a reasonable cost.

Design Procedures involve procedures for sizing the devices.

Preparing a consent application involves documenting the design process and filling out forms for submission of a building consent to AC. A resource consent for the discharge and diversion of stormwater may also be required by the regional plan.

Positioning Soakage Devices - Soakage devices must be placed in an appropriate position on the property if they are to work effectively and comply with flood hazard policy and not affect buildings.

Selection of Soakage Systems – The flow chart includes suggestions for selecting the most appropriate system. The need for pre-treatment for maintenance purposes is assessed in Section 7.

6.4 Soakage to Peat

There is a significant area of peat and soils with high organic content in the legacy Papakura District, as shown in Figure 10 on page 24. The majority of this area is planned for either future greenfields development, or infill subdivisions. Historically soakage devices within the peat are confined to individual residential and commercial developments and therefore are limited to small catchments.

Development reduces the permeable area which in turn reduces the amount of rainwater that could infiltrate into the soil and recharge the groundwater. This could result in a gradual lowering of the groundwater levels. This is a significant issue in peat soil areas because dewatering the peat soils may result in consolidation and shrinkage, which can cause significant damage to roads, building foundations, and underground services.

The peat soakpits are designed to retain the stormwater runoff arising from the first 15mm of any rainfall event. However, to prevent sediments from clogging the soakpit media, only water from the roofs of new developments is directed to the soakpit without treatment. Runoff from other impervious areas will require treatment to remove coarse sediment and other gross pollutants prior to discharge to the soakpit.

6.4.1 Site Investigation

Site specific investigations should be carried out to check for the presence of peat to determine the need for a soakpit for the purposes of groundwater recharge.

A geotechnical investigation is required to confirm that the soil conditions in the proposed location of the soakpit are similar to the generic conditions that the soakpit design (refer to Appendix B) was based on. The required results from this investigation are as follows:

- Depth to top of peat layer.
- Depth to groundwater level.

Where required the investigation should also review other issues such as distances of soakpits to structures and property boundaries.

6.4.2 Design Criteria

The design method follows that previously contained within the PDC DC (PDC, 2010). The main steps of this method are summarised below:

1. The soakpits may be required for all new developments with over 50m2 impervious area. This may include additions to existing structures, residential infill subdivisions, and large scale green-fields residential or commercial developments.
2. The total site impervious area threshold (from PDC DC) for requiring a soakpit is 50m2, however all developments between 50m2 and 100m2 may require a device sized for 100m2. Any development on a site that increases the impervious area by 20m2 or more may require a soakpit sized for and connected to the entire impervious area of the site.
3. The largest contributing catchment for one soakpit is 1000m2 of new impervious area. For developments with over 1000m2 new impervious area, a number of soakpits may be required. If required these should be spaced equi-distantly around the site where possible, with the locations to be confirmed with AC (PDC DC).
4. For residential infill subdivisions in existing developed areas, only the new development may require a soakage device.
5. Soakage devices should not be located within three metres of buildings or site boundaries. Where this is not practical, a site geotechnical investigation report, and possibly an alternative soakage device design, should be undertaken to take into account the effect of the device on building foundations.
6. Runoff from ground level impermeable areas, such as driveways and patios, should not be discharged directly into the soakage device. The pre-treatment options should be in accordance with the legacy document ARC TP10, which details devices such as swales, filter strips and coarse sediment traps. These pre-treatment devices should be sized for at least the 10% of the Water Quality Volume in accordance with ARC TP10 (or other AC requirements).
7. If the depth to the peat layer or the groundwater level is less than 1m or greater than 2.5m, consultation with the AC Development Engineer is required to determine whether an amended version of the standard design or a different site specific groundwater soakage device is required. The current AC requirements should be consulted.
8. For large ground level impermeable areas such as car parks, the soakpit should be located at the end of a treatment train. Pre-treatment devices such as swales, raingardens or sand filters are possible, however special care must be taken in the design of the entire treatment train to ensure that the soakpit can be located at the appropriate depth below ground level.
9. These devices may not be suitable for new roads where there is limited space available in the road reserve. In general, devices such as swales, raingardens or sand filters should be used where soakpits are infeasible in order to maintain some form of groundwater recharge.

10. It is at Council's discretion as to whether new roads in these areas will require these soakage devices

7.0 Pre-treatment

7.1 Introduction

This section discusses the need for pre-treatment for soakage devices and uses a simple model to assess potential clogging of rockbore soakholes and soakpits. The methodology and results of the modelling are discussed and recommendations made. Methods of pre-treatment are also covered.

7.2 Need for Pre-treatment

Pre-treatment is the use of various methods to remove and/or reduce the volume of sediment entering a soakage device. Pre-treatment methods are discussed in later sections of this report.

Stormwater entrains debris and contaminants as it flows overland to soakage devices. Depending upon the contaminant load, it may be necessary to provide pre-treatment to maintain the efficient functioning of the soakage devices (i.e. to not become clogged) and in the case of the basalt aquifer to reduce any adverse effects on the water quality of the groundwater.

7.3 Clogging Assessment

7.3.1 General

This section reviews the clogging mechanisms for soakpits and rockbore soakholes. It also discusses the simple models developed to assess the clogging effects, the analysis and results of the assessments for soakpits and rockbore soakholes.

Clogging is the process by which the sediment decreases the permeability of the fractured basalt or the soil matrix surrounding rockbore soakholes and soakpits respectively.

All sediment causes clogging. However coarse sediment can cause this to occur more quickly than fine sediment as it takes up more space and is likely to get caught closer to the soakpit or rockbore soakhole wall assuming that the fracture and pores reduce in size.

Fine sediment typically has higher concentrations of adsorbed contaminants and may be transported deeper into rock fissures of a rockbore soakhole - it therefore potentially affects the water quality of the aquifer, but the extent of transmission into fissures and consequent effect on groundwater quality is unknown. Fine sediment can also become trapped in the soil matrix around a soakpit reducing permeability resulting is declining performance and without maintenance, finally clogging of the sides and base of the soakpit

The risk of clogging is greater where catchments have high sediment loads - such as in some industrial sites, arterial roads, pervious/garden areas and construction sites.

7.3.2 Soakage pits

Soakpits are assumed to be excavated into a soil matrix, and backfilled with drainage rock, and at times a chamber, as a means of maintaining an open void and providing some water storage volume. The drainage rock is generally wrapped in filter cloth. Blockage occurs once sufficient incoming sediment particles block up the voids in the filter cloth or insitu soil/rock and reduces the hydraulic capacity. Soakpits are sized in the ACC SDM (ACC, 2003) so that the available soakage area is a proportion of the area of the base plus side walls. A simplified model that evaluates the effects of clogging has been developed by PDP for this report. The model prepared uses the following as variables:

- incoming catchment areas and average sediment loading rates (separately for pervious and impervious areas).
- pit dimensions and void space.
- in situ soil permeability of the wall and base (with typical rates used to represent soakage to volcanic ash and peat).
- a ratio of the base and wall areas being blocked by the total incoming sediment load.

7.3.2.1 Method

The model calculates daily sediment load for a 30 year time series. Suspended solid loads are for New Zealand catchments (Figure 3.6, Urban Runoff Data Book) (Williamson, 1993). The model applies the sediment load as a blinding cover accumulating gradually with inflow over the base of the soakpit. As it accumulates on the base, a proportion of the incoming sediment volume is assumed to be directed to the wall areas. It models the depth of base and wall sediment accumulation on a daily basis, and determines the resulting hydraulic capacity of the base and walls. The hydraulic capacity assesses both the insitu soil permeability and the reduced permeability in the base and walls due to the accumulated sediment. The overall hydraulic capacity is compared to the required flow rate and when the required flow rate is exceeded then the device is said to have been blocked (a reduced discharge would still occur).

No calibration or verification has been carried out on the model. Parameters have been selected to be generally consistent with current experience of soakpit dimensions and ground characteristics. The model would particularly be improved by calibration of the amount of sediment moving horizontally through the walls versus vertically to the base.

A full range of soakpit dimensions have not been tested but a sensitivity analysis has been carried out for:

- the incoming sediment load to represent both different land use loading rates for TSS and the provision of pre-treatment.
- the effects of changing the ratio of sediment directed to the base versus walls.

Typical urban stormwater loads were used to represent different land-uses and typical grading curves were used to infer the proportion of sediment that would be caught by pre-treatment devices operating to different levels of efficiency. Sediment loads will in fact contain a variety of particle sizes at various stages of the water travelling through the reticulation and soakage device, but this assumption is considered adequate for assessing the relative time to blockage for different scenarios.

Note that the model does not rout flows and is therefore conservative in that the time to blockage is calculated from the time when the soakpit hydraulic capacity is below the peak runoff inflow.

7.3.2.2 Analysis

The scenarios modelled used sediment loading from the various land use types as follows:

- Construction site or bare soil – 5000 kg/ha/yr
- Industrial site – 1500 kg/ha/yr
- Residential site – 350 kg/ha/yr
- Roof runoff – 20 kg/ha/yr

A single benchmark option was defined as follows:

- Roof area of 150m^2
- Yard area of 150m^2

In the modelling the land use type for the yard area was changed with sediment loadings in line with the scenarios listed above. These scenarios were analysed assuming a wall to base sediment split ratio of 1:5.

For the scenario tested, under normal residential roof land-use conditions, standard permeabilities for basalt and tuff and no sediment capture (even by catchpits) there is limited sediment load going into a soakpit and the model predicts it would take over 35 years for the flow rate out of the soakpit to drop below the incoming design flow rate. Where runoff from paved residential areas is directed to the soakpit, the design inflow rate is restricted after about 18 years.

Using 1500 kg/ha/year (to represent industrial site loading) the capacity is reduced after about 4.5 years. Where sediment loading rates are elevated, such as for construction sites, the soakpit blocks much more quickly. This effect could be prevented by sediment pre-treatment.

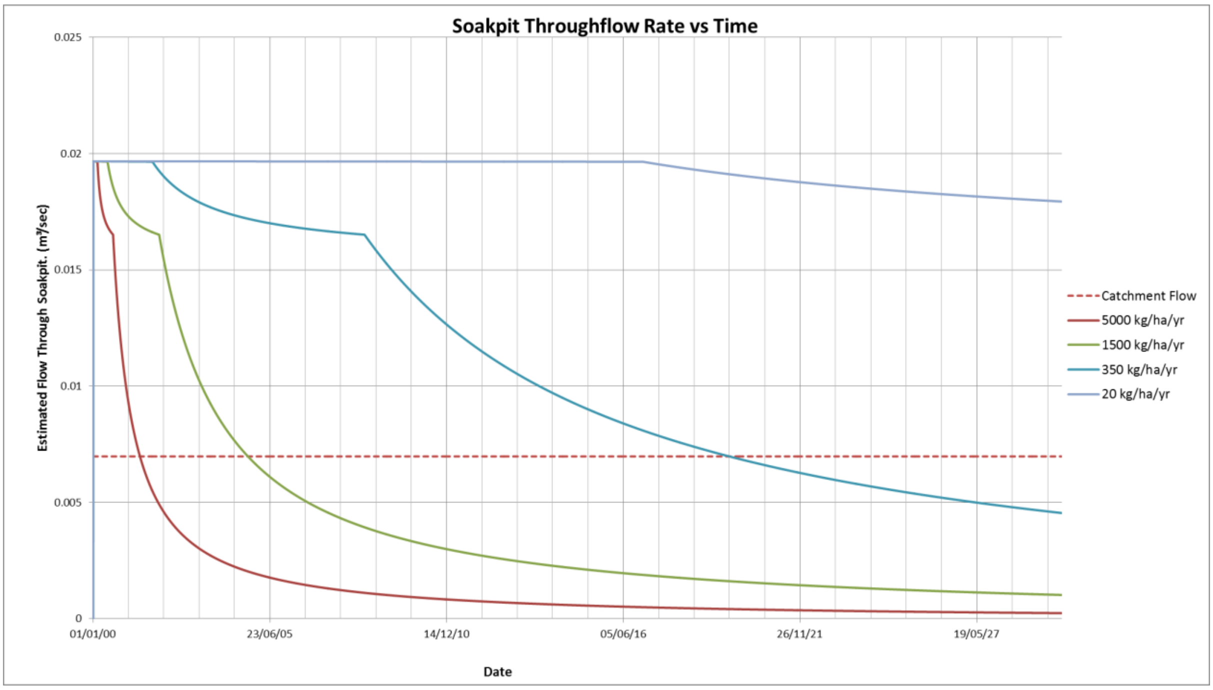


Figure 12: Effect on soakpit of selected sediment loadings

7.3.2.3 Results

In general the blockage mechanism works in three stages. Initially, there is no hydraulic restriction caused by sediment and the hydraulic capacity is governed by the permeability of the base and walls. Once sufficient sediment collects on the base of the soakpit, the infiltration rate through the base reduces to less than the insitu material and this governs the hydraulic capacity through the base. Similarly, over time, the hydraulic capacity of the soakpit walls reduces as sediment "collects" in the assumed layer on the walls. Each stage of blockage is represented by a change in gradient on the results chart.

The results are summarised in Table 6 below.

Table 8: Soakpit Clogging Results

Sediment Loading (kg/ha/yr)	Time to clog base of soakpit (mths)	Time to clog soakpit flow below design flow (yrs)
5000 (construction site or bare soil)	2	1.5
1500 (industrial site)	6	4.5
350 (residential site)	10	18
20 (roof runoff)	186	>30

From this table as expected it is clear that sites with a higher sediment potential would clog soakpits much sooner than sites with a lower sediment load. The implications of this are that the soakpits serving industrial and other high polluting sites will require frequent maintenance and renewing if the runoff is not treated prior to entering the soakpit. It is also evident that construction site runoff is likely to clog soakpits every quickly. Soakpits should be isolated from construction site runoff and constructed after the majority of the site has been stabilised.

7.3.3 Rockbore Soakholes

Rockbore soakholes discharge water directly into rock. Generally stormwater discharges into a chamber from catch pits that is equipped with one or more boreholes drilled into the fissured and fractured basalt. There is often no screening sleeve in the hole, just a borehole in the basalt. The borehole generally has an upstand that requires ponding of water in the device which provides some limited removal of coarse sediment.

A clogging model similar to the one previously discussed for soakpits was developed.

7.3.3.1 Method

This model is similar to the previous soakpit model except that the available volume for accumulation of sediment is the borehole itself and volume of fissures in the rock for an assumed effective radius around the rockbore soakhole. The volume of affected fissures is derived from the typical basalt porosity of 8%. The rockbore soakhole sensitivity analyses repeated the previous tests and also tested the assumed radius around the rockbore and porosity of the rock.

Field investigations to determine the effective radius and calibration of this in the model would improve its predictions.

7.3.3.2 Analysis

The scenarios modelled are the same as for the soakpit model. The same single benchmark option was modelled for the rockbore soakhole option. The rockbore soakhole was defined as having a 150mm diameter borehole drilled to 20m depth with an effective clogging radius around the bore of 1m. These scenarios were analysed assuming a wall to base sediment split ratio of 1:5.

As for the soakpit scenario, rockbore soakholes take a very long time to be effectively blocked by sediment loads from roofs. However, for other scenarios, blockage occurs more quickly. For the scenario shown in Figure 13; including standard residential paved driveway loadings leads to blockage after 28 years, including industrial yard loadings leads to blockage after 6.5 years and construction sediment loading leads to blockage after 2 years.

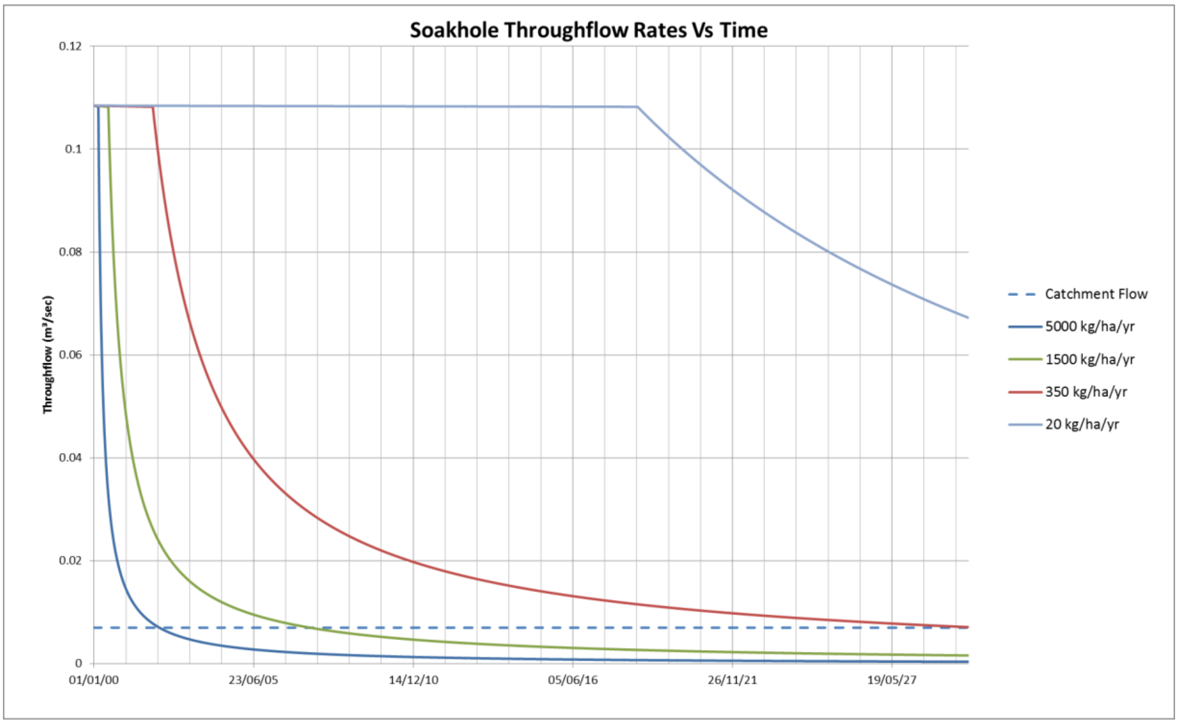


Figure 13: Effect on rockbore soakhole of selected sediment loadings

7.3.3.3 Results

In general the blockage mechanism works in three stages. Initially, there is no hydraulic restriction caused by sediment and the hydraulic capacity is governed by the permeability of the base and walls. Once sufficient sediment collects on the base of the rockbore soakhole, the infiltration rate through the base reduces to less than the insitu material and this governs the hydraulic capacity through the base. In rockbore soakholes, the initial stage occurs very quickly as the rockbore soakhole base is only the150mm hole diameter and the flow through the base area is negligible compared to the walls.

In the second stage (with flow through the base governed by the base sediment layer and flow through the walls governed by the insitu wall permeability) the hydraulic capacity reduces at different rates depending upon the ratio of base to wall sediment used.

At the final stage (where both base and wall sediment restrict flow) the rate of change of capacity is consistent with the sediment permeability.

The results are given in Table 9 below.

Table 9: Rockbore soakhole Clogging Results

Sediment Loading (kg/ha/yr)	Time to clog base of soakhole (mths)	Time to clog soakholes flow below design flow (yrs)
5000 (construction site or bare soil)	0.5	2
1500 (high traffic road/ industrial site)	2	6.5
350 (residential site)	20	28
20 (roof runoff)	204	-

7.3.4 Sensitivity

The soakpit model is sensitive to the proportion of sediment that is directed to the base of the pit versus the walls of the pit. It has been assumed that the volume of sediment accumulating on the walls is proportional to the volume accumulating on the base. Varying the ratio varies the hydraulic capacity of the pit significantly.

A 1:5 ratio below indicates 200L of sediment is directed to the walls of the pit for every 1000L directed to the base. The ratio is unknown currently and the sensitivity assessment was carried out to check the effect of this ratio. Field investigation would be required to assess this further.

