Sodic Soils Assessment

Wallan South Precinct Area

06 | Final

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Victorian Planning Authority

Sodic Soils Assessment

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Contents

Executive Summary

Jacobs was engaged by the Victorian Planning Authority (VPA) to provide an assessment of the distribution of sodic and dispersive soils, erosion risks and consider their implications for future planned development in the Wallan South Precinct Area.

The soils of the Wallan South Precinct Area that were assessed in this investigation are predominantly classified as Sodosols, with a clear or abrupt textural B horizon in which the major part of the upper B2 horizon is sodic and not strongly acid. Chromosols were also identified. The topsoil is typically non-sodic with Exchangeable Sodium Percentage (ESP) values < 5%, the subsoils exhibit non-sodic to very high and extreme sodicity, with ESP values ranging from <5 to >15% (max 25%). Deeper samples recorded higher ESP values, ranging from 9 to 33%. A horizon topsoil depths vary across the Precinct, with measurements in the field ranging from 7-125 cm.

A vulnerability assessment approach was used to assess the implications of sodic soils for the construction phase and for the future developed land use.

Vulnerability (V) = Exposure (E) + Sensitivity (S)

Exposure (E): refers to attributes of soils that characterise their sodicity and propensity to erosion. Exposure criteria included sodicity of topsoil and subsoil, A horizon depth and slope.

Sensitivity (S) refers to attributes of the land or activities that influence the extent to which the land and urban developments may be disrupted or detrimentally affected by sodic soils. Sensitivity criteria included position relative to waterway, potential disturbance associated with construction activity for different land use types and water balance change expected for future land use.

During construction, areas identified as particularly vulnerable to sodic soil erosion risks are the waterways and steeper slopes. Activities that expose these soils to rainfall and associated runoff will present significant construction challenges and need to be managed carefully.

Water balance changes resulting from future developed land use and associated impervious areas will generate high volumes of runoff, which will drain into the surrounding waterways, including Strathaird Creek. Strathaird Creek is already in a degraded condition, further increases in flows would be expected to accelerate erosion of bed and bank materials.

Areas identified with a high vulnerability to sodic soils erosion risks and recommended treatments include:

- Drainage depressions/seasonal wetlands – Ideally these areas should be identified and reserved as linear green spaces to maintain their important hydrological function in retaining and temporarily storing water in the landscape and regulating the flow of water and nutrients throughout a catchment. Surface ground cover measures are critical for protecting the soils against dispersion and erosion.
- Strathaird Creek – This waterway is in a degraded state and further increases in runoff from urban development may result in increased erosion. Significant engineering works are likely to be required to stabilise this waterway so that it is resilient to stormwater runoff from future land development.
- Steeper slopes – Cutting into these slopes will expose underlying subsoils, and erosion risk is increased with slope. Road batters must be designed with consideration to the erodibility of the soils. Stable linings that are resistant to rainfall and runoff will be required.

It is recommended that detailed plans are developed for managing sodic soil-related erosion risks in high vulnerability areas identified in this investigation.

Important note about your report

The purpose of this report and the associated services performed by Jacobs is to provide an assessment of the distribution of sodic soils and erosion risks that relate to the characteristics of these soils, their position in the landscape and the implications of this for future planned development within the Wallan South Precinct Area. Advice is also provided on the range of treatment options that are available to manage identified sodic soils and erosion risks. The work has been conducted in accordance with the scope of services set out in the contract between Jacobs (Australia) and Victorian Planning Authority.

In preparing this report, Jacobs has relied upon, and presumed accurate information provided by Victorian Planning Authority and/or other sources as referenced in the report. Except as otherwise stated in the report, Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, the observations and conclusions in this report may change.

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This report has been prepared on behalf of, and for the exclusive use of, Victorian Planning Authority, subject to, and issued in accordance with, the provisions of the contract between Jacobs and Victorian Planning Authority.

1. Introduction

1.1 Background

Jacobs was engaged by the Victorian Planning Authority (VPA) to map sodic soils and erosion risk and provide advice on treatment options in light of future planned development in four Precinct Areas located to the north of Melbourne: Beveridge North West, Shenstone Park, Wallan South and Wallan East.

1.2 Scope

This report provides an assessment of the distribution of sodic soils and erosion risks that relate to the characteristics of these soils, their position in the landscape and the implications of this for future planned development within the Wallan South Precinct Structure Plan (PSP).

Wallan South PSP has been identified as a project on the VPA's Fast Track Program. The VPA are currently in a phase of completing background studies, landowner and agency input in plan preparation. The VPA will shortly commence preparation of a draft PSP and planning scheme amendment before proceeding to agency engagement. This phase will be followed by a phase of final public consultation.

Wallan South PSP covers a total of 806 hectares and is bounded by Old Sydney Road to the West, Hume Freeway to the east and Wallan Township to the north/north-east. Wallan South is expected to have a residential focus, with the precinct supported by associated services and facilities such as town centres, schools, community centres and parks. Figure 1-1 shows the Concept Place-Based Plan that has been prepared for the Wallan South PSP area. It represents the direction for the PSP area and key elements that it should contain following the next phase, agency endorsement and public consultation.

Vulnerability assessment was used to explore the implications of sodic soils for future planned urban development. This assessment was completed for two scenarios, first the construction phase and second for the future developed land use. Advice is provided on the range of treatment options that are available to manage identified sodic soils and erosion risks.

1.3 Report structure

This report has been structured as follows:

- Section 2 provides a brief summary of sodic and dispersive soils definitions and terms used in this report, Victorian context regarding the distribution of sodic soils and their implications for urban development.
- Section 3 describes our approach to mapping sodic soils and erosion risks.
- Section 4 presents the results of the assessment.
- Section 5 provides discussion and recommendations on options to manage identified erosion risks, including potential planning control measures.
- Section 6 documents gaps in knowledge/requirements for further soil investigations and further work to validate the predictions of the distribution of sodic soils and erosion risks.

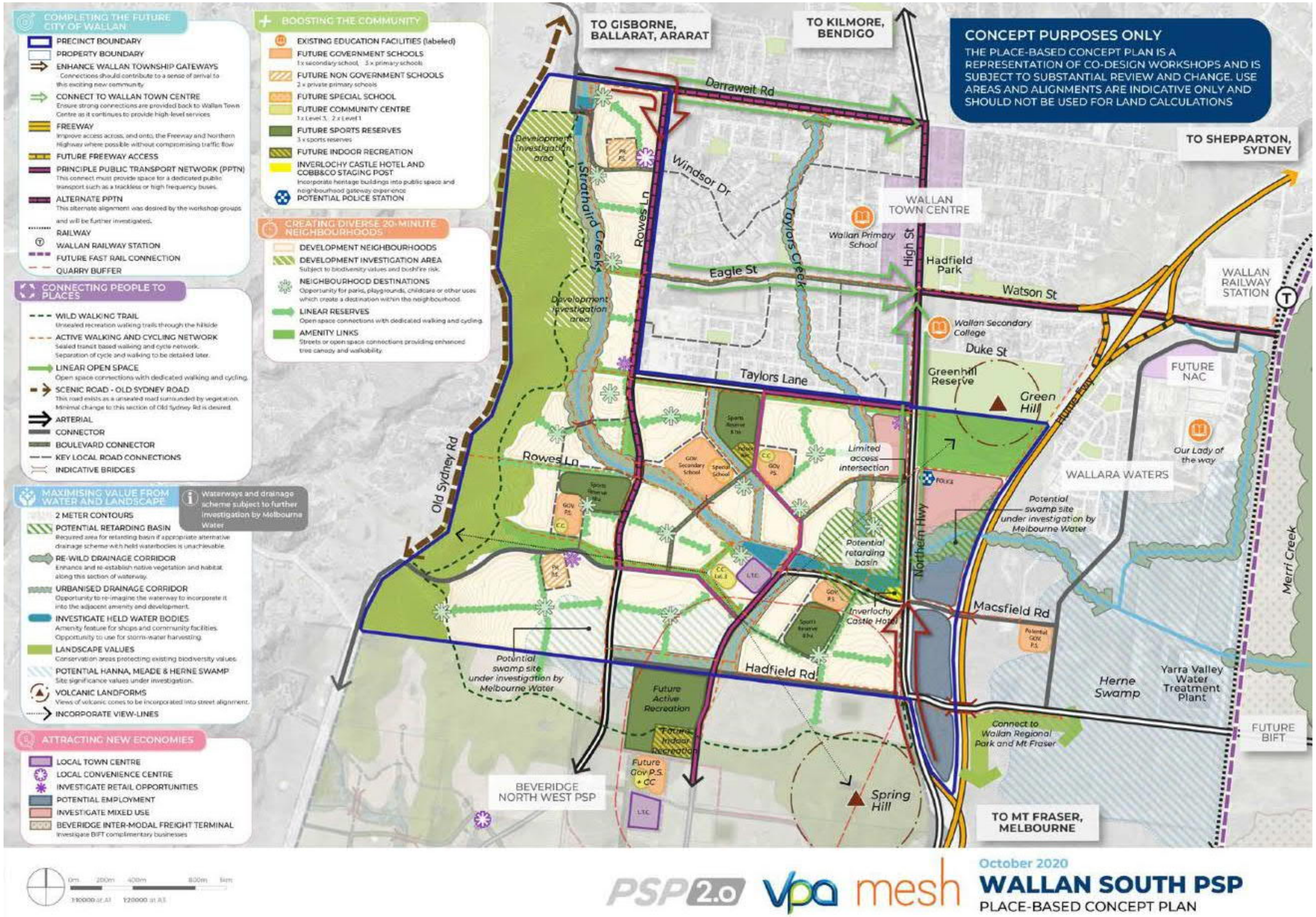


Figure 1-1: Wallan South PSP Place-Based Concept Plan (Victorian Planning Authority 2020).

2. Sodic and dispersive soils

2.1.1 Sodic and dispersive soil definitions and terms used in this report

Sodic soils are defined in Australia as those with an exchangeable sodium percentage (ESP) of 6% or greater (Northcote and Skene 1972). An ESP of 6% is considered to be the threshold where the cation sodium in soil has an adverse impact on soil structure when in contact with fresh water, causing clay dispersion (Northcote and Skene 1972). Soils may also reveal dispersive behaviour under the influence of elevated exchangeable potassium (K) and magnesium (Mg) (Marchuk and Rengasamy 2012, Dang *et al.* 2018). These considerations are necessary in the evaluation of sodic and dispersive soils where dispersion is evident when ESP levels are below 6%. Figure 2-1 provides examples of the Emerson Aggregate Test where varying levels of dispersion are recorded (Armstrong 2019).

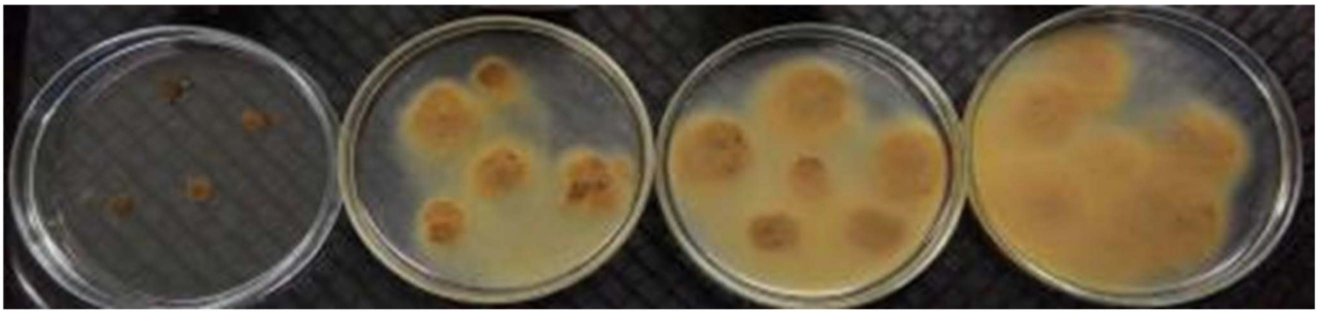


Figure 2-1: Examples of soil aggregates subject to the Emerson Aggregate Test, showing nil dispersion on the left with increasing levels of dispersion to the right (Armstrong 2019).

Wetting of sodic and dispersive soils may lead to soil structural decline, crusting, waterlogging, low rates of hydraulic conductivity, excessive runoff, erosion and poor agricultural performance. Sheet, rill, gully and tunnel erosion may all be observed in areas with sodic and dispersive soils. Erosion is exacerbated when sodic soils are disturbed or groundcover is removed or absent. Figure 2-2 shows photographs of erosion that has developed in sodic and dispersive soils, elevated turbidity and sedimentation in waterways. Charman and Murphy (2007) provide further details of the impact of sodic and dispersive soils in an Australian context.

Figure 2-2: Example of erosion of sodic and dispersive soils which can result in elevated turbidity and sedimentation in waterways.

The Australian Soil Classification (Isbell and NCST 2021) outlines 14 soil orders, several of these contain soil materials that are sodic and dispersive. The soil order 'Sodosol' is a specific class that has strong texture contrast between the A horizon and sodic B horizon, with the latter characteristically being dispersive. This report seeks to identify 'Sodosols' and other soil orders across the Wallan South Precinct. Soil orders other than Sodosols can be identified with sodic and dispersive properties.

2.1.2 Sodic soil distribution across Victoria.

The distribution of sodic soils across Victoria is well known and documented by Ford *et al.* (1993) with further mapping by others, including Agriculture Victoria (2020), as shown in Figure 2-3. Sodic soils are common across large expanses of land used for agricultural and urban development. Sodicity and dispersion characteristics vary depending on parent material, geomorphic processes, particle size distribution, rainfall and leaching. In most cases, soils with sodic horizons are texture contrast soils with a clear or abrupt A horizon topsoil layer overlying a finer textured, clay-dominant B horizon subsoil with lower permeability and a high propensity to adsorb cations including sodium.

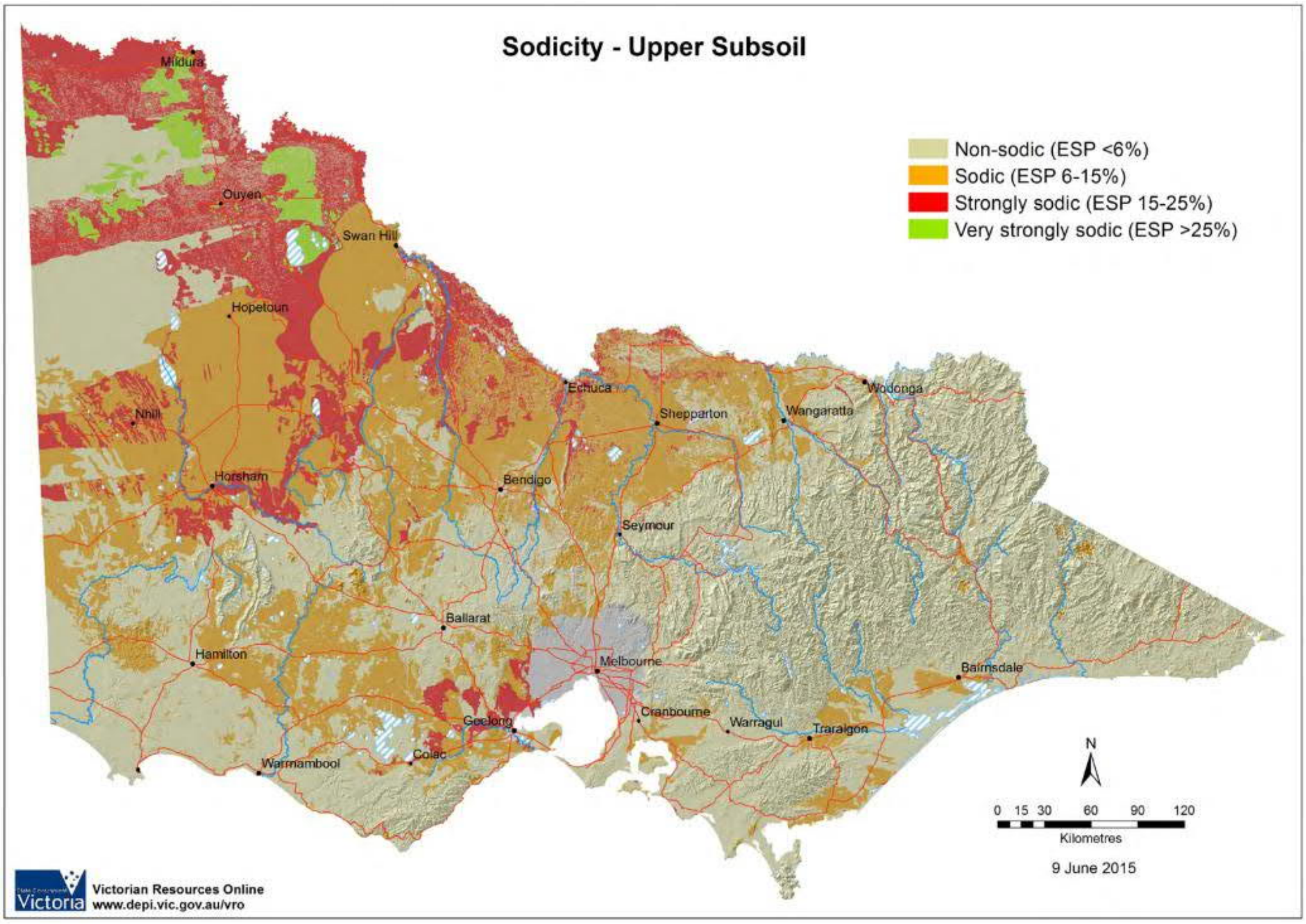


Figure 2-3: Mapping of Sodicity in Upper Subsoil, Victoria (Agriculture Victoria 2020).

2.1.3 Sodic soil implications for urban development

Urban development and site construction cause significant ground disturbance, eliminate vegetative ground cover and expose sodic soils to erosion. Erosion risks are directly influenced by sodic soil exposure and changes in landscape hydrology. Changes to hydrology, including the concentration of flow in culverts, runoff from impervious areas and ponding of rainfall contribute to increased erosion risk.

Urban development and site construction cause significant ground disturbance, impacting surface ground cover and exposing sodic soils to erosion.

Development on sodic and dispersive soils potentially have on and off-site impacts. On-site impacts include:

- Dispersion of topsoil and subsoil.
- Loss of topsoil and subsoil with overland and subsurface flow (sheet, rill, tunnel and gully erosion).
- Poor infiltration and increased volumes of stormwater runoff.
- Water ponding in hollows, break of slope areas or depressions, increasing groundwater recharge.
- Poor ability to establish vegetation due to adverse soil chemical conditions.
- Lack of trafficability.

Other on-site or off-site development impacts arising from sodic and dispersive soil conditions include:

- Increased turbidity in waterways in response to runoff from development areas and a deterioration in water quality and degradation of aquatic flora and fauna habitat with effects on populations.
- Increased erosion potential in downstream waterways in response to larger volumes of stormwater runoff from developed areas eroding sodic and dispersive soils.

3. Method

3.1 Spatial Logic Assessment Framework

Jacobs' Spatial Logic Assessment Framework was used in the delivery of this project (Figure 3-1). Spatial Logic is an approach that brings together source information, with the data used to represent criteria that reflect exposure or sensitivity. An assessment was made of potential sodic/dispersible soils' extent and their level of vulnerability to proposed future land uses.

Spatial Logic has 5 key stages (Figure 3-1):

- Define – Define the sodic soil/landscape profile relationships, scenarios for assessment and supporting data sources, including an assessment of data suitability.
- Collate and integrate – Collate source data and document for transparency, collate any accessible literature that supports soil studies in the area of interest that will inform or be the basis of the assessment. Integrate by converting source data into documented criteria.
- Assess – With reference to landscape profile criteria, undertake an assessment of potential sodic soil extent, severity and/or risk. The assessment indicates where sodic/dispersible soils may occur and their level of risk, based on available evidence.
- Communicate – Provide a report on the study area, the project evidence base, assessment of findings and the information package.

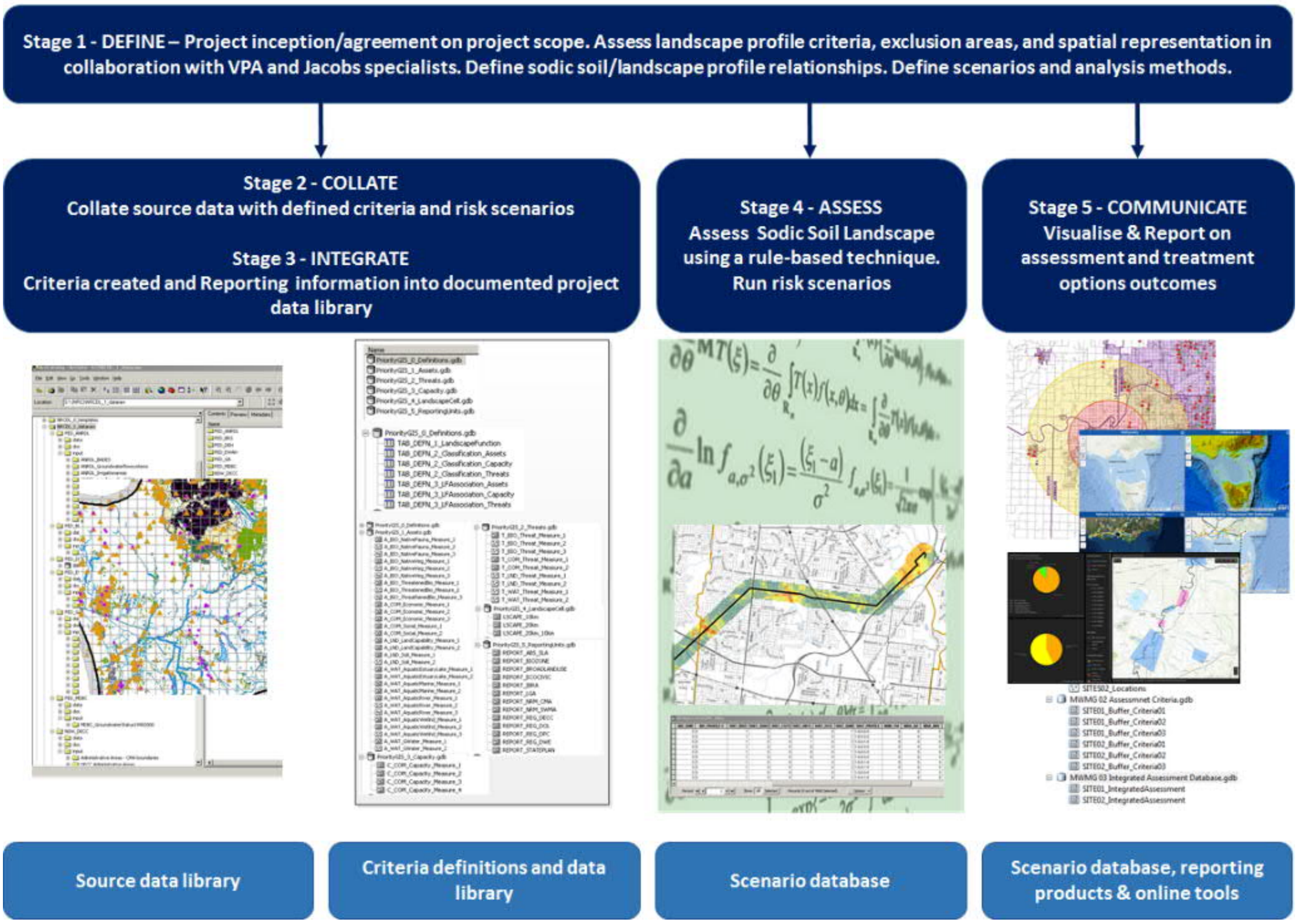


Figure 3-1: The Spatial Logic Assessment Framework.

