STORMWATER DISCHARGE BY SOAKAGE IN THE AUCKLAND REGION

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ABSTRACT

Soakage of stormwater is part of the natural water cycle that feeds groundwater and stream flows. In some parts of Auckland, soakage systems have been used for many years as a means of easily and cheaply disposing of stormwater close to source. Some of these systems have been ignored and poorly maintained leading to a gradual build-up of sediment and a reduction in performance over time. Areas suitable for soakage have not always been well defined and soakage has been attempted in areas outside suitable geology. In Papakura, soakage to peat soils also maintains groundwater levels to avoid land settlement.

Auckland Council has released "Stormwater Disposal by Soakage in the Auckland Region" (Technical Report 2013:040). This contributes to Council's new Code of Practice for Land Development and Subdivision which provides a consistent set of standards for the design and construction for stormwater infrastructure across the region.

The use of soakage can contribute to water sensitive design and has advantages such as; allowing a discharge to occur close to its origin, avoiding the need for a pipe network, reducing flow to any downstream network and providing groundwater recharge.

KEYWORDS

Basalt, on site drainage, peat, soakage, water sensitive design

PRESENTER PROFILE

Roger Seyb is a water resources engineer with Pattle Delamore Partners in Auckland. His experience includes assessing the effects of discharges, consenting, stormwater drainage design and construction and stormwater treatment. Roger has a long interest in the interaction of water and land and its management.

1 INTRODUCTION

1.1 REPORT SCOPE AND PURPOSE

Auckland Council has released "Stormwater Disposal by Soakage in the Auckland Region" (Technical Report 2013:040). The purpose of this report was to provide technical information regarding disposal of large quantities of stormwater into the ground via soakage. In this context a "large" quantity is so that soakage provides the primary drainage system level of service (typically for a 10 year rainfall event). The report focuses on soakage to fractured basalt and peat soils. Peat soils were included due to their infiltrative capacity and the importance of maintaining ground water levels to prevent shrinkage and settlement. Previous council documents provided methods for soakage design, primarily in the former Auckland City Council (ACC) and Papakura District Council (PDC) areas. TR2013:040 now provides a consistent approach to soakage design across the region.

Soakage maps were developed to indicate areas in the Auckland Region that have confirmed (through previous testing) soakage into basalt and peat soils. They also showed areas where soakage is inferred (based on a comparison of soil/geological types) and gave an indication of the relative level of soakage expected. The ultimate purpose of the maps was to inform designers at the concept stage of the likely availability of soakage (which then needs to be confirmed through site investigations). Site specific soakage conditions may vary and other localised pockets of high infiltration capacity may exist that are not identified on these maps, e.g. sandy or peat areas on the west coast.

The design method for soakage devices has been reviewed and carried forward from the previous ACC soakage design manual, with some additional guidance regarding clogging.

The clogging analysis assessed the potential for sediment to block the sides and walls of soakage devices and predict the reduction in soakage capacity over time. This analysis was to inform designers of the typical land-use conditions requiring pre-treatment and give an indication of maintenance cycles.

1.2 PREVIOUS COUNCIL DOCUMENTS AND REPORTS

Two ACC documents were reviewed in order to reproduce key messages relating to soakage. These were, the Soakage Design Manual (SDM) and the On-site Stormwater Management Manual (OSSMM). A further document - the PDC Development Code includes a requirement to discharge a portion of stormwater runoff to ground in areas of peat soils (for the purposes of ground water recharge). This requirement was considered likely to be carried forward by the proposed Auckland Council Stormwater Code of Practice and a review of this document was therefore also included.

Soakage was also used by former councils in other volcanic areas such as Pukekohe, Devonport and Wiri – however specific design guidance documents were not identified.

A key purpose of TR2013:040 was to consolidate and update the information given in the identified documents and to provide a common resource for soakage design across the region.

2 SOAKAGE MAPS AND AREAS OF POTENTIAL APPLICATION

The Auckland Volcanic field covers a significant part of Auckland with significant basalt flows across the Auckland Isthmus and around volcanoes in Pukekohe, Manukau and the North Shore. In Papakura, peat beds can provide soakage; in fact, ongoing soakage is necessary to maintain groundwater levels and prevent settlement. These areas include 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 soakage testing, boreholes and experience of the geological characteristics of the areas.

The relative degrees of soakage for basalt 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