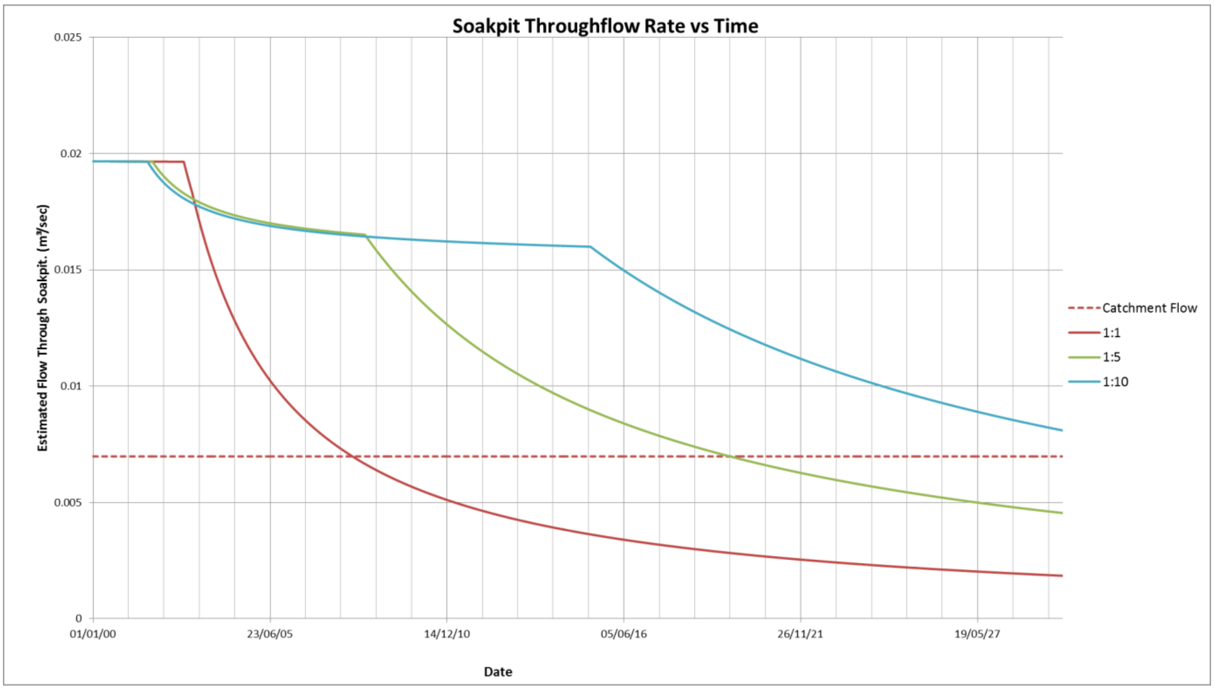


Figure 14: Effect of varying wall to base sediment layer thickness ratio from 1:1 to 1:5 to 1:10

7.3.5 Discussion

The results of the modelling done above are comparative and cannot be seen to be quantitative. The comparison indicates that soakpits and rockbore soakhole receiving stormwater runoff from roofs receive less sediment and take longer to clog (if at all) compared to those devices receiving high sediment load flows.

The modelling confirms the logical conclusion that stormwater with a greater sediment load will cause soakage devices to clog quicker than stormwater with lesser sediment loads. The point of interest is that the stormwater runoff from roofs (at 20kg/ha/yr) does not reduce the flow capacity of a device to below its design capacity within the 30 year period modelled.

7.4 Recommendations for Pre-treatment

Based on the above modelling and assessment the following approach to providing pre-treatment is considered appropriate:

- Pre-treatment for sediment is not required for typical residential roof loadings.
- Driveways areas for typical residential roof loading do not accumulate significant sediment, but we consider it is an appropriate precaution to provide catchpits as pre-treatment.
- Pre-treatment should be provided if there are heavy loadings of sediment (such as from high volume roads, industrial or construction sites). The amount of pre-treatment required should be calculated based on the expected incoming sediment loads and achieving a service life between maintenance of at least ten years or as required by AC. If no judgement can be made about the expected sediment loads for these land uses, as a default, TP10 treatment to remove 75% TSS on a long term basis should be provided. TP90 erosion and sediment controls should be used for construction sites.

Note that there may be requirements for stormwater treatment in addition to the requirements set out here as a result of rules in the Regional Plan. The pre-treatment identified above is for maintenance purposes and may contribute to the amount of treatment required under the Regional Plan rules.

The rockbore soakhole scenario tested showed the hydraulic capacity reducing after about two months at the industrial loading rate with clogging of the hole taking place in a 6.5 year period. It is recommended that rockbore soakhole chambers be inspected for sediment accumulation at no greater than one year intervals.

The extent of sediment transmission into rock and rockbore soakhole effective radius is unknown and needs to be assessed further through field investigations and calibration of the model.

7.5 Pre-treatment methods

7.5.1 Pre-treatment Devices

A pond or tank can provide efficient sediment pre-treatment and can be varied in size to target different particle sizes of suspended sediment. . These often have applicability in industrial sites for managing heavy sediment loading. Tanks are often used where space constraints require underground treatment and open tanks where frequent maintenance access is required. They will require complementary treatment methods where other contaminants such as dissolved metals need to be treated.

Four other types of pre-treatment systems identified in the SDM are:

1. Sandfilters.
2. Raingardens.
3. Filter strips.
4. Scoria trenches.

Each of these devices can provide effective sediment treatment, but may become overwhelmed under heavy sediment loadings. Where filter media in sandfilters or raingardens becomes blocked, the sediment will need to be removed and the media rehabilitated to the depth of sediment penetration. In heavy load situations therefore these devices may require a primary settlement chamber to remove coarse/heavy loads and be used for treatment of finer sediment. Scoria trenches are susceptible to media or base/wall blockage and are difficult to maintain once this has occurred – they are not recommended for use except in low sediment loading situations.

7.5.2 Pre-Treatment Requirements

Table 10 is intended to assist with selecting soakage and pre-treatment devices. The reasoning behind the tables is based on the following guidelines:

- All runoff from high volume roads, industrial sites, construction sites (or other paved areas with sediment loading heavier than standard residential sites) should have pre-treatment.
- All runoff from roof areas should have leaf traps or methods to prevent the ingress of gross solids and organic materials (such as leaves).
- Runoff from residential paved areas need only pass through a standard catchpit.

Table 10: Summary of Pre-treatment Requirements

Situation	Pre-Treatment Devices
Non residential areas (such as arterial roads and industrial areas)	Sediment Pond, Sediment tank (in conjunction with other treatment downstream when other contaminants need to be treated) Sandfilter, Raingarden (in conjunction with a primary settlement tank upstream in heavy sediment loading situations)
Paved residential areas	Catchpit (300x450 standard catchpit) *provides minimal treatment*
Roof areas	Prevent gross solids and organic material entering the system

7.5.3 Design Standards for Pre-Treatment Devices

The design methodology for pre-treatment devices has the following basis:

1. Pre-treatment devices must accept runoff from all paved areas.
2. Pre-treatment devices are designed to remove suspended solids so that the resulting average loading is no greater than the paved area of an average residential lot.
3. Estimations of stormwater runoff are based on the ARC method detailed in TP108, assuming a time of concentration of 10 minutes and a runoff depth of 25 mm.
4. Filter-strip sizing in Appendix A has been based on a filter-strip slope of 1%. For other slopes, designers are referred to TP10.

It may be possible for designers to size treatment devices to less than 75% TSS on a long term average for medium loading scenarios. For example, tanks and ponds can be sized to provide different levels of TSS treatment depending upon the proportion of the water quality volume provided. However note that at the industrial sediment loading rate of 1500 kg/ha/yr, treatment of about 75% would be required to achieve the residential loading rate of 350 kg/ha/yr.

8.0 Operation and Maintenance

8.1 Operation and Maintenance requirements

The primary operational requirement of a soakage device is to maintain soakage rates at or above the design level of service flow rate. Clogging the device due to sediment and debris ingress is the key factor in this regard. The estimated time for clogging to occur under different sediment loading scenarios has been discussed in Section 7. The following factors from the Section 7 assessment are identified in determining maintenance frequency:

- The sediment loading from the catchment.
- The use of catchpits.
- Whether the device is a rockbore soakhole or soakpit.

It is difficult to rehabilitate soakage once clogging has occurred. Sediment in rockbore soakholes becomes caught in fractures and fissures in the rock while sediment in soakpits becomes caught underground within the pit media or filter cloth. Maintenance can attempt to clean out sediment through replacement of the media or hydro-jetting rockbore soakholes, but this is often not completely effective. Maintenance must therefore be targeted at prevention of clogging.
Details of specific maintenance requirements for soakage devices are set out in the schedules in Appendix A.

8.2 Soakage Devices in Basalt

8.2.1 Owner's Obligations

The procedures given below are based on the legacy ACC SDM requirements and should be compiled either at building consent stage, or prior to installation if no consent is required.

Once installed, soakage and pre-treatment devices should not be modified or removed (unless a further consent is obtained from AC). In addition, the owner should carry out the following tasks for all devices except nominal soakage designs:

1. Fill out the standard form "OSM-O&M Plan" giving owner/site details etc.
2. Make a copy of the "OSM-O&M Routine" sheets listing the routine operation and maintenance requirements.
3. Fill-out a 'Device-Specific O&M Detail' form for each device on the property.
4. If required by a building consent, submit all forms to AC along with a schematic drawing of each device. The drawings in the Soakage Design Manual may be used for this purpose but should be modified (or an alternative drawing submitted) if any details do not match the site-specific design.
5. Carry out periodic inspections, as detailed in the device-specific plans.
6. Carry out annual inspections to check for build up of sediment in the rockbore soakhole or soakpit. When inspections are carried out, the contractor must fill out an 'OSM-O&M-Cert' Form (as given in Appendix A). If required by a consent, this form must be submitted to AC once completed.

7. Allow AC staff access to inspect any device, as required by the Building Act 2004. The access must be requested in writing and within normal working hours.
8. Make any repairs requested by AC staff in writing, as required by the Building Act 2004. The owner may be required to demonstrate that the repairs have been performed, such as by submitting appropriate certification.
9. Ensure that all operations are carried out to a safe standard. Note that particular care should be taken with confined spaces, which are found on Sand-filters, Onehunga Soakpits and Rockbore Soakholes. Entry to confined spaces can be dangerous, and should only be attempted by suitably qualified people. In general, operations should be undertaken according to the Australian/New Zealand Standard AS/NZS 2865:2001 Safe Working in a Confined Space.

8.2.2 Access Requirements

Effective maintenance relies on ready access to the soakage or pre-treatment device. The following points should be considered:

1. Onehunga Soakpits and Rockbore Soakholes are cleaned most effectively using vacuum-type systems. These systems are generally mounted on trucks and can only be used if the vacuum pipes are able to stretch from the truck to the soakage or pre-treatment device. Smaller trucks normally need to be within 20 to 30m of the soakage device. Large street-cleaning trucks may have pipes that can stretch 75m or more, but will be more expensive to hire.
2. All soakage devices (except Rockbore Soakholes) may eventually require excavation of soil or scoria/gravel layers, so that repairs can be made. An access way at least 2m wide should be allowed for, so that at least a small excavator can gain entry. Alternatively a proven reserve soakage site with better access could be identified.
3. Re-drilling Rockbore Soakholes normally requires an access way that is around 3 m wide. This is not a regular maintenance procedure, but may be required eventually depending upon the sediment load entering the device.

8.3 Soakage Devices in Peat

An operation and maintenance manual including procedures, initial settings and other specific requirements for operation, and a maintenance schedule detailing the tasks and occurrence frequency, should be prepared for the stormwater quantity and quality management devices. These documents should be in accordance with AC requirements.

9.0 Conclusions

9.1 General

Overall, soakage is a well-known method of disposal of stormwater in the basalt areas around the Auckland region and within the Papakura peat. There is potential for stormwater disposal to ground in other basalt and peat areas as identified in Figure 7 to Figure 9 (pages 21 to 23).

The design methodologies for private and commercial soakage devices are well documented and have been utilised within the legacy Auckland City Council and Papakura District Council areas over the last few decades.

The processes involved in the design of public devices are not well documented and these devices have been created and upgraded as part of the development of the public soakage system over the years. In particular within the legacy Auckland City Council area, Metrowater (superseded) were the custodians some of the public devices (generally historic and those related to flood prone areas) whilst ACC Traffic and Roading Services (TARS) were involved in the development of additional devices within the road reserve across the isthmus. Auckland City Environments were responsible for consenting and as such maintained the property files and associated soakage test information as part of their responsibilities.

Therefore the information relating to soakage, devices, performance and information was not centralised for ease of access and the institutional knowledge was split over three custodians of the data. With the formation of the Auckland Council, functions are split across AC Regulatory Services, AC Stormwater (Planning, Design, Operations) and Auckland Transport.

As previously discussed under Section 4.4 a central database containing all the soakage testing information as well as all the borehole data would provide a mechanism to capture all the relevant data and make it easily accessible. This would facilitate more informed decisions to be made with regard to the use of soakage as a method of stormwater disposal. This data could then be used by all those involved in developing soakage devices within the Auckland region.

Also as noted earlier a similar database system has been set up in the Canterbury region to collect and collate all geotechnical data gathered from site investigations in the region. The information is provided to the Council and professional engineering companies involved with the Canterbury Recovery, the Government, the Councils and the Earthquake Commission. A similar system could be implemented within the Auckland region dealing with borehole data and soakage testing results.

9.2 Soakage on Basalt

The knowledge base with regard to the character of the majority of the Auckland Isthmus basalt aquifers has grown and the potential of the aquifers to accommodate soakage is now better understood. This level of knowledge is reflected in the soakage maps shown in Figure 7 to Figure 9 (pages 21 to 23).

There are many soakage tests which have been carried out on private and commercial properties within the legacy Auckland City area and the results are contained within the property files. This data is unfortunately not easily accessible to provide AC with guidance on the soakage potential on adjacent properties. All current soakage testing conducted in accordance with the SDM is also currently kept on the property file.

The state of knowledge of the basalt aquifers outside the Auckland Isthmus is not well known and information is not easily available. It is most likely that there is data on soakage within the property files held by the other legacy City and District Councils. Soakage areas are limited in the legacy Rodney, North Shore and Manukau areas.

9.3 Soakage on Peat

The state of knowledge of the Papakura peats is based on a 2006 review of the available soakage testing that has been carried out in the Papakura area based on records of applications for disposal of stormwater to ground. A review of all property files for properties located on the peat areas would most likely yield additional test results.

As noted in previous sections these tests were conducted by various parties and to varying standards. Following the publication of the PDC Development Code in 2010 the soakage test results from that time onwards should all be in accordance with the Development Code and therefore should be comparable. All this data should be added to the base of existing knowledge and the soakage potential of the peat area further characterised.

9.4 Clogging

As expected the clogging of a device is related to the land use of the catchment draining to the device. For average residential loadings the modelling undertaken indicates that pre-treatment is not required – a catchpit is adequate to prevent clogging for sediment from residential driveways. However for industrial, commercial and construction sites pre-treatment is a requirement in order to ensure the effective on going functioning of the soakage device. In heavy sediment loading industrial areas, a sediment settlement tank or pond is recommended.

Maintenance of the device is also an important element to minimise the effects of clogging due to the entrained sediment within the stormwater. As a default for sites generating heavy sediment loadings the pre-treatment design should be in line with TP10.

9.5 Design Method

The design approach for both basalt and peat follows the methodologies given in Appendices A and B. The main factor in the design for the soakage devices located in the basalt is the site specific investigation to identify the area of most suitable soakage with the device located in the area of most fractured basalt. For the peat devices the site investigation is also important to identify the depth to the peat and the groundwater level within the peat.

The maps shown in Figures 7, 8 and 9 provide an indication of the potential of various soakage areas. The criteria used to generate the maps given in Section 4 provide a useful guide to aid in the interpretation of site investigation data to determine the potential for soakage.

10.0 Recommendations

This report has shown that soakage is a viable method of disposing of stormwater and should be used as one of the tools to provide stormwater drainage as well as provide recharge to aquifers.

Issues raised include the lack of access to the soakage test data and the associated borehole information, the lack of guidelines relating to the design, operation and maintenance of public soakage systems and the need for coordination between various council departments on the issue of soakage and soakage devices.

The following recommendations are made:

1. The design methodology for soakage to basalt given in Appendix A be used for the design of private and commercial soakage devices throughout the Auckland Region for those areas where soakage to a basalt aquifer occurs.
2. The design methodology for peat soakage devices given in Appendix B be used for the design for soakage devices in peat.
3. A database capturing all soakage testing data, constructed devices and operational and maintenance requirements be developed to provide a central storage system for the soakage information.
4. The recommended database be populated (over a period of time) with all the available soakage test and device data for the various property files held by the previous councils as well as other test data held by various council departments.
5. The LRIS data be investigated for use as general guide for implementation of soakage systems from small (less than100m2) catchments, mainly in the rural areas.
6. The clogging model has identified that soakage devices on residential sites are at low risk of clogging and that devices on industrial, commercial and construction sites are at a higher risk of clogging. Pre-treatment should entail:
    a. No treatment for roofs with standard sediment loadings other than leaf traps
    b. Catchpits and annual inspections/maintenance for residential sites/ driveways
    c. Sediment treatment removal for non residential sites should be assessed based on incoming sediment loads and treated so that the resultant average loading is no greater than the average residential driveway. If no loading information is available, treatment to 75% TSS removal should be provided. Inspections and maintenance of pre-treatment devices should be carried out at least annually.
    d. TP90 erosion and sediment controls for construction sites and monitoring of sediment accumulation in soakage devices. Isolate soakage device from construction runoff is possible. Rehabilitation of soakage device at end of construction period if required.
7. The clogging model should be calibrated and developed further. The extent of sediment transmission into rock and rockbore soakhole effective radius is unknown and needs to be assessed further through field investigations and calibration of the model.

8. Where discharging directly into the aquifer (ie via a rockbore soakhole) full treatment should be provided, prior to the rockbore soakhole, which meets the relevant water quality standard for discharging to an aquifer.

11.0 References

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Appendix A

Soakage Design in Basalt - Design Procedure

INFILTRATION TESTS

The ability of the ground to accept stormwater can vary enormously within soakage areas, even within individual properties. Because of this, at least one infiltration test will normally be required for every soakage device that is constructed.

The exception to this rule is if the soakage device is for an impervious areas less than $20m^2$. Small impervious areas such as these can often be served by 'nominal' designs that do not require infiltration tests.

For soils with low permeability rates, tests must be carried out by a suitability qualified person.

Boreholes/Test Pits

Infiltration tests are normally carried out in boreholes. These may be bores drilled in rock using a drilling rig or bores drilled in soil using a hand auger or post hole auger. If drilling is attempted with a drilling rig but found to be impossible due to ground conditions (such as in scoria areas), then infiltration tests can be carried out in testpits. Boreholes and testpits should be constructed according to the following guidelines:

- Boreholes of 100 mm to 150 mm diameter should be bored to at least 1.5 m below the bottom of the intended soakage device.
- Testpits must only be constructed after drilling has failed. The pits should be excavated to the level of the proposed soakage device, have a minimum base area of 1 m2 and be laid back at a suitable angle to prevent caving-in and erosion during the test. Note that the testpit methodology in the Soakage Design Manual is intended for use in scoria areas. It is not suitable for use in soil areas.
- Boreholes and test pits should be logged (that is, geological layers and soil types should be recorded).
- At least one borehole or test pit should be constructed for every soakage device. Soakage devices with a large surface area (such as porous paving) will need at least one borehole/ test pit for every 50 m2 of soakage device.
- Water-table levels should be recorded at the time of excavation (if observed). If the fieldwork is carried out between October and May (spring – autumn), winter water table levels should be estimated at 1.0 m higher than observed water table levels.
- The locations of boreholes and test pits should correspond with the position of the proposed soakage devices.

Preparation of Boreholes/Test Pits for Infiltration Tests

- Boreholes in soil should be prepared for testing by carefully scratching the sides with a sharp-pointed tool to remove any smeared soil surfaces and to provide a natural soil interface through which water may infiltrate.
- All loose materials should be removed from the hole.
- If collapse of a drilled borehole seems likely, a PVC pipe should be inserted into the hole to prevent collapse. If scouring of a test pit seems likely, about 50 mm of sand or fine gravel should be added to the pit to protect the bottom from scouring or sediment blinding.
- Holes in soil areas must be thoroughly pre-soaked to emulate winter conditions. In spring, summer or autumn (October to May), holes must be kept full for a minimum of 17 hours prior to testing. This will normally provide adequate time for the soils surrounding the hole to become saturated, and for any clay soils to swell. During wet winter conditions, holes must be kept full for a minimum of 4 hours.
- Holes in rock areas must be pre-soaked to ensure that any cavities in the rock are filled before testing begins. The hydrant must be open at a high flow rate for a minimum of 10 minutes before testing begins.

Falling-Head Percolation Tests

Falling-head percolation tests determine the percolation rate of an area by filling a borehole with water and recording the rate at which it drains away. This test method is most suitable for use in soils with medium to low permeability. Equipment required to carry out a falling head test includes a suitable water supply, tape measure or water dipper, stopwatch, a copy of WORKSHEET 1 and pen for recording information. A torch may also be useful.

To carry out a falling head percolation test on a borehole:

- Note that if percolation rates are likely to be below 1.0 litres/m2/min then the test should be carried out by an IANZ laboratory.
- Thoroughly pre-soak the hole according to the instructions in the above Section. In spring, summer or autumn (October to May), holes must be filled to the top and maintained full for a minimum of 17 hours prior to the test.
- Fill the hole to within 0.75 m of ground level and record the drop in water level against time at evenly spaced intervals of no greater than 30 minutes, until the water level is around 0.25 m from the base of the hole or 4 hours has passed. Where the hole drains quickly, the test should be repeated several times.
- Graph the results according to the method on WORKSHEET 1 and derive the percolation rate in L/m2/min from the minimum slope of the curve.

Constant-Head Percolation Tests

Constant-head percolation tests determine the percolation rate of an area by maintaining a constant head of water in a test pit or borehole. The water that drains out of the test hole is replenished at the same rate from a water source such as a fire hydrant or reservoir. The stabilised flow rate of water entering the hole is measured over time to determine the permeability of the soil. This test method is most suitable for use in rock areas (or areas with high permeability). Equipment required to carry out a constant-head test includes a hose and fire hydrant, flow meter, tape measure or water dipper, stopwatch, a copy of WORKSHEET 2 and pen for recording information.