3.2 Vulnerability Assessment

A specialist workshop was convened early on in the project to define sodic soil/landscape profile relationships, risk scenarios and analysis methods for the Beveridge North West, Shenstone Park, Wallan South and Wallan East PSP sodic soils assessments. The principles of the Vulnerability Assessment approach and how they would be applied to this assessment were agreed upon in this workshop. Vulnerability is defined for the purposes of this assessment as:

Vulnerability (V) = Exposure (E) + Sensitivity (S)[1]

Where Exposure (E): Attributes of soils that characterise their sodicity and propensity to erosion
Sensitivity (S): Attributes of the land or activities that influence the extent to which the land and urban developments may be disrupted or detrimentally affected by sodic soils.

3.2.1 Exposure criteria

Attributes of soils that were used to characterise their sodicity and exposure to erosion are:

- Sodicity of topsoil (0-10 cm) - Exchangeable Sodium Percentage (ESP) values. This soil layer is also referred to as A horizon topsoil throughout the report.
- Sodicity of subsoil (30-40 cm) – ESP. In most cases this layer is B horizon subsoil clay, but can include A2 horizon topsoil where topsoils were deeper than 40cm.
- A horizon depth – subsoil exposure/erosion risk decreases with depth.
- Slope – erosion risk increases with slope (which, for this assessment, was derived using 2017 LiDAR)

These attributes form the exposure criteria, with criteria values ranked according to the scoring system outlined in Table 3.1. Table 3.2 provides a description of the Exchangeable Sodium Percentage (ESP) values used to define the Sodicity exposure criteria.

3.2.2 Sensitivity criteria

Attributes of the land or activities that influence sensitivity to sodic soils are:

- Position relative to waterway – Based on mapped drainage extent in Future Urban Structure (FUS) Dataset.
- Construction activity – Potential disturbance of construction for future land use sub types mapped in FUS Dataset.
- Water balance change – Potential for change in water balance due to future land use (based on FUS classes)[2]. This considers potential for increases in overland flow from impervious surfaces and stormwater pipes in proposed developments.

These attributes form the Sensitivity criteria, with criteria values ranked according to the scoring system outlined in Table 3.3. Table 3.4 and Table 3.5 provides a description of scorings used for Construction Activity and Water Balance Change criteria.

[1] Vulnerability is typically expressed as Exposure (E) + Sensitivity (S) – Adaptive Capacity (AC). In this case we have not included Adaptive capacity (AC) in the assessment. The Vulnerability assessment is essentially an assessment of potential impacts. Adaptive capacity is included in the discussion when considering aspects of urban development that can be managed to mitigate risks.

[2] This is an assessment of where in the PSP landscape the water balance is likely to change the most due to development. Note that waterways within the PSP may experience additional impacts caused by changed hydrology outside of the PSP area, this potential has not been considered by this high-level assessment.

Table 3.1: Exposure criteria and scores. For further descriptions of ESP values/scores, refer to Table 3.2.

	Score				
Criteria	1	2	3	4	5
Sodicity of Topsoil (ESP)	<5%	5 to <7%	7 to <10%	10 to <15%	>15%
Sodicity of Subsoil (ESP)	<5%	5 to <7%	7 to <10%	10 to <15%	>15%
A horizon depth	>40cm	30-40cm	20-30cm	10-20cm	<10cm
Slope	0-1 %	1-5%	5 to 10%	10 to 20%	>20%

Table 3.2: Exchangeable Sodium Percentage (ESP) values used to define Sodicity exposure criteria.

Score	ESP Range	Description
1	<5%	Non-sodic, unlikely to reveal dispersion when in contact with fresh rainfall or runoff.
2	5 to <7%	Transition between non-sodic and sodic soil (sodic soil of 6%). Clay fraction within samples likely to evince dispersion when in contact with fresh rainfall or runoff.
3	7 to <10%	Moderate to high sodicity. Dispersion likely to occur when in exposed to fresh rainfall or runoff.
4	10 to <15%	High to very high sodicity. Dispersion likely. Significant erosion risk when exposed to fresh rainfall or runoff.
5	>15%	Very high to extreme sodicity. Significant erosion risk when exposed to fresh rainfall or runoff.

Table 3.3: Sensitivity criteria and scores. For further description of Construction Activity and Water Balance Change values/scores, refer to Table 3.4 and Table 3.5.

	Score				
Criteria	1	2	3	4	5
Waterway[1]	No	-	-	-	Yes
Construction activity	Minimal disturbance				High level of disturbance
Water balance change	Low (stay the same, infiltration)				High (generate runoff)

[1] Based on waterway extent as mapped as Drainage (LU_TYPE Attribute) in Future Urban Structure (FUS)

Table 3.4: Descriptions of scorings for Construction Activity ranked by level of disturbance expected for Land Use Sub Types (LU_SUBTYPE Attribute) mapped in the Future Urban Structure (FUS).

Score	Level of Disturbance	Land Use Sub Types (LU_SUBTYPE)
1	Minimal disturbance	Conservation, Local Park
2		*(No land use subtypes fall in this category)*
3		Local Sports Reserve
4		Business, Community Facilities, Emergency Services, Existing Road Reserve, Future Arterial Road, Government School, Indoor Recreation, Local Convenience Centre, Local Town Centre, Medium Density Residential, Mixed Use, Non-Government School, Residential
5	High level of disturbance	Waterways, Waterway within Conservation

Table 3.5: Description of scorings for Water Balance Change expected for Land Use Classes (LU_CLASS Attribute) mapped in the Future Urban Structure (FUS).

Score	Water Balance Change	Land Use Class (LU_CLASS)
1	Low (stay the same, infiltration)	Credited Open Space, Uncredited Open Space (Conservation LU_TYPE)
2		*(No land use classes fall in this category)*
3		*(No land use classes fall in this category)*
4		Education/Community/Government, Developable Area – Residential, Developable Area - Employment
5	High (generate runoff)	Transport, Uncredited Open Space (Drainage LU_TYPE)

3.2.3 Risk scenarios

The distribution of erosion risk associated with sodic soils was modelled using the collated datasets. This assessment was undertaken using Jacobs' Vulnerability Assessment Engine (VAE) - a tool that assists in assembling and analysing spatial data sets.

The VAE was used to assess the risks associated with sodic soils for the following two scenarios:

- Construction phase, where the Vulnerability of land and urban development to sodic soil erosion risks during the construction phase is a function of the following Exposure and Sensitivity criteria:
  - Exposure (E) – Sodicity topsoil, Sodicity subsoil, A horizon Depth, Slope
  - Sensitivity (S) - Waterway, Construction Activity
- Future developed land use, where the Vulnerability of land and urban development to sodic soil erosion risks in the future land use is a function of the following Exposure and Sensitivity criteria:
  - Exposure (E) - Sodicity topsoil, Sodicity subsoil, A horizon Depth, Slope
  - Sensitivity (S) - Waterway, Water Balance Change

Exposure and Sensitivity criteria scores are summed to calculate Vulnerability. The decision was made to apply an equal weighting of scores to Exposure and Sensitivity criteria, they are all considered to be similarly important. The spatial distribution and range of Vulnerability scores informs an assessment of the potential impact of land and urban developments have on sodic soils erosion risks.

4. Results

4.1 Sodicity of soils and their exposure to erosion

The soils of the Wallan South Precinct sampled for this investigation are predominantly classified as Sodosols. The characteristics of these soils is consistent with definition of Sodosols (Isbell and NCST 2021), as 'soils with a clear or abrupt textural B horizon in which the major part of the upper B2 horizon is sodic and not strongly acid'.

Chromosols were also identified, these soils have duplex conditions with non-sodic and not strongly acid (neutral to alkaline) conditions throughout the upper B horizon.

The stability provided by organic matter including ground cover, plant growth and plant roots is vital for preventing erosion of both Sodosols and Chromosols with sodic and dispersive soil horizons. Disturbance to land such as clearing of vegetation, topsoil removal or construction of drainage channels impacts these sources of organic matter and exposes subsoil layers with negligible organic matter to fresh rainfall, increasing susceptibility to erosion. A good cover of grasses was present at the time of sampling.

Some photographs of the field area showing land slopes and the degraded condition of Strathaird Creek are presented in Figure 4-1.

Figure 4-1: Selected photographs of Wallan South Precinct: steeper slopes and headwater areas (top left), lower slopes and drainage depressions (top right), upper Straithard Creek which has experience historical incision and gullying (bottom left) and lower Straithard Creek which forms a constructed incised drainage channel.

The sodicity of soils of the Wallan South Precinct is summarised with reference to exchangeable sodium percentage (ESP) values as follows:

- 0-10cm (A1 horizon topsoil): Average ESP of 4.3%. Of the 66 samples collected, 56 samples (87.5%) were deemed non-sodic while 8 samples (12.5%) were deemed sodic. Sodic topsoil sites are all positioned on Silurian deposits along the western extent coinciding with rising land or break-of-slope zones. Almost all of the alluvial deposits and volcanic soils recorded non-sodic conditions in the 0-10cm range. Note that further discussion of geology is provided in Appendix A.
- 30-40cm (mixture of subsurface A2/A3 horizon loams and B-horizon clay subsoil): Average ESP of 7.8%. Of the 64 samples collected, 36 samples were sodic (56%). Sodic samples include a mix of A2/A3 horizon material along with some clay B horizon samples. 28 samples were non-sodic, with ESP levels of <6%. A total of 30 samples (44%) including both A2/A3 horizon topsoil and B horizon clay recorded non-sodic conditions.
- 60-140cm soil samples were also collected: A total of 17 deeper samples were collected. All samples were of high or very high sodicity with the ESP averaging 22.1% in this range.

In addition to the results for ESP, the following observations are made from the data set:

- 0-10cm samples: Most samples that are non-sodic are also non-dispersive. The pattern is relatively consistent. There were 8 samples where this pattern was not perfectly clear, however in many cases there were other factors that may have contributed to the presence or lack of dispersion, including high organic carbon.
- 30-40cm samples: While 36 samples were sodic (56%), there were 52 samples (77%) that were dispersive. Based on observation of the data set, several samples that were non-sodic in the ESP range of 4-6% were dispersive. Dispersion may be occurring under the associated influence of exchangeable potassium, or where organic carbon and EC levels are low, limiting soil stability.
- Samples below 40cm: With very high ESP levels, almost all were dispersive. Those that were non-dispersive may be influenced by an elevated EC level, whereby the electrolyte concentration is maintaining a relatively stable soil condition under high ESP.

Detailed tables of soil test results are included in Appendix A.

An inverse distance weighted (IDW) interpolation was used to estimate values of soil sodicity (topsoil and subsoil) and A horizon depths at unsampled locations across the Precinct. IDW interpolation is a standard method that is used for spatial interpolation and development of soil maps (Mueller *et al.* 2004).

Maps showing the spatial distribution of these three exposure criteria are presented on the following pages (Topsoil Sodicity -Figure 4-2, Subsoil Sodicity - Figure 4-3; A horizon depth - Figure 4-4). The final exposure criteria used is slope, with classes shown in Figure 4-5.

Figure 4-6 presents the sum of the four exposure criteria (Topsoil sodicity, Subsoil sodicity, A horizon depth and slope). Soils on the western and northern parts of the precinct have higher subsoil ESP values and greater erosion risk. Slope influences exposure to erosion, particularly in areas where gradients are higher than 10%.

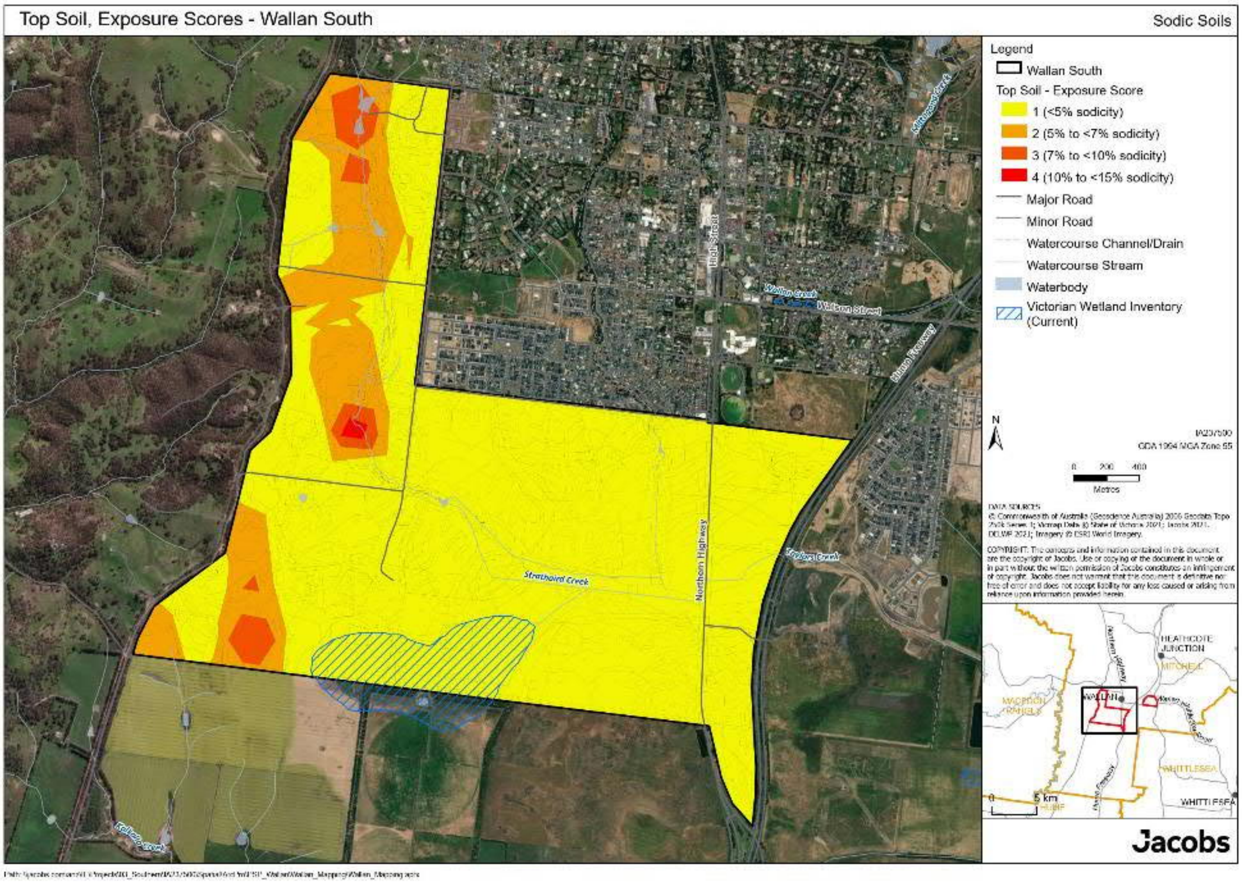


Figure 4-2: Sodicity of topsoil.

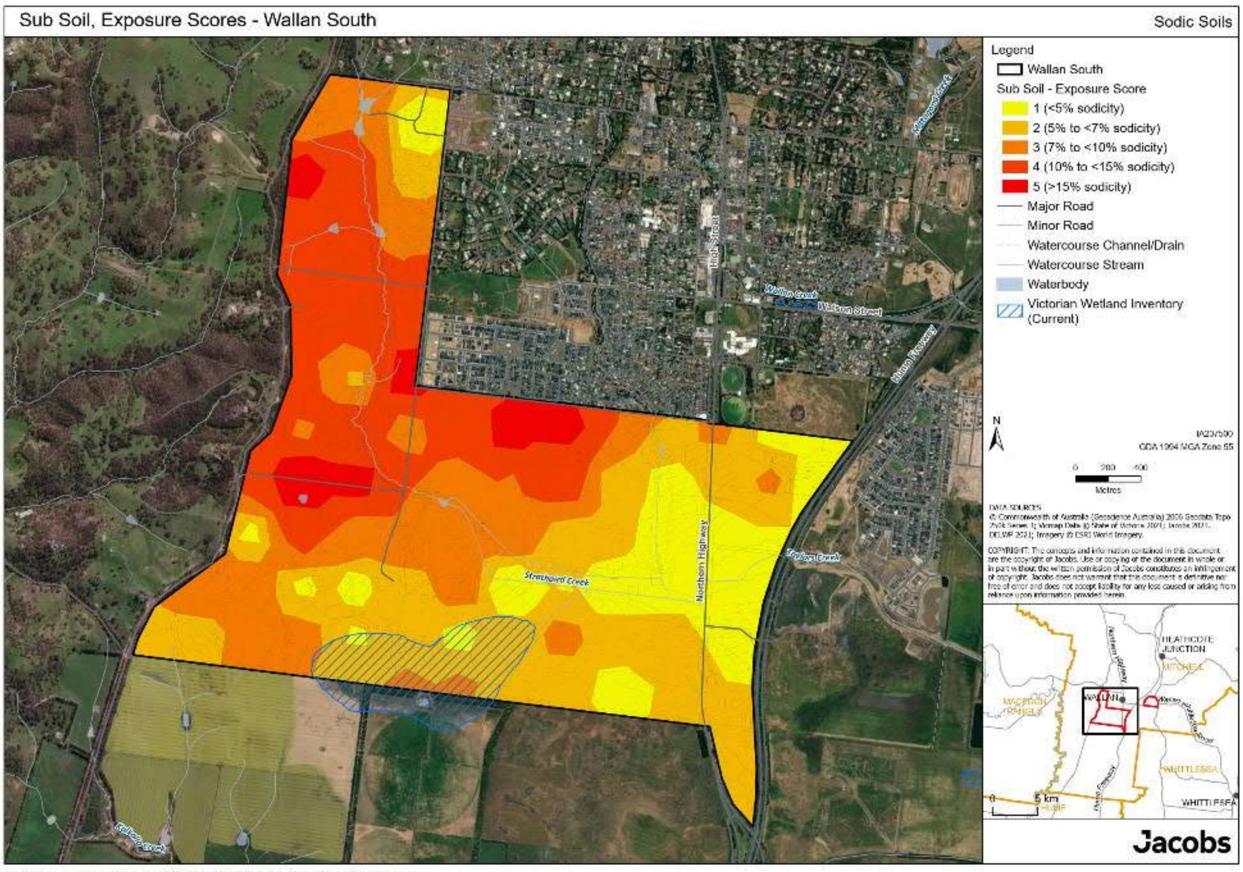


Figure 4-3: Sodicity of subsoil.