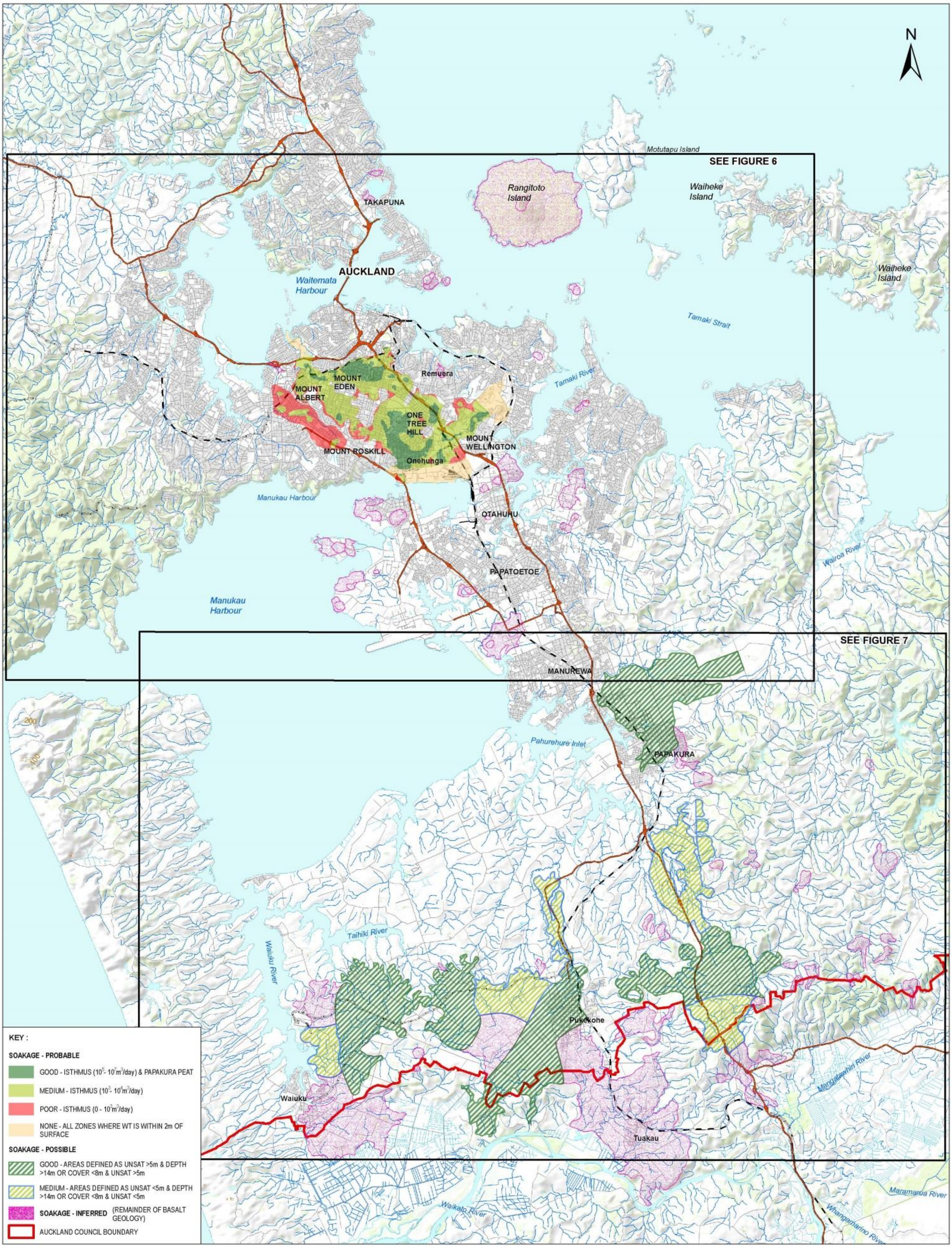
- The unsaturated depth of the basalt.

Soakage areas have been divided into three main areas, namely; 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 no 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.

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. There will therefore 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.

The following maps are adapted from the original report and detail areas of good, medium, low, or no potential soakage.



SOURCE:
1. TOPOGRAPHY INFORMATION DERIVED FROM LINZ.

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0 1.5 3 6
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Figure 1: Soakage in the Auckland Region

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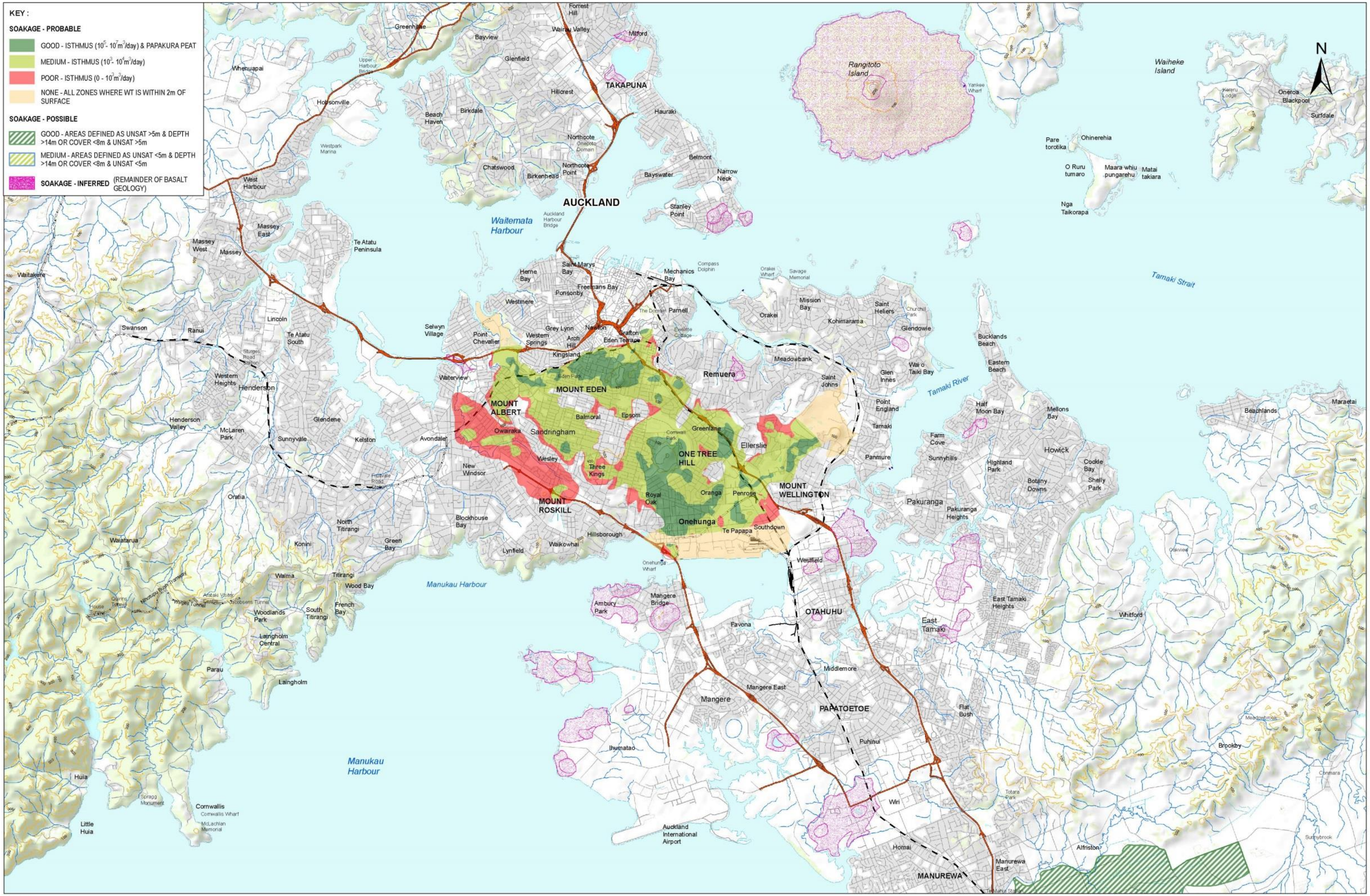