To carry out a constant head test on a rockbore:

- Obtain permission from Watercare to use water from the hydrant. Where there are no hydrants water should be supplied from a water tanker.
- Fill the bore using a pipe connected to a flow meter. Observe the water level and adjust the hydrant valve until the bore is maintained close to full. This step must be continued for at least 10 minutes to ensure the hole is adequately pre-soaked.
- Bores positioned within 10 m of each other must be tested simultaneously.
- Continue the test for a further 10 to 15 minutes, and ensure a constant rate is achieved.
- Use WORKSHEET 2 to record the instantaneous flow rate required to maintain a constant head.
- Apply a factor of safety of 1.4 to account for the likely reduction in future soakage rate due to clogging.

To carry out a constant head test on a test pit:

- Obtain permission from Watercare to use water from the hydrant. Where there are no hydrants water should be supplied from a water tanker.
- Fill the hole to about half the maximum depth using a pipe connected to a flow meter and adjust the hydrant valve to maintain the water level. This step must be continued for at least 10 minutes to ensure the hole is adequately pre-soaked.
- Continue the test for a further 10 to 15 minutes, and ensure a constant rate is achieved.
- Use WORKSHEET 2 to record the instantaneous flow rate required to maintain constant head.
- Apply a factor of safety of 1.4 to account for the likely reduction in future soakage rate due to clogging.
- Use WORKSHEET 2 to convert the flowrate into a L/m2/min percolation rate.

In practice, the use of a fire hydrant will only be appropriate for soakage holes which have capacities below the maximum flow rate able to be provided by the fire hydrant (usually 20 L/s). For holes with excessive soakage capacity, a water truck can be used to provide higher flow rates.

Minimum Infiltration/Percolation Rate for Soil Areas

The guideline for the minimum infiltration rate is 0.5 litres/m^2/min. If infiltration rates are near or below this value, it will be difficult to obtain building consents for soakage systems. When soil types are such that the infiltration rate is less than 1 litres/m^2/min— or is likely to be less than 1 litres/m^2/min—or may drop to less than 1 litres/m^2/min over the lifetime of a building—then the infiltration tests are to be carried out by a suitably qualified person.

DESIGN PROCEDURES

Design Standards for Soakage Devices

The design methodology for soakage devices in this Manual has the following basis:

1. Soakage devices must accept runoff from all paved areas and roof areas, and from pervious areas if they will contribute runoff.
2. Soakage devices are designed to accept rainfall events up to the 10% ARI storm.
3. Estimations of stormwater runoff are based on the ARC method detailed in TP108, but with the following simplifications:
    a. A time of concentration of 10 minutes is assumed.
    b. A uniform rainfall depth is applied over all areas of the Region.
    c. The 10% ARI 24-hour rainfall depth is taken to be 130mm.
4. The surface area available for soakage is assumed to be the base area of the soakage devices plus half the wall area.
5. The soakage devices must drain within 24 hours of the end of the design rainfall event.
6. The guideline for the minimum soakage rate is 0.5 litres/m2/min [see Section – "Minimum Infiltration Rate for Soil Areas" above].

Design Standards for Pre-Treatment Devices

The design methodology for pre-treatment devices in this methodology has the following basis:

1. Pre-treatment devices must accept runoff from all paved areas.
2. Pre-treatment devices are designed to remove around 75% of solids in the stormwater for rainfall events up to a 25 mm water quality storm. This is consistent with ARC guidelines in TP10.
3. Estimations of stormwater runoff are based on the ARC method detailed in TP108, assuming a time of concentration of 10 minutes and a runoff depth of 25 mm.
4. Filter-strip sizing in this design methodology has been based on a filter strip slope of 1%. For other slopes, designers are referred to TP10.

Design Areas for Sizing

The sizing of soakage devices, pre-treatment devices and rainwater tanks is determined by the type of surface that covers the property, and the amount of area it covers. In general, design areas can be divided into the categories shown in Table A1.

Table A1 Symbols for design areas

Design Area	Symbol
Roof Area	A_R
Paved Area (concrete, patio etc)	A_C
Pervious Area (grass or garden)	A_P
Porous Paved Area	A_{PP}
Equivalent impervious area (see Table A2)	A_E

The following points should be noted with respect to these areas:

1. AR - Roof area is the area of roof feeding to the spouting system. Roof area must be included in the sizing of soakage devices and rainwater tanks, but not in the sizing of pre-treatment devices.
2. AC - Paved area is any sealed ground-level area, such as driveways or patios. Paved area must be included in the sizing of soakage devices and pre-treatment devices.
3. AP - Pervious area is the area covered in vegetation or garden. Pervious area should be included in the sizing of soakage devices if it will contribute runoff to the soakage system. This normally requires that the pervious area is at a higher elevation than the paved areas, and typically only applies to a small portion of the total pervious area.
4. APP - Porous paved area is the area of the property that is covered in porous paving. The porous paving must be designed as a soakage device.
5. AE - Equivalent impervious area must be calculated before sizing soakage systems. For roof and paved areas, the equivalent impervious area is simply the sum of the areas. For pervious areas, the equivalent impervious area must be calculated using the ratios and equation listed in Table A2.

Table A2 Equation for calculation of equivalent impervious area

Design Area	Symbol
Ratio for pervious area	RE = 0.3
Equivalent impervious area	$A_E = A_R + A_C + R_E \times A_P$

Ratios used for Sizing

The charts and worksheets in this Manual use a number of ratios. These must be applied correctly for correct sizing of soakage devices and rainwater tanks, and each is described below (the Charts referred to are given in Annexure B):

1. **The soakage device Area Ratio R1** (m2 soakage device/m2 equivalent impervious area) is read off CHART 1 for a known infiltration/percolation rate and soakage device depth. R1 is multiplied by the amount of equivalent impervious area feeding to the soakage device, to give the required area of soakage device. The area of soakage device is the plan area and is only applicable to soakage devices filled with scoria (with a porosity of 0.5). [See Example 1 in Annexure C]

2. **The Catchment Soakage Ratio P3** (L/min/m2 equivalent impervious area) must be known to use CHART 2 and CHART 6. P3 is the soakage capacity of the soakage device (in L/min) divided by the amount of equivalent impervious area feeding to the soakage device. [See Example 2, Example 7 and Example 8 in Annexure C]
3. **The Storage Ratio R2** (m3/m2 equivalent impervious area) is read off CHART 2 for a known catchment soakage ratio. R2 is multiplied by the amount of equivalent impervious area feeding to the soakage device, to give the required volume of storage. [See Example 2 and Example 7 in Annexure C]
4. **The Orifice Area Ratio Z** (mm2/m2 roof area) is read off CHART 6. Z is multiplied by the amount of roof area to give the required orifice area. [See Example 8 in Annexure C]

Sizing of Soakage Devices

Soakage devices must be sized to accept runoff from all roof areas and paved areas and any pervious areas that can contribute runoff (pervious areas will normally only contribute runoff if they are above the level of paved areas). The following notes outline the procedures to follow (refer Annexure C for Worksheets and Annexure B for Charts):

1. Onehunga soakpits can be sized by one of two methods, depending on the circumstances and the accuracy that is required:
    a. The first method is easier and faster, and uses WORKSHEET 3 and CHART 1. This method is only suitable if the equivalent impervious area is less than 1,000 m2, and if there is no use of rainwater tanks or on-site storage. The method does not take into account the additional storage space provided by the chamber, but in most cases this does not result in a significant difference in the size of the final soakage device. [For situations where the chamber takes up the entire soakpit, there may be a 35% reduction in the final size. However, because most chambers are only about 1 m in diameter, the overall reduction in the surface area of the soakage device is normally around 0.45 m2.]
    b. The second method uses WORKSHEET 8 and CHART 2. This method is more difficult to use (iteration is required), but is more flexible and provides more accurate sizing. It must be used if the impervious area is greater than 1,000 m2, if additional storage is going to be used, if the infiltration/percolation rate is outside the range of CHART 1, or if the media to be used in the soakage device does not have a porosity of 0.5.
    c. The significant difference in accuracy between the two methods occurs for rectangular soakage devices with a large length to width ratio.
2. Filter-strip soakpits should be sized in the same manner as Onehunga Soakpits, but the filter-strip should be designed first [see Section "Sizing of Pre-treatment Devices"] so that the length of the soakpit can be adjusted to suit the width of the filter-strip.
3. Rockbore Soakholes should be sized using WORKSHEET 4 and CHART 2.
4. Rain-gardens for soakage and pre-treatment should be sized using WORKSHEET 5 and CHART 1.
5. Nominal Soakpits should be sized using part 1 of WORKSHEET 7.

6. Porous Paving does not need to be sized unless a site specific design is completed. However, designers must check that the slope of the paving and the infiltration/percolation rate comply with the details given on Drawing 6 (Annexure A).

Sizing of Pre-Treatment Devices

Pre-treatment devices must be sized to accept runoff from all paved areas. The following notes outline the procedures to follow:

1. Rain-gardens that are for pre-treatment only should be sized using steps 1 and 2 of WORKSHEET 6.
2. Filter-strips should be sized using CHART 4 and steps 1 and 4 of WORKSHEET 6. (Note that this design methodology is only valid for a filter-strip slope of 1%. The methodology in TP10 should be applied for slopes greater than 1%). If the filter-strip is to be used with soakage devices other than a filter-strip soakpit, a scoria trench can be used to transfer the runoff from the filter-strip to the soakage device.
3. Sand-filters may be approximately sized using steps 1 and 3 of WORKSHEET 6. Note that this is not a formalised design procedure, and is only intended to give approximate sizing. Commercially available sand-filters are specified by the amount of impervious area they can serve, so an appropriate filter can normally be selected without carrying out detailed design procedures. Detailed design procedures must be carried out for any sand-filters constructed on-site, and in this case reference should be made to TP10 guidelines.
4. Scoria trenches should be sized using steps 1 and 5 of WORKSHEET 6.

Standard Details

Standard details are shown on the Drawings in Annexure A, and compliance with these standards must be demonstrated (for example on building permit drawings). The drawings corresponding to each device are as listed below:

Table A3 Device Drawing Numbers

Design Area	Drawing
Nominal soakpit	Drawing 1
Onehunga soakpit	Drawing 2
Filter-strip and filter-strip soakpit	Drawing 3
Rain-garden • for soakage and pre-treatment • for pre-treatment only	 Drawing 4 Drawing 7
Rockbore soakhole	Drawing 5
Porous paving	Drawing 6
Scoria trench	Drawing 8
Settling chamber (for roof runoff)	Drawing 9

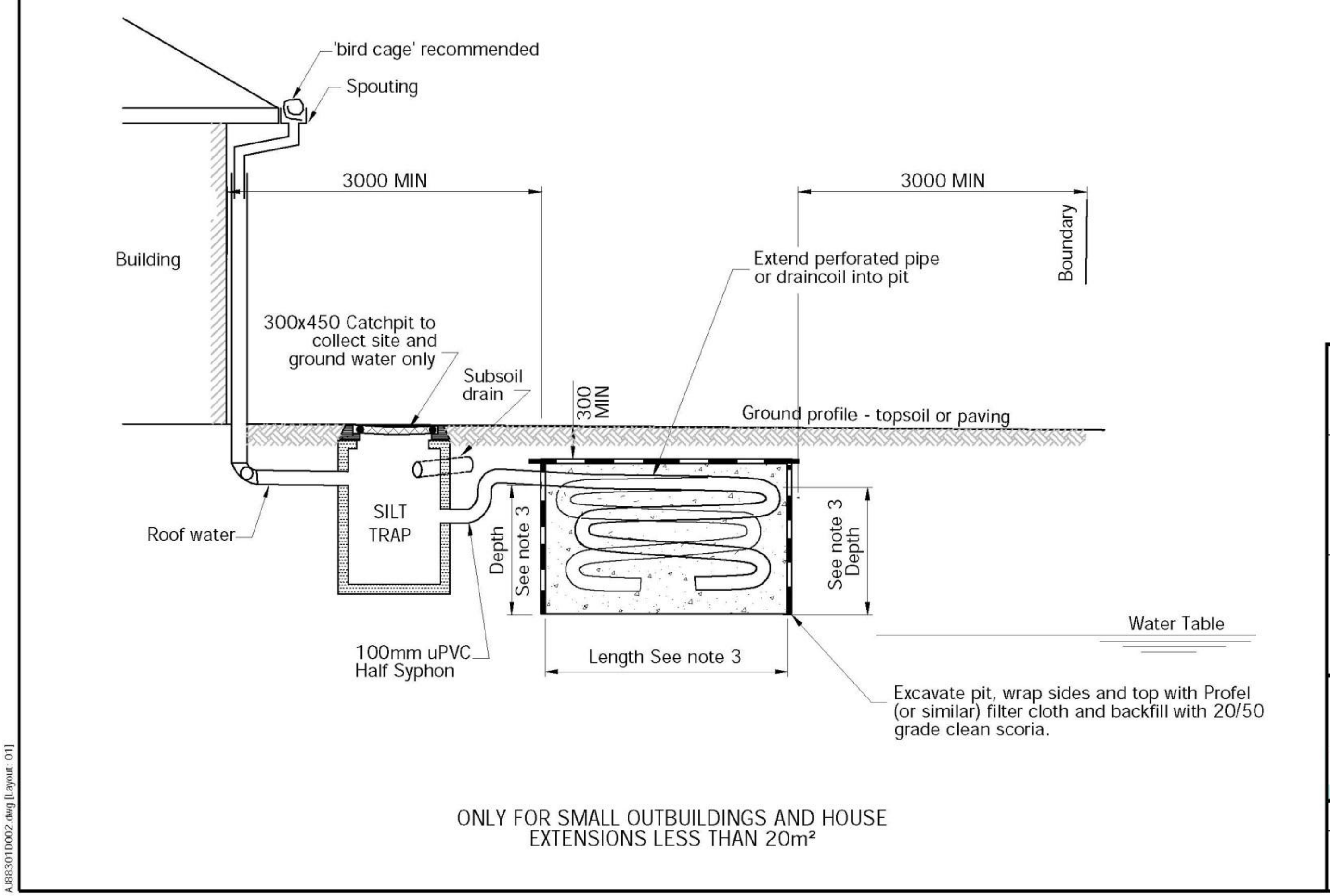
Innovative Designs and Variation of Soakage and Pre-treatment Devices

It is recognized that there will be cases when the design approach in this report may need to be modified. For example:

- If site parameters are outside the ranges given in the charts
- Cases where the applicant wants to vary the design, such as to rework the design/sizing or change the design detail and standard dimensions
- The applicant wishes to use an alternative device, such as a proprietary system
- For cases such as these, it is recommended that the following course of action is adopted:
- Discuss broad plans with AC, and provide explanations for the need to depart from the normal design approach
- Receive guidance from AC regarding the preparation of the site specific design. In general, appropriate analysis/modelling will be required, and will need to be accompanied by clear documentation
- Proceed to prepare and document the design as necessary, ensuring compliance with all AC standards and policies.

Annexure A - Drawings

No.	Title
1	Nominal Soakhole [referred to as Nominal Soakpit]
2	Onehunga Soakhole [referred to as Onehunga Soakpit]
3	Filter-strip and Soakhole [referred to as Filter-strip and Soakpit]
4	Raingarden (soakage and pre-treatment)
5	Rockbore Soakhole
6	Porous Paving
8	Scoria Trench



Notes :

1. All dimensions are in mm (unless otherwise specified)
2. This type of soakpit is only suitable as a pit. Strip soakpits are not acceptable.
3. Provide $1m^3$ of soakpit for every $10m^2$ of impervious area. Maximum depth 1.0m.
4. Soakpit shall be positioned NOT closer than 2.0m to any sanitary sewer.

Client : AUCKLAND CITY

Project : Stormwater Soakage Design Manual

Title : Nominal Soakhole

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Project No. :	Drawing No. :	Revision :
AJ88301	01	A

Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Exact depth to be determined by site soakage test rate and contributing area.
3. Soakholes shall not be located within 3.0m of buildings or boundaries or 2.0m of sanitary sewers without specific geotech report.
4. An operation and maintenance plan is required. Refer to Form SM001.
5. Soakholes may not be located within any building or in a subfloor/basement carpark.

Table A

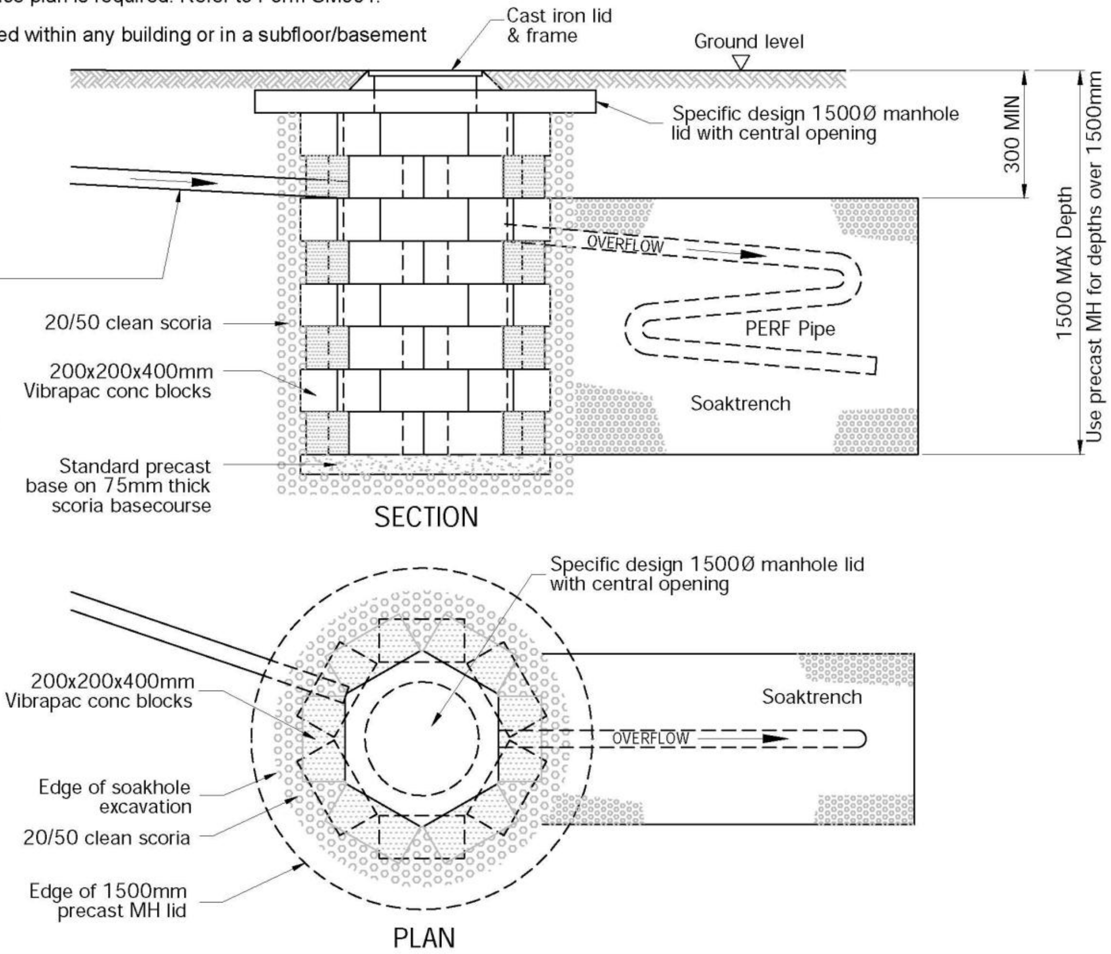
MAX Catchment Area*	MIN Overflow Pipe Size (mm)	
210 m^2	100	
350 m^2	125	
550 m^2	150	
1000 m^2	200	

* Measured as equivalent impervious area (tick)

uPVC sewer grade pipe, sized from Table A.

-Runoff from roof areas must pass through a settling device. Refer to Drawing 09.

-If the total paved area exceeds 20m², site runoff must be pre-treated. Refer to Drawings 07, 08, 10.