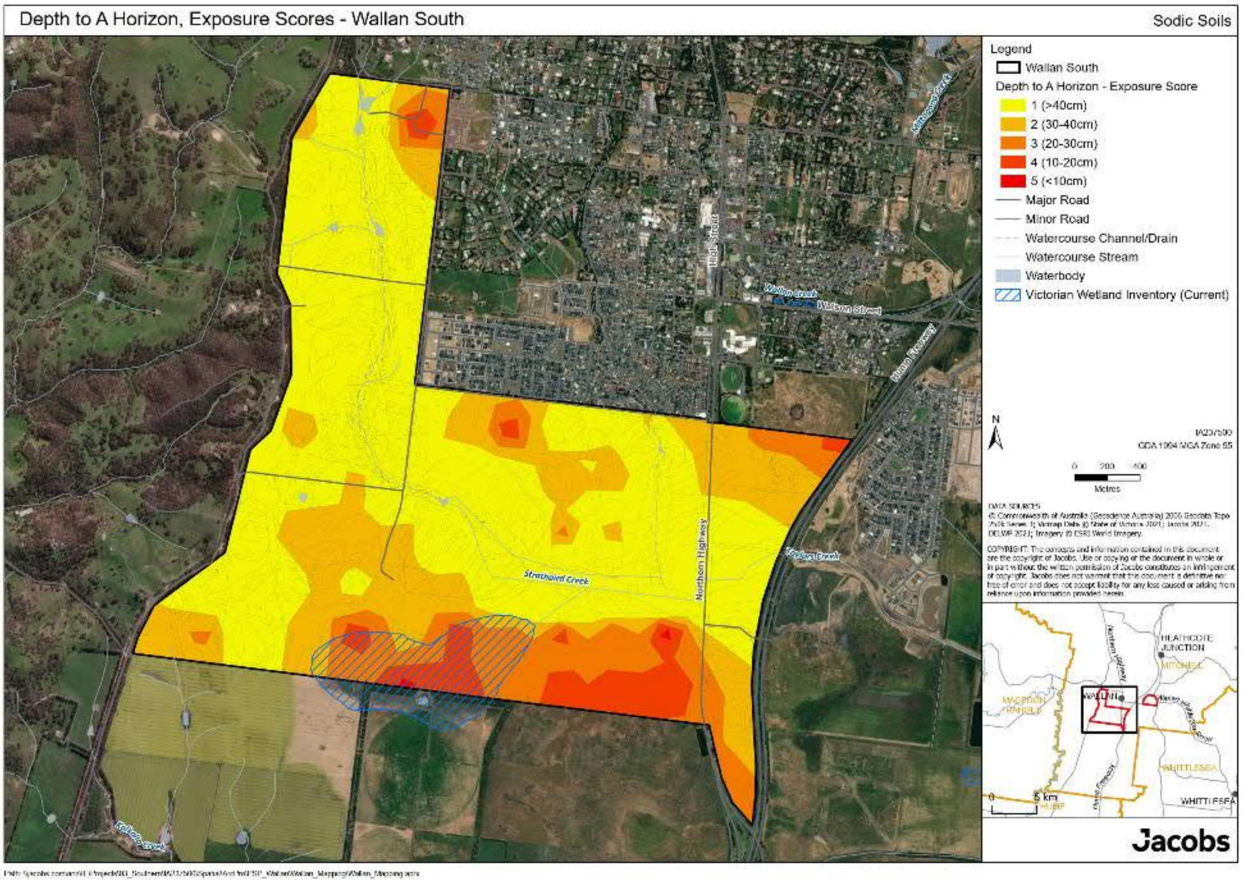


Figure 4-4: A horizon depth.

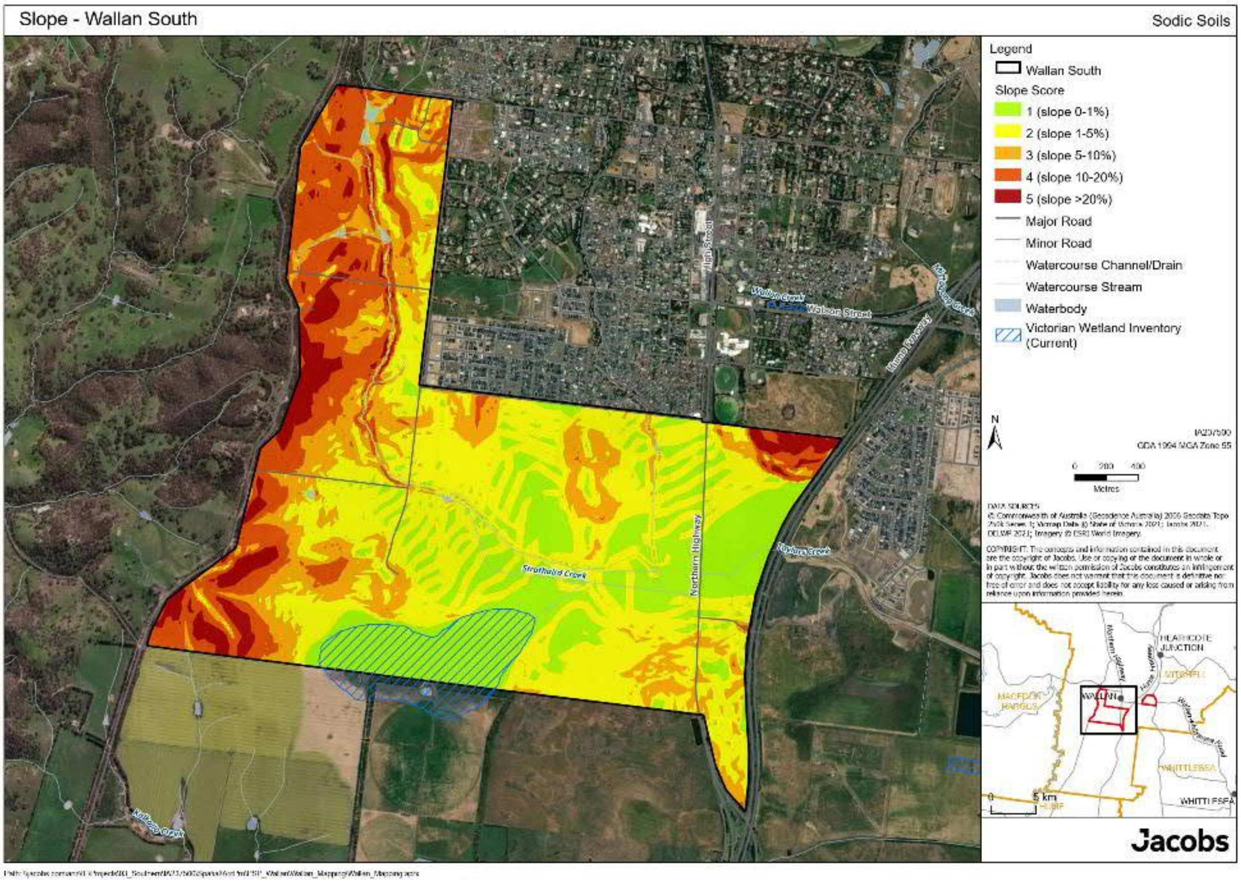


Figure 4-5: Slope.

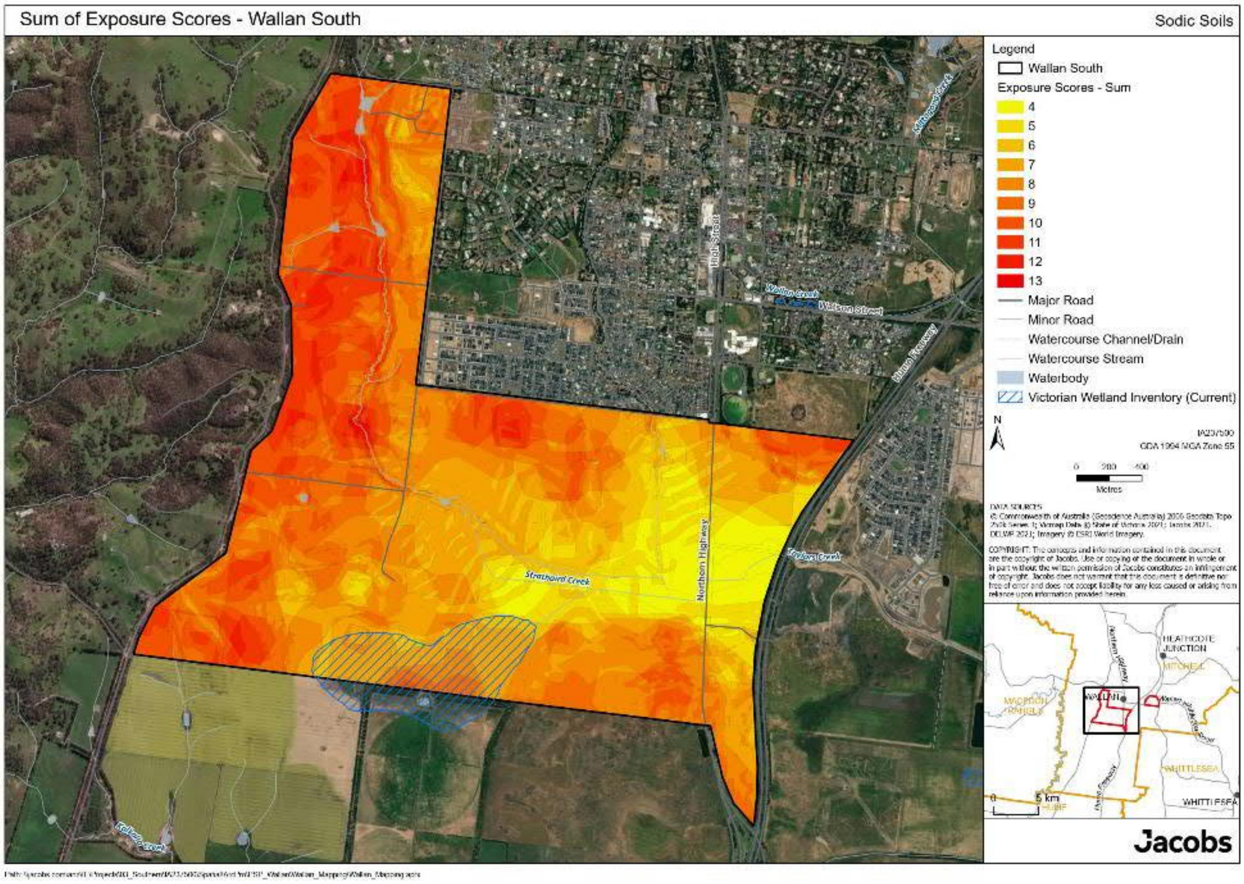


Figure 4-6: Sum of Exposure Criteria.

4.2 Sensitivity of land and urban development to sodic soils

The Future Urban Structure (FUS) dataset has been used as the basis for defining the sensitivity of land and urban development to sodic soils. Waterways are identified as areas that are particularly sensitive to disturbance of sodic soils. The waterway extent across the Precinct is mapped as Drainage in the FUS. These areas score 5, whereas all other areas outside of the waterway extent score 1 (Figure 4-7).

Figure 4-8 and Figure 4-9 present the spatial distribution of sensitivity scores as applied to the FUS dataset for construction activity and water balance change. Construction activities in different land use types are ranked on a scale for sensitivity from minimal disturbance (low sensitivity) to high levels of disturbance (high sensitivity). Areas that are set aside for conservation values / local park have low levels of development and are scored as minimal disturbance (1), with the level of disturbance increasing with the intensity of development. The majority of the land use sub types are given a score of 4, with Waterways experiencing the highest level of disturbance (5). Similarly, in scoring water balance change, open space areas, with the exception of areas with a Drainage LU_TYPE are expected to experience low levels of water balance change (1). Increasing development of land use, will result in development of impervious areas that generate runoff and therefore result in high levels of water balance change (5).

Figure 4-10 and Figure 4-11 present the combined sensitivity scores for the construction and future development scenarios. These show a similar pattern in that Waterways are identified as areas of highest sensitivity. Transport corridors are also identified as areas with high sensitivity in the future urban structure, due to the high water balance change and generation of runoff associated with impervious surfaces in these corridors.

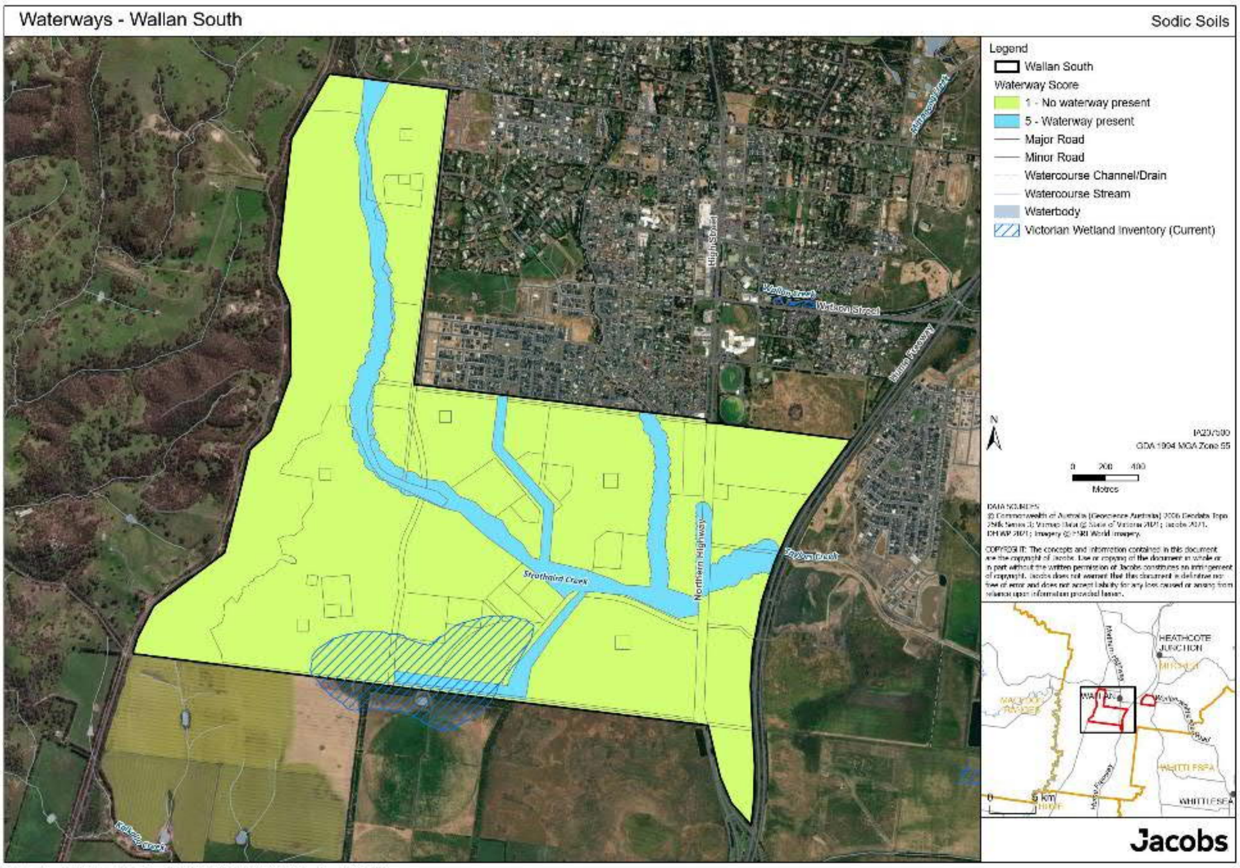


Figure 4-7: Waterway extent as mapped as Drainage in Future Urban Structure (FUS) Dataset.

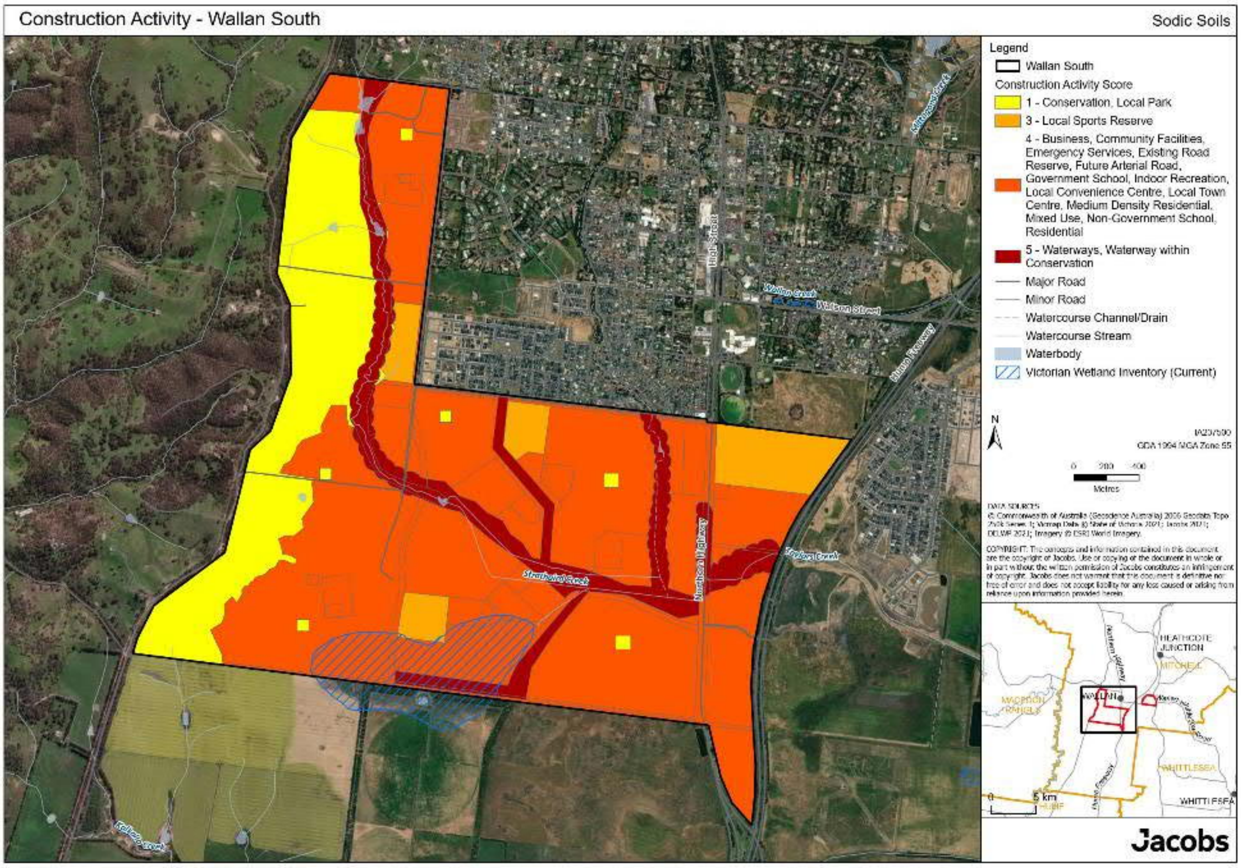


Figure 4-8: Construction activity.

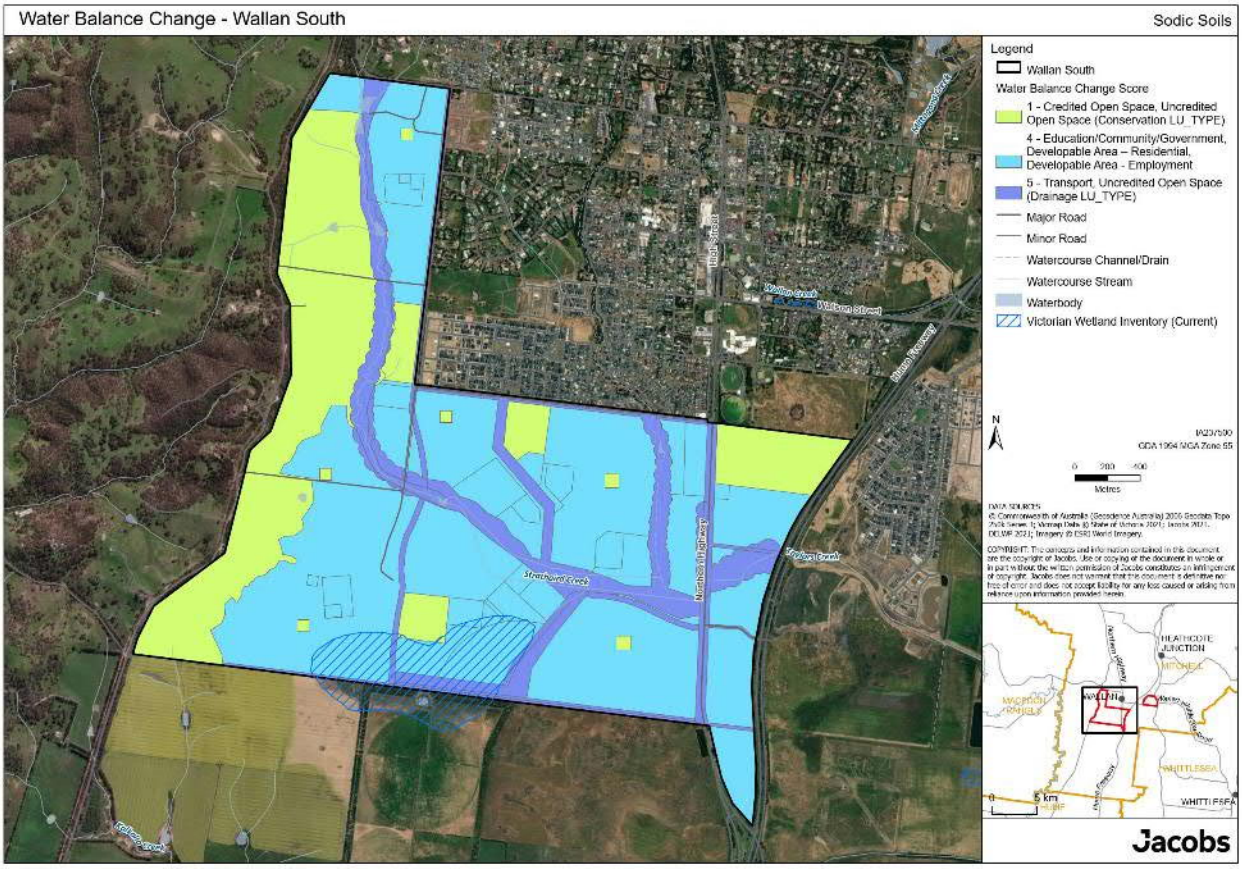


Figure 4-9: Water balance change.