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Figure 2: Soakage in the Auckland Region - north

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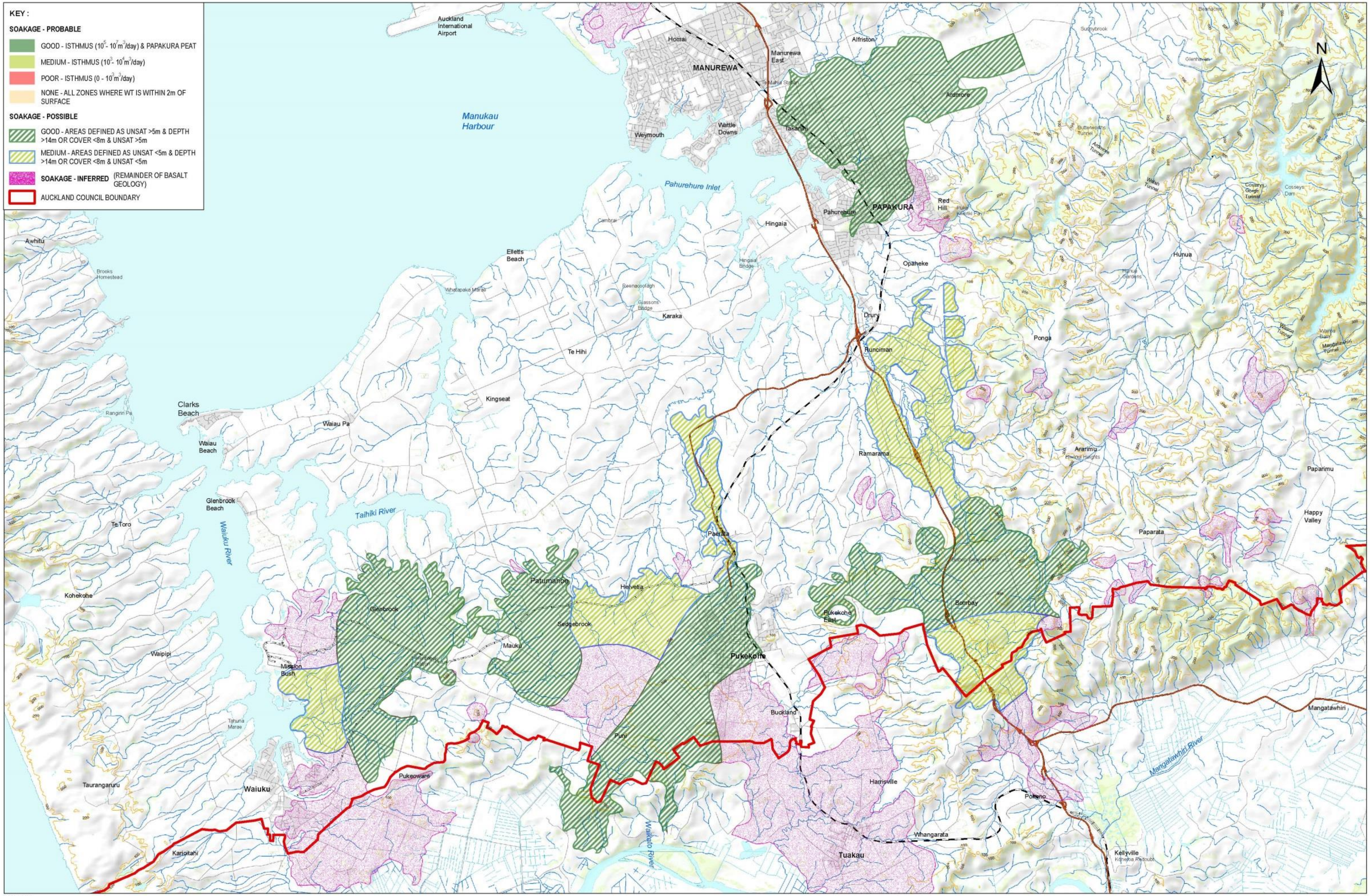