Client : AUCKLAND CITY

Project : Stormwater Soakage Design Manual

Title : Onehunga Soakhole

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Project No. :	Drawing No. :	Revision :
AJ88301	02	A

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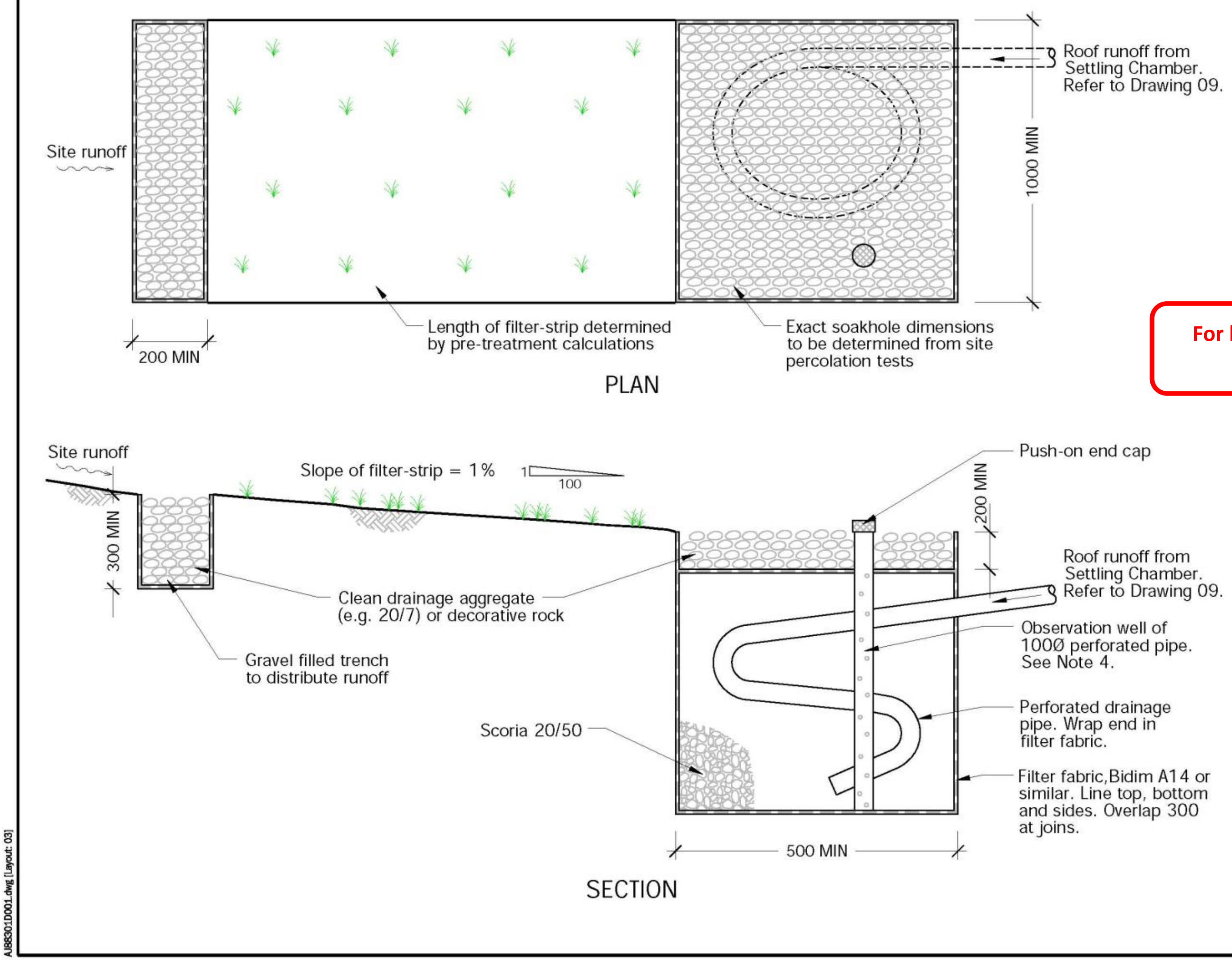
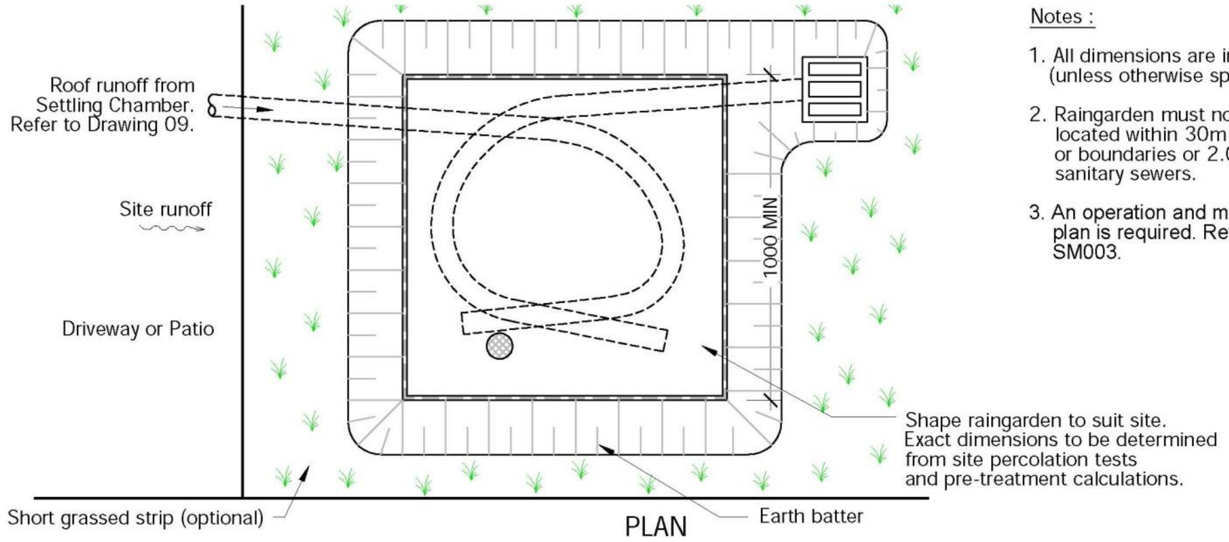


Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Soakholes must not be located within 3.0m of buildings or boundaries or 2.0m of sanitary sewers.
3. An operation and maintenance plan is required. Refer to Forms SM002 and SM008.
4. Observation well to be uPVC sewer grade, with at least 4 10Ø holes per 100 length and anchored at base.

For low to medium sediment loading sites only

Client : AUCKLAND CITY		
Project : Stormwater Soakage Design Manual		
Title : Filter-strip and Soakhole		
PATTLE DELAMORE PARTNERS LTD (pdp solutions for your environment) Auckland Wellington Christchurch		
Scale: NTS		
Project No. : AJ88301	Drawing No. : 03	Revision : A



Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Raingarden must not be located within 30m of buildings or boundaries or 2.0m of sanitary sewers.
3. An operation and maintenance plan is required. Refer to Form SM003.

Table A

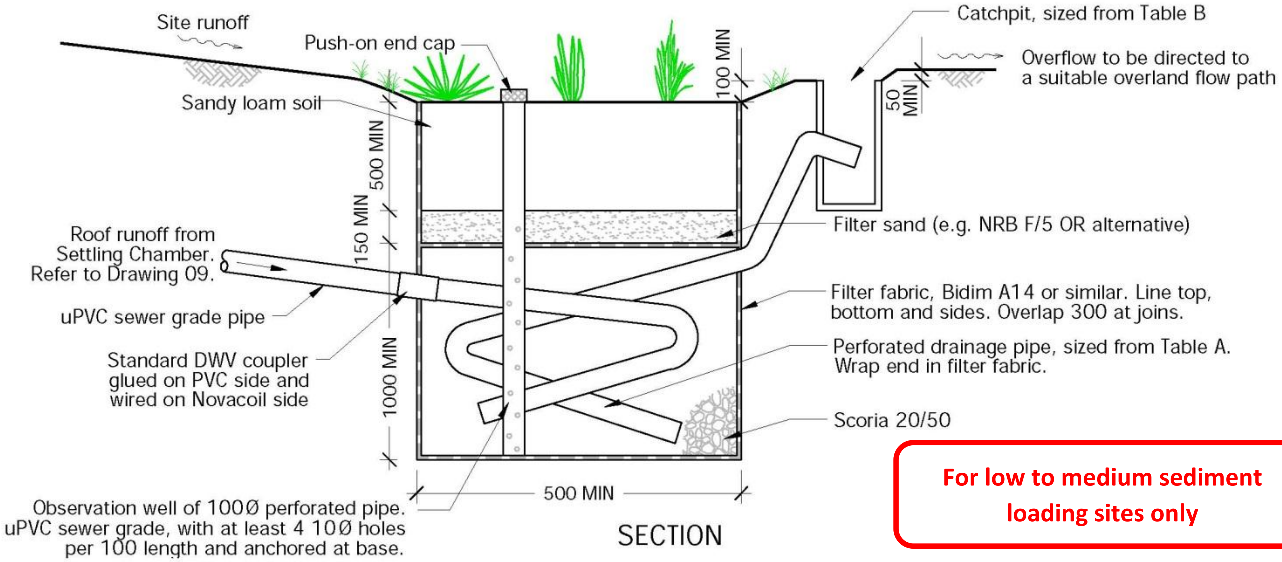
MAX Catchment Area*	MIN Overflow Pipe Size (mm)	
210 m^2	100	
350 m^2	125	
550 m^2	150	
1000 m^2	200	

(tick)

Table B

MAX Catchment Area*	MIN Catchpit Size (mm)	
210 m^2	300 x 300	
350 m^2	300 x 300	
550 m^2	450 x 300	
1000 m^2	450 x 300	

* Measured as equivalent impervious area (tick)



For low to medium sediment loading sites only

Client : AUCKLAND CITY

Project : **Stormwater Soakage Design Manual**

Title : **Raingarden (soakage and pre-treatment)**

PATTLE DELAMORE PARTNERS LTD

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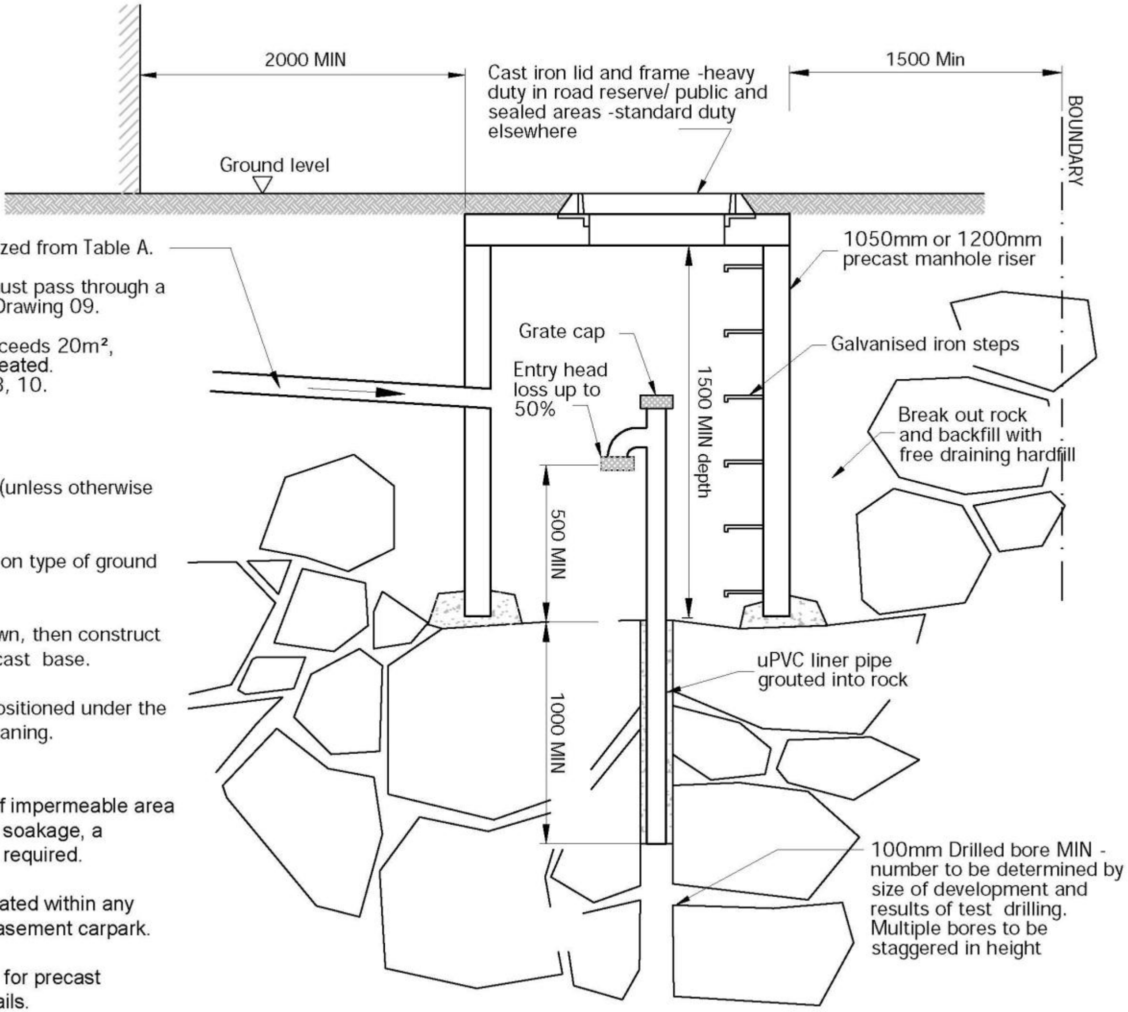
Auckland Wellington Christchurch

Scale: NTS		
Project No. : AJ88301	Drawing No. : 04	Revision : A

AJ88301D001.dwg [Layout: 04]



Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Depth will vary depending on type of ground encountered.
3. If rock is deeper than shown, then construct manhole on standard precast base.
4. The drilled bore is to be positioned under the MH access for ease of cleaning.
5. ARC requirements:-
   Where 1000m² or more of impermeable area is to be drained to ground soakage, a Resource Consent will be required.
6. Soakholes may not be located within any building or in a subfloor/basement carpark.
7. Refer plan No. 12908/201 for precast manhole construction details.
8. An operation and maintenance plan is required. Refer to Form SM005.

Table A

MAX Catchment Area*	MIN Overflow Pipe Size (mm)	
210 m^2	100	
350 m^2	125	
550 m^2	150	
1000 m^2	200	

* Measured as equivalent impervious area (tick)

Client : AUCKLAND CITY

Project : Stormwater Soakage Design Manual

Title : Rockbore Soakhole

pdp solutions for your environment
PATTLE DELAMORE PARTNERS LTD
Auckland Wellington Christchurch

Scale: NTS

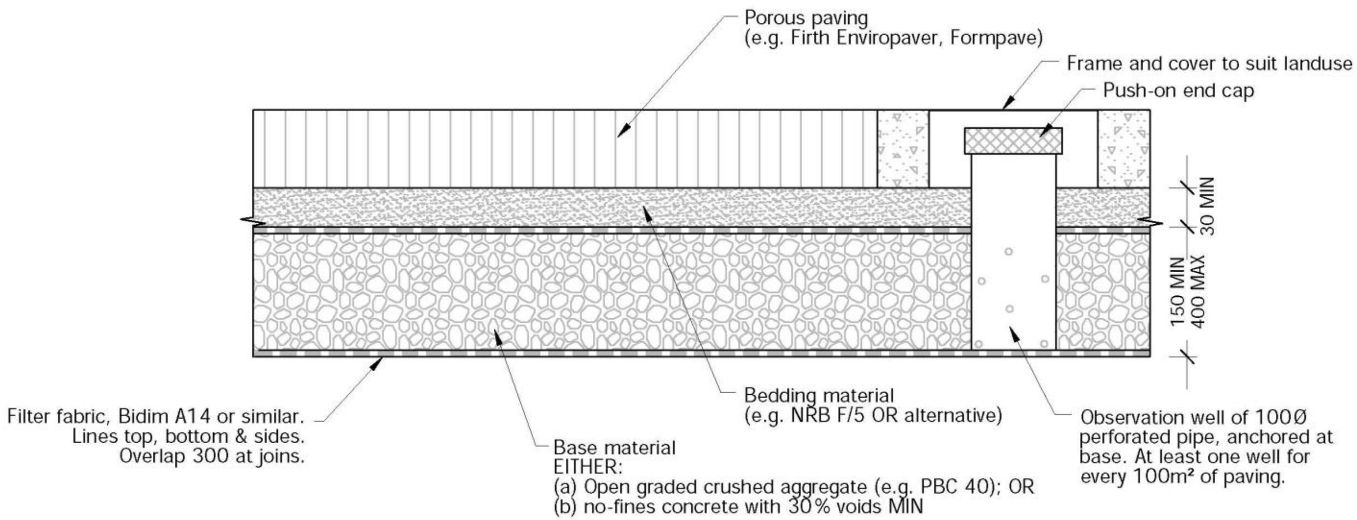
Project No. :	Drawing No. :	Revision :
AJ88301	05	A

AJ88301D004.dwg [Layout: 05]

Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Maximum slope = 3% unless baffles installed. These must be designed specifically to suit the site. 3% = 3/100
3. The porous base material must not be located within 1.0m of buildings or boundaries.
4. Only approved pavers may be used e.g. Firth Enviropaver or Formpave Aquaflow (all layers must have a minimum permeability of 2.5×10^{-4} m/s, and blocks must have proven long term performance).
5. Area to be paved must not be excessively travelled by heavy construction equipment either before or after paving installation.
6. Excavation to design depth should be left until all other construction is complete. Once paving is installed, it should only be used by light vehicles (unless otherwise specified by the manufacturer).
7. Paving to be installed according to manufacturers specification.
8. An operation and maintenance plan is required. Refer to Form SM006.

For low sediment loading sites only



Client : AUCKLAND CITY

Project : Stormwater Soakage Design Manual

Title : Porous Paving

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Scale: NTS

Project No. :	Drawing No. :	Revision :
AJ88301	06	A

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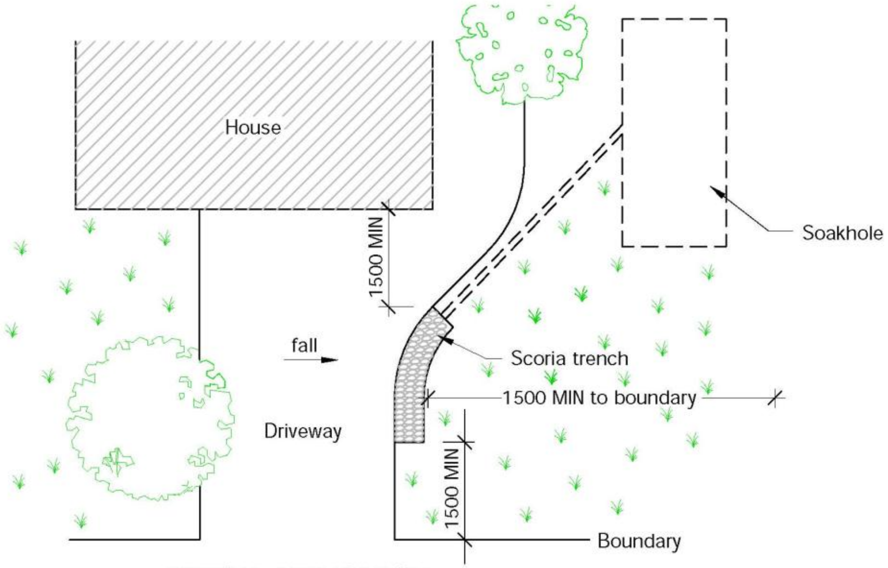


TYPICAL APPLICATION

Notes :

1. All dimensions are in mm (unless otherwise specified).
2. Trench not to be located beside retaining walls or within 2.0m of sanitary sewers.
3. Slope of trench to be between 0.5% and 5%.
4. Maximum driveway gradient of 5%.
5. Catchment to be less than 500m² equivalent impervious area.
6. 1.0m of trench to be provided for every 15m² of paved area.
7. An operation and maintenance plan is required. Refer to Form SM010.