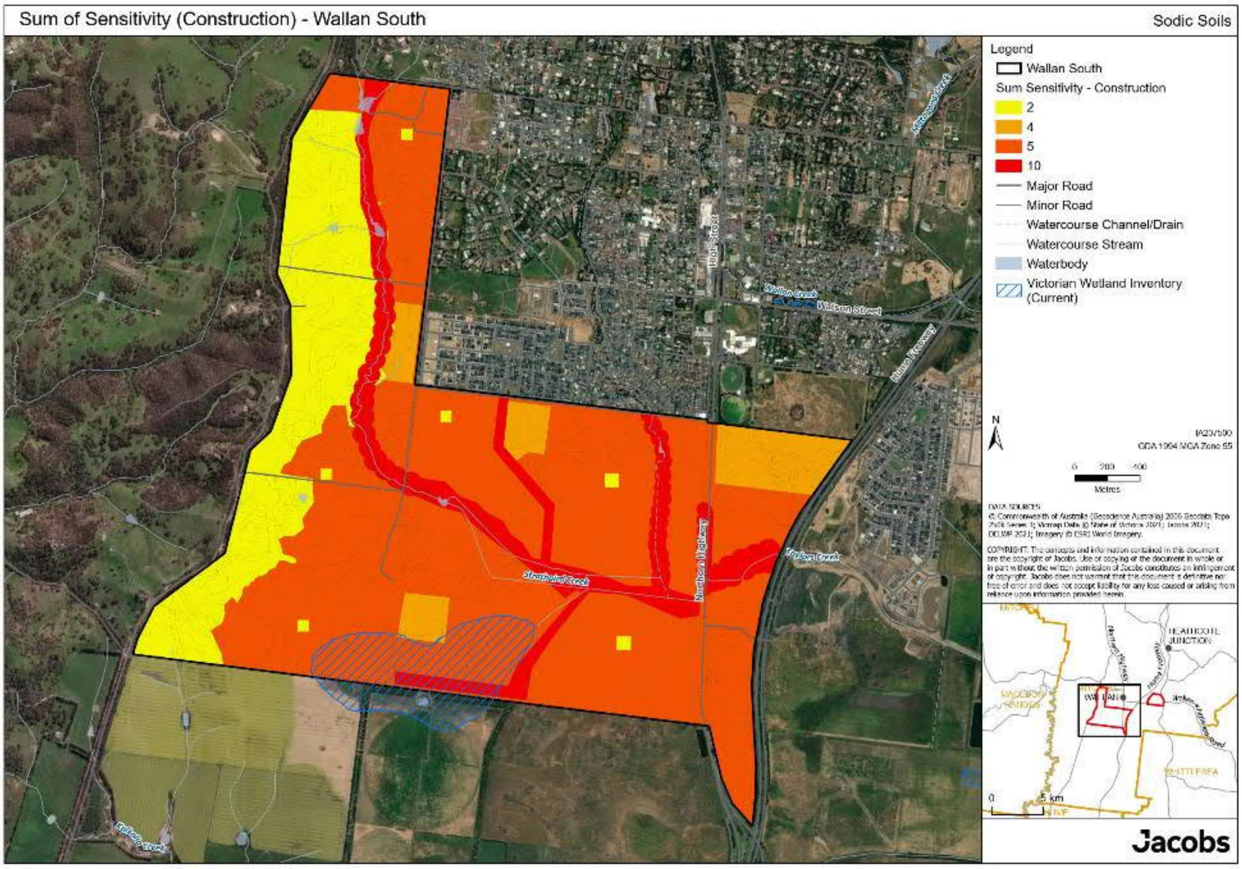


Figure 4-10: Sum of Sensitivity Criteria for Construction.

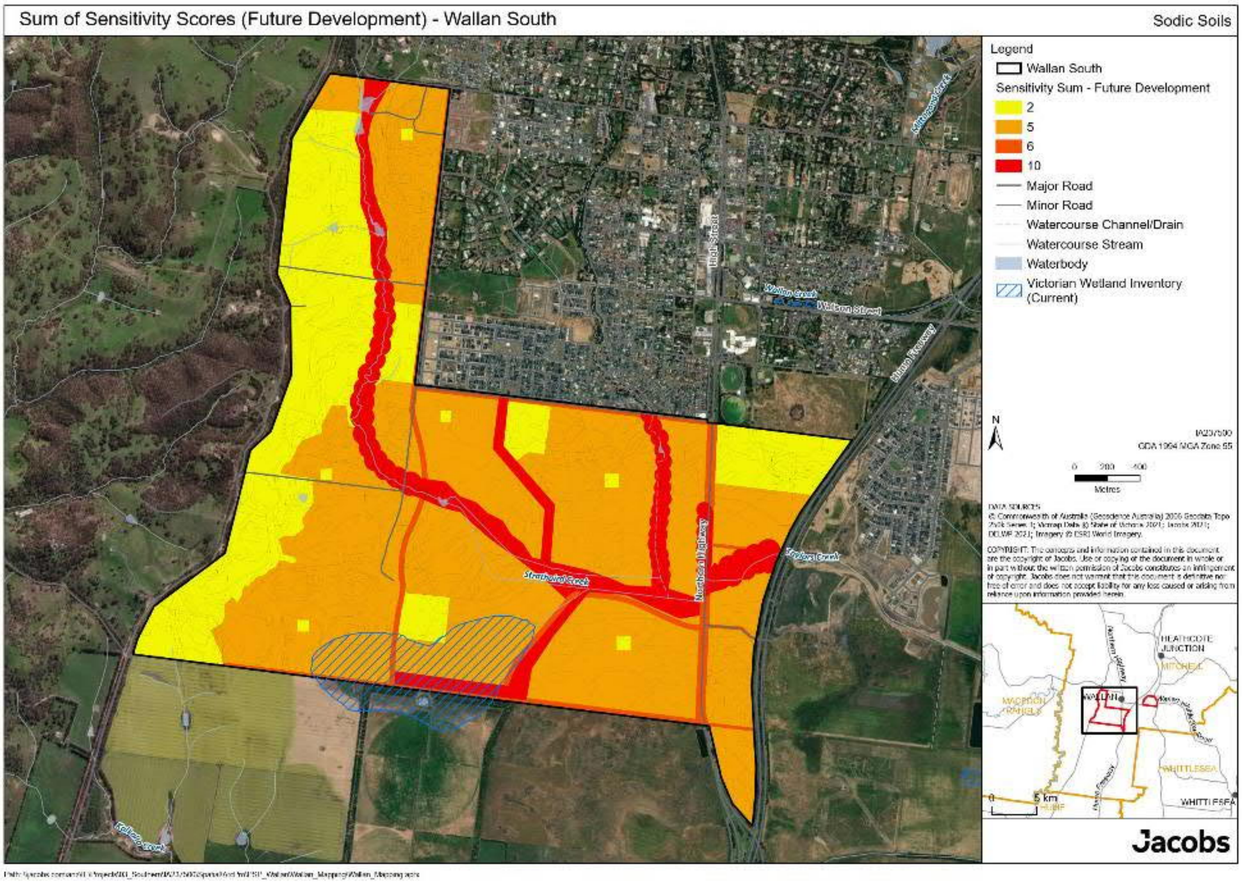


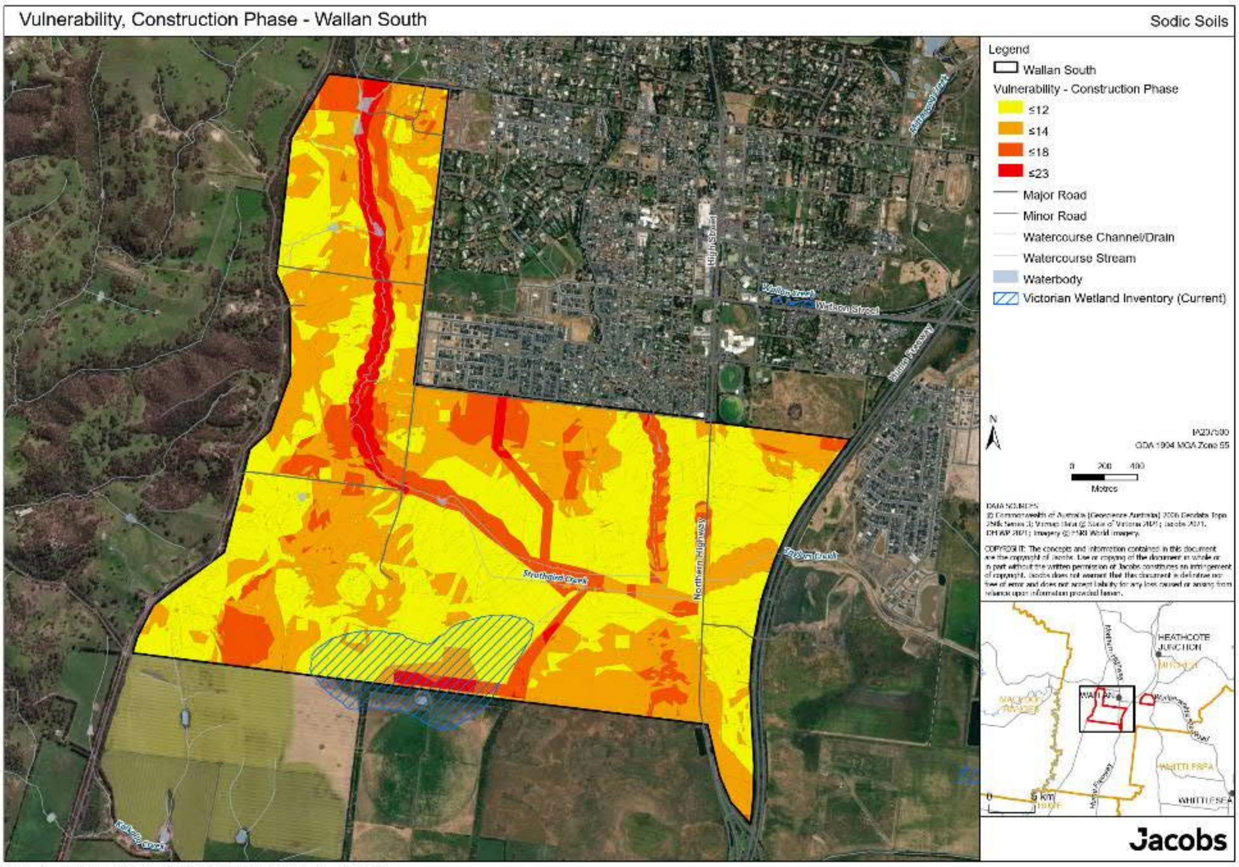
Figure 4-11: Sum of Sensitivity Criteria for Future Urban Structure.

4.3 Vulnerability assessment

The outcomes of the vulnerability assessment for the construction phase and future developed land use scenarios are presented in Figure 4-12 and Figure 4-13.

During construction, areas identified with a high vulnerability to sodic soil erosion are the waterways and steeper slopes (Figure 4-12). Activities that expose these soils to rainfall and associated runoff will present significant construction challenges and need to be managed carefully.

For future developed land use, waterways and steeper slopes are areas identified with a high vulnerability to sodic soil erosion (Figure 4-13). Water balance changes resulting from future developed land use and associated impervious areas will generate high volumes of runoff, which will drain into the surrounding waterways, including Strathaird Creek. Strathaird Creek is already in a degraded condition, further increases in flows would be expected to accelerate erosion of bed and bank materials.



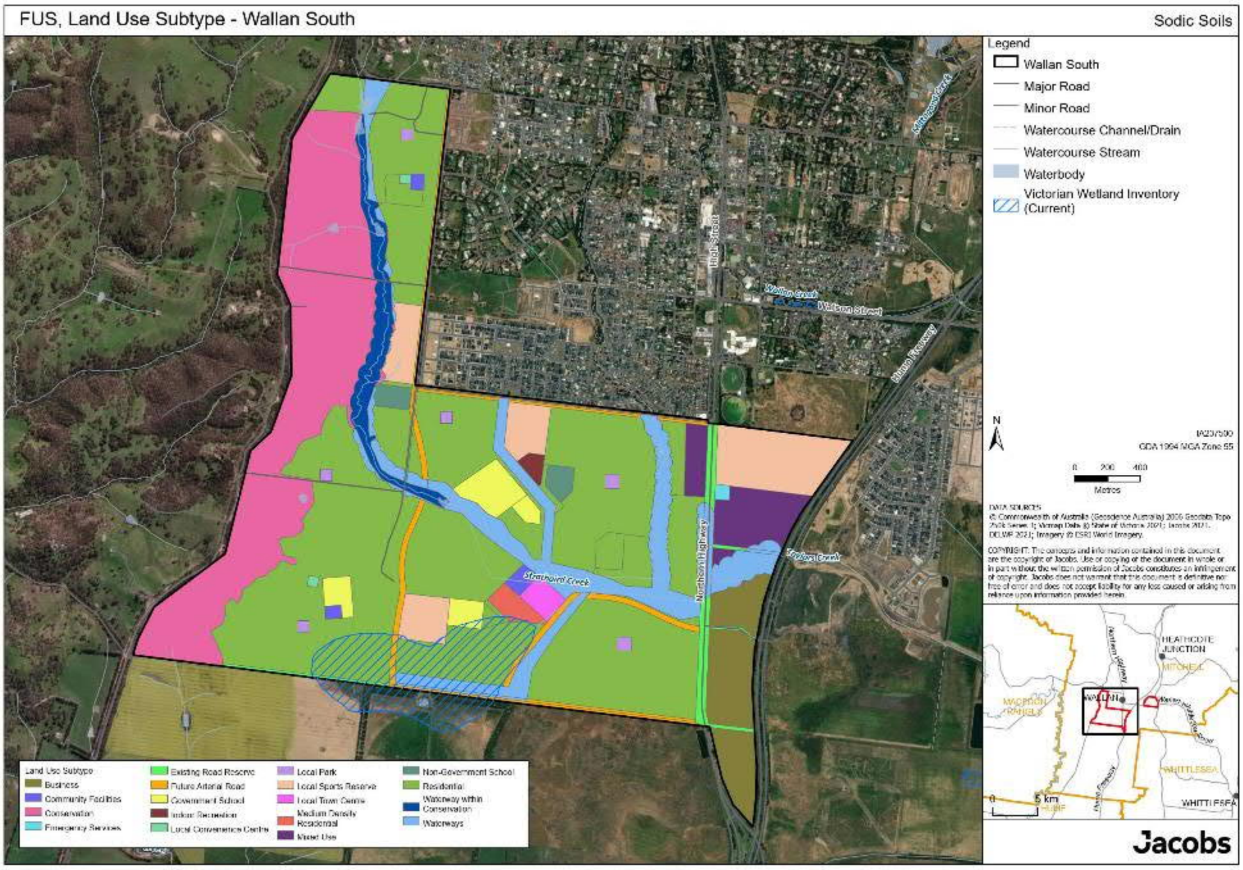
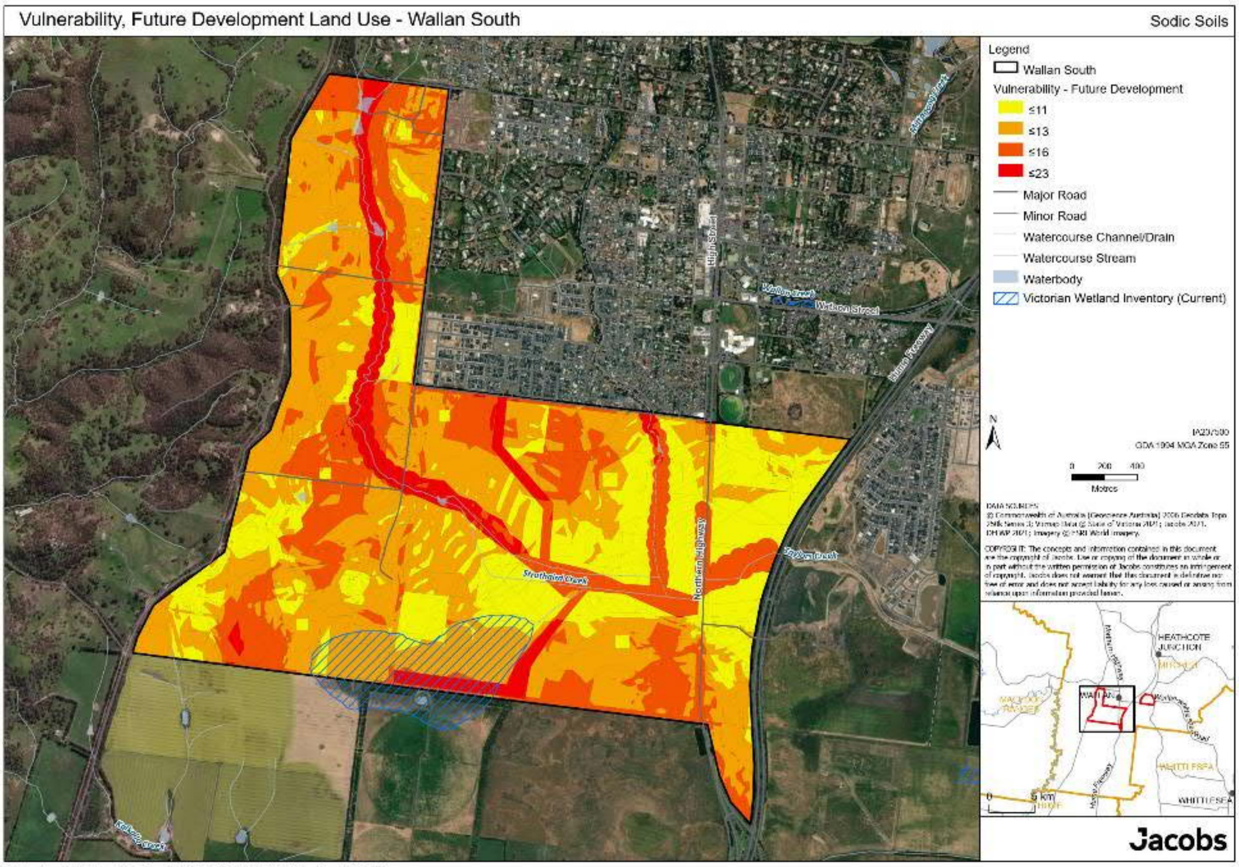


Figure 4-12: Vulnerability Construction Phase (upper). Yellow represents bottom 25% of data (low vulnerability) and red top 25% of data (high vulnerability). Map of Future Land Use Sub Types (below).



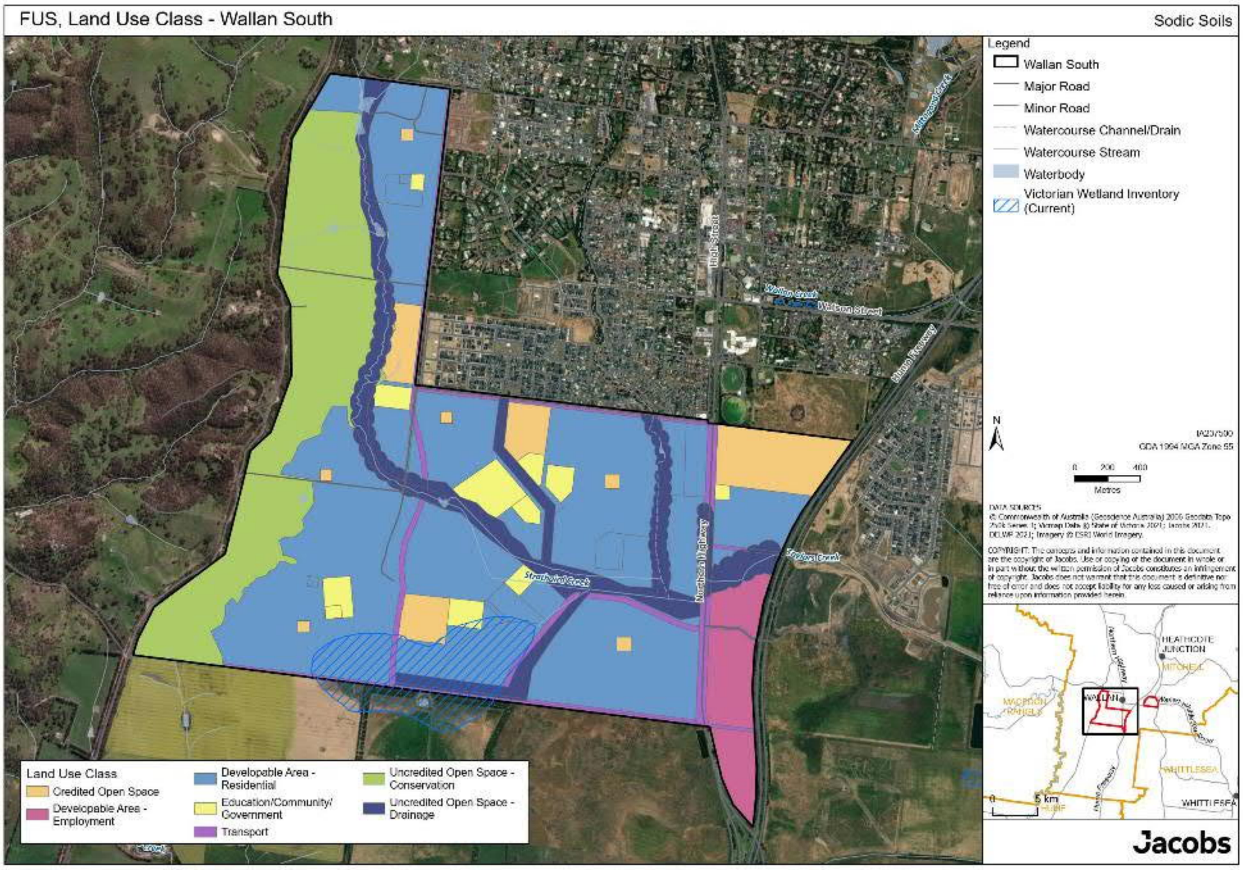


Figure 4-13: Vulnerability Future Developed Land Use (upper). Yellow represents bottom 25% of data (low vulnerability) and red top 25% of data (high vulnerability). Map of Future Land Use Classes (below).

5. Discussion and recommendations

5.1 Erosion risks

Erosion risks are directly influenced by sodic soil exposure and changes in landscape hydrology. Examples of activities that may potentially expose sodic and dispersive soils include disturbance to vegetation and groundcover, removal of topsoil, subsoil excavations (cut and fill), supply of services by trenches and construction of roads and culverts. Changes to hydrology, such as the concentration of flow in culverts, runoff from impervious areas and ponding of rainfall can lead to concentrated, elevated velocity water flow and may also increase erosion risk.