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Figure 3: Soakage in the Auckland Region - south

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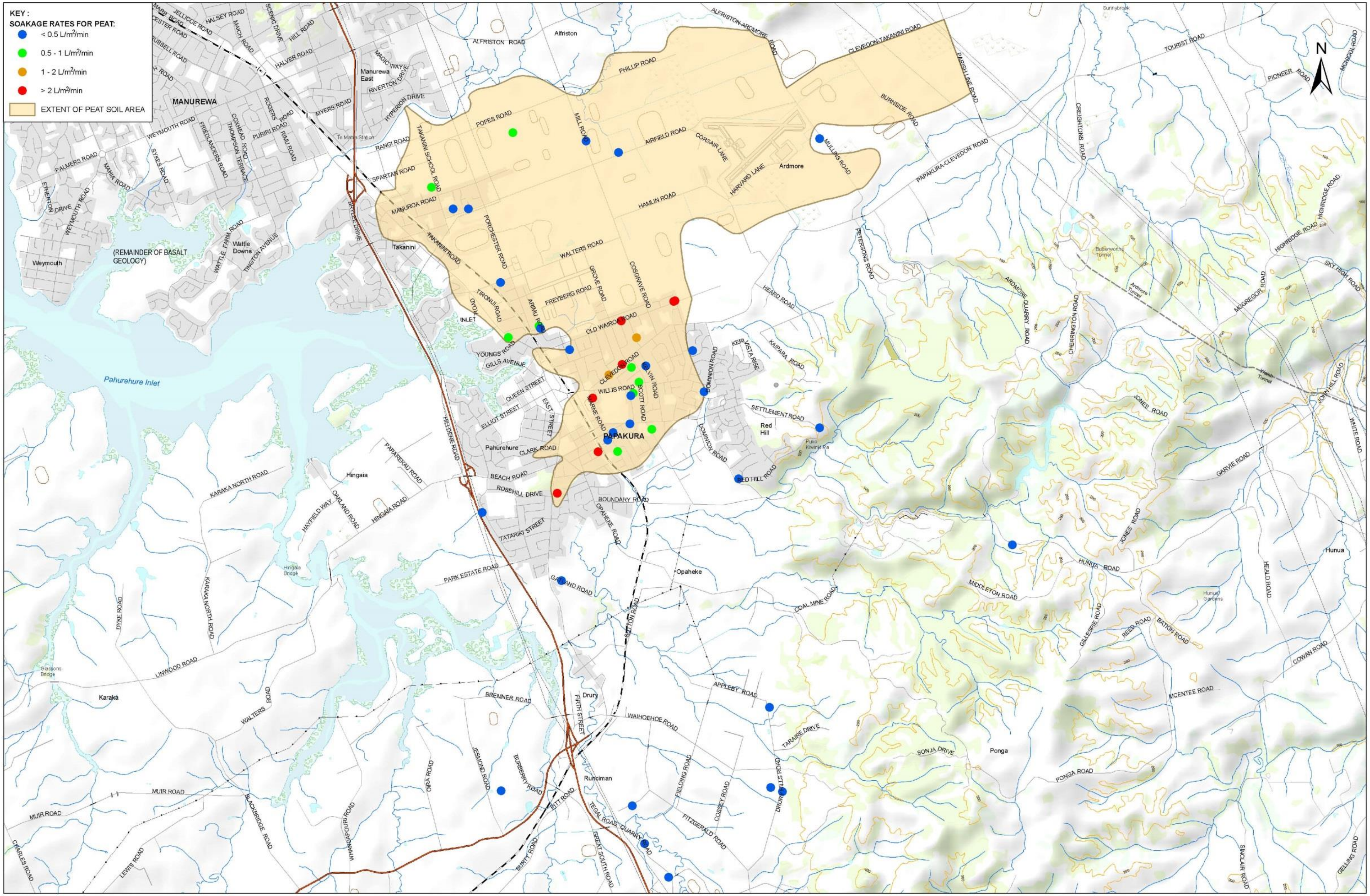

SOURCE:
1. EXTENT OF PEAT AREA ASSESSED FROM DISCUSSIONS WITH PAPAKURA DISTRICT COUNCIL STAFF, NZ GEOLOGICAL MAP, AND REVIEW OF SITE INVESTIGATION REPORTS HELD IN COUNCIL SITE FILES AND BARTLEY CONSULTANTS' SOIL CBR STRENGTH RATING MAP.
2. SOAKAGE RATE RESULTS OBTAINED FROM REVIEW OF SITE INVESTIGATIONS 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 4: Soakage in peat areas

SCALE: 1:50,000 (A3)