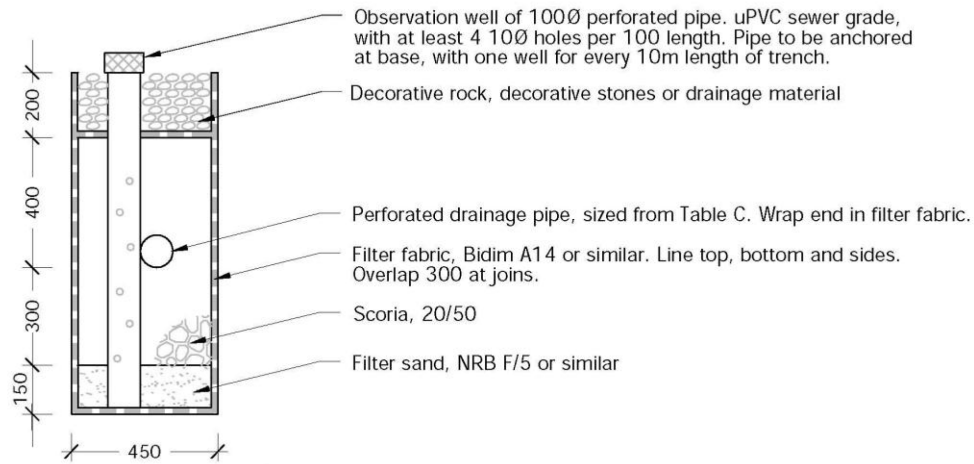
5% = 5 / 100

Table C

MAX Catchment Area*	MIN Pipe Size (mm)	
210 m²	100	
350 m²	125	
500 m²	150	

* Measured as equivalent impervious area (tick)

For low sediment loading sites only



SECTION

Client : AUCKLAND CITY

Project : Stormwater Soakage Design Manual

Title : Scoria Trench

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PATTLE DELAMORE PARTNERS LTD

Scale: NTS

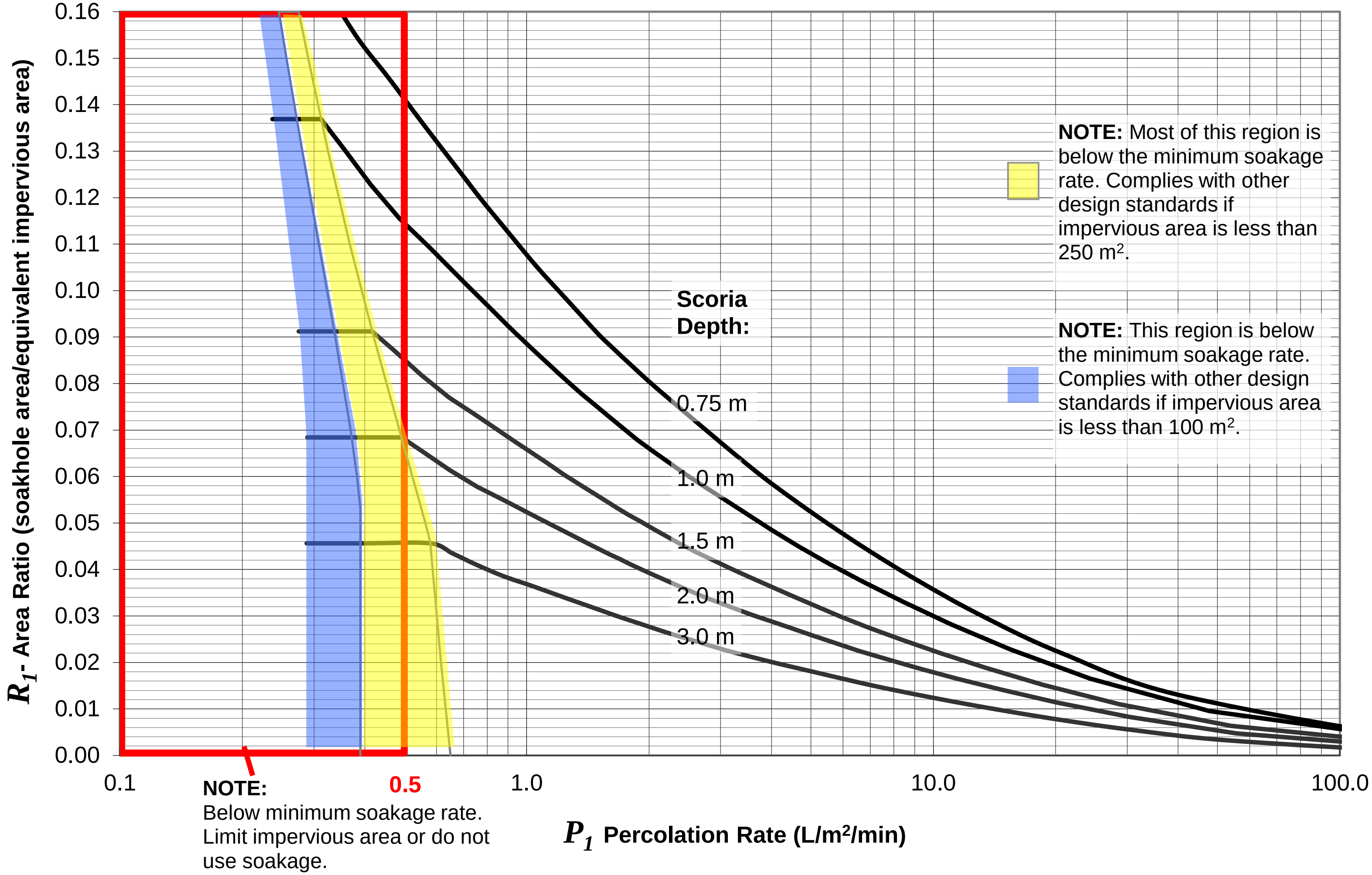
Project No. :	Drawing No. :	Revision :
AJ88301	08	A

AJ88301D001.dwg [Layout: 08]

Annexure B – Charts

No.	Title
1	Area Ratios for Soakholes [Soakpits]
2	Storage Requirements for all Soakholes [Soakpits]
3	Filter-strip Sizing
4	Permanent Storage Sizing
5	Orifice Area to Diameter Conversion
6	Orifice Area Sizing

CHART 1. Area Ratios for Soakholes (only valid if equivalent impervious area < 1000 m²)



C1

CHART 2 -Storage Requirements for all Soakholes

C2

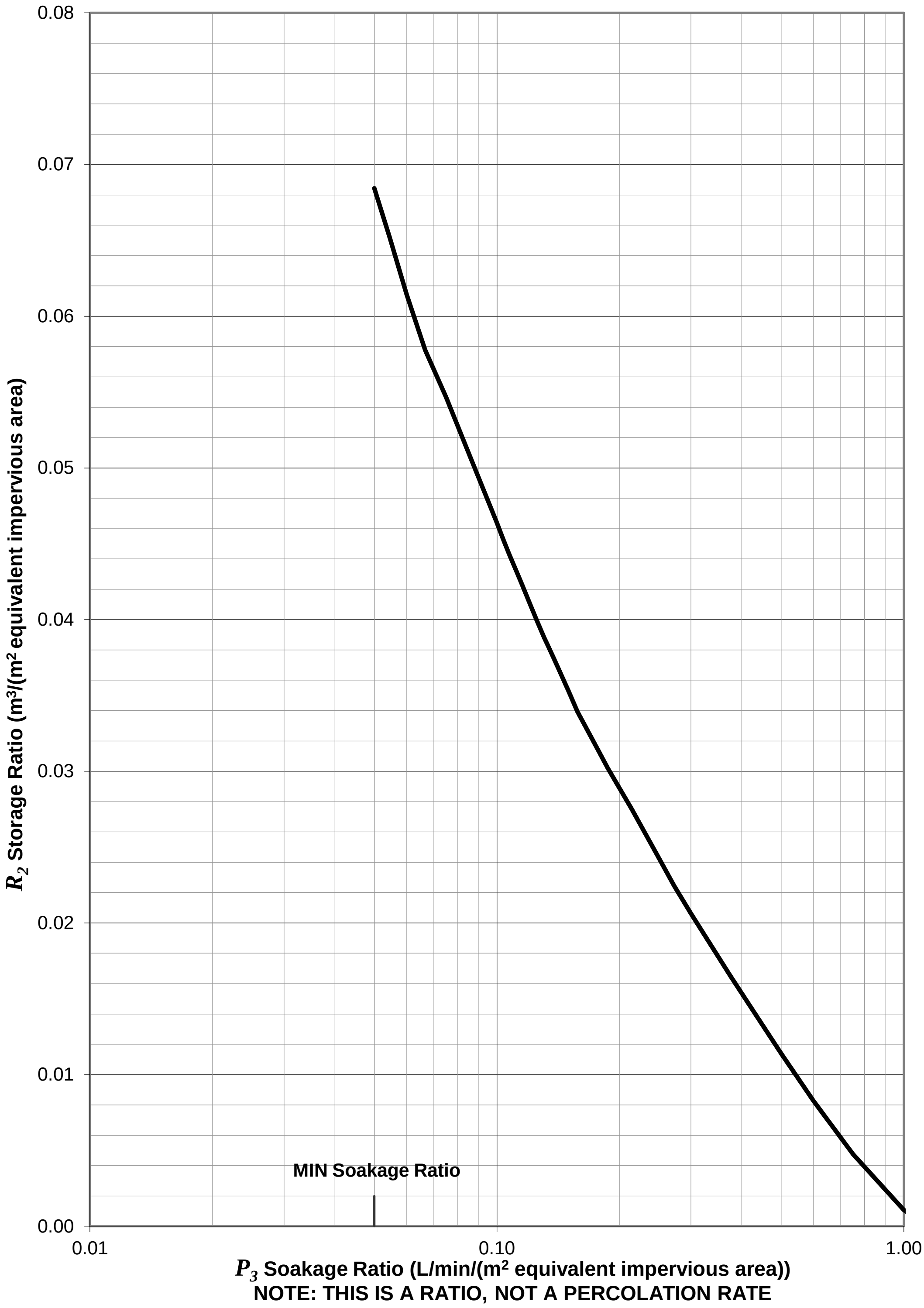
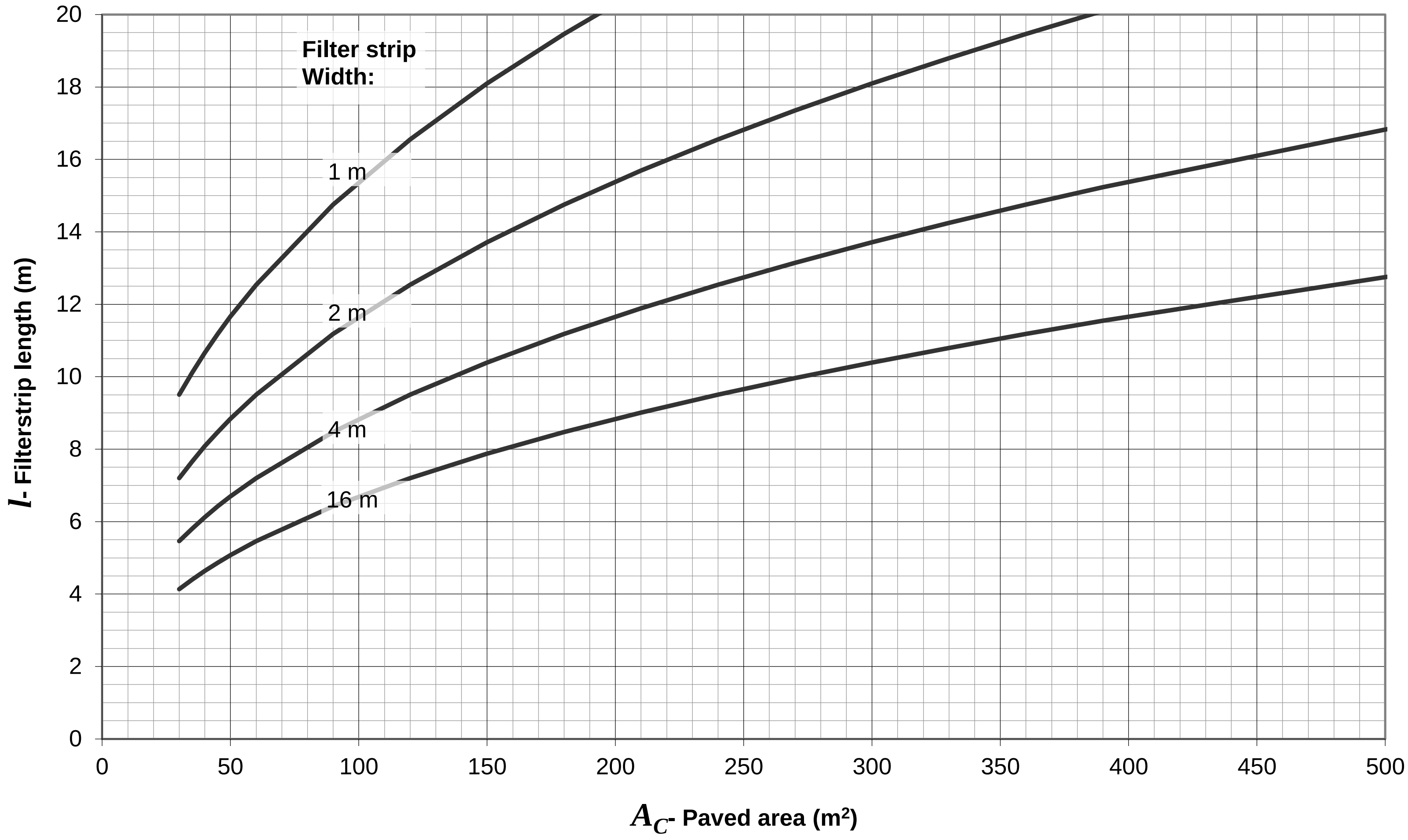


CHART 3. Filterstrip Sizing



C3

CHART 4: Permanent Storage Sizing

C4

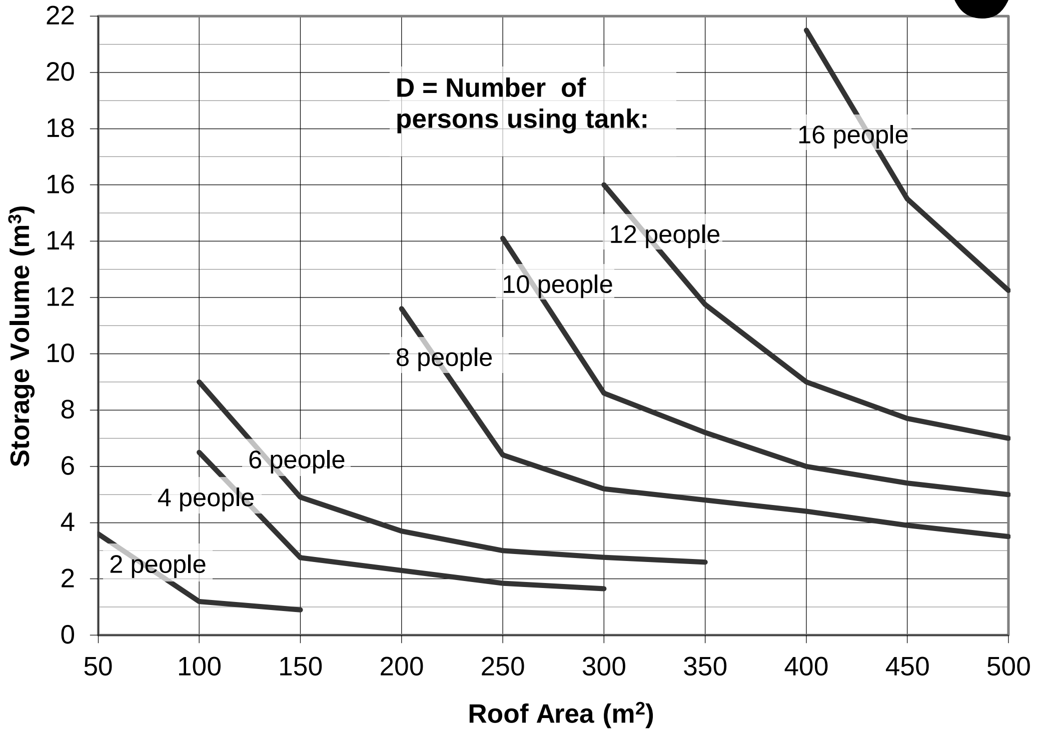


CHART 5: Orifice Area to Diameter Conversion

C5

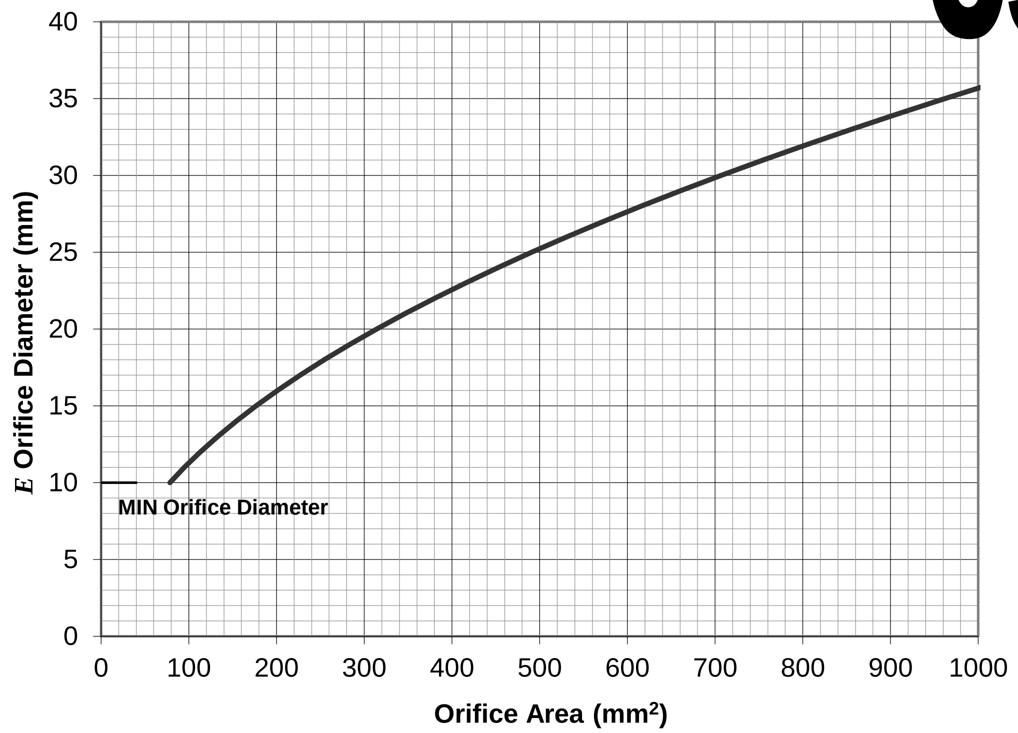
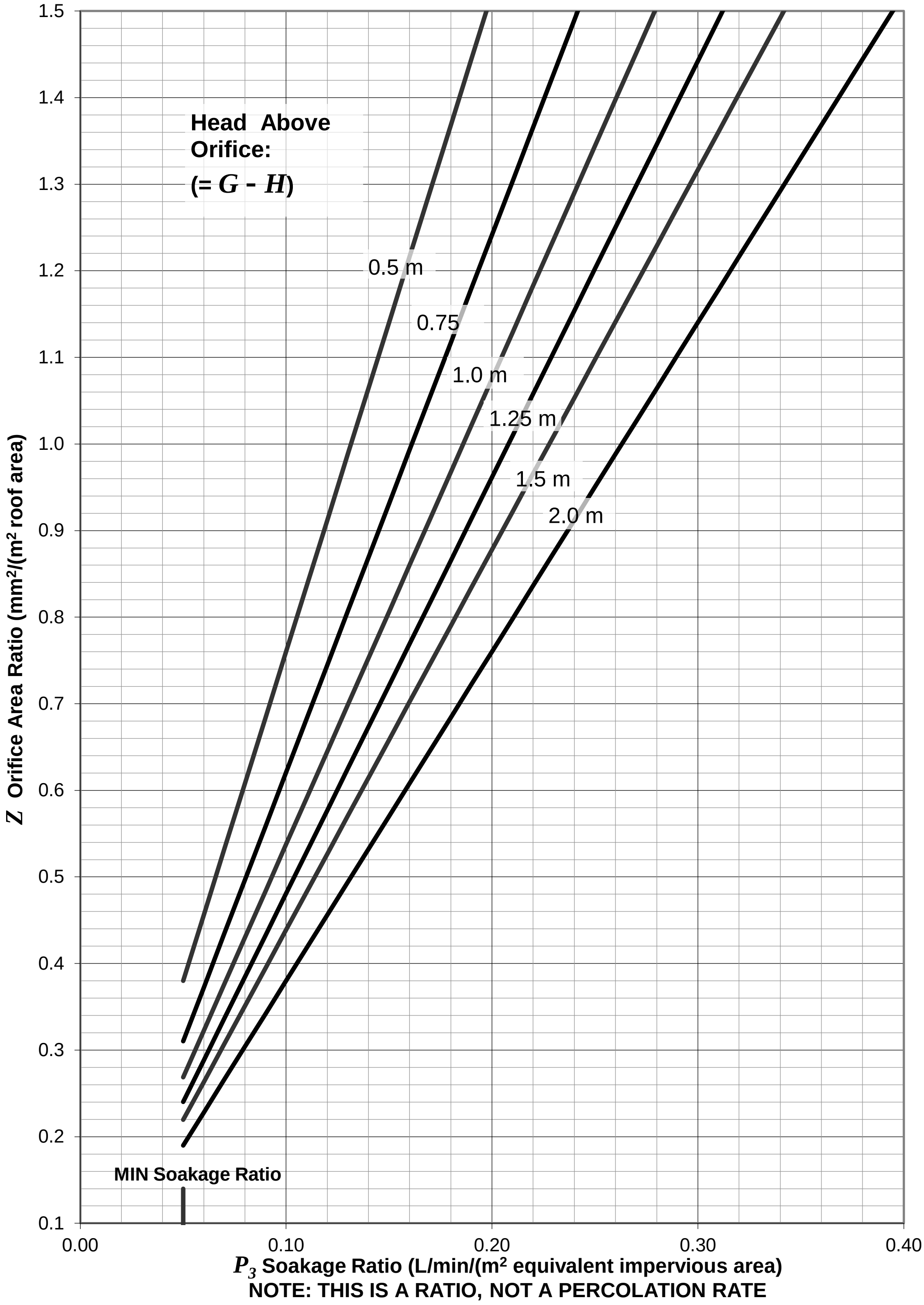


CHART 6 -Orifice Area Sizing

C6



Annexure C - Worksheets

WORKSHEETS:

No.	Title
1	Falling Head Percolation Test
2	Constant Head Percolation Test
3	Onehunga and Filter-strip Soakpits
4	Rockbore Soakhole
5	Raingarden for Soakage and Pre-treatment
6	Pre-treatment Devices
7	Nominal Soakhole [Soakpits] and On-site Storage
8	All Soakholes except Rockbore [ie soakpits]
9	Raintank Sizing

EXAMPLES:

No.	Title
1	Worksheet 3
2	Worksheet 4
3	Worksheet 5
4	Worksheet 6
5	Worksheet 7
6	Worksheet 7
7	Worksheet 8
8	Worksheet 9

W1

WORKSHEET 1. FALLING-HEAD PERCOLATION TEST

Site Address: ______________________________

Completed by: ______________________________

Date of test: ____________________ Signature: ____________________

Attach the following:

- ☐ Log of hole showing depth, soil type and moisture content
- ☐ Site-plan showing the location of the hole
- ☐ Graph of water level against time

(tick when attached)

- ☐ Civil Engineer
- ☐ Engineering Technician
- ☐ Engineering Geologist

(tick one)

Ensure the following procedures are followed:

- ☐ Hole is kept full for 17 hours prior to test (for pre-soaking)
- ☐ Drop in water level is recorded at intervals of 30 minutes or less
- ☐ Test is continued for 4 hours or until hole is empty
- ☐ Stop test or refill hole when water level is 0.25m above the base of the bore
- ☐ Percolation rate is determined from the minimum slope of the curve

(tick when complete)

1. Test Details

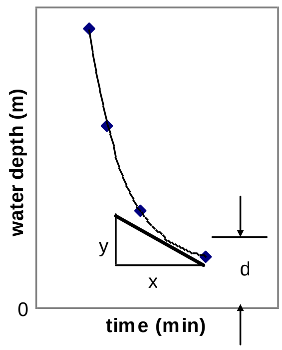
a) diameter of bore = D = ____________ m

(b) Water Depth(m)	Time (min)	Water Depth(m)	Time (min)

2. Calculate minimum gradient

(a) Minimum gradient** = $\frac{y}{x}$ = ____________ m/min

**a straight line interpolation between the last two points on the graph



3. Calculate percolation rate

(a) Percolation rate = $P_1 = \frac{D \times gradient \times 1000}{4 \times d*}$ = ____________ L/m^2/min

$*d$ =distance between the midpoint of the last two readings and the base of the borehole.