Clay-loam and clay-dominant soil textures were recorded across all of the surveyed areas. Soils with these characteristics evince slow or poor infiltration and permeability. Consequently, when rainfall intensity exceeds the soils' capacity to infiltrate water, or when profiles are at field capacity, rainfall is rejected and becomes subject to accessions by overland flow. Overland flows will entrain sand, silt and clay particles when they are loose and disturbed, when velocity or shear stress of flows exceed thresholds for particle entrainment or where dispersive conditions lead to a deterioration in soil structure, breaking down aggregates and soil particles leaving them liable to erosion. Clay dispersion from fresh rainfall contact with sodic clay may induce sheet or rill erosion on exposed surfaces. This is the primary threat to the quality of stormwater, where turbidity will be high if soils on disturbed areas remain untreated. Turbid water will pond in localised depressions, or enter drainage lines and result in increased turbidity in connecting waterways off-site.

Erosion may also occur in areas of localised groundwater discharge, following recharge of rainfall upslope, seepage on top of clay or rock layers and a soak or discharge point appearing where clay or rock is close to the surface and/or there is break in slope. Erosion risk is potentially compounded by the accumulation of salt in groundwater discharge areas as water is evaporated. This increased erosion risk is typically associated with the break of slope below steeper slopes and was observed across several sample areas. Erosion issues are also expected to arise along drainage depressions and waterways and may be compounded by historical changes to the physical form of the waterway, such as the removal of vegetation from the landscape and the formation of artificial drains. Initiation of scour in drainage depressions arising from increased runoff, exposure of subsoils and the dispersive nature of these soils require specific management. Future urban development, with clearing and removal of topsoils, trenching and changes to drainage patterns increases the erosion risk. Sand and silt particles are heavy by comparison with suspended clay particles. All will migrate downslope with the flow of water, however sand and silt are likely to fall out of suspension in low-energy detention points, or where erosion control measures are installed. There are high prospects for the capture of sand and silt particles with erosion control measures proposed but not suspended clay particles.

The following areas are identified as areas of high erosion risk:

- Drainage depressions/seasonal wetlands – These areas can be broadly classified as headwater streams – small flow lines (swales/wetlands), creeks and streams that are closely linked to adjacent slopes. They may only flow or have ponds of water periodically following rainfall events, however they do play an important role in retaining and temporarily storing water in the landscape (Jacobs 2016). This ability slows down the rate of flow over the land and assists in regulating flows and reducing downstream flood peaks. The infiltration of surface water in headwater streams into the local groundwater system also plays an important role contributing to groundwater levels and maintaining base flows in downstream waterways. In fact, many headwater streams have their source of water as groundwater. If small headwater streams are destroyed because of urbanisation there is likely to be an increase in the number of high flows to downstream reaches. These high flow events can cause bed and bank erosion that significantly degrade community and environmental values (Bond and Cottingham 2008).

  Headwater streams make up a significant proportion of the stream network and collect the majority of the runoff and dissolved nutrients from a catchment. Nutrient cycling and retention in headwater streams can significantly reduce nutrient exports to downstream reaches, estuaries and bays. This is because headwater streams provide the ideal mix of shallow depths, high surface-to-volume ratios, water-sediment exchange and biotic communities required for nutrient cycling (Peterson *et al.* 2001). If the nutrient processing capacity of headwater streams is diminished (for example through changed flows or the clearing of riparian vegetation), or lost altogether (e.g. through drainage and urbanisation), then more nutrients are delivered to downstream reaches (Jacobs 2016). With urban development, many headwater streams are converted into stormwater drains and these modified drainage courses become a key driver in the degradation of downstream reaches (SKM 2013).

- Strathaird Creek – This waterway in its upper parts has experienced historical bed and bank erosion, whilst in its lower parts it has the form of an agricultural drain. Further increases in runoff from urban development may result in increased erosion.
- Steeper slopes – The hillslopes in the precinct area vary in gradient. Cutting into steeper slopes will likely lead to the exposure of dispersive subsoils. Runoff from steep slopes will result in higher velocity flow with a greater risk of scour and erosion. Sediments eroded from these areas will be deposited on lower slopes or be carried into connecting waterways, adversely affecting water quality.

5.2 Planning measures

Erosion risks associated with sodic and dispersive soils can be managed by appropriate planning. This report concurs with the planning requirements and guidelines documented in the Beveridge North West and Shenstone Park PSPs that relate to Integrated Water Management (Victorian Planning Authority 2019a, Victorian Planning Authority 2019b). These are reproduced in Table 5.1.

Table 5.1: Integrated Water Management Requirements and Guidelines (Victorian Planning Authority 2019a, Victorian Planning Authority 2019b).

Requirements
Stormwater conveyance and treatment must be designed in accordance with the relevant Development Services Scheme unless otherwise agreed by Melbourne Water and the responsible authority.
Final designs and boundaries of constructed wetlands, retarding basins, stormwater quality treatment infrastructure, and associated paths, boardwalks, bridges, and planting, must be to the satisfaction of both the responsible authority and Melbourne Water.
Development staging must provide for the delivery of ultimate waterway and drainage infrastructure, including stormwater quality treatment. Where this is not possible, development proposals must demonstrate how any interim solution adequately manages and treats stormwater generated from the development and how this will enable delivery of an ultimate drainage solution, to the satisfaction of Melbourne Water and the responsible authority.
Stormwater runoff from the development must meet the performance objectives of the CSIRO Best Practice Environmental Management Guidelines for Urban Stormwater prior to discharge to receiving waterways, unless otherwise approved by Melbourne Water and the responsible authority. Proposals that exceed the performance objectives will be considered to the satisfaction of the relevant authority.
Applications must demonstrate how: ▪ Waterways and integrated water management design enables land to be used for multiple recreation and environmental purposes. ▪ Overland flow paths and piping within road reserves will be connected and integrated across property/parcel boundaries. ▪ Melbourne Water and the responsible authority freeboard requirements for overland flow paths will be adequately contained within the road reserves.
Guidelines
Relevant Integrated Water Management (IWM) requirements of this PSP will be achieved to the satisfaction of the retail water authority, including the supply of recycled water where required by the relevant water authority.
The design and layout of roads, road reserves, and public open space should optimise water use efficiency and long-term viability of vegetation and public uses through the use of overland flow paths, Water Sensitive Urban Design initiatives such as street swales, rain gardens and/or locally treated storm water for irrigation to contribute to a sustainable and green urban environment.
Where practical, and where primary waterway or conservation functions are not adversely affected, land required for integrated water management initiatives should be integrated with the precinct open space and recreation system.

The Wallan South Precinct Area is located in one of the Stormwater Priority Areas identified in the 2018 Healthy Waterways Strategy (Melbourne Water 2018b, Melbourne Water 2018a). One of the specific target objectives that have been set for this area is to constrain directly connected imperviousness (DCI)[3] levels to <2% and this will require undertaking significant harvesting and infiltration of stormwater. The current Taylors Creek Development Services Scheme (DSS) appears to include limited provision for stormwater harvesting or for protection of existing drainage depressions/wetlands and waterways in the Precinct (Figure 5-1). It is noted that there are two retardation basins distributed throughout the precinct, however, it is not clear how they will function in the landscape or how effective they will be in treating stormwater. Stormwater control measures can only protect waterways downstream of where they are located.

It is acknowledged that Melbourne Water are in the process of completing a range of investigations that are exploring alternative options for the location of stormwater treatment assets (Alluvium 2020) which may result in a different layout to that outlined in the April 2017 Taylors Creek DSS (Figure 5-1)

It is recommended that further work is undertaken to align the DSS with Best Practice as summarised by the following references:

- *Urban Water: Best Practice Environmental Management Guidelines* (CSIRO 1999) states that stormwater management should be based on the principles of preservation, source and structural controls:
  - Preservation: preserve existing valuable elements of the stormwater system, such as natural channels, wetlands and stream-side vegetation;
  - Source control: limit changes to the quantity and quality of stormwater at or near the source; and
  - Structural control: use structural measures, such as treatment techniques or detention basins, to improve water quality and control streamflow discharges.
  - These principles should be applied as part of an ordered framework to achieve environmental objectives as described in Figure 5-2.
- "Best practice planning for urban development requires that the catchment's hydrologic response is maintained as close as practicable to pre-development conditions. Appropriately conceived and designed water management infrastructure can achieve this outcome" (Melbourne Water 2009).
- Following on from this, it is now understood that maintaining ecologically and geomorphically important flow metrics close to their natural values requires preventing almost all the additional surface runoff generated by urbanisation from entering waterways (Duncan *et al.* 2016).

It is recommended that Melbourne Water undertake further work on the Taylors Creek DSS in light of the planned development in Wallan South PSP. This should consider the existing form of the waterways and how these may be protected or modified in future land developments. One design concept that Jacobs (2019) have previously recommended is that of distributed seasonal wetlands and swales that provides some stormwater treatment and flow conveyance. Further details of this design concept are provided here:

- Configuration - A series of seasonal wetlands positioned along and across the width of the waterway corridor, which are connected by a low-flow channel or series of low-flow channels (rocky/grassed swales).
- Hydraulic behaviour – Seasonal wetland and channel features extend across the width of the waterway corridor. Widening of features within the corridor and reduction of overall gradient will assist in lowering boundary shear stresses[4]. Low-flow channel(s) convey and spill water into wetland areas.
- How surface treatments may vary – Treatment of sodic soils with chemical and physical ameliorants will be required throughout, but it is expected that treatments will vary. For example, within the body and margins of a wetland, gypsum treatment, geotextile barrier, minimal topsoil and revegetation may be sufficient. More extensive rock treatment may be required in areas of high boundary shear stress (along

[3] The proportion of impervious area within a catchment that is directly connected to a stream via the stormwater drainage system
[4] Refers to the hydraulic forces acting on the channel bed, often used as a criteria to assess potential for erosion and sediment transport

low-flow channels and where water spills into wetland). Less rock treatment may be required within the body and margins of wetland where water ponds and boundary shear stresses are lower.

Figure 5-3 is a schematic to help illustrate the design concept and show how the wetland and swale/low-flow channel would be distributed and connect along the waterway corridor. Further detail in relation to the sizing and configuration of wetlands and low-flow channel(s) in the waterway corridor and how surface treatments (chemical amelioration, physical armouring/protecting) may vary would need to be worked through as part of the design process. It is expected that the hydraulic aspects of the design will require a number of iterations, varying the longitudinal grade and cross-sectional grades so as to distribute flow within the system of low-flow channels and seasonal wetlands, minimising bed shear stresses whilst also providing the required conveyance along the waterway corridor.

Careful design and construction of swale and wetland features, with particular attention to the formation of a protective layer on top of sodic soils will be required to provide a stable waterway corridor. In the case of Merrifield Central Waterway, this concept is considered to provide better outcomes as it more closely aligns with the characteristics and functioning of the existing waterway as a headwater stream, which is a broad depression/seasonal wetland that periodically hold water following rainfall events. Similar design concepts may also be applicable to the waterway corridors in the Wallan South Precinct Area. Jacobs, Spiire and South East Soil and Water are also currently completing a project for Melbourne Water to redesign scheme water treatment assets in the Kalkallo Retarding Basin to cater for the sodic and dispersive soils within the catchment and the basin itself. The outcomes of this work will also be relevant for the future design of stormwater assets in the Wallan South PSP.

Wherever construction is proposed, it is critical that on-site management includes measures that provide for protection and treatment of sodic and dispersive soils so as to limit the potential for erosion and generation of turbid water. Turbid water from construction areas also needs to be treated on site, as once clays are in suspension and turbid water runs off into waterways, it is very difficult to remove this from the water. Vegetated swales and wetlands along waterways will assist with stormwater treatment and entrapment of silt and sand fractions , but are unlikely to be effective in removing dispersed clay from suspension. Treatment of water collected in sedimentation basins within the construction site may be required to remove suspended clays from water, prior to discharge of water into waterways. Water collected in sedimentation basins may be treated with a flocculant and involve the use of cyclones to improve water quality, prior to entering waterways.

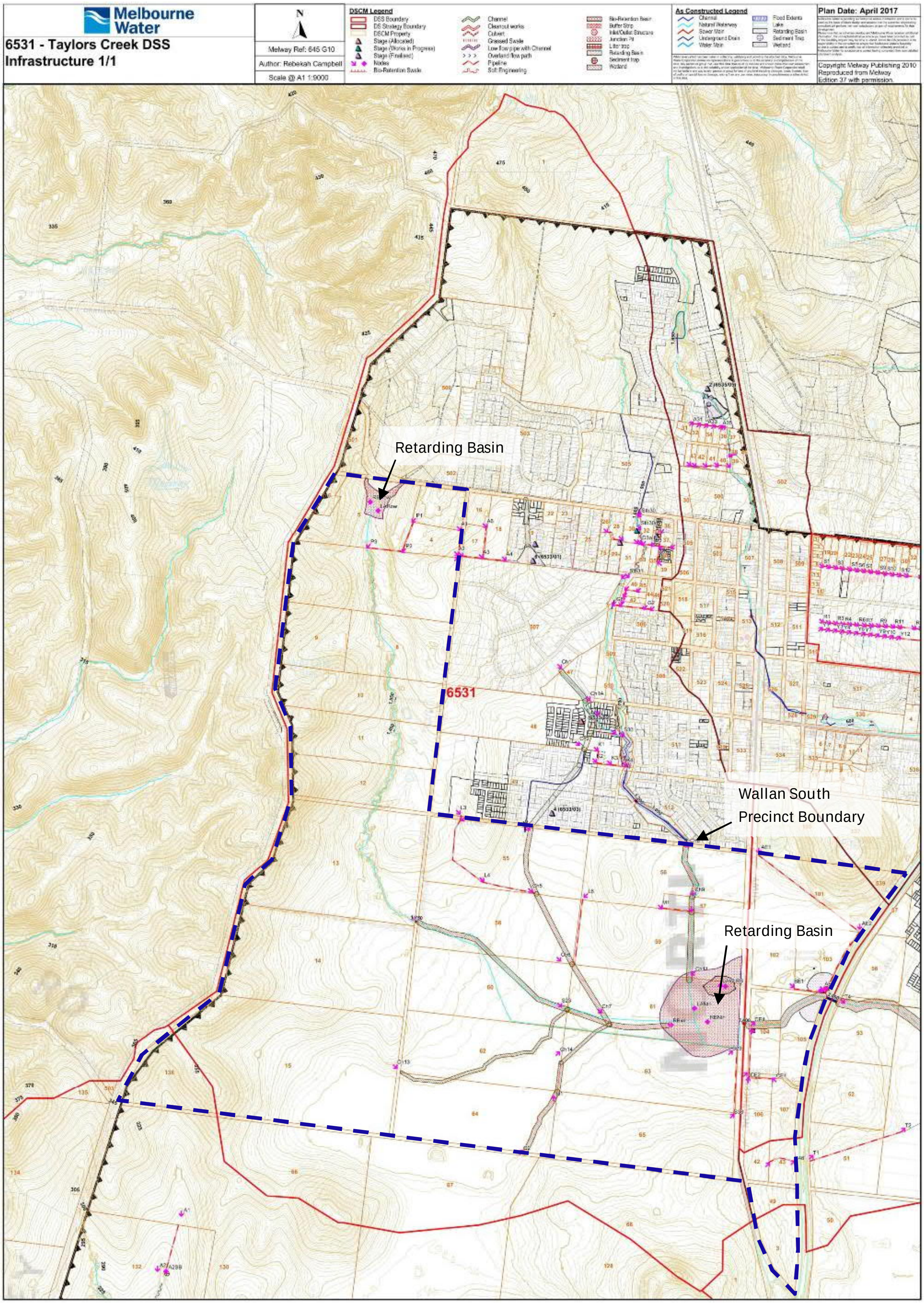


Figure 5-1: Taylors Creek DSS Infrastructure (Melbourne Water 2017).

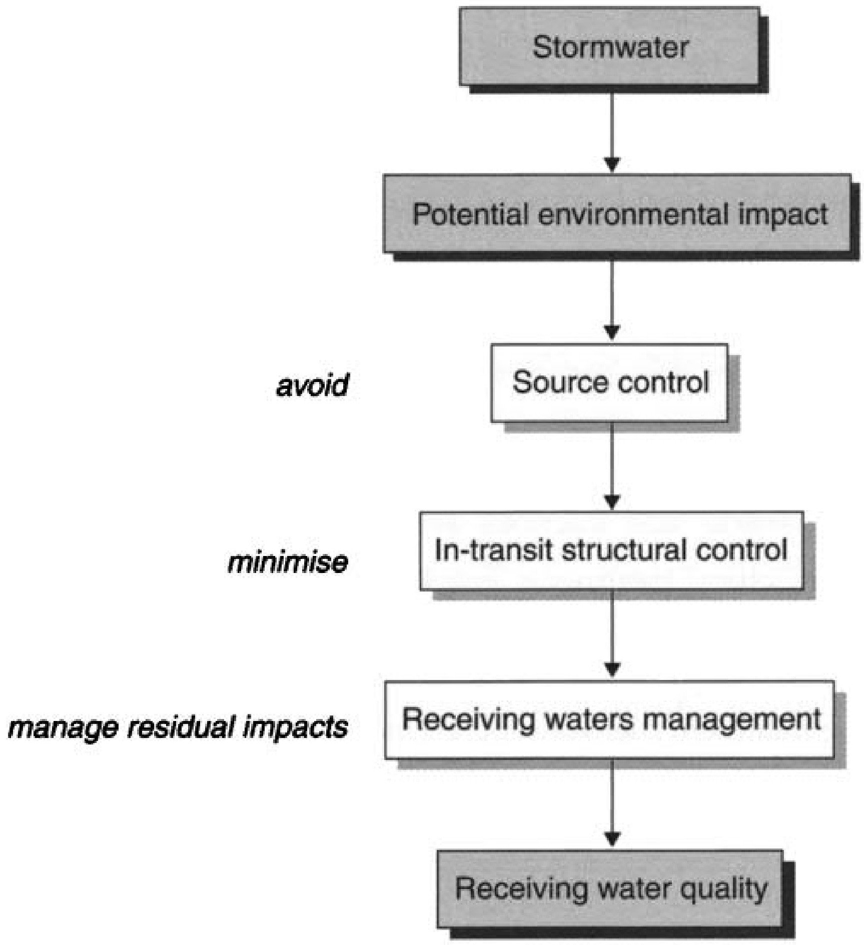


Figure 5-2: Stormwater management framework (CSIRO 1999).

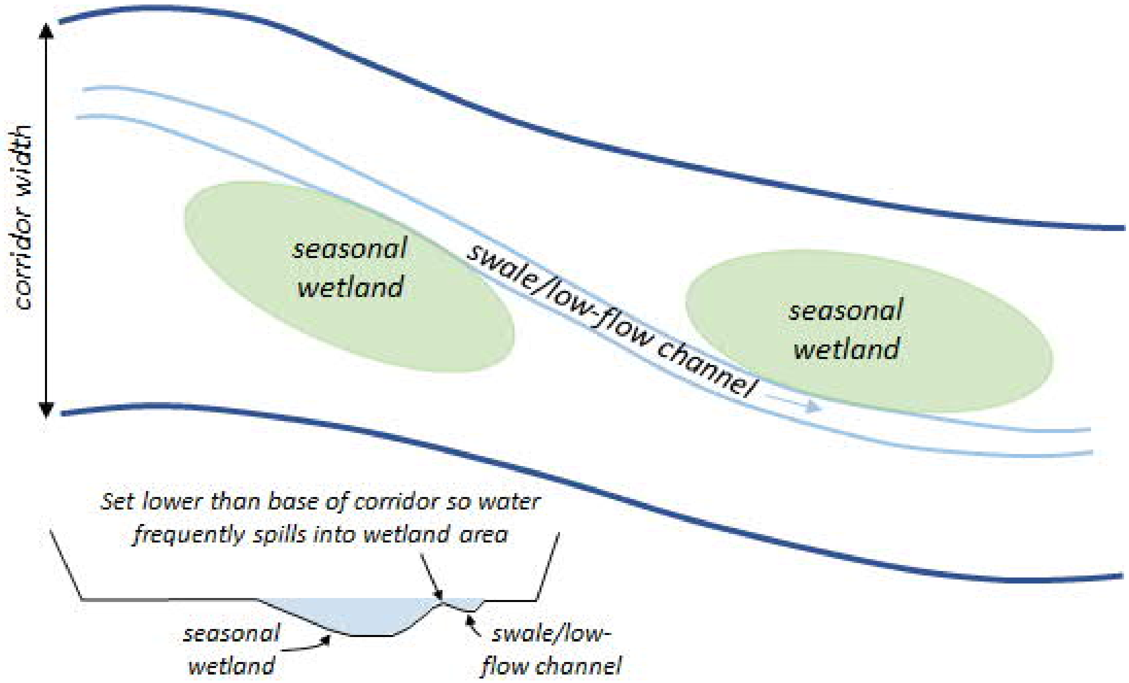


Figure 5-3: Schematic of distributed seasonal wetlands and swale/low flow channel (Jacobs 2019).

5.3 Treatment options

For areas identified with a high vulnerability to sodic soil erosion risks, treatment options include:

- Drainage depressions/seasonal wetlands – Ideally these areas should be identified and reserved as linear green spaces to maintain their important hydrological function in retaining and temporarily storing water in the landscape and regulating the flow of water and nutrients throughout a catchment. Ecosystem services provided by these landscape features include reducing flood peaks, supporting infiltration to groundwater, maintaining base flows and reducing downstream export of nutrient and sediment to receiving waters(Jacobs 2016, Walsh *et al.* 2016). Surface ground cover measures, specifically managing organic matter including ground cover, plant growth and roots are critical for protecting the soils against dispersion and erosion.
- Strathaird Creek – Upper reaches of this waterway have experienced historical bed and bank erosion, whilst the lower reaches form an agricultural drain. Further increases in runoff could increase erosion. Significant engineering works are likely to be required to stabilise this waterway so that is resilient to stormwater runoff from future land development (chemical and physical amelioration of sodic and dispersive soils, construction of grade-control structures, geosynthetic clay liners / rock treatment of low-flow channels and where water spills into wetlands).
- Steeper slopes – Cutting into these slopes exposes underlying subsoils, and erosion risk is increased with slope. Road batters must be designed with consideration to the erodibility of the soils. Stable linings that are resistant to rainfall and runoff will be required. Appropriate drainage at the base of cuttings is also essential to manage flows, reduce velocities and trap sediments, which if not checked could have detrimental effects to waterways.