0 0.5 1 2
KILOMETRES

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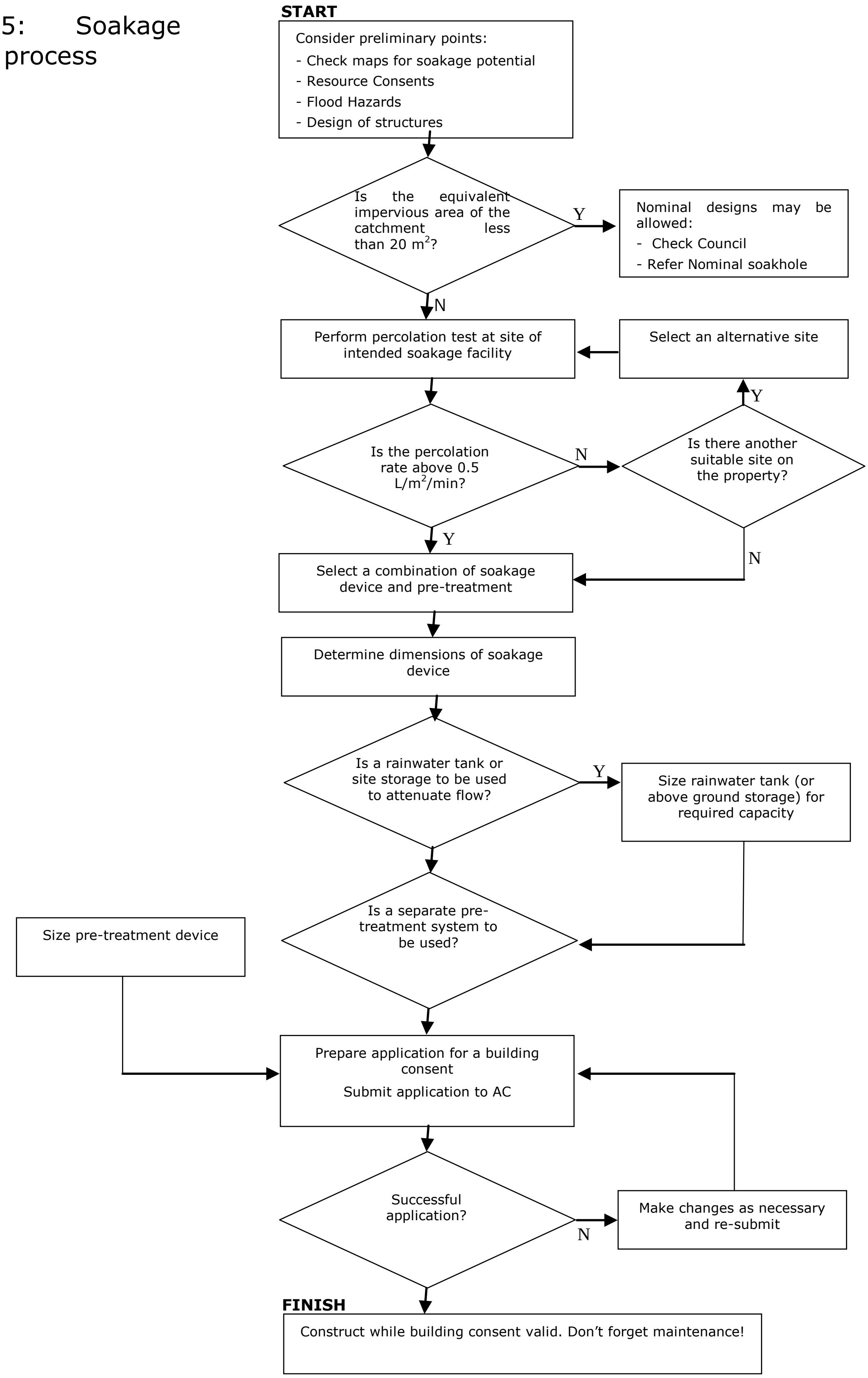
3 DESIGN PROCESS

3.1 KEY DESIGN ISSUES

The design method for soakage devices has been reviewed and carried forward from the ACC soakage design manual as this was the most comprehensive of the design information available. Figure 5 summarises the design process.

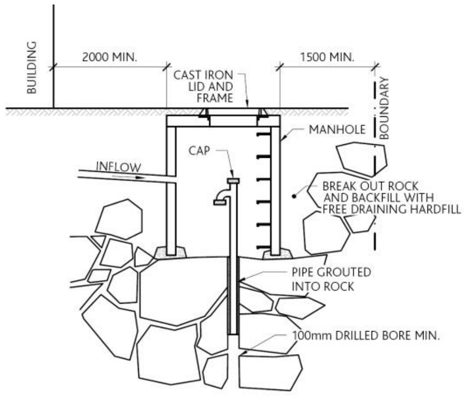
Figure 5: Soakage design process



3.2 DESCRIPTIONS OF SOAKAGE DEVICES

ROCK-BORE SOAKHOLES

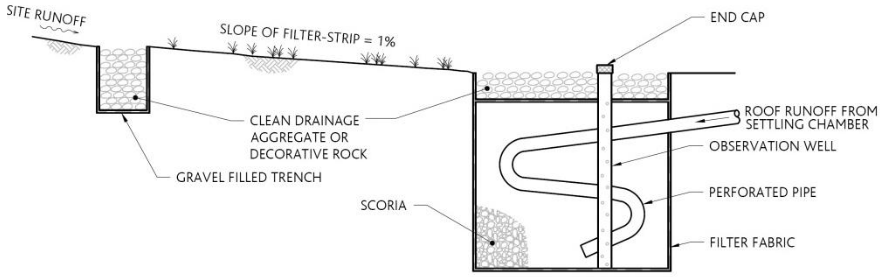
Rock-bore soakholes are chambers with bores drilled into fractured rock. Site runoff enters the chamber via catchpits while roof runoff enters the chamber directly. Some settling may occur in the chamber. Water enters the basalt aquifer directly through the base of the chamber if it is unsealed or builds up and enters through a pipe upstand drilled 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. The upstand requires the stormwater to pond within the chamber which provides limited treatment prior to discharge into the unsaturated aquifer.