WORKSHEET 2. CONSTANT-HEAD PERCOLATION TEST

W2

Site Address: ______________________

Completed by: ______________________

Date of test: ______________________ Signature: ______________________

Attach the following:

- ☐ Log of borehole showing depth, geological layers and water table
- ☐ Site-plan showing the location of the hole

(tick when attached)

- ☐ Civil Engineer
- ☐ Engineering Technician
- ☐ Engineering Geologist

(tick one)

Ensure the following procedures are followed:

- ☐ A permit is obtained from Metrowater
- ☐ Hole is pre-soaked for 10 minutes prior to test
- ☐ Test is continued for 10 to 15 minutes
- ☐ Rockbores are maintained full
- ☐ Testpits are maintained ½ full
- ☐ Bores within 10m of each other are tested simultaneously
- ☐ Borehole drilling is attempted before constructing a testpit

(tick when complete)

3. Test Details

Time	Flowrate (L/s)	Time	Flowrate (L/s)

4. Determine capacity of rockbore/testpit :

(a) Capacity of bore = $P_2 = \dfrac{Flowrate*}{1.3}$ = ______________ L/s

* Use the end-of-test flowrate.

6. Percolation Rate (testpit only)

(do not complete this step for rockbores)

(a) Soakage surface (½ total wall area + base area) = ______________ m^2

(b) Percolation rate = $P_1 = \dfrac{P_2 \times 60}{(soakage\_surface)}$ = ______________ $L/m^2/min$

WORKSHEET 3. ONEHUNGA AND FILTER-STRIP SOAKPITS

W3

Site Address: ______________________________

Design by: ____________________ Date: ____________

1. Equivalent Impervious Area

Cover Type	Area (m^2)	Ratio, R_E	Area x R_E (m^2)
Roof	A_R =	1	
Paved	A_C =	1	
Pervious (lawn etc)	A_P =	0.3	

(a)Equivalent impervious area(A_E): $\sum$ A_E = ____________ m^2

2. Determine Soakpit Area

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = ____________ $L/m^2/min$

(b) Choose soakpit depth = d = ____________ m

(c) Read off soakpit area ratio (from CHART 1) =R_1 = ____________ m^2/m^2

(d) Calculate soakpit area= $A_1 = R_1 \times A_E$ = ____________ m^2

Notes:

1. Use WORKSHEET 8 if A_E >1000m^2
2. Minimum soakpit width = 0.5 m
3. Minimum soakpit length = 1.0 m
4. Sizing is based on a porosity of 0.5
5. WORKSHEET 8 can be used for more accurate sizing

WORKSHEET 4. ROCKBORE SOAKHOLE

W4

Site Address: ______________________________

Design by: ____________________ Date: ____________

1. Equivalent Impervious Area

Cover Type	Area (m^2)	Ratio, R_E	Area x R_E (m^2)
Roof	A_R =	1	
Paved	A_C =	1	
Pervious (lawn etc)	A_P =	0.3	

(a)Equivalent impervious area(A_E): $\sum$ A_E = ____________ m^2

2. Rockbore Capacity (if no storage provided)

(a) Constant-head flow (from WORKSHEET 2)=P_2= ____________ L/s

(b) Maximum area that can be served by bore = $\frac{P_2 \times 60}{1.1}$ = ____________ m^2

(c) If area from (b)>A_E, no storage is needed and step 3 does not need to be completed.

3. Storage Required

(a)Catchment soakage ratio = $P_3 = \frac{P_2 \times 60}{A_E} =$ ____________ *

(b)Read off storage ratio (from CHART 2)=R_2= ____________ m^3/m^2

(c) Calculate storage required=R_2 x A_E = ____________ m^3

(d)Compare to available storage= ____________ m^3

*L/min/(m^2 equivalent impervious area)

WORKSHEET 5. RAIN-GARDEN FOR SOAKAGE AND PRE-TREATMENT

W5

Site Address: ____

Design by: ____________________ Date: ____________

1. Equivalent Impervious Area

Cover Type	Area (m^2)	Ratio, R_E	Area x R_E (m^2)
Roof	A_R =	1	
Paved	A_C =	1	
Pervious (lawn etc)	A_P =	0.3	

(a)Equivalent impervious area(A_E): $\sum A_E =$ ____________ m^2

2. Minimum Soil Area for Treatment

(a) Minimum area of soil = $A_T = A_C$ x 0.07= ____________ m^2

3. Minimum Scoria Area for Soakage

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = ____________ $L/m^2/min$

	Trial 1	Trial 2	
(b) Choose scoria depth = d =	________	________	m
(c)Read off soakhole area ratio(from CHART 1)=R_1 =	________	________	m^2/m^2
(d) Calculate scoria area= $A_1 = R_1 \times A_E$ =	________	________	m^2

(e) Compare A_1 and A_T. Designs are most cost effective if A_1 approximately equals A_T.

4. Raingarden Area

(a) Raingarden area is largest of A_1 and A_T = ________ ________ m^2

Notes:

1. Maximum A_E = 1000 m^2. If A_E>1000 m^2, use two or more smaller raingardens
2. If $A_1 > A_T$, consider increasing scoria depth and repeating 3(b) to 3(d).
3. If $A_1 < A_T$, consider decreasing scoria depth and repeating 3(b) to 3(d).
2. Minimum raingarden width = 0.5 m
3. Minimum raingarden length = 1.0 m

WORKSHEET 6. PRE-TREATMENT DEVICES

W6

Site Address: ____

Design by: ____________________ Date: ____________

1. Area feeding to Pre-treatment Devices

(a) Paved area = A_C = ____________ m^2

2. Rain-garden

(a) Minimum area of soil = A_C x 0.07 = ____________ m^2

Notes:

1. Maximum A_C = 1000 m^2
2. Minimum width = 0.5 m
3. Minimum length = 1.0 m

3. Sand-filter (approximate sizing only)

(a) Minimum area of sand = A_C x 0.007= ____________ m^2

Notes:

1. This sizing is based on a sand depth of 0.5 m, with 0.5 m of water above the sand.
2. Sandfilters should be constructed according to ARC design specifications in TP10[3].

4. Filter-strip

(a) Choose width of filter strip = W = ____________ m

(b) Read off minimum filter strip length (CHART 4) = ____________ m

Notes:

1. Minimum width = 1.0 m
2. Only valid for filterstrip slopes of 1% (0.01 m/m). See ARC TP10[3] for other slopes.
3. Design the fiterstrip soakhole using WORKSHEET 3.
4. The fiterstrip soakhole must be at least as long as the filterstrip is wide.
5. The grass length must be between 50 mm and 150 mm.

5. Scoria Trench

(a) Minimum length of trench = A_C x 0.067 = ____________ m

Notes:

1. If using with a filter-strip, length of trench should equal width of filter-strip.

WORKSHEET 7. NOMINAL SOAKHOLE & ON-SITE STORAGE

W7

Site Address: ______________________________

Design by: ____________________ Date: ____________

1. Nominal Soakhole

(a) Roof area + paved area = $A_R + A_C = A_E =$ ____________ m^2

(b) Soakhole volume = $A_E \times 0.1$ = ____________ m^3

Notes:

1. A_E must be less than 20 $m.^2$
2. Soakhole must be at least 0.5 m wide.

2. On-site Storage

(a) Storage required (from WORKSHEET 8) = V_1 = ____________ m^3

(b) Additional storage required (from WORKSHEET 8)= V_3 = ____________ m^3

(c) Maximum onsite storage allowed = V_5 = 0.4 x V_1 = ____________ m^3

Notes:

1. If $V_3 > V_5$, the dimensions of the soakage system must be increased.
2. On-site storage must not exceed a maximum depth of 250 mm.
3. Attach sheet showing calculations of on-site storage.
4. Stored water must comply with Building Act and District Plan requirements for floodwaters.
5. There must be a freeboard of 20 to 50 mm.

WORKSHEET 8. ALL SOAKHOLES EXCEPT ROCKBORE

W8

Site Address: ______________________________

Design by: ____________________ Date: ____________

1. Equivalent Impervious Area

Cover Type	Area (m^2)	Ratio, R_E	Area x R_E (m^2)
Roof	A_R =	1	
Paved	A_C =	1	
Pervious (lawn etc)	A_P =	0.3	

(a)Equivalent impervious area(A_E): $\sum$ A_E = ______ m^2

2. Soakhole Area

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = ______ $L/m^2/min$

	Trial 1	Trial 2	
(b) Choose dimensions of soakage system (width, length and depth of scoria: see Notes 1,2)	______	______	
	______	______	
	______	______	
(c) Calculate surface area for soakage =(soakhole base area) + 0.5(soakhole wall area) = A_2 =	______	______	m^2
(d)Catchment soakage ratio = $P_3 = \frac{P_1 \times A_2}{A_E} =$	______	______	*
(e)Read off storage ratio (CHART 2)=R_2 =	______	______	m^3/m^2
(f) Calculate storage required= $V_1 = R_2 \times A_E$ =	______	______	m^3
(g)Calculate available storage (see Notes 3, 4) = V_2 =	______	______	m^3
(h)Additional storage required (see Note 5) = $V_3 = V_1 - V_2$ =	______	______	m^3

*L/min/(m^2 equivalent impervious area)

Notes:

1. WORKSHEET 3 and CHART 1 may assist with 2(b)
2. Minimum soakhole length = 1.0 m, minimum soakhole width = 0.5 m
3. Use 0.5 as the void ratio for scoria
4. For scoria-filled holes, V_2 = length x width x depth x 0.5
5. If V_3 > 0, either provide site storage (WORKSHEET 7), a raintank (WORKSHEET 9) or increase dimensions of soakage system and repeat 2(a)-(h).

____

Example 1

This example demonstrates the use of Worksheet 3 for a property with the following characteristics:

Roof area: *200 m²*

Paved area: *100 m²*

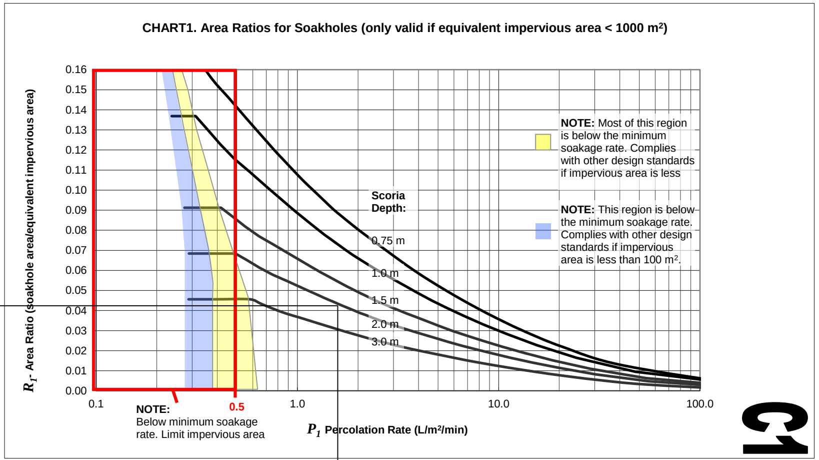
Grassed area that will contribute runoff: *100 m²*

Soil conditions: *Non-rock area*

Percolation rate = 1.5 L/m²/min

The design will be used as an Onehunga soakhole, with a 1.05 m diameter chamber placed inside the soakhole.

0.044



1.5

WORKSHEET 3. ONEHUNGA AND FILTER-STRIP SOAKHOLES **W3**

Site Address: *130 Example Ave, Epsom*

Design by: *Joseph Bloggs* Date: *03/09/02*

1. Equivalent Impervious Area

Cover Type	Area (m²)	Ratio, R_E	Area x R_E (m²)
Roof	A_R=*200*	1	*200*
Paved	A_C=*100*	1	*100*
Pervious (lawn etc)	A_P=*100*	0.3	*30*

(a)Equivalent impervious area(A_E): $\sum$ A_E=*330* m²

2. Determine Soakhole Area

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = *1.5* L/m²/min

(b) Choose soakhole depth = d = *2.0* m

(c) Read off soakhole area ratio (from CHART 1) =R_1 = *0.044* m²/m²

(d) Calculate soakhole area= $A_1 = R_1 \times A_E$ = *14.5* m²

Notes:
1. Use WORKSHEET 8 if A_E >1000m²
2. Minimum soakhole width = 0.5 m
3. Minimum soakhole length = 1.0 m
4. Sizing is based on a porosity of 0.5
5. WORKSHEET 8 can be used for more accurate sizing

If width = 3 m, length = 5 m.

Example 2

This example demonstrates the use of Worksheet 4 for a property with the following characteristics:

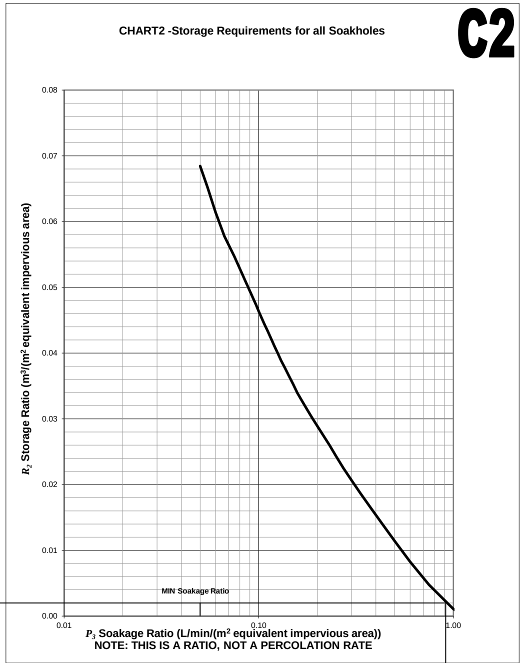
Roof area: *200 m²*

Paved area: *100 m²*

Grassed area that will contribute runoff: *100 m²*

Soil conditions: *Rock area*

Capacity of bore = 5.0 L/s



0.002

0.91

WORKSHEET 4. ROCKBORE SOAKHOLE **W4**

Site Address: *130 Example Ave, Epsom*

Design by: *Joseph Bloggs* Date: *03/09/02*

1. Equivalent Impervious Area

Cover Type	Area (m²)	Ratio, R_E	Area x R_E (m²)
Roof	A_R=200	1	200
Paved	A_C=100	1	100
Pervious (lawn etc)	A_P=100	0.3	30

(a)Equivalent impervious area(A_E): $\sum$ A_E=330 m²

2. Rockbore Capacity (if no storage provided)

(a) Constant-head flow (from WORKSHEET 2)=P_2= 5 L/s

(b) Maximum area that can be served by bore = $\frac{P_2 \times 60}{1.1}$ = 273 m²

(c) If area from (b)>A_E, no storage is needed and step 3 does not need to be completed.

3. Storage Required

(a)Catchment soakage ratio = $P_3 = \frac{P_2 \times 60}{A_E} =$ 0.91 *

(b)Read off storage ratio (from CHART 2)=R_2= 0.002 m³/m²

(c) Calculate storage required=$R_2 \times A_E$ = 0.66 m³

(d)Compare to available storage= 1.3 * m³

**If a 1.05 m diameter chamber is used (1.5 m deep)*

*L/min/(m² equivalent impervious area)

Example 3

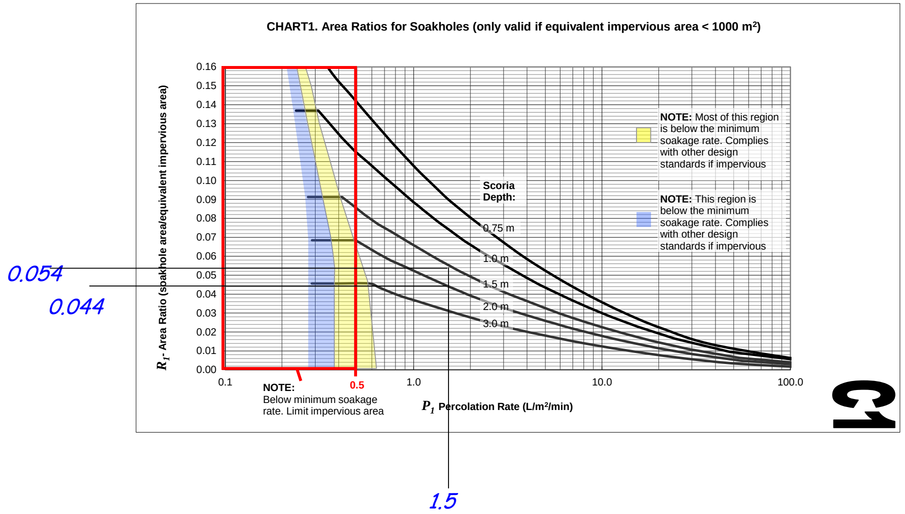
This example demonstrates the use of Worksheet 5 to size a raingarden to dispose of site runoff only:

Paved area: $100\ m^2$

Grassed area that will contribute runoff: $100\ m^2$

Soil conditions: *Non-rock area*

Percolation rate = 1.5 L/m² /min



WORKSHEET 5. RAIN-GARDEN FOR SOAKAGE AND PRE-TREATMENT **W5**

Site Address: *130 Example Ave, Epsom*

Design by: *Joseph Bloggs* Date: *03/09/02*

1. Equivalent Impervious Area

Cover Type	Area (m²)	Ratio, R_E	Area x R_E (m²)
Roof	A_R = *0*	1	*0*
Paved	A_C = *100*	1	*100*
Pervious (lawn etc)	A_P = *100*	0.3	*30*

(a)Equivalent impervious area(A_E): $\sum A_E$ = *130* m²

2. Minimum Soil Area for Treatment

(a) Minimum area of soil = $A_T = A_C$ x 0.07= *7* m²

3. Minimum Scoria Area for Soakage

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = *1.5* L/m²/min

	Trial 1	Trial 2	
(b) Choose scoria depth = d =	*2.0*	*1.5*	m
(c)Read off soakhole area ratio(from CHART 1)=R_1 =	*0.044*	*0.054*	m²/m²
(d) Calculate scoria area= $A_1 = R_1 \times A_E$ =	*5.7*	*7.0*	m²

(e) Compare A_1 and A_T. Designs are most cost effective if A_1 approximately equals A_T.