The management of water flows over and through dispersive soils is a key tool in control of detrimental effects. Approaches may include:

- Diversion of water flows away from these materials. This is not always possible due to the extensive distribution of these dispersive soils.
- Minimising potential convergence and/or ponding of surface flows, particularly on disturbed soils;
- Development of appropriate cover/protection of dispersive soils (i.e. creation of stable linings that a resistant to rainfall and runoff);
- Compacting to reduce pore spaces and minimise water movement through the material. This will reduce the potential for soil dispersion and piping developing, however it will promote overland flow. For road formation levels and any other areas stripped or in shallow excavations (culverts, utility ducts) consideration should be given to running plant over the surface a number of times or placing engineered fill. In the case of utility trenches, backfill material should be at least the same density as the material surrounding to minimise ponding, infiltration, leaching within the trench and around the ducting/piping;
- The use of concave batter slopes without benching or contour banks has been shown to reduce the potential for convergence of water flows and to minimise flow velocities leading to gullying. However, it should be borne in mind that building extensive bank systems on dispersive soils can be problematic in themselves due to their surface erosion and tunnelling/piping potential; and
- Reducing the potential for undercut and piping failures for proposed road formations could be achieved by excavating interception trenches below and parallel with both sides of the formations. If these trenches are to carry large flows, then the use of agricultural pipes with appropriate granular backfill would be appropriate, and where low flows are anticipated then the use of use appropriate granular porous backfill to the trench may be relevant. It may also be appropriate to line the trenches with impervious materials.

Soil chemical ameliorants are recommended for short-term stabilisation of dispersive soils on construction sites. Three primary soil chemical ameliorants and their uses for stabilising dispersive soils on construction sites are:

- Gypsum ($CaSO_4$), primarily for stabilising dispersive topsoil or subsoil not intended for construction or geotechnical use. Gypsum flocculates soil and increases soil permeability, rendering materials less favourable for compaction and geotechnical use. Gypsum significantly reduces dispersion of clay and turbidity of runoff.
- Hydrated Lime ($Ca(OH)_2$). When slaked in water, hydrated lime stabilises soil cations by supply of calcium (reducing or eliminating dispersion and sodicity) and increases soil strength. Hydrated lime is the favoured soil chemical ameliorant for stabilisation of soils in civil and geotechnical works such as around pipes, structures, roads, trenches and any works requiring compaction upon reinstatement.
- Agricultural Lime ($CaCO_3$). Standard agricultural lime will provide minor soil stability however the solubility is low and immediate response is poor. Where topsoils are acidic (pH water average 5.77) agricultural lime could be used to support improving plant growing conditions by adjustment of soil pH. However, the effect on soil stability is expected to be low or negligible in the short term by comparison with gypsum. Agricultural lime will be a critical ameliorant in the reuse of topsoil across recreational and environmental areas upon completion of works, where soils are acidic and an improvement in soil health and plant growth is sought with the application of agricultural lime.

Soil physical ameliorants are recommended for long-term structural stability of soils. Their effectiveness varies, depending on the nature of the ameliorant and how effective it is for protecting dispersive soils from direct contact with fresh water and erosion, or slowing down water flow. Examples of soil physical ameliorants and options include:

- Geotextile fabrics and mattings that provide sodic soil protection, shrouding and assist with plant establishment.
- Organic matter. Used as a protective shroud on topsoils, improving soil physical structure and biological condition. Hydro-mulching is a form of stabilisation using organic matter. Organic matter is not suitable for stabilisation of soils for civil or geotechnical works unless it is a final layer of protection used for shrouding.
- Direct seeding of sites to fast-growing species by seed drills, spreader trucks or aerial seeding. This option will not necessarily reduce sodicity and dispersion.

A range of technical guidelines and manuals are available which provide advice on options for reducing the risk of soil erosion during construction arising from development works on dispersive soils (SCA 1979, DPIW 2008, Witheridge 2012, ICC 2016). Management options start with preservation and treatment of topsoil, with options variable depending on the level of disturbance (Table 5.2).

The stormwater drainage requirements of a site to be developed within the Precinct Area also needs to be appropriately incorporated into all stages of construction. This will require the development of temporary drainage control measures, separate to the sites' permanent drainage system. This will need to recognise the requirements and provide an appropriate drainage design for the diversion of up-slope "clean" water as opposed to the delivery of sediment-laden water generated within the construction site to sedimentation ponds. Appropriate hydrologic and hydraulic design is needed to size the drainage control measures for both the temporary and permanent drainage system (IECA 2008).

Table 5.2: Management options for reducing risk of erosion during construction for sodic and dispersive soils.

Management options	
Preservation and treatment of topsoil	▪ Preservation of A-horizon topsoil should be used to shroud sodic and dispersive subsoil in all areas across the precinct. ▪ Topsoils with clay-loam textures have a greater resilience to erosion by comparison with finer textured clay-dominant subsoils. Topsoils are also easier to stabilise from dispersion and erosion. ▪ Gypsum treatment of all topsoils to minimise dispersion of any clay within topsoil or subsoil. Gypsum treatment of topsoil is a simple, fast and cost-effective solution that can be applied without use of specialised equipment.

Management options	
Undisturbed sites	▪ Maintenance of topsoil across undisturbed land, preferably with grasses to provide surface soil stability and root anchorage. ▪ Maintenance of tree cover where trees exist. ▪ Groundcover including a mix of perennial grasses and larger shrubs and overstory vegetation is critical for slowing down overland flow and providing root anchorage of soil.
Disturbed sites – large scale surface disturbance	▪ Minimise the amount of time land is exposed (e.g. by staging development). ▪ Apply gypsum to all topsoils for improved stability. ▪ Avoiding removal or disturbance to topsoil or vegetation until absolutely necessary. ▪ Covering dispersive subsoils with a shroud of stabilised topsoil (100-150mm), should works cease for any period of time or prolonged rainfall is forecast. ▪ Consider using appropriately specified geotextile barriers and other engineering measures to protect disturbed areas particularly where there is minimal topsoil, or where steep slopes occur. ▪ Re-vegetate exposed areas immediately after completion of earthworks, with specific emphasis on steep slopes. ▪ Avoid construction techniques that result in exposure of dispersive subsoils. ▪ Use alternatives to 'cut and fill' construction such as pier and pile foundations. ▪ Use of interception trenches stabilised with topsoil to catch runoff in a controlled fashion and divert flow to sedimentation ponds to capture sediments. ▪ Use of organic materials on finished surfaces to soften the impact of rainfall, filter runoff and aid the germination of seed or growth of turf. ▪ Use of agricultural fertilisers at sound agronomic rates to expedite the process of vegetation establishment.
Disturbed sites – Trenching, culverts and drains	▪ Where possible avoid the use of trenches for the construction of services i.e. water & power. ▪ Limit extents of trench open at any one time. Material stockpiles from trenching, particularly dispersive soils, to be covered temporalily as required. ▪ Ensure that trench backfill is properly compacted, treat with hydrated lime (subsurface treatment) and gypsum (topsoils) to limit dispersion and erosion. ▪ Consider alternative trenching techniques that do not expose dispersive subsoils. i.e. use of trenchless technology installations of utilities/services such as horizontal directional drilling. ▪ Ensure runoff from hardstand areas is not discharged into areas with dispersive soils. ▪ If necessary, create safe areas for discharge of runoff. ▪ If possible do not excavate culverts and drains in dispersive soils. ▪ Following engineered design, consider placement of non-sodic soil to create appropriate road surfaces and drains without the need for excavation. ▪ Ensure that culverts and drains excavated into dispersive subsoils are capped with non-dispersive topsoil, gypsum stabilised and vegetated.

Where strongly duplex soils exist, management and amelioration of lighter-textured topsoil is normally favoured because it provides a source of cover and protection of dispersive subsoil. Lighter textured topsoils are also easier to ameliorate by comparison with clay loams and clays. As organic matter plays a significant role in maintaining soil structure and providing some resilience to dispersion and erosion, careful management of any available topsoil is imperative. Staging of earthworks to minimise disturbance of soils and immediate gypsum treatment is recommended to reduce potential dispersion of clay with rainfall and runoff events.

Table 5.3 provides calculated rates of gypsum to minimise or eliminate dispersion based on the analysis of soils across the precinct. These rates are a guide only and should be further refined with the development of sodic soil management plans at an individual subdivision level.

Table 5.3: Calculated rates of gypsum to minimise or eliminate dispersion for soils in the Wallan South Precinct.

Gypsum treatment	Topsoil (0-10cm)	Subsoil (30-40cm)	Deeper subsoil (>40cm)
Full gypsum rate to displace exc. Na, Mg and K to optimum levels (t/Ha/100mm).	2.06 0.20% w/v.	6.76 0.67% w/v.	19.53 1.95%w/v.
Gypsum rate to displace exc. Na to below 5% (t/Ha/100mm).	0.29	0.56	5.07
Gypsum rate to displace exc. Mg to below 15%.	2.08	6.34	14.46
Gypsum rate to displace exc. K to below 5% (t/Ha/100mm).	0.28	0.28	0.00

The drainage schemes for the waterways, in particular Strathaird Creek need to be designed with specific consideration to the erosion risks associated with sodic and dispersive soils. A high level of engineering will be required to create waterway corridors that are stable and can withstand the volume of water that will be generated from the developed areas. It is expected that all of the waterways will need to have a constructed form, with appropriate channel linings and/or armouring to provide protection for dispersive subsoils. Where possible, it is recommended that the waterway corridor includes distributed wetland and swales, to assist with attenuation and treatment of stormwater runoff.

It is recommended that further consideration is given to staging construction works, to manage erosion risks. In principle, it is better to work from top of catchment/higher areas in the landscape first and then progressively work downstream, but this may not be practical. Disturbances to high risk areas should be minimised, if not totally avoided, especially during the most erosive periods of the year (wetter months). The development sequence should allow the installation of temporary drainage and erosion control measures, and preferably permanent stormwater drainage system as soon as practicable. As waterways are a high risk, if possible, it makes sense to start on these first and construct the drainage schemes and get the waterway corridors ready for the future developed land use.

Runoff from construction sites should be managed by temporary drainage and sedimentation ponds, with the aim that it does not enter the waterway corridor until development is near completion. Harvesting of stormwater in appropriately designed sedimentation ponds within each development area, then dosing these with flocculants to drop out clay and improve water clarity before releasing downstream is recommended. Runoff dams can be designed and managed to capture runoff events, with immediate dosing and release in the days following collection. Consideration should also be given to the use of cyclones and appropriately designed sedimentation ponds and/or cascading v-notch weir type arrangement from inlets to outfalls so that clays and fine sediments are caught. These would require maintenance to remove captured sediments.

6. Knowledge gaps and recommendations for further investigations

6.1 Knowledge gaps

The spatial assessment undertaken in this investigation broadly considers surface erosion potential, however subsurface seepage and tunnel erosion impacts are difficult to relate with the data currently available. Processes of recharge and discharge are not well understood across the precinct area and are not represented in the spatial assessment. An assessment of the potential for subsurface seepage and tunnel erosion impacts should be undertaken as early as possible in the Structure Plan Preparation process to inform subsequent planning stages.

This assessment has focused on sodic and dispersive characteristic of soils as they relate to erosion risks. Some of the soils assessed may experience significant shrinking and swelling, resulting from drying and wetting. This often results in the development of features such as surface cracking and gilgai formation. These features are of significant importance for engineering purposes and controls against the adverse impacts of these soils character will be important if there is to be proposed development (pavement, shallow foundations, subsurface utilities etc). The controls to manage the effects of reactive soils may differ to those applicable to sodic, erosive soils. As for sodicity, it is recommended that the potential adverse effects of reactive soils on proposed developments should also be considered as early as possible in the planning stages to assess their associated risks, avoidance/elimination or the scope & cost of appropriate preventative measures.

6.2 Recommendations for further investigations

It is recommended that detailed Site Environment Management Plans (SEMPs) and Erosion and Sediment Control Plans (ESCPs) are developed for managing sodic soil related erosion risks. These plans would be developed during the planning of building and construction projects within the Precinct Area. This should include consideration of staging of development from initial bulk earthworks down to the construction of individual lots. It is expected that further sampling of soils, testing and analysis of the sodicity of soils, dispersion and erosion potential will be required at a higher resolution to inform construction techniques and management of erosion risks.

It is recommended at a minimum that sodic soil management plans are a requirement at a subdivision / zone level, and at the individual block level. The subdivision level needs to be a detailed investigation with a report that covers all aspects of the subdivision, works to occur and management techniques to manage sodic and dispersive soil and erosion. The individual block level could simply be a set of requirements set by local council that ensure good soil management practices are mandated and sodic soil exposure and disturbances are minimised, with disturbed areas treated or shrouded where possible.

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Appendix A. Soil Sampling and Analysis

A.1 Project scope

Jacobs and project partners South East Soil and Water (SESW) were engaged by Victorian Planning Authority to complete additional soil sampling and analysis so as to obtain additional data on the sodicity of soils in the Wallan South Precinct. The soil sampling and analysis methodology is similar to that which was undertaken for the Sodic Soils Assessment of the Beveridge North West and Shenstone Park Precincts (Jacobs 2020a, Jacobs 2020b).

Fieldwork of the Wallan South and Wallan East (Part 1) precinct areas was carried out by Peter Sandercock of Jacobs and Christian Bannan of South East Soil and Water on the 10, 11, 23, 24, and 25 February. Samples were collected using a gridded sampling program, with approximately one sampling site per 10-hectares of land available for sampling. The extent of samples collected allow for a suitable representation of the range of geological conditions for use in interpolating data and providing an indication of variability of soil characteristics across the Precinct.

The total number of sites inspected in Wallan South was 66 with the total number of samples collected recorded at 149. Figure A provides an overview of the sampling sites. A Garmin 76CX handheld GPS was used to locate sites in the field. The breakdown of samples comprised of:

- 0-10cm samples: 66
- 30-40cm samples: 64
- Deeper samples from 60-140cm: 17

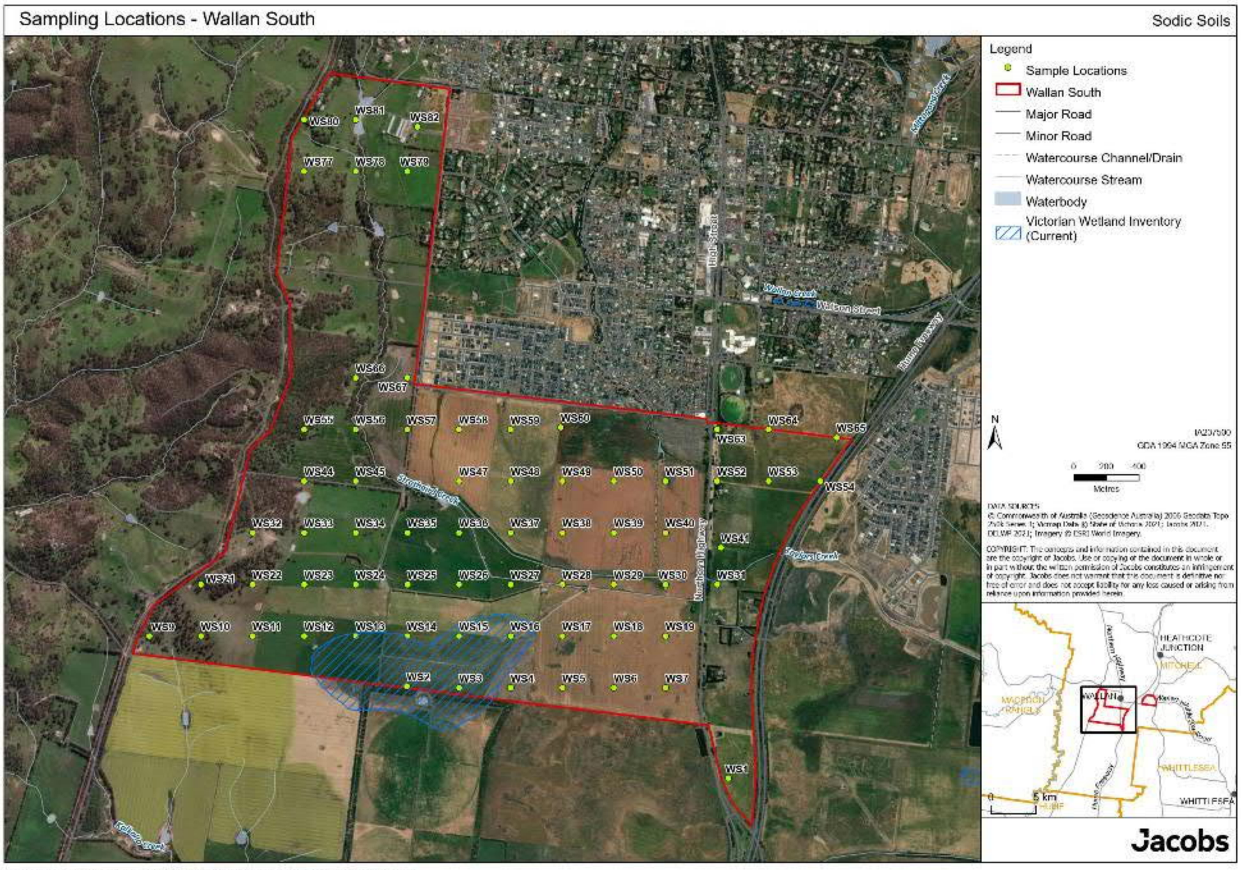

Figure A.1: Wallan South Sample Sites February 2021.

Access and sampling was not possible for a number of properties for a range of different reasons (1470 and 1500 Old Sydney Road, 90 Rowes Lane, 30 Macsfield Road, 20 and 260 Northern Highway). Soil conditions for these areas have been interpolated from data collected at adjacent properties.

For accessible sites, soil cores were collected from proposed sample points at 0-10cm and 30-40cm, limited by the depth to rock. There were 17 selected sites where samples were collected from depths greater than 40cm to gain general information on deeper sodicity and textural characteristics. Examples of soil cores from selected sites are shown in Figure A, Figure A., Figure A. and Figure A..

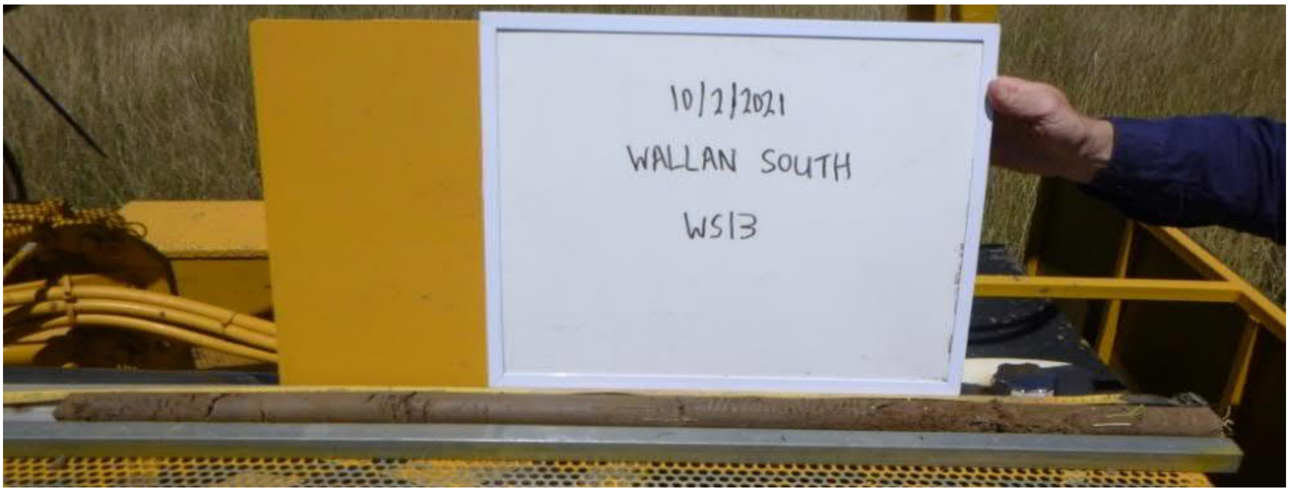

Figure A.2: Soil core from sample site WS13.

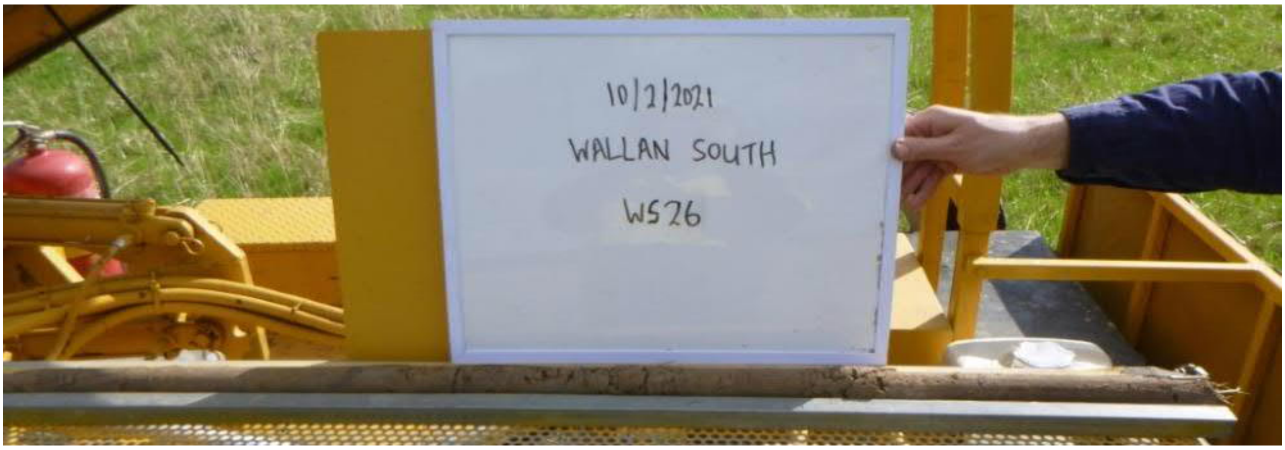

Figure A.3: Soil core from sample site WS26.