SECTION

SOAKPITS (AND FILTER STRIPS)

The soakpit is one of the most common soakage devices, consisting of a scoria filled trench which is sized to be a balance of soakage through the base and walls and volume for attenuation and storage while soakage occurs. Where there is underlying basalt a rockbore soakhole may be added to improve the soakage capacity.

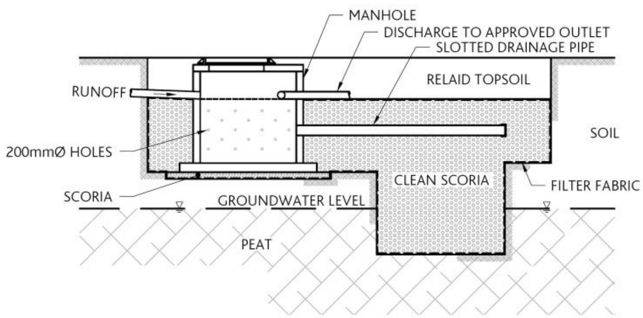


SECTION

A filter strip may be added prior to the pit to provide pre-treatment for site and yard runoff. A gravel filled trench collects and spreads water so it flows evenly over a vegetated surface for bio-filtration. 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.

PEAT SOAKPITS

Because of the greater uniformity of soakage rates within the peats there is a more standardised design procedure for soakage devices above peat aquifers. The 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



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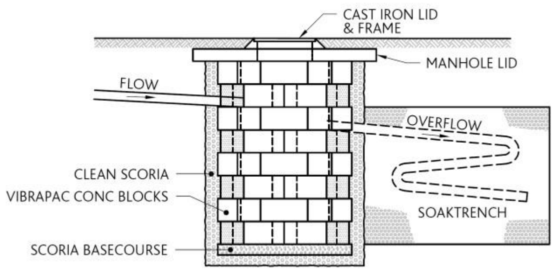
deciding the appropriateness and size of the device are:

1. Underlying ground conditions (depth to peat and groundwater level).

2. Size of the property being treated.

3. Change in impermeable area.

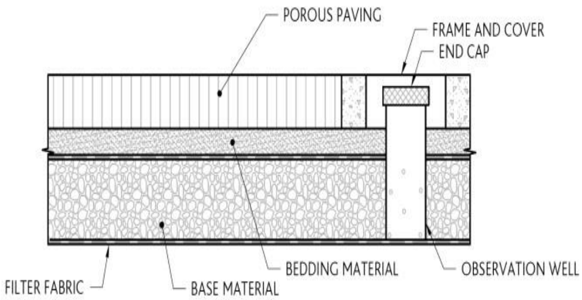
ONEHUNGA SOAKPIT



Historically called the "Onehunga Soakhole" the Onehunga Soakpit is a central chamber (constructed from either porous concrete blocks or brick) and scoria backfill around the circumference. The central chamber is empty and increases the void volume and hence the overall storage capacity and provides a space for sediments to settle out. Overflow and additional capacity is provided by an adjacent scoria filled trench. The scoria filled sections are normally covered with filter cloth and around 300 mm of soil, but the main chamber normally extends to the surface with a lid to allow access for maintenance. Rainwater enters the main chamber through pipes in the walls.

Provided the percolation rate is above 0.7 L/m^2/min, a reduction in the size of the soakpit may be allowed for small areas (due to there being sufficient storage in the chamber versus the available outflow rate). The reduction in size is normally only significant if the soakhole chamber takes up more than 50% of the soakhole volume. The chambers get more expensive above 1.0m diameter, so it is often more economic 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.

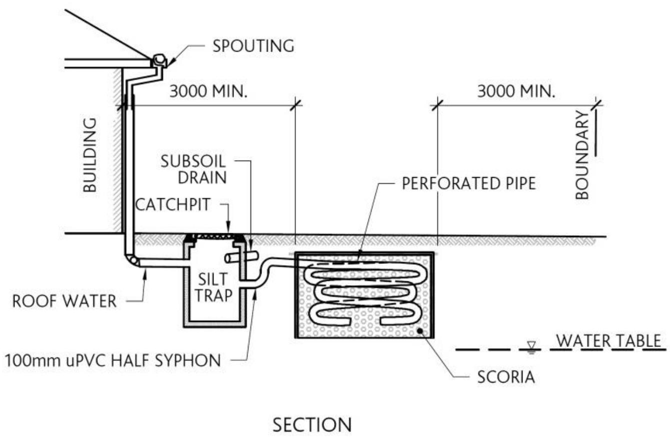
POROUS PAVING



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.

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 ACC in the past, and had the advantage that percolation tests did 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 up to a 10yr event.



4 ASSESSMENT OF SEDIMENT ACCUMULATION

4.1 CLOGGING

Clogging is the process by which entrained sediment decrease the permeability of the local fractured basalt or the soil matrix surrounding 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 soakhole wall (assuming that the fracture and pores reduce in size with distance from the wall).