4. Raingarden Area

(a) Raingarden area is largest of A_1 and A_T = *7* m²

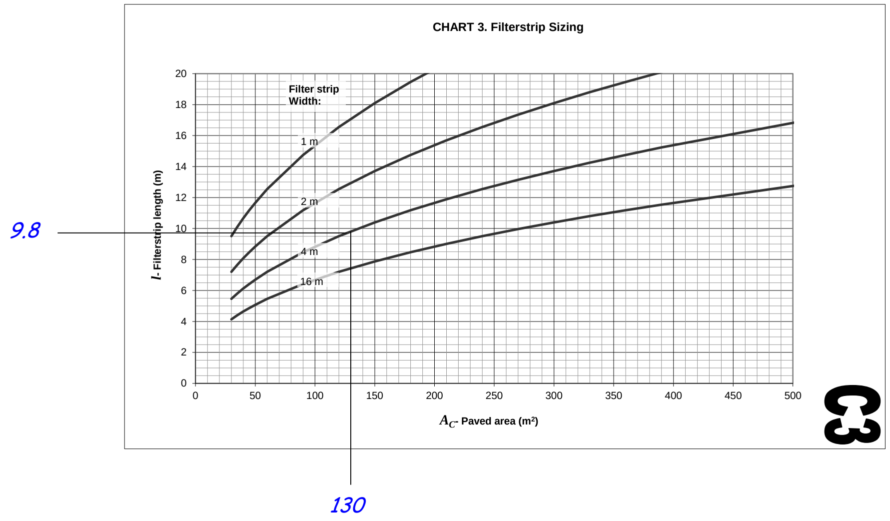
Notes:

1. Maximum A_E = 1000 m². If A_E >1000 m², use two or more smaller raingardens
2. If $A_1 > A_T$, consider increasing scoria depth and repeating 3(b) to 3(d).
3. If $A_1 < A_T$, consider decreasing scoria depth and repeating 3(b) to 3(d).
2. Minimum raingarden width = 0.5 m
3. Minimum raingarden length = 1.0 m

Example 4

This example demonstrates the use of Worksheet 6 to size pre-treatment devices for site runoff:

Paved area: 130 m^2



WORKSHEET 6. PRE-TREATMENT DEVICES **W6**

Site Address: 130 Example Ave, Epsom

Design by: Joseph Bloggs Date: 03/09/02

1. Area feeding to Pre-treatment Devices

(a) Paved area = A_C = 130 m^2

2. Rain-garden

(a) Minimum area of soil = A_C x 0.07 = 9.1 m^2

Notes:

1. Maximum A_C = 1000 m^2
2. Minimum width = 0.5 m
3. Minimum length = 1.0 m

3. Sand-filter (approximate sizing only)

(a) Minimum area of sand = A_C x 0.007= 0.9 m^2

Notes:

1. This sizing is based on a sand depth of 0.5 m, with 0.5 m of water above the sand.
2. Sandfilters should be constructed according to ARC design specifications in TP10[3].

4. Filter-strip

(a) Choose width of filter strip = W = 4 m

(b) Read off minimum filter strip length (CHART 4) = 9.8 m

Notes:

1. Minimum width = 1.0 m
2. Only valid for filterstrip slopes of 1% (0.01 m/m). See ARC TP10[3] for other slopes.
3. Design the fiterstrip soakhole using WORKSHEET 3.
4. The fiterstrip soakhole must be at least as long as the filterstrip is wide.
5. The grass length must be between 50 mm and 150 mm.

5. Scoria Trench

(a) Minimum length of trench = A_C x 0.067 = 8.7 m

Notes:

1. If using with a filter-strip, length of trench should equal width of filter-strip.

Example 5

This example demonstrates the use of Worksheet 7 to size a nominal soakhole:

Roof area: $20\ m^2$

Example 6

This example demonstrates the use of Worksheet 7 to check that on-site storage can be used for the soakhole sized in Example 7.

WORKSHEET 7. NOMINAL SOAKHOLE & ON-SITE STORAGE **W7**

Site Address: 130 Example Ave, Epsom

Design by: Joseph Bloggs Date: 03/09/02

1. Nominal Soakhole

(a) Roof area + paved area = $A_R + A_C = A_E$ = 20 m^2

(b) Soakhole volume = $A_E \times 0.1$ = 2 m^3

Notes:

1. A_E must be less than 20 m.[2]
2. Soakhole must be at least 0.5 m wide.

2. On-site Storage

(a) Storage required (from WORKSHEET 8) = V_1 = 12.2 m^3

(b) Additional storage required (from WORKSHEET 8)= V_3 = 3.2 m^3

(c) Maximum onsite storage allowed = $V_5 = 0.4 \times V_1$ = 5.0 m^3

Notes:

1. If $V_3 > V_5$, the dimensions of the soakage system must be increased.
2. On-site storage must not exceed a maximum depth of 250 mm.
3. Attach sheet showing calculations of on-site storage.
4. Stored water must comply with Building Act and District Plan requirements for floodwaters.
5. There must be a freeboard of 20 to 50 mm.

Example 7

This example demonstrates the use of Worksheet 8 for a property with the following characteristics:

Roof area: *200 m^2*

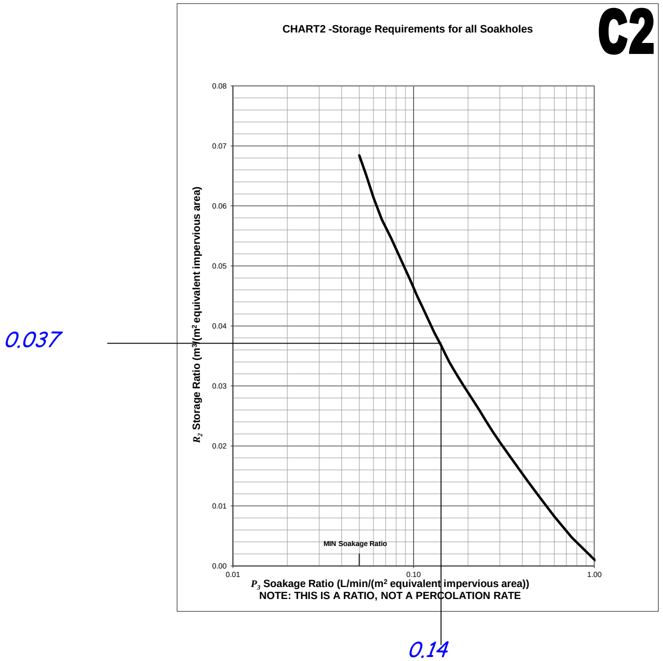
Paved area: *100 m^2*

Grassed area that will contribute runoff: *100 m^2*

Soil conditions: *Non-rock area*

Percolation rate = 1.5 L/m^2 /min

The soakhole has been undersized slightly, so that additional storage is required



WORKSHEET 8. ALL SOAKHOLES EXCEPT ROCKBORE **W8**

Site Address: *130 Example Ave, Epsom*

Design by: *Joseph Bloggs* Date: *03/09/02*

1. Equivalent Impervious Area

Cover Type	Area (m^2)	Ratio, R_E	Area x R_E (m^2)
Roof	A_R=*200*	1	*200*
Paved	A_C=*100*	1	*100*
Pervious (lawn etc)	A_P=*100*	0.3	*30*

(a)Equivalent impervious area(A_E): $\sum A_E$=*330* m^2

2. Soakhole Area

(a) Percolation rate (from WORKSHEET 1 or WORKSHEET 2)=P_1 = *1.5* L/m²/min

	Trial 1	Trial 2	
(b) Choose dimensions of soakage system (width, length and depth of scoria: see Notes 1,2)	*width =1.8 m*		
	length =10 m		
	depth = 1.0 m		
(c) Calculate surface area for soakage =(soakhole base area) + 0.5(soakhole wall area) = A_2 = *(1.8mx10m)+0.5(10mx1mx2+1.8mx1mx2)*	*29.8*		m²
(d)Catchment soakage ratio = $P_3 = \frac{P_1 \times A_2}{A_E}$ =	*0.14*		*
(e)Read off storage ratio (CHART 2)=R_2=	*0.037*		m³/m²
(f) Calculate storage required= $V_1 = R_2 \times A_E$ =	*12.2*		m³
(g)Calculate available storage (see Notes 3, 4) = V_2 =	*9.0*		m³
(h)Additional storage required (see Note 5) = $V_3 = V_1 - V_2$=	*3.2*		m³

Notes: *L/min/(m² equivalent impervious area)

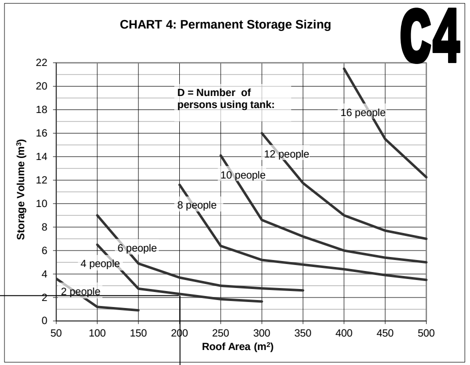
1. WORKSHEET 3 and CHART 1 may assist with 2(b)
2. Minimum soakhole length = 1.0 m, minimum soakhole width = 0.5 m
3. Use 0.5 as the void ratio for scoria
4. For scoria-filled holes, V_2 = length x width x depth x 0.5
5. If V3 > 0, either provide site storage (WORKSHEET 7), a raintank (WORKSHEET 9) or increase dimensions of soakage system and repeat 2(a)-(h).

Example 8

This example demonstrates the use of Worksheet 9 to size a rainwater tank for the soakhole sized in example 7.

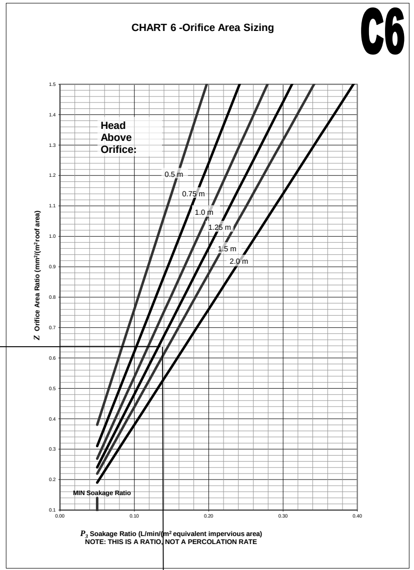
Note that two smaller rainwater tanks have been used instead of one large tank. The tanks will be connected together so they function as one tank, with a single orifice. This reduces the head above the orifice, and allows a larger orifice to be used.

2.2

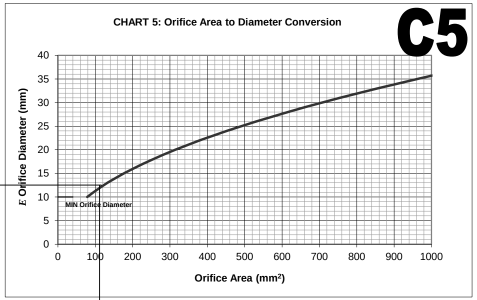


200

0.64



13



0.14

128

WORKSHEET 9. RAINWATER TANK SIZING

W9

Site Address: *130 Example Ave, Epsom*

Design by: *Joseph Bloggs* Date: *03/09/02*

1. Data (from WORKSHEET 8):

(a) Storage required = V_1 = *12.2* m³

(b) Additional storage required = V_3 = *3.2* m³

(c) Roof area = A_R = *200* m²

(d) Equivalent impervious area = A_E = *330* m²

2. Check that the Raintank can Provide Adequate Storage:

(a) Calculate roof component of storage= $V_4 = V_1 \times \frac{A_R}{A_E} =$ *7.4* m³

check: V_4 must be larger than V_3. If $V_4 < V_3$, the size of the soakage device should be increased.

3. Size Permanent Storage:

(a) Design number of people (= no. of bedrooms + 1) = D = *4* people

(b) Permanent storage capacity (CHART 4) = S = *2.2* m³

4. Select Tank

(a) Calculate minimum tank capacity = $T = V_3 \times 1.2 + (A_R \times 0.01) + S$ = *8.04* m³

(b) Select tank from available sizes: tank capacity = C = *2x4.4* m³

note: minimum C = 2m³

tank height (to overflow) = G = *1.87* m

5. Orifice Sizing

(a) Catchment soakage ratio (from Worksheet 8) = P_3 = *0.14* *

(b) Orifice height from base of tank = $H = \frac{G \times S}{C} =$ *0.47* m

(c) Read off orifice area ratio (CHART 6) = Z = *0.64* mm²/(m² roof area)

(d) Calculate orifice area = $A_R \times Z$ = *128* mm²

(e) Read off orifice diameter (CHART 5)** = E = *13* mm

**OR calculate using $E = 1.13 \times (\text{orifice area})^{0.5}$

*L/min/(m² equivalent impervious area)

note: Orifice diameters must be 10mm or larger. The orifice must be screened and details of the screen must be submitted for approval.

Annexure D – Worksheets

Operation & Maintenance Forms

FORM “OSM-O&M-PLAN”

(A) SITE & OSM DEVICE DETAILS:

(1) Site Address:____

(2) Owners Name:____

(3) Details of OSM Device(s):

Ref. No	Type	Size (eg m2 or m3)	Location	Runoff Source*

* eg roof, paved area

(4) Name & Address of Parties Responsible for Inspecting and Maintaining the Devices:

____

(B) O&M PLAN PREPARED BY:

(1) Firm:____

(2) Responsible Individuals Name: ________________________________

(3) Firms Address:____

(C) ATTACHED FORMS:

(1) Form “OSM-O&M-Routine”

(2) Forms “DEVICE-SPECIFIC O&M DETAILS”: (one for each OSM device)

Ref. No	Type

________________________ ________________

Signed Date

AC Office Use:

Reference No. ________________

Checked by: __________________ Date:______________

Entered by: __________________ Date:______________

FORM “OSM-O&M-ROUTINE”

List of Routine Maintenance Requirements

(a) Monitoring & Inspection Programme:

Routine monitoring and inspections are required to:

- Develop a condition history
- Improve scheduling efficiency
- Apply preventative maintenance

Inspection records are to be used to:

- Determine where special maintenance conditions exist
- Determine optimal frequencies for future inspection and maintenance
- Establish scheduled and unscheduled maintenance provisions
- Assure OSM device operation and aesthetics

Specific requirements cover:

- The owner will be responsible for conducting inspections (or having then done on his/her behalf) with the OSM device “as-built” plans in hand, generally at the following intervals (noting that this may vary, depending on site-specific conditions):
    - quarterly basis for the first 2 years
    - minimum of semi-annually thereafter
- The owner will be responsible for keeping inspection records to track the progressive development of the OSM device(s) over time, covering (note that these are to be available to the maintenance contractor noted in Section 11.2 and/or the City/ACE as may be required):
    - general condition of vegetation area(s), predominant plant species, distribution, and success rate (where applicable)
    - sediment condition and depth in forebay (or other pre-treatment structure), treatment facility, bench planting zones, and other sediment removal components
    - water elevations/observations (sheen, smell, etc.)
    - condition of the inlet, outlet, and overflow structures/devices, etc
    - unscheduled maintenance needs
    - components that do not meet performance criteria and require immediate maintenance
    - common problem areas, solutions, and general observations
    - aesthetic conditions

(b) Soils in Stormwater Planters & Rain Gardens:

The following requirements apply:

- Test the pH of planting bed soils in areas where vegetation has died:
  - if the pH is below 5.2, apply limestone
  - if the pH is above 7.0, add iron sulfate plus sulfur to reduce the pH
- Use core aeration of unvegetated areas if the surface of the bed becomes clogged with fine sediments over time: redesign plantings to correct problems, and re-establish soil coverage

(c) Vegetation Management:

Vegetated stormwater facilities may require a number of control practices, especially during the 2-year establishment period. Corresponding required practices cover:

- Maintain plantings for a period of 2 years after date of the Building Consent final inspection
- During the establishment period, remove undesired vegetation with minimal (or preferably no) use of toxic herbicides and pesticides at least three times in year 1, and once or twice in the summer of year 2; replace plants that die during this period within 3 months
- At the end of the second year, healthy plant establishment shall be achieved for at least 90% of the vegetation
- Selectively irrigate if necessary during the establishment period, during times of drought, or until the vegetation becomes established: it is preferred that the facility be designed to sustain its function without a permanent irrigation system
- Replenish mulch at least annually, and specify the mulching schedule in the O&M Plan; noting also that mulching shall be done to retain topsoil, heat, and moisture, and to inhibit weed growth
- Schedule maintenance outside sensitive wildlife and vegetation seasons
- Minimise plant disturbance during maintenance activities
- Do not use fertilisers, herbicides, or pesticides for vegetation maintenance, unless it is specifically called for in the O&M Plan
- Use replacement plants that conform with the initial planting plan

(d) Sediment Management/Pollutant Control:

Sediment and other pollutants that degrade water quality will accumulate in OSM devices and require removal to ensure proper operational performance. Corresponding requirements cover:

- Remove sediment when accumulations reach 100 mm in depth, or 50% of the designed sediment storage depth, or if sediment accumulation inhibits facility operation
- Dispose of the sediment in a safe manner
- If sediment and/or other pollutants are accumulating more rapidly than assumed when the O&M Plan was formulated, investigate and rectify the cause

(e) Access and Safety:

O&M programmes must provide for safe and efficient access to a facility. The following are general requirements; specific conditions may require site-specific modifications:

- Secure easements necessary to provide facility and maintenance access (if applicable)
- Use only suitably trained personnel to access confined spaces
- Maintain ingress/egress routes to design standards, in a manner that allows efficient maintenance of the facility
- Ensure that fencing is in good repair

FORM “OSM-O&M-CERT”

(A) SITE & OSM DEVICE DETAILS:

Site Address:____

Owners Name:____

Device(s):

Ref. No	Type	Size (eg m2 or m3)	Date Installed

(B) MAINTENANCE CONTRACTOR’S DETAILS:

Firms Name: ____

Firms Address: ____

Name of Serviceperson:____

Date(s) of Service:____

(C) SERVICE DETAILS:

Device Ref. No	Checklist Completed	MAINTENANCE ACTION	
		Item	**Action (describe, eg “pipe replaced”)**
	1	(a)	
		(b)	
		(c)	
		(d)	
	2	(a)	
		(b)	
		(c)	
		(d)	
	3	etc….(continue on a separate sheet)	

* on attached form “Device-Specific O&M Details”

(D) CERTIFICATION:

I/we hereby certify that:

- The OSM device inspection and maintenance programme has been undertaken in accordance with the provision of Section 11 of the City's "OSM Manual" dated 2002
- The details above and on the attached form(s) are a full and correct record of the work performed
- The OSM device(s) are in sound working order
- The owner has been advised of the problems found (if any) and alerted as to the need to inspect for any recurrences and rectify such promptly

_______________________   _______________

Signed   Date

ACE Office Use:

Reference No. _________________

Checked by: __________________   Date:______________

Entered by: __________________   Date: _______

FORM "DEVICE SPECIFIC O&M DETAIL SM001"- PAGE 1 OF 2
OPERATION AND MAINTENANCE OF ONEHUNGA SOAKPIT

Note: One form required for each OSM device on a site

(A) DESCRIPTION OF ONEHUNGA SOAKPIT

The Onehunga soakpit is a scoria filled pit that has a cavity constructed from either concrete or brick, called the "main chamber". The scoria filled part is covered with at least 300mm of soil, but the main chamber normally extends to the surface with a cast iron lid to allow access. Rainwater enters the main chamber through pipes, and then seeps away into the ground.

(B) OPERATIONAL POINTS

- The main chamber provides storage space, and helps catch silt and dirt that would otherwise travel into the scoria filled pit. While cleaning the chamber is an added expense, it will increase the lifetime of the soakage device.
- The soakpit should be empty 24 hours after a storm event. This can be checked by observing the water level in the main chamber.
- Any site runoff (from paved areas) feeding to the soakpit must first pass through a pre-treatment device. Maintenance of the pre-treatment device is covered under a separate O&M form, which also covers maintenance of any catchpits or stormwater pipes feeding to the pre-treatment device.
- Roof runoff flows through a separate smaller chamber before entering the main chamber (does not apply to soakpits installed prior to 2003). The small chamber will be connected to the pipework between the spouting and the soakpit.

(C) GENERAL O&M NEEDS

- Maintenance of flow through the spouting and downpipe system.
- Removal of leaves and sediment from the small chamber.
- Removal of accumulated sediment from the main chamber.

Checking the soakage capacity of the soakpit

(D) RECORD KEEPING

- Completed Form must be submitted to AC. For 2 yearly inspections, the form must be submitted with and OSM-O&M Cert" form.
- A copy of the completed form (and any additional records) is to be kept on-site and made available to the plumber/drainlayer

Site Address:____
Building Consent Number:________________________________
Reference Number (from Form "OSM-O&M-Plan"):________________
Date Installed____

FORM "DEVICE SPECIFIC O&M DETAIL SM001" PAGE 2 OF 2

CHECKLIST – ONEHUNGA SOAKPIT

Frequency				Action	Estimates and Notes
After storm	Every 3 months	Every year	Every 2 years*		
√	√	√	√	**Spouting, downpipes and small chamber:** • Check for debris accumulation, blockages and leaks. • Remove waste material and maintain as necessary.	
			√	**Soakpit and main chamber:** • Check sediment level in chamber. Keeping sediment depths below 300mm will help extend the life of the soakpit. • Remove sediment as necessary. This is best achieved using an air vacuum system, and should be carried out at least every 4 years on commercial sites or 6 years on residential sites. • Check the water level in the chamber. Providing there has been no heavy rainfall for 24 hours, the chamber should be dry. If there is standing water in the soakpit, it should be repaired or replaced.	