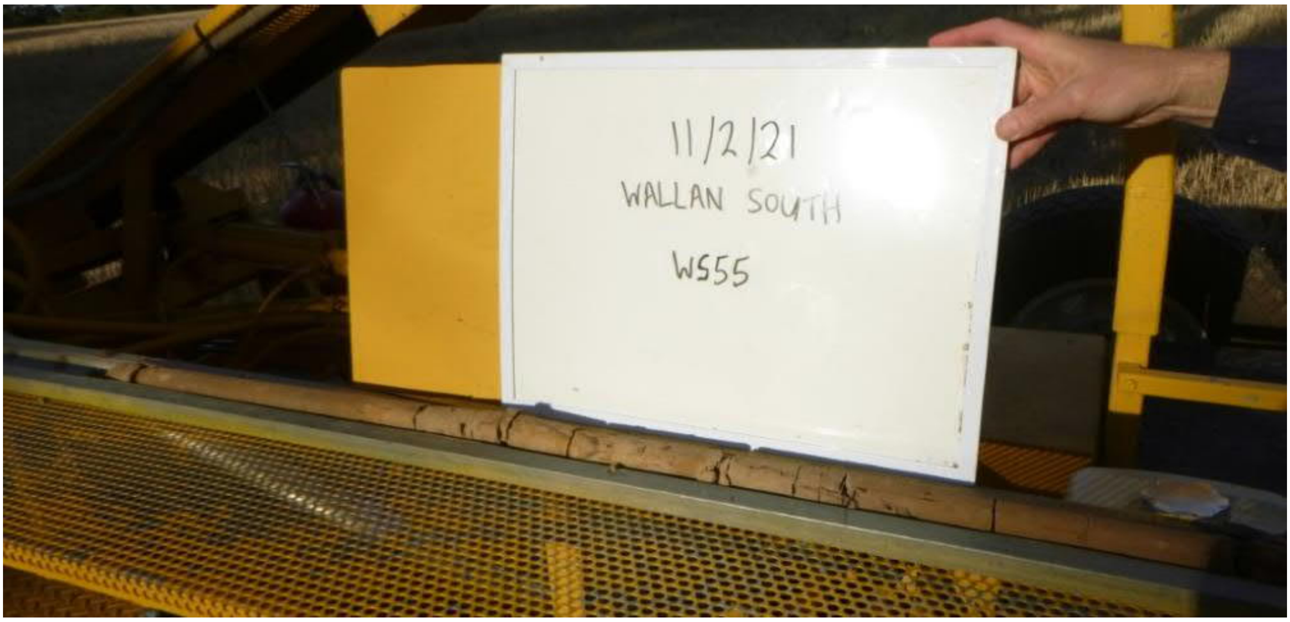

Figure A.4: Soil core from sample site WS55.

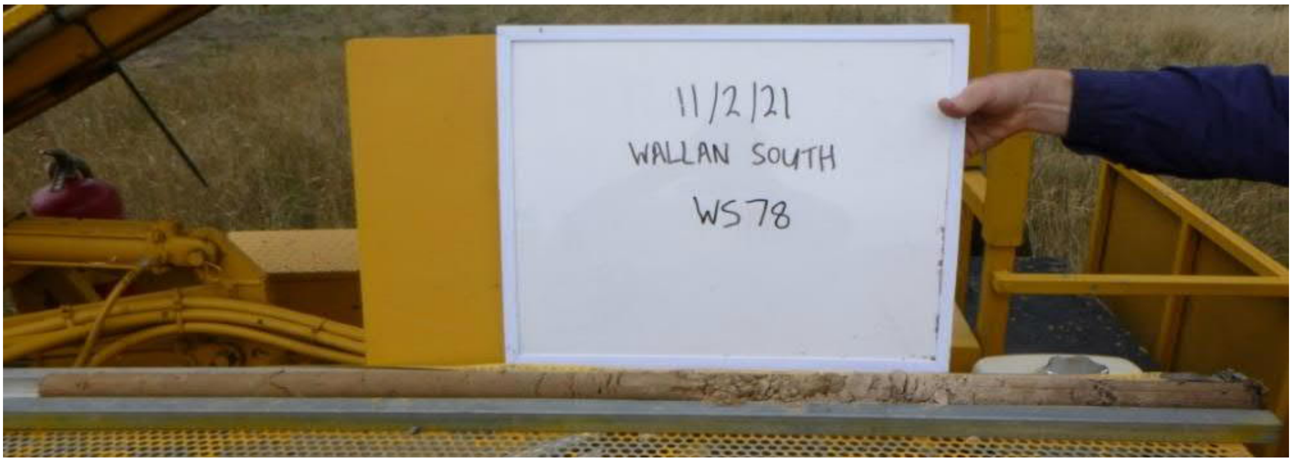

Figure A.5: Soil core from sample site WS78.

A.2 Soil sampling and laboratory analysis

At each location, a soil core was collected to sample specific soil depths and carry out a basic visual and textural classification of the profile. The following parameters were recorded:

- depth of A horizon topsoil.
- hand texture of the A and B horizons
- visual colour and Munsell colour of the A and B horizons
- other notes on soil physical characteristics defined by the assessor
- photograph of the core or sample collected.

Samples were collected from two depths, A horizon topsoil (0-10cm) and B horizon subsoil (30-40cm). Additional samples were also collected at greater depths at some locations (ranging from 60-140cm) sporadically across the sample areas.

Soil samples were dispatched to Nutrient Advantage (NA) Laboratories, Werribee, Victoria on the 2nd of March with results received on the 19th of March.

NA are an ASPAC and NATA accredited laboratory. The following laboratory analysis were undertaken of the soil samples:

- Soil pH (water)
- Soil pH (CaCl2)
- Electrical Conductivity (1:5 soil water) (uS/cm and dS/m)
- Exchangeable Cations, including calcium, magnesium, potassium, sodium and aluminium (cmol/kg and base saturation percentage)
- Emerson Dispersion Class
- Loveday & Pyle Dispersion Score
- Calculated ESP and exchangeable cation levels.

Total Organic Carbon analysis was also undertaken for the 0-10cm samples. In addition to receival of laboratory results, calculations were carried out on all samples to calculate cation levels in mg/kg. Indicative gypsum calculations were carried out by SESW and results are provided in this report as a guide to gypsum requirements for minimising soil dispersion.

A.3 Summary

A.3.1 Geology and Soils

The Wallan South PSP area covers several groupings of soils which occur in association with the underlying geology, land systems and landscape mapping units of the site and broader region (Jeffrey 1981, Jones *et al.* 1996) (Figure A.6). Soils across the precinct area generally divided into the following groups:

- Soils on alluvial deposits, associated with the geology units ‘Qa2’ and ‘Qm1’ (Geovic, 2021) across the break of slope, lower slope, drainage depression areas and other waterways or drainage lines on the site. Soils are duplex with a sharp transition between loamy A horizons and clayey B horizons. A horizons vary from shallow (<20cm) to deep (>50cm). Their occurrence is predominantly across southern half of the PSP area. In some areas where shallow cores were collected, sands appeared deep although clay was expected with deeper coring.
- Soils on Silurian deposits, covering lower slopes, gentle slopes, waterways, drainage lines and apron areas around this geology unit. Soils are associated with geology unit ‘Sxk’ (Kilmore Siltstone) (represented as ‘Dxh’ on Figure A.6) and are duplex and include alluvial and colluvial deposits depending on position in the landscape. Soils vary from shallow to deep overlying parent material. These are most common throughout the eastern part of the PSP area.
- Shallow soils on Silurian deposits, covering mid to upper slope sections overlying weathered rock. These soils also lie on the ‘Sxk’ geology unit on moderately steep to steep sections of the landscape, occurring in the far western extent parallel with Old Sydney Road. Soils are duplex with shallow A horizons overlying clayey B horizons, often containing rock, gravel or weathered rock material.
- Volcanic soils on basalt, occurring in the far east and south-eastern sections of the PSP area. Soils occur in association with geology unit ‘Qno1’ (Unnamed sheetflow basalt) (represented as ‘Neo’ on Figure A.6) and are generally shallow overlying basalt rock across sloping land. Typical profiles include shallow clay-loams and light clays, overlying medium to heavy clay of variable thickness over basalt. These soils are gradational or uniform soils (not strongly duplex).

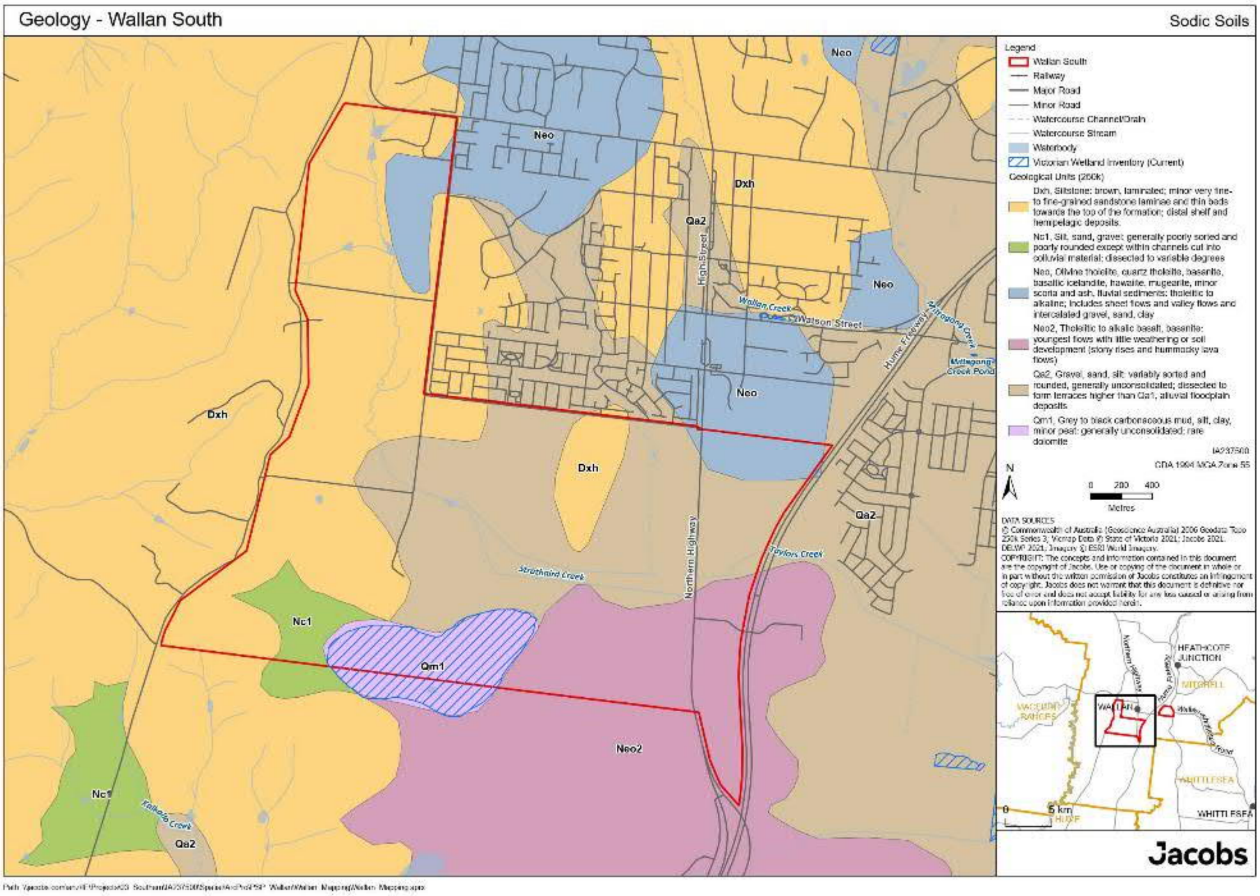

Figure A.6: Local geology.

Soils across the precinct area closely relate to geology and geomorphology, with the greatest variability observed on the apron area across Silurian deposits or where this geology type merges with alluvial deposits. Soils on volcanic flows are more predictable in their occurrence and profile characteristics. The results show moderate consistency with previous mapping by Jones *et al.* (1996) and (Jeffrey 1981). Almost all soils are moderate to strongly duplex in characteristics. Where A-horizon topsoil is greater than 20cm in thickness, a well-defined, bleached A2 horizon exists above clay subsoil, reflecting low permeability in the B horizons and seasonal perching of water.

A.3.2 Soil Classification

Soils across the PSP area are broadly classified as follows in accordance with Isbell and NCST (2021):

- Duplex soils on alluvial deposits: Soils are classified as Sodosols, where ESP levels throughout the B-horizon, particularly in the upper part of the B2 horizon are sodic at 6% or greater. In accordance with old soil classification system, these soils are known as Solodic Soils (Stace *et al.* 1968).
- Duplex soils on Silurian deposits: These soils are broadly classified as:
  - Sodosols, as previously described, or
  - Chromosols, where duplex conditions exist and non-sodic and not strongly acid (neutral to alkaline) conditions occur throughout the upper B horizon.
- Volcanic soils on basalt: Sodosols, where ESP levels throughout the A-horizon, or upper part of the B2 horizon are sodic at 6% or greater.

Soils across the precinct area soils are dominated by Sodosols, mainly by their occurrence of sodic (exchangeable sodium percentage or ESP of 6% or greater) conditions in the B2 horizon. These observations are consistent with literature from Jones *et al.* (1996), Jeffrey (1981) and a previous report by Jacobs (2020a) covering soil sodicity across the Beveridge North West PSP area. Ford *et al.* (1993) and Agriculture Victoria (2020) also record a dominance of sodic soils covering the Wallan South PSP area. These observations are a normal occurrence across Victorian soils with many areas of urban and environmental development located on Sodosol soil types.

A.3.3 Soil Sodicity

A total of 66 sites and 147 samples were collected across the precinct area to characterise soil sodicity trends throughout soil profiles. In developing exposure criteria (refer to Section 3.2.1) we have chosen to base this on the Exchangeable Sodium Percentage (ESP), or 'sodicity' value where 6.0% is the trigger level (Ford *et al.* 1993, Isbell and NCST 2021). Exchangeable Sodium Percent (ESP) is the most common analytical technique used to identify sodic or potentially dispersive soils in Australia and there are general trends showing this correlation (DPIW 2008).

Of the sites and samples collected, sodicity results measured in terms of exchangeable sodium percentage (ESP) are summarised as follows:

- 1-10cm, total of 66 samples (A1 horizon topsoil): Average ESP of 4.3%. A total of 56 samples (87.5%) were deemed non-sodic while 8 samples (12.5%) were deemed sodic. Sodic topsoil sites are all positioned on Silurian deposits along the western extent coinciding with rising land or break-of-slope zones. Almost all of the alluvial deposits and volcanic soils recorded non-sodic conditions in the 0-10cm range.
- 30-40cm, total of 64 samples (mixture of subsurface A2/A3 horizon loams and B-horizon clay subsoil): Average ESP of 7.8%. Of the 64 samples collected from this depth, results are summarised as follows:
  - 36 samples were sodic (56%). Sodic samples include a mix of A2/A3 horizon material along with some clay B horizon samples. There is not a clear pattern of variability.
  - 28 samples were non-sodic, with ESP levels of <6%. As previously noted, there is no clear pattern of variability in texture across these results. A total of 30 samples (44%) including both A2/A3 horizon topsoil and B horizon clay recorded non-sodic conditions.
- Deeper samples below 40cm and extending to 140cm, totaling 17 samples: Most of these samples reflect the natural B2 horizon, with all textures recorded as clays, mostly medium or heavy. All samples were of high or very high sodicity with the ESP averaging 22.1% in this range. Most samples were taken from 100-140cm.

In addition to the results for ESP, the following observations are made from the data set:

- 0-10cm samples: Most samples that are non-sodic are also non-dispersive. The pattern is relatively consistent. There were 8 samples where this pattern was not perfectly clear, however in many cases there were other factors that may have contributed to the presence or lack of dispersion, including high organic carbon.
- 30-40cm samples: While 36 samples were sodic (56%), there were 52 samples (77%) that were dispersive. Based on observation of the data set, several samples that were non-sodic in the ESP range of 4-6% were dispersive. Dispersion may be occurring under the associated influence of exchangeable potassium, or where organic carbon and EC levels are low, limiting soil stability.
- Samples below 40cm: With very high ESP levels, almost all were dispersive. Those that were non-dispersive, or recorded low Loveday and Pyle scores may be influenced by an elevated EC level, whereby the electrolyte concentration is maintaining a relatively stable soil condition under high ESP.

This data set shows several consistencies with previous work by Jacobs covering the Beveridge North West PSP area, adjoining the southern boundary of this PSP area. Laboratory results and field observations from the 30-40cm sample depths suggest that in general, soils across alluvial areas may contain deeper A-horizon topsoil over clay. The characteristics of profiles and their sodicity trends with depth into the subsoil are relatively consistent. The results obtained confirm that hillslope and rising soils show a more common trend with higher ESP values.

Organic carbon was tested in the A-horizon samples from 0-10cm to gain a greater understanding of factors influencing stability of the surface horizon. The results confirm that the average organic carbon levels are 3.2% across the precinct area, which correspond with an organic matter level averaging 5.4%. These levels are acceptable for sandy topsoils of this region under pasture production, or dryland cropping with a long history of pasture production. It is of a high likelihood that acceptable organic carbon levels are assisting with maintaining stable conditions in the A-horizons, noted by slaking class most commonly recorded as water stable and Emerson Class most commonly recorded as 7, nil slaking and swelling.

Across this PSP area, exposure and risk of sodic soil impacts are likely and will amplify according to the following processes:

1) Removal of the surface A1 horizon topsoil with low ESP values and high organic carbon, exposing less stable or unstable subsurface topsoil or clay subsoil.
2) Exposure of B-horizon clay with sodic and dispersive characteristics.
3) Increased depth of excavation or stripping, where higher ESP subsoil becomes exposed, or
4) Larger areas or footprints subject to soil stripping, increasing the catchment area for rainfall and runoff in contact with unstable or dispersive subsoil.

Sodicity and dispersive soil risks across this precinct area are high and increase proportional to the depth of exposure or excavation. We maintain that the measure of sodicity with reference to ESP values is effective for inferring dispersive soil risks to erosion across the precinct.

A.3.4 Gypsum Stabilisation

The results confirm that gypsum responses are likely to be observed. Table A.1 provides calculated rates of gypsum to minimise or eliminate dispersion. Calculations adopt the following criteria:

- Reduce ESP to below 5%
- Reduce exchangeable magnesium to below 15%
- Reduce exchangeable potassium to below 5%.

Table A.1: Calculated rates of gypsum to minimise or eliminate dispersion.

Gypsum treatment	Topsoil (0-10cm)	Subsoil (30-40cm)	Deeper subsoil (>40cm)
Full gypsum rate to displace exc. Na, Mg and K to optimum levels (t/Ha/100mm).	2.06 0.20% w/v.	6.76 0.67% w/v.	19.53 1.95%w/v.
Gypsum rate to displace exc. Na to below 5% (t/Ha/100mm).	0.29	0.56	5.07
Gypsum rate to displace exc. Mg to below 15%.	2.08	6.34	14.46
Gypsum rate to displace exc. K to below 5% (t/Ha/100mm).	0.28	0.28	0.00

A.4 Analytical results

Results from the laboratory were collated with additional information collected in the field. Results from the field and laboratory analysis of soils are also documented here in the following pages.

Table A.2: Wallan South Field Sheet.