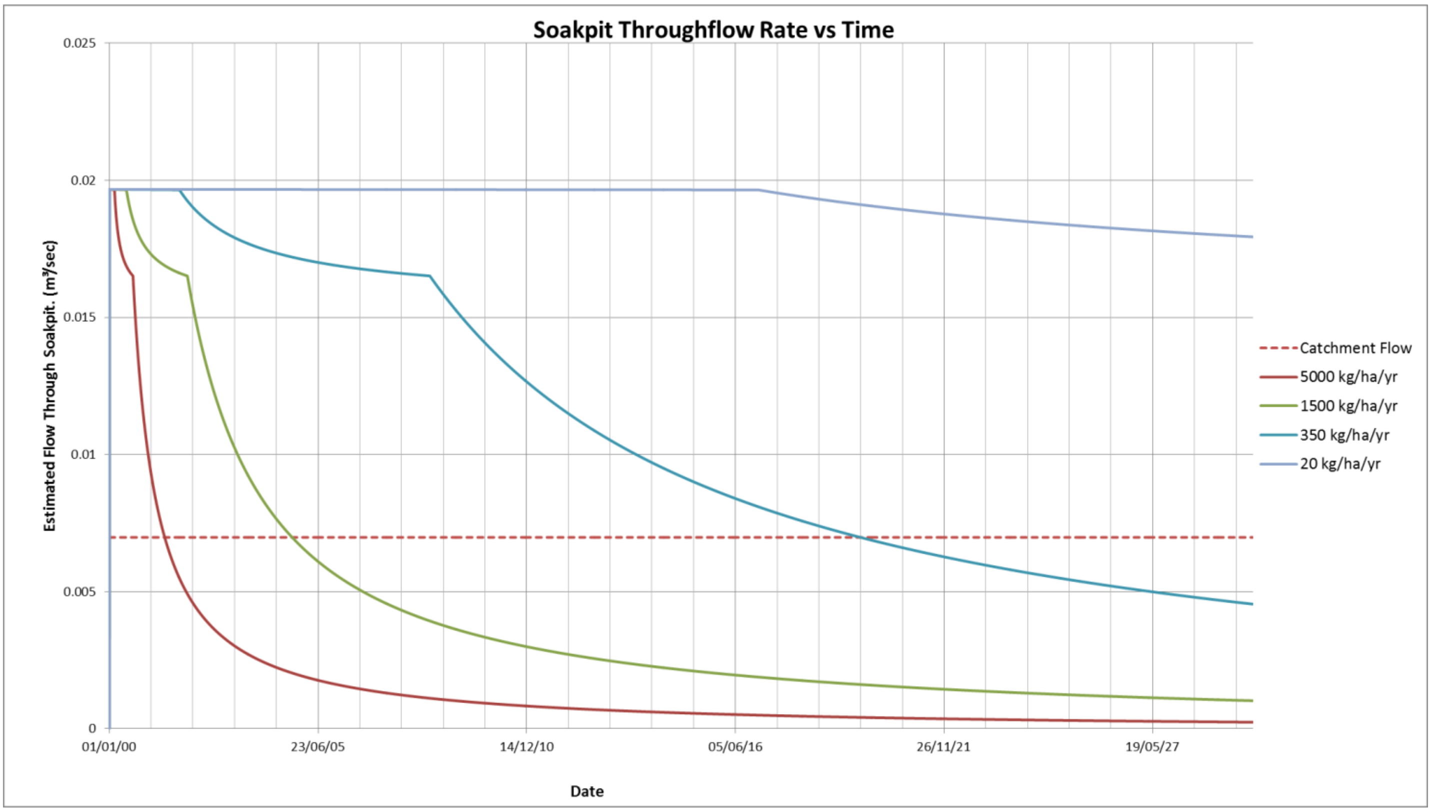
Fine sediment typically has higher concentrations of adsorbed contaminants and may be transported deeper into rock fissures of a soakhole - it therefore potentially has greater effects on the water quality of the aquifer, but the extent of transmission into fissures and consequent effect on groundwater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

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

A sediment and clogging model was developed to assess the timeframes over which clogging will occur under different loading rates and soil properties. 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.