*Plumber/Drainlayer Checklist

Plumber/Drainlayer Signature Date

Name Reg No

Company Name

Company Address

Site Address:

Building Consent Number:

Reference Number (from Form "OSM-O&M-Plan"):

Date Installed

<u>FORM "DEVICE SPECIFIC O&M DETAIL SM002"- PAGE 1 OF 2</u>

<u>OPERATION AND MAINTENANCE OF FILTERSTRIP SOAKPIT</u>

Note: One form required for each OSM device on a site

(A) DESCRIPTION OF FILTERSTRIP SOAKPIT

The Filterstrip soakpit is a rock filled pit that extends to the surface. There is 200mm of clean gravel or river rock in the top of the soakpit, followed by a filter fabric layer and then a scoria layer extending to the base. The soakpit also has an observation well, and this should be visible on the surface.

Rainwater from paved areas first flows over a grass filterstrip before entering the soakpit through the gravel or river rock layer. If the soakpit accepts rainwater from roof areas, this will be piped directly into the soakpit (without passing over the filterstrip).

(B) OPERATIONAL POINTS

- The soakpit should be empty 24 hours after a storm event. This can be checked by observing the water level in the observation well.
- If rainwater from roof areas enters the soakpit, it will pass through a small chamber first. The small chamber will be connected to the pipework between the spouting and the soakpit.
- Maintenance of the filterstrip is covered under a separate O&M form.

(C) GENERAL O&M NEEDS

- Removal of debris and sediment from the top of the soakpit.
- Checking the soakage capacity of the soakpit.
- Maintenance of flow through the spouting and downpipe system (if roof areas are connected).

(D) RECORD KEEPING

- Completed Form must be submitted to AC. For 2 yearly inspections, the form must be submitted with and OSM-O&M Cert" form.
- A copy of the completed form (and any additional records) is to be kept on-site and made available to the plumber/drainlayer

Site Address:____

Building Consent Number:______________________________________

Reference Number (from Form "OSM-O&M-Plan"):__________________

Date Installed____

.

FORM "DEVICE SPECIFIC O&M DETAIL SM002"- PAGE 2 OF 2
CHECKLIST – FILTERSTRIP SOAKPIT

Frequency				Action	Notes
After Storm	**Quarterly**	**Annually**	**2 Yearly***		
	√	√	√	**Spouting and downpipes:** • Check for debris accumulation, blockages and leaks. • Check that the overflow is not obstructed. • Check that any leaf-removing devices are operating correctly. • Carry out maintenance as necessary.	
		√	√	**Soakpit:** • Check for debris and sediment accumulation. • Remove debris and sediment as necessary.	
			√	**Soakpit:** • Check the water level in the inspection well. Providing there has been no heavy rainfall for 24 hours, the inspection well should be dry. • If there is standing water in the soakpit it should be repaired or replaced. • Remove top 200mm of stones to check filter fabric layer and sediment build up in stones. • Remove sediment and replace filter fabric as necessary.	

*Plumber/Drainlayer Checklist

Plumber/Drainlayer Signature Date
Name Reg No
Company Name
Company Address

Site Address:
Building Consent Number:
Reference Number (from Form "OSM-O&M-Plan"):
Date Installed

FORM "DEVICE SPECIFIC O&M DETAIL SM005"- PAGE 1 OF 2
OPERATION AND MAINTENANCE OF ROCKBORE SOAKHOLE"

Note: One form required for each OSM device on a site

(A) DESCRIPTION OF ROCKBORE SOAKHOLE :

The rockbore soakhole is a concrete chamber with a borehole extending down into fractured rock beneath the chamber. The chamber normally extends to the surface with a steel lid to allow access. The top of the borehole is lined with a PVC liner that ends in syphon or a coil of perforated pipe. Rainwater is piped into the concrete chamber, and flows into the borehole through the syphon or perforated pipe.

(B) OPERATIONAL POINTS

- Any site runoff (from paved areas) feeding to the soakhole will first pass through a pre-treatment device, such as a raingarden or a sandfilter. Maintenance of the pre-treatment device will be covered under a separate O&M form, and this will also cover maintenance of any catchpits or stormwater pipes feeding to the pre-treatment device.
- Roof runoff flows through a small chamber before entering the soakhole (does not apply to soakholes installed prior to 2003). The small chamber will be connected to the pipework between the spouting and the soakhole.

(C) GENERAL O&M NEEDS

- Maintenance of flow through the spouting and downpipe system.
- Removal of accumulated sediment from the chamber.
- Cleaning of the rockbore soakage surface.
- Checking the soakage capacity of the soakhole.

(D) RECORD KEEPING

- Completed Form must be submitted to AC. For 2 yearly inspections, the form must be submitted with and OSM-O&M Cert" form.
- A copy of the completed form (and any additional records) is to be kept on-site and made available to the plumber/drainlayer

Site Address:____
Building Consent Number:______________________________
Reference Number (from Form "OSM-O&M-Plan"):_______________
Date Installed____

FORM “DEVICE SPECIFIC O&M DETAIL SM005”- PAGE 2 OF 2

CHECKLIST – ROCKBORE SOAKHOLE

Frequency				Action	Notes
After Storm	**Quarterly**	**Annually**	**2 Yearly***		
√	√	√	√	**Spouting and downpipes:** • Check for debris accumulation, blockages and leaks. • Check that the overflow is not obstructed. • Check that any leaf-removing devices are operating correctly. • Carry out maintenance as necessary.	
			√	**Rockbore and chamber:** • If chamber is dry, remove sediment manually (eg using a shovel and bucket). • If chamber is wet, remove sediment using an air-vacuum system. • Check perforated pipe for clogging and correct operation. Clean and repair as necessary. • Remove borehole cap and check borehole is dry. • Carry out rockbore cleaning as required and at least every 4 years on commercial sites and 6 years on residential sites (process detailed below).	
				Rockbore cleaning: • Remove accumulated sediment from borehole using an air-vacuum system. • Hydro-blast borehole. • Use the air vacuum system to remove sediment loosened by hydroblasting. • Check that rockbore is draining correctly (if not, it may require replacement).	

*Plumber/Drainlayer Checklist

Plumber/Drainlayer Signature Date

Name Reg No

Company Name

Company Address

Site Address:

Building Consent Number:

Reference Number (from Form “OSM-O&M-Plan”):

Date Installed

FORM "DEVICE SPECIFIC O&M DETAIL SM006"- PAGE 1 OF 2
OPERATION AND MAINTENANCE OF POROUS PAVING"

Note: One form required for each OSM device on a site

(A) DESCRIPTION OF POROUS PAVING

Porous paving is a permeable paving surface covering a layer of gravel or no-fines concrete. Rain falling on the porous paving percolates through the paving surface, is temporarily stored in the gravel or no-fines concrete, and then seeps away into the ground. There is a layer of filter sand underneath the paving, and this helps filter out any contaminants in the rainwater. There is an observation well extending down into the gravel layer (normally installed beneath a plastic or metal cover).

(B) OPERATIONAL POINTS

- The gravel layer should be dry 24 hours after a storm event. This can be checked by observing the water level in the observation well.
- The porous paving can only accept runoff from grassed areas, not other paved areas paved with conventional paving.

(C) GENERAL O&M NEEDS

- Maintenance of plants overhanging the paving surface.
- Removal of debris and sediment from the permeable paving surface.
- Removal of debris and sediment from the overflow.
- Checking the soakage capacity of the gravel or no-fines concrete layer.

(D) RECORD KEEPING

- Completed Form must be submitted to AC. For 2 yearly inspections, the form must be submitted with and OSM-O&M Cert" form.
- A copy of the completed form (and any additional records) is to be kept on-site and made available to the plumber/drainlayer

Site Address:____
Building Consent Number:______________________________
Reference Number (from Form "OSM-O&M-Plan"):_______________
Date Installed____

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FORM “DEVICE SPECIFIC O&M DETAIL SM006”- PAGE 2 OF 2

CHECKLIST – POROUS PAVING

Frequency				Action	Notes
After Storm	**Quarterly**	**Annually**	**2 Yearly***		
	√	√	√	**Paving Surface:** • Remove debris and sweep, vacuum or mechanically brush surface as appropriate. • Maintain any vegetation that is supposed to be growing in the paving. This includes watering, fertilising and replacing dead plants. Grasses should be mown to less than 10cm using a catcher to catch clippings.	
			√	**Paving Drainage:** • Check that paving is draining adequately, with no ponding on the surface. • If necessary, lift paving and replace sand layer.	
√		√	√	**Overflow:** • Check that overflow is not obstructed. • Remove debris and sediment from top of overflow. • Remove top layer of stones and check for sediment build-up and/or clogging of the filter fabric layer. • Remove sediment and repair or replace filter fabric as necessary.	

*Plumber/Drainlayer Checklist

Plumber/Drainlayer Signature Date

Name Reg No

Company Name

Company Address

Site Address:

Building Consent Number:

Reference Number (from Form “OSM-O&M-Plan”):

Date Installed

Appendix B Soakage Design in Peat - Design Procedures

Peat recharge soakage devices (soakage device) consist of a 1050mm diameter manhole with an open base as the primary sedimentation chamber, connected to the soakage device with 110mm diameter slotted drainage coil. The soakage device is connected to groundwater via a 1m wide trench in the base of the soakage device excavated approximately 500mm into the peat layer.

20mm holes are drilled in the manhole at approximately 150mm spacing to provide additional paths for the stormwater to enter the soakage device. 300mm of dead storage is provided at the base of the manhole to allow for the accumulation of sediment not removed by the pre-treatment device. The soakage device is lined with geotextile filter cloth and backfilled with clean 20/50mm clean drainage scoria.

The sizing table is summarised as Table B1 below, and the standard details of the standard design is included as Figures B1 and B2 below.

A spreadsheet for calculating the soakage device dimensions is provided in the legacy Papakura Development Code (Appendix C of the Development Code). An Example Soakage Device Design in Peat calculation is shown in Figure B3.

The total site impervious area threshold for requiring a recharge device is 50m^2, however all developments between 50m^2 and 100m^2 require a device sized for 100m^2. Any development on a site that increases the impervious area by 20m^2 or more will require a soakage device sized for and connected to the entire impervious area of the site.

The largest impermeable area that can be used by one soakage device is 1000 m^2. For sites with more than 1000m^2 impervious area, a number of soakage devices will be required, which shall be spaced equidistantly around the site.

A minor geotechnical investigation is required to confirm the soil conditions in the proposed location of the soakage device.. The required results from this investigation are as follows:

- Depth to top of peat layer
- Depth to groundwater level

If the depth to the peat layer or the groundwater level is less than 1m or greater than 2.5m, consultation with AC engineers shall be undertaken to determine whether an amended version of the standard design or a different site specific groundwater recharge device is required.

Innovative designs, using items such as Mega-tanks with an assumed porosity in the range of 90-95%, should only be acceptable provided that the AC engineers are satisfied that the underlying design principle (i.e. storage and recharge of the first 15mm rainfall and runoff from all impervious areas (HG 2000)) is maintained.

Table B1 Recharge Device Dimension Table for Impervious Areas above 100m^2

Impervious Area of Proposed Development (m^2)	Soakage device Length (m)	Soakage device Width (m)	Base Trench Length (m)
100 or less	2.69	1.08	0.73
200	4.07	1.63	1.5
300	5.09	2.04	2.26
400	5.94	2.38	3.02
500	6.68	2.67	3.79
600	7.35	2.94	4.55
700	7.96	3.18	5.32
800	8.53	3.41	6.08
900	9.06	3.62	6.85
1000	9.56	3.82	7.61

It is recommended that soakage devices for sites within urban areas get sized for the maximum possible impervious area allowed by the relevant Plan, and not just the actual impervious area of the new development. This is so that any future developments on the site that may increase the actual impervious area will be possible without having to retrofit the soakage device to accommodate the increased runoff. Soakage devices for sites in rural areas can be sized for the actual impervious area of the development.

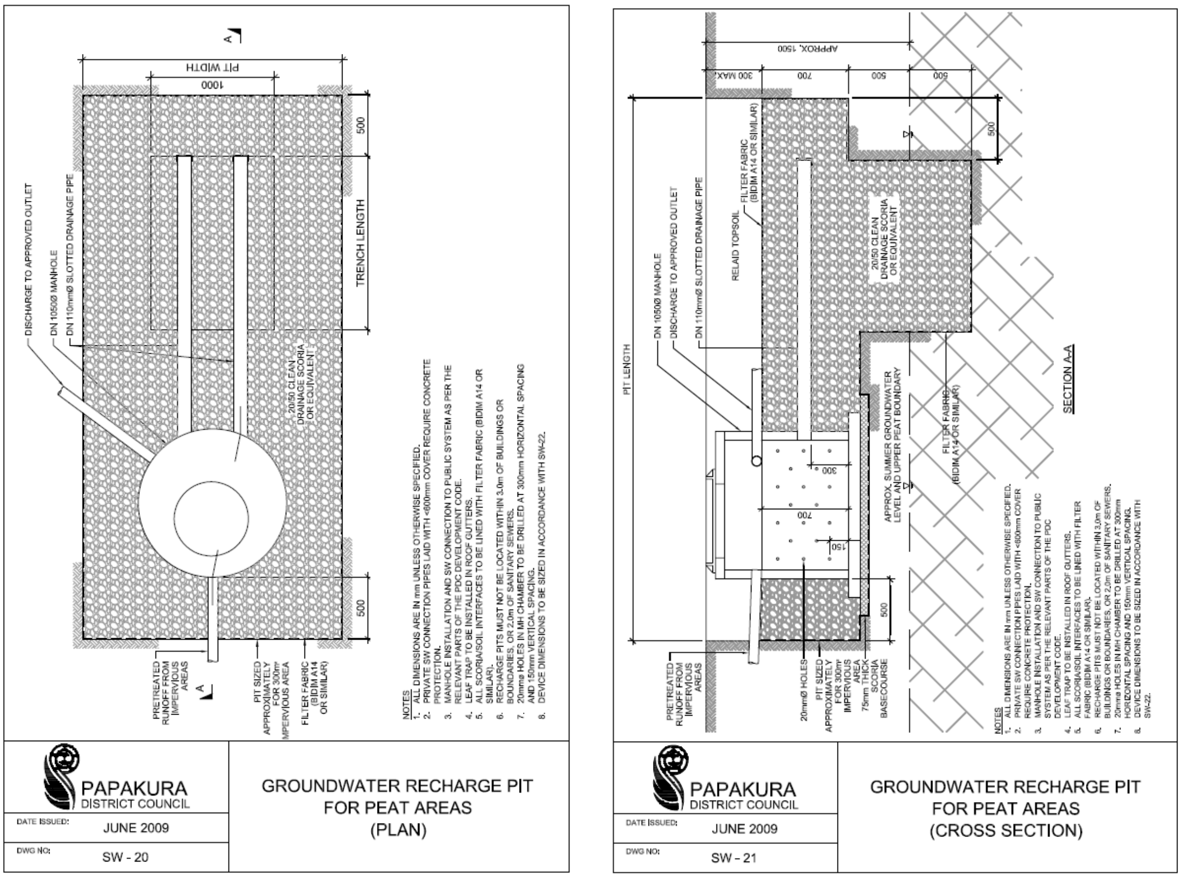


Figure B1- Relevant Drawings from Papakura Development Code

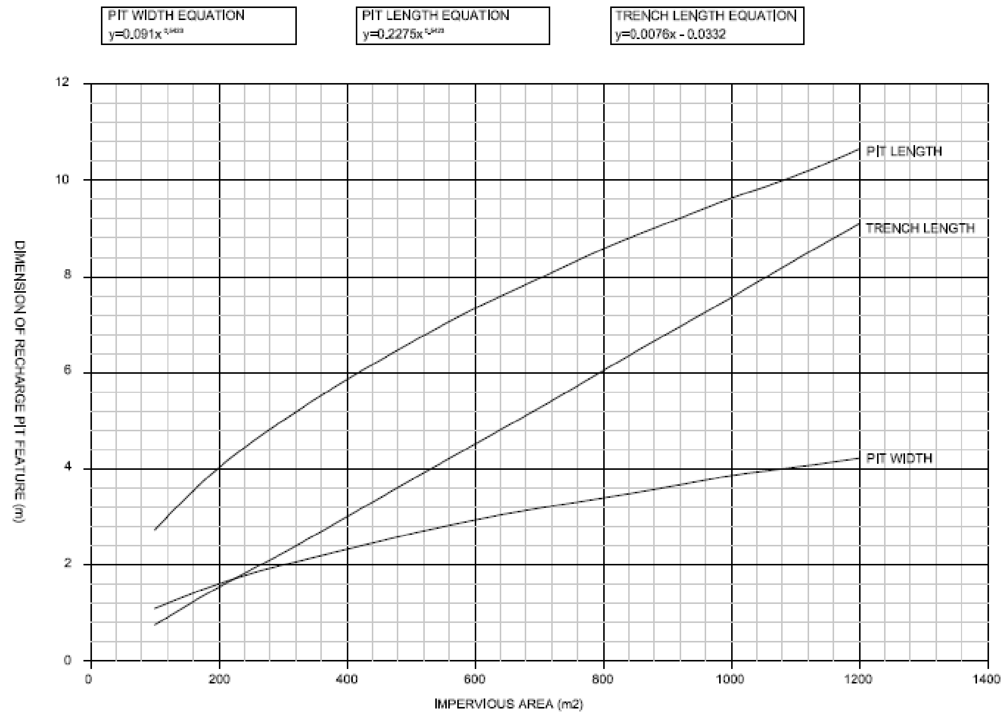
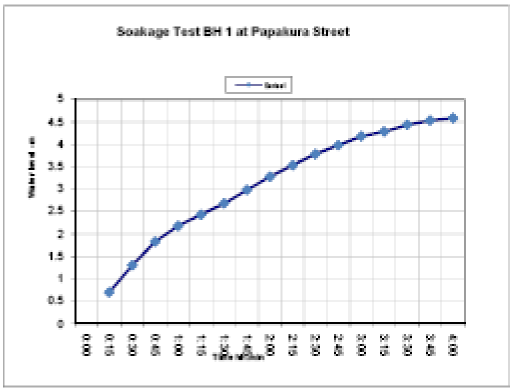


Figure B2 – Sizing of Recharge Pit

Soakage Pit Design

Refer Section 4.7 Stormwater Soakage
Note: Soakage Pit Design is to be carried out in accordance with the methodology used in the below example

Soakage Test Result at BH 1		
Time	Depth to Water	Total depth of water drop
0:00	0	
0:15	0.7	0.7
0:30	0.6	1.3
0:45	0.53	1.83
1:00	0.35	2.18
1:15	0.25	2.43
1:30	0.25	2.68
1:45	0.3	2.98
2:00	0.3	3.28
2:15	0.25	3.53
2:30	0.25	3.78
2:45	0.2	3.98
3:00	0.2	4.18
3:15	0.1	4.28
3:30	0.15	4.43
3:45	0.1	4.53
4:00	0.05	4.58



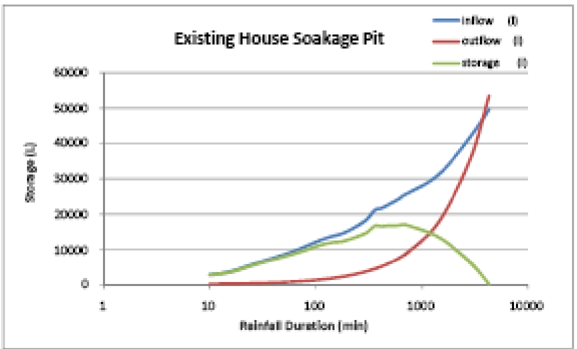
Borehole details		
Diameter of Hole (D)	m	0.1
Depth of Hole (H)	m	1.5
Average depth of water	m	0.928
Average Soakage Rate	mm/min	19.08
Area of Hole	m^2	0.299
Volume of Hole	m^3	0.15

Soakage Pit Design Parameters - Existing House Site		
Roof Area	m^2	100
Run off coefficient	C	0.96
Paved Area	m^2	50
Run off coefficient	C	0.8
Pervious Area	m^2	180
Run off coefficient	C	0.3
Total CA	m^2	194
Percolation Rate (Pa)	$L/m^2/min$	0.50
Pit Depth	m	1.5
Pit Width	m	3
Pit Length	m	6
Void Ratio		60%
Pit Volume	m^3	16.2
Pit Surface Area (As)	m^2	24.75

Existing House Soakage Pit - Onehunga Type

STORAGE (10 year)				
time	depth	inflow	outflow	storage
(min)	(mm)	(l)	(l)	(l)
10	14.0	2716	124	2592
15	18.0	3492	186	3306
20	24.0	4656	248	4408
30	33.0	6402	372	6030
60	48.0	9312	743	8569
120	67.0	12998	1486	11512
180	75.0	14550	2229	12321
240	85.0	16490	2972	13518
300	95.0	18430	3715	14715
360	**109.0**	**21146**	**4458**	**16688**
420	112.0	21728	5201	16527
480	117.0	22698	5944	16754
540	121.0	23474	6687	16787
600	125.0	24250	7430	16820
660	130.0	25220	8173	17047
720	133.0	25802	8917	16885
1440	161.0	31234	17833	13401
2880	216.0	41900	35666	6234
4320	256.0	49664	53499	0

inflow=`CA'dev"depth
outflow=As"Pa"time
storage=inflow-outflow



Emptying Time = 23 hrs

Figure B3– Example Soakage Device Design in Peat