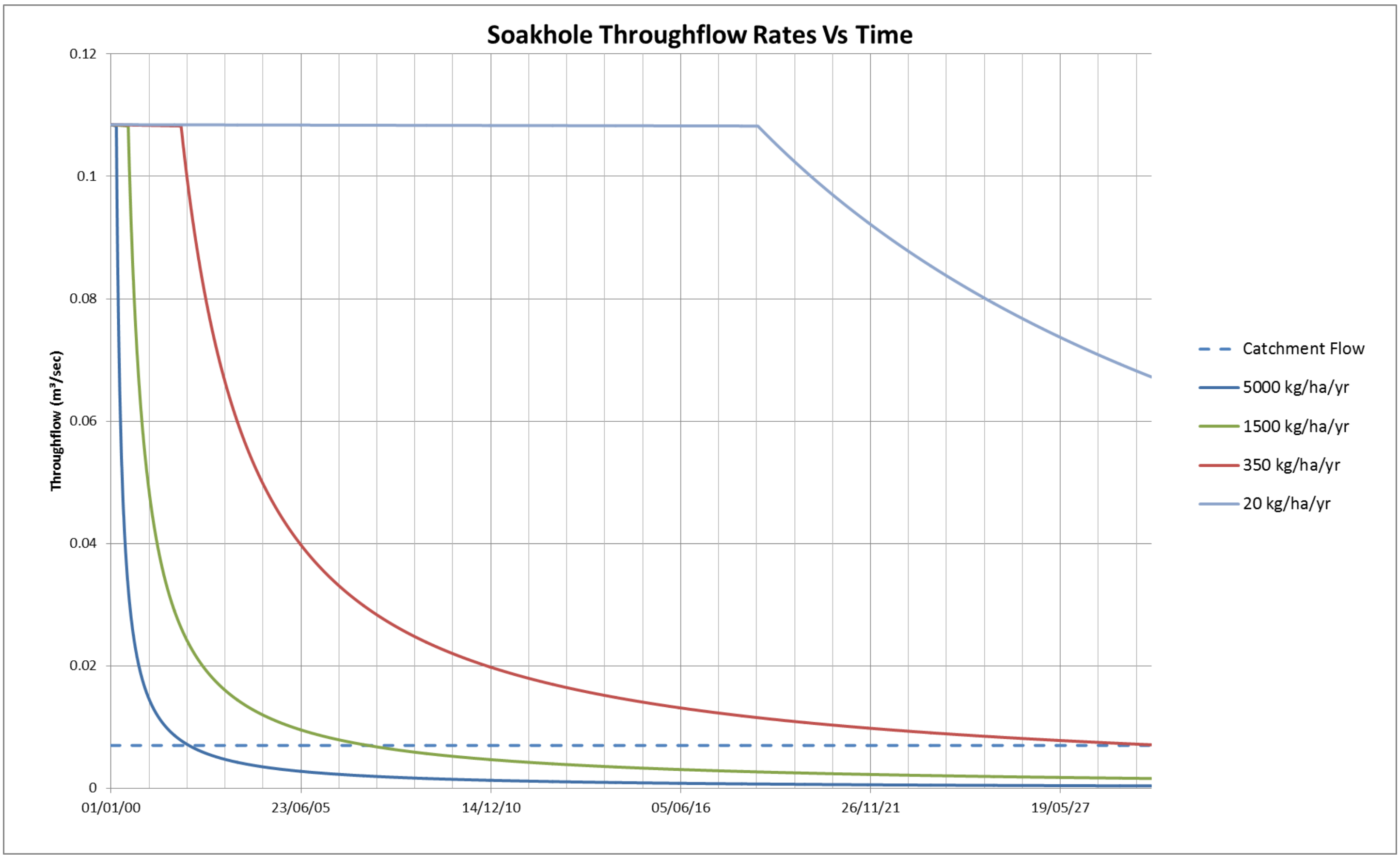
A number of ratios were used, with the results for a 1:5 ratio (indicates 200L of sediment is directed to the walls of the pit for every 1000L directed to the base) presented below. The ratio is unknown currently and the sensitivity assessment was carried out to check the effect of this ratio. Field investigation would be required to assess this further.

Figure 6: Soakpit Throughflow rate vs Time



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 soakpit 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.

Figure 7: Soakhole Throughflow rate vs Time



In a soakhole, the blockage mechanism again 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. However, in soakholes, the initial stage occurs very quickly as the soakhole base is only the 100 or 150mm hole diameter and the flow through the base area is negligible compared to the walls. Tables 1 and 2 summarise the times for different stages of clogging to occur.

Table 1. Soakpit Clogging Results

Sediment Loading (kg/ha/yr)	**Time to clog base of soakpit (months)**	**Time to clog soakpit flow below design flow (years)**
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

Table 2. Soakhole Clogging results

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

4.2 RECOMMENDATIONS FOR PRE-TREATMENT

The model shows it takes a long time for clogging to occur from typical residential roof loadings and therefore pre-treatment for sediment is not required.

Driveways areas for typical residential loadings also do not accumulate significant sediment, but it is considered 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 predicted maintenance clean-outs 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. Construction phases are critical times for protecting soakage and TP90 erosion and sediment controls should be used.

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 or Unitary Plans. The pre-treatment identified above is for maintenance purposes and may contribute to the amount of treatment required under the Plan rules.

The 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 soakhole chambers be inspected for sediment accumulation at no greater than one year intervals.

The extent of sediment transmission into rock and soakhole effective radius is however still unknown and needs to be assessed further through field investigations and calibration of the model for more definitive results.

4.3 MAINTENANCE OF SOAKAGE DEVICES

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 soakhole. 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 in situ soil faces or scoria/gravel media 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 for re-drilling depending upon the sediment load entering the device.

5 CONCLUSIONS

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

The design methodologies for soakage devices are well documented, particularly within Auckland City Council and Papakura District Council development codes.

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. The maps provide an indication of the potential of various soakage areas. The criteria used to generate the maps is given in Section 2 and provide a useful guide to aid in the interpretation of site investigation data to determine the potential for soakage.

The state of knowledge of soakage into the Papakura peats is based on a 2006 review of the available soakage testing from records of consent applications for disposal of stormwater to ground.

The design approach for basalt and peat follows the methodologies used in the Auckland City Council Soakage Design Manual and Papakura District Council development code. The main factor in the design for the soakage devices located in the basalt is a 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 it is also important for the site investigation to identify the depth to the peat and the groundwater level within the peat.

The clogging of a soakage device is related to the land use of the catchment and sediment loading 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 ongoing functioning of the soakage device. In heavy sediment loading from construction sites, erosion and sediment controls in accordance with TP90 are recommended.

Maintenance of the device is important 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 (or TP90 for construction sites).

ACKNOWLEDGEMENTS

Thank you to my co-authors.

REFERENCES

Strayton G. and Lillis M., October 2013, Soakage Technical Report, Prepared by Pattle Delamore Partners Ltd for Auckland Council.