				Topsoil 0-10cm Sample						Subsoil 30-40cm Sample					Deeper Sample below 40cm					
New Site Name	Photo Collect	Easting	Northing	Lab Barcode	0-10cm Sample Collected	Depth of A Horizon (cm)	0-10cm Sample Texture	0-10cm Sample Visual Colour	0-10cm Sample Munsell Colour	Lab Barcode	30-40cm Samp Collected.	30-40cm Sample Texture	30-40cm Sample Visual Colour	30-40cm Sample Munsell Colour	Lab Barcode	Deep Sample Collected	Deep Sample Depth	Deep Sample Texture	Deep Sample Visual Colour	Deep Sample Munsell Colour
WS1	Y	321237	5854088	22314844	Y	30	Clay Loam	DGB	10YR4/2	22314845	Y	Medium-Heavy Clay	DGB	10YR4/3						
WS2	Y	319269	5854650	22317529	Y	8	Light Clay	GB	10YR4/2	22317530	Y	Heavy Clay	DG	10YR4/1		N	40-70	Heavy Clay	DG	10YR4/1
WS3	Y	319588	5854642	22317531	Y	12	Clay Loam	DG	10YR4/2	22317532	Y	Heavy Clay	DGB	10YR3/1		N	50-90	Heavy Clay	DGB	10YR2/1
WS4	Y	319904	5854642	22317533	Y	22	Clay Loam	DGB	10YR4/2	22317534	Y	Heavy Clay	DG	10YR4/1	22317535	Y	100-110	Heavy Clay	DG	2.5Y4/1
WS5	Y	320221	5854642	22317537	Y	13	Sandy Clay Loam	DGB	10YR4/3	22317536	Y	Heavy Clay	DGB	10YR4/2		N	55-65	Heavy Clay	DG	10YR3/1
WS6	Y	320536	5854642	22317538	Y	12	Clay Loam	DGB	10YR4/2	22317539	Y	Heavy Clay	DG	10YR3/1		N	55-65	Heavy Clay	DG	10YR2/1
WS7	Y	320852	5854642	22317540	Y	11	Sandy Clay Loam	DGB	10YR4/3		N	Weathered Basalt				N				
WS9	Y	317692	5854958	22317591	Y	35	Fine Sandy Loam	GB	7.5YR5/3	22317590	Y	Sandy Loam	LG	10YR6/3		N	80-90	Medium Clay	OB	10YR4/6
WS10	Y	318008	5854958	22317593	Y	28	Fine Sandy Loam	GB	7.5YR5/3	22317592	Y	Sandy Loam / Weathered Rock	LG	7.5YR6/2		N		Heavy Clay / Weathered Rock	YB	10YR6/6
WS11	Y	318234	5854958	22317595	Y	55	Sandy Loam	GB	10YR4/3	22317594	Y	Sandy Loam	G	10YR5/1		N	50-70	Medium Clay		10YR6/6
WS12	Y	318640	5854958	22317603	Y	36	Sandy Loam	GB	10YR4/2	22317602	Y	Light Sandy Clay Loam	G	10YR5/2		N	70-80	Medium-Heavy Clay	DG	10YR4/1
WS13	Y	318956	5854958	22317597	Y	14	Sandy Loam	DG	10YR4/2	22317580	Y	Medium-Heavy Clay	DG	10YR4/1	22317579	Y	110-120	Heavy Clay	DG	10YR4/2
WS14	Y	319270	5854958	22317553	Y	35	Fine Sandy Loam	GB	10YR4/2	22317598	Y	Sandy Clay Loam	G	10YR5/1		N	80-90	Heavy Clay	YB	10YR5/3
WS15	Y	319589	5854958	22317551	Y	14	Clay Loam	DG	10YR4/2	22317552	Y	Medium-Heavy Clay	DG	10YR4/1		N	70-80	Heavy Clay	DG	10YR3/1
WS16	Y	319904	5854958	22317548	Y	23	Light Sandy Clay Loam	G	10YR4/2	22317549	Y	Medium-Heavy Clay	DGB	10YR4/3	22317550	Y	130-140	Heavy Clay	G	2.5Y5/3
WS17	Y	320220	5854958	22317545	Y	17	Light Sandy Clay Loam	DGB	10YR4/2	22317546	Y	Heavy Clay	YGB	2.5Y4/3	22317547	Y	65-75	Heavy Clay	YG	2.5Y4/2
WS18	Y	320537	5854958	22317543	Y	21	Clay Loam	DGB	10YR4/2	22317544	Y	Heavy Clay / Wethered Rock	YGB	2.5Y4/3		N				
WS19	Y	320852	5854958	22317542	Y	7	Clay Loam	DG	10YR4/1	22317541	Y	Heavy Clay	YG	2.5Y4/2		N	75-85	Heavy Clay	YGB	2.5Y3/2
WS21	Y	318008	5855274	22317589	Y	52	Fine Sandy Loam	DGB	10YR5/3	22317588	Y	Sandy Loam	LG	10YR6/2	22317587	Y	110-120	Medium-Heavy Clay	YGB	10YR5/6
WS22	Y	318324	5855274	22317599	Y	60	Fine Sandy Loam	GB	10YR4/3	22317596	Y	Fine Sandy Loam	LGB	10YR6/2		N		Heavy Clay	OGB	10YR3/3
WS23	Y	318640	5855274	22317601	Y	40	Sandy Loam	GB	10YR4/3	22317600	Y	Sandy Loam	LGB	10YR5/2		N	70-80	Medium-Heavy Clay	YB	10YR3/3
WS24	Y	318956	5855274	22317575	Y	43	Fine Sandy Loam	GB	10YR4/3	22317574	Y	Fine Sandy Loam	G	10YR6/2		N	90-100	Medium-Heavy Clay	YGB	10YR5/6
WS25	Y	319272	5855274	22317573	Y	38	Fine Sandy Loam	GB	10YR5/3	22317572	Y	Sandy Loam	LGB	10YR6/3		N	70-80	Medium-Heavy Clay	OGB	10YR3/6
WS26	Y	319588	5855274	22317571	Y	37	Fine Sandy Loam	GB	10YR5/3	22317570	Y	Sandy Loam	LG	10YR6/3	22317569	Y	120-130	Heavy Clay	OG	10YR4/1
WS27	Y	319905	5855274	22317568	Y	80	Fine Sandy Loam	B	7.5YR5/4	22317567	Y	Fine Sandy Loam	G	10YR6/2		N	100-110	Heavy Clay	DGB	10YR4/2
WS28	Y	320220	5855274	22317566	Y	125	Fine Sandy Loam	B	10YR5/4	22317565	Y	Fine Sandy Loam	YB	10YR6/4		N	125-145	Medium Clay	DGB	10YR4/2
WS29	Y	320536	5855274	22317563	Y	90	Fine Sandy Loam	YB	10YR5/4	22317564	Y	Sandy Loam	YB	10YR6/4		N	80-90	Fine Sandy Loam	DG	10YR4/2
WS30	Y	320851	5855274	22317562	Y	85	Fine Sandy Loam	GB	10YR5/3	22317561	Y	Fine Sandy Loam	GB	10YR5/3	22317560	Y	130-140	Medium Clay	DG	10YR5/1
WS31	Y	321168	5855274	22318002	Y	55	Clay Loam	GB	10YR5/3	22318001	Y	Clay Loam	GB	10YR5/2	22318000	Y	120-130	Heavy Clay	DGB	2.5Y6/2
WS32	Y	318324	5855590	22317584	Y	43	Sandy Loam	GB	7.5YR4/3	22317586	Y	Sandy Loam	LG	7.5YR6/2		N	45-75	Medium Clay	YB	10YR5/6
WS33	Y	318640	5855590	22317585	Y	32	Fine Sandy Loam	GB	10YR4/3	22317583	Y	Sandy Loam	LG	10YR6/2		N	80-90	Medium-Heavy Clay	OB	10YR5/6
WS34	Y	318956	5855590	22317577	Y	36	Fine Sandy Loam	GB	7.5YR5/3	22317576	Y	Sandy Loam	LG	10YR6/3		N	65-75	Medium-Heavy Clay	OB	10YR4/6
WS35	Y	319273	5855590	22317695	Y	39	Fine Sandy Loam	GB	10YR4/3	22317694	Y	Fine Sandy Loam	LGB	10YR6/3	22317693	Y	130-140	Medium-Heavy Clay	OGB	10YR5/6
WS36	Y	319588	5855590	22317692	Y	52	Fine Sandy Loam	GB	10YR5/3	22317691	Y	Fine Sandy Loam	G	10YR6/2		N	120-130	Heavy Clay	DG	10YR4/1
WS37	Y	319904	5855590	22317690	Y	55	Fine Sandy Loam	GB	10YR5/2	22317689	Y	Fine Sandy Loam	G	10YR6/2		N	100-110	Sandy Clay	OGB	10YR5/4
WS38	Y	320219	5855590	23317679	Y	27	Fine Sandy Loam	GB	10YR4/2	22317678	Y	Heavy Clay	DGB	10YR4/3		N	100-110	Heavy Clay	G	10YR5/1
WS39	Y	320536	5855590	22317666	Y	33	Fine Sandy Loam	DGB	10YR4/3	22317665	Y	Sandy Clay Loam	GB	10YR5/1	22317664	Y	120-130	Heavy Clay	YG	2.5Y5/3
WS40	Y	320852	5855590	22317668	Y	115	Fine Sandy Loam	GB	7.5YR4/3	22317667	Y	Fine Sandy Loam	GB	10YR5/4		N	120-130	Heavy Clay	DG	10YR4/3
WS41	Y	321191	5855499	22314857	Y	63	Fine Sandy Loam	DGB	10YR4/2	22314858	Y	Fine Sandy Loam	DGB	10YR4/2		N	90-100	Heavy Clay	DGB	10YR4/1
WS44	Y	318640	5855906	22317582	Y	45	Fine Sandy Loam	B	7.5YR5/3	22317581	Y	Sandy Loam	G	7.5YR7/2	22317578	Y	110-120	Heavy Clay	YB	10YR4/6
WS45	Y	318956	5855906	22317559	Y	37	Fine Sandy Loam	DGB	7.5YR4/2	22317558	Y	Fine Sandy Loam	G	10YR6/2		N	80-90	Heavy Clay	GB	10YR4/6
WS47	Y	319589	5855906	22317680	Y	68	Fine Sandy Loam	GB	10YR5/3	22317681	Y	Fine Sandy Loam	LG	10YR6/3		N	110-120	Heavy Clay	YGB	10YR6/6
WS48	Y	319904	5855906	22317688	Y	48	Fine Sandy Loam	GB	10YR5/3	22317687	Y	Fine Sandy Loam	G	10YR7/2	22317686	Y	130-140	Heavy Clay	OG	10YR5/2
WS49	Y	320220	5855906	22317677	Y	32	Fine Sandy Loam	GB	10YR5/3	22317676	Y	Medium-Heavy Clay	GB	10YR5/4		N	120-130	Heavy Clay	G	10YR5/1
WS50	Y	320536	5855906	22317673	Y	35	Fine Sandy Loam	GB	10YR4/3	22317672	Y	Light Sandy Clay Loam	GB	10YR5/3		N	120-130	Heavy Clay	DG	10YR5/2
WS51	Y	320851	5855906	22317671	Y	45	Silty Loam	DGB	10YR4/2	22317670	Y	Silty Loam	DG	10YR4/1	22317669	Y	120-130	Heavy Clay	YGB	10YR6/4
WS52	Y	321167	5855906	22314725	Y	30	Fine Sandy Loam	GB	10YR4/3	22314723	Y	Heavy Clay	DGB	10YR4/2		N				
WS53	Y	321482	5855906	22314744	Y	30	Fine Sandy Loam	GB	10YR5/3	22314722	Y	Heavy Clay	DGB	10YR4/2		N				
WS54	Y	321799	5855906	22314746	Y	30	Light Sandy Clay Loam	GB	10YR4/2	22314755	Y	Clay Loam	DGB	10YR3/1		N				
WS55	Y	318640	5856222	22317554	Y	35	Fine Sandy Loam	GB	10YR5/4	22317698	Y	Sandy Loam	G	10YR6/2		N	60-70	Medium Clay	YB	10YR5/8
WS56	Y	318955	5856222	22317557	Y	85	Fine Sandy Loam	GB	10YR5/3	22317556	Y	Fine Sandy Loam	LG	10YR6/2	22317555	Y	120-130	Sandy Clay	YGB	10YR6/4
WS57	Y	319271	5856222	22317700	Y	42	Fine Sandy Loam	GB	10YR4/3	22317701	Y	Fine Sandy Loam	LGB	10YR5/3	22317699	Y	130-140	Heavy Clay	YB	10YR5/8
WS58	Y	319587	5856222	22317683	Y	37	Sandy Loam	DGB	10YR3/2	22317682	Y	Sandy Loam	G	10YR6/3		N	120-130	Heavy Clay	G	2.5Y6/1
WS59	Y	319903	5856222	22317685	Y	14	Fine Sandy Loam	GB	10YR5/3	22317684	Y	Heavy Clay	YGB	10YR4/3		N	100-110	Heavy Clay	YB	2.5Y5/4
WS60	Y	320209	5856235	22317675	Y	48	Fine Sandy Loam	GB	10YR4/3	22317674	Y	Fine Sandy Loam	G	10YR6/2		N	130-140	Heavy Clay	G	10YR5/1
WS63	Y	321167	5856222	22314726	Y	33	Fine Sandy Loam	GB	10YR5/2	22314727	Y	Medium Clay	DGB	10YR4/2		N				
WS64	Y	321483	5856222	22314724	Y	25	Clay Loam	DGB	10YR3/2	22313928	Y	Medium Clay / Weathered Rock	DGB	10YR3/2		N				
WS65	Y	321899	5856173	22324718	Y	15	Clay Loam	DGB	7.5YR3/2		N	Clay Loam / Weathered Rock				N				
WS66	Y	318954	5856538	22317703	Y	40	Fine Sandy Loam	GB	10YR5/3	22317702	Y	Fine Sandy Loam	G	10YR6/2		N	80-90	Heavy Clay	OGB	10YR4/6
WS67	Y	319271	5856538	22317679	Y	42	Fine Sandy Loam	GB	10YR4/3	22317696	Y	Sandy Clay Loam	LGB	10YR5/3		N	100-110	Heavy Clay	YB	10YR6/6
WS77	Y	318639	5857802	22317654	Y	40	Sandy Loam	GB	10YR4/3	22318003	Y	Sandy Loam	LG/W	10YR7/3		N	70-80	Medium Clay / Weathered Rock	YB	10YR5/6
WS78	Y	318955	5857802	22317997	Y	55	Fine Sandy Loam	GB	10YR5/3	22318008	Y	Fine Sandy Loam	G	10YR7/2	22318028	Y	120-130	Heavy Clay	YGB	10YR5/6
WS79	Y	319271	5857802	22317656	Y	40	Fine Sandy Loam	GB	7.5YR4/2	22317655	Y	Sandy Loam	B	7.5YR4/4		N	80-90	Sandy Clay Loam	OB	10YR6/8
WS80	Y	318639	5858118	22317658	Y	35	Fine Sandy Loam	GB	10YR5/3	22317657	Y	Sandy Clay Loam	LGB	10YR7/3		N	110-120	Medium-Heavy Clay	OGB	10YR5/8
WS81	Y	318955	5858118	22317661	Y	70	Fine Sandy Loam	GB	10YR4/3	22317660	Y	Fine Sandy Loam	GB	10YR5/3	22317659	Y	120-130	Heavy Clay	YB	10YR5/8
WS82	Y	319334	5858075	22317663	Y	13	Clay Loam	DG	10YR3/2	22317662	Y	Heavy Clay	DG	10YR3/1		N	60-70	Heavy Clay/WR	DG	10YR4/1

Table A.3: Wallan South Field Sheet (Continued).

New Site Name	Slope	Aspect	Notes
WS1	Mid slope	East	Thick ground cover.
WS2	Flat	Gentle to the east, north/east	Orange mottling in all horizons. This area was under flood when completing Beveridge North West Assessment
WS3	Flat	Flat to the east	Orange mottling in A1 and B1 horizons
WS4	Mid to lower	North west	Weathered basalt at 115cm. See photo.
WS5	Mid	North west	Core refusal at 65cm on weathered rock.
WS6	Mid to upper	North west	Refusal on weathered rock at 65cm
WS7	Upper slope	North/north west	Layer of heavy clay from 11-19cm over weathered basalt.
WS9	Mid slope	South East	A2 horizon from 30-40cm contains sandstone/gravel.
WS10	Upper/steep	West	Sandstone/gravel throughout the A2 horizon from 10-35cm and in the B horizon from 35-70cm.
WS11	Mid slope/steep	East to northeast	Colluvial sandstone/hillwash throughout the A2 horizon.
WS12	Lower slope	South East	Deep topsoil with a bleached A2 horizon from 25-36cm.
WS13	Flat	North	Valley fill/drainage depression (unincised). Expect area would function as a headwater stream/seasonal wetland.
WS14	Flat to lower	South	Deep topsoil on break of slope. Orange mottling in A2 horizon from 35-45cm. B horizon starts at 45cm.
WS15	Flat	South	Orange mottling throughout all horizons.
WS16	Flat	East	
WS17	Mid to lower slope	North west	Refusal on rock at 80cm
WS18	Mid slope	North west	Refusal on rock at 50cm
WS19	Mid slope	North	Refusal on rock at 85cm. Unsure if consolidated rock or a floater.
WS21	Upper slope/steep	South east	Strong bleached A2 horizon.
WS22	Mid slope/steep	South east	Colluvial sandstone from 40-60cm.
WS23	Mid slope	North	Sandstone hillwash throughout the B horizon and A2 horizon.
WS24	Mid to lower slope	South	Bleaching in the A2 horizon above clay.
WS25	Lower slope	South east	Bleaching in the A2 horizon.
WS26	Lower slope to flat	East	Bleaching in the A2 horizon, colluvial sandstone throughout clay subsoil.
WS27	Flat	East	Strong bleaching the A2 horizon from 40-80cm.
WS28	Flat	East	Bleaching in the A3 horizon from approximately 100-125cm.
WS29	Flat to gentle slope	North east	Drained valley fill, large area of deposition.
WS30	Flat	East	Drained valley fill, large area of deposition. Bleaching in the A3 horizon from 60-85cm, orange mottling in the A3 and B horizons.
WS31	Flat/drainage line	East	Drained valley fill. Bleaching in the A2 horizon from 15-55cm.
WS32			Strong bleached A2 horizon with sandstone/gravel.
WS33	Mid slope	East to north east	Bleaching in the A2 horizon, strong duplex profile.
WS34	Lower slope	North east	Bleaching and sandstone hillwash in the A2 horizon.
WS35	Gentle slope	South east	Strong orange mottling throughout the A2 and B horizons.
WS36	Gentle slope	South east	Orange mottling in the A2 and B horizons. Most profiles are duplex with a sharp transition between the A and B horizons.
WS37	Flat to gentle slope	East	Bleaching in the A2 horizon, duplex profile. Topsoil is consistently fine sandy loam across the area.
WS38	Flat	South east	A2 horizon is sandy loam from 20-30cm.
WS39	Gentle lower slope	South	Shallower topsoil, duplex profile, heavy clay subsoil.
WS40	Gentle	South	Bleaching in the A3 horizon from 60-115cm.
WS41	Flat to gentle slope	South to south west	Site within Palaris pasture paddock. Good root growth to 20cm, soil appears stable, obvious erosion. Waterlogging evident by wheel tracks.
WS44	Mid to lower slope	East	Bleached A2 horizon. Deep topsoil over clay.
WS45			
WS47	Flat to gentle slope	South east	Strong bleaching, sandstone/gravel from 55-70cm
WS48	Flat to gentle slope	East	Duplex profile, strong bleaching in the A2 from 40-50cm.
WS49	Lower slope	South east	Bleaching from 22-32 cm in the A2 horizon. Sandstone fragments (some) in the B1 horizon.
WS50	Lower slope	East	Moderate bleaching in the A2 horizon.
WS51	Flat to gentle slope	South east	Drained valley fill. Core contains silty material. Area possibly was a former swamp/confluence of number of drainage depressions.
WS52	Flat to gentle	South	Bleaching in A2 from 20-30cm above clay.
WS53	Flat to gentle	South east	Bleaching in th A2 horizon from 20-30cm. A2 horizon is clay loam.
WS54	Lower slope	East	Buckshot layer below 40cm, looks like basalt. Well drained.
WS55	Mid slope	South east	Bleached A2 horizon,sandstone/gravel throughout A2. B1 horizon contains weathered sandstone rock.
WS56	Mid to lower slope/edge of gully	South east	A2 horizon bleached, hard, fine sandy loam.
WS57	Mid slope	South east	Bleached A2 horizon above clay subsoil.
WS58	Mid slope	South to south west	Heavy clay from 37cm onwards, at 1.0 metre there is weathered sandstone, strong orange and red mottling onwards. Bleaching in the A2 horizon.
WS59	Lower slope	South west	Shallower topsoil over clay, weak bleach from 10-14cm.
WS60	Lower slope	South east	Bleaching in the A2 horizon, clay from bottom of A horizon onwards.
WS63	Lower slope	South west	Bleaching in the A2 horizon above clay.
WS64	Upper slope/steep	South west	Rock in the B horizon is basalt. A horizon is well strucured clay loam. Site located 3/4 up steep hill.
WS65	Mid to supper slope	East	Site located 1/2 way upslope. Shallow topsoil over rock. Full pasture cover.
WS66	Lower slope/edge of gully	South east	Bleached A2 horizon, strongly duplex profile. Deep gully erosion 50m to the east on waterway.
WS67	Open depression (waterlogging noted)	South east	Waterlogged patches in this area.
WS77	Upper slope	North east	Strong bleached A2 horizon with angular sandstone gravel.
WS78	Lower slope adjacent to gully	East	Strong bleach in the A2 horizon. Sub angular to sub rounded sandstone/gravel in the A2 horizon.
WS79	Crest	South	Thin layer of medium clay from 40-65cm. May be fill in the A horizons. The A2 from 30-40cm contains sandstone.
WS80	Mid to upper slope	South	Bleached A2 horizon from 25-35cm and B horizon contains weathered sandstone rock.
WS81	Mid to lower slopes	East to South east	Strong bleach in the A3 horizon above clay. Sandstone/gravel throughout the A3 and B horizons.
WS82	Upper	South east	Site may contain fill.

Table A.4: Wallan South 0-10cm Sample Analytical Results.

Sample ID	Site	Sample Name	Sample Start Depth	Sample End Depth	Zone	GPS Easting	GPS Northing	Texture	pH (1:5 Water)	pH (1:5 CaCl2)
			cm	cm				SESW Field Classification		
22314844	WS1	WS1. 0-10	0	10	55H	321168	5854326	Clay Loam	5.3	4.6
22317529	WS2	WS2. 0-10	0	10	55H	319272	5854642	Light Clay	6.3	5.6
22317531	WS3	WS3. 0-10	0	10	55H	319588	5854642	Clay Loam	6.0	5.2
22317533	WS4	WS4. 0-10	0	10	55H	319904	5854642	Clay Loam	5.6	5.1
22317537	WS5	WS5. 0-10	0	10	55H	320220	5854642	Sandy Clay Loam	6.2	5.4
22317538	WS6	WS6. 0-10	0	10	55H	320536	5854642	Clay Loam	5.5	4.8
22317540	WS7	WS7. 0-10	0	10	55H	320852	5854642	Sandy Clay Loam	5.0	4.3
22317591	WS9	WS9. 0-10	0	10	55H	317692	5854958	Fine Sandy Loam	5.5	4.5
22317593	WS10	WS10. 0-10	0	10	55H	318008	5854958	Fine Sandy Loam	5.4	4.6
22317595	WS11	WS11. 0-10	0	10	55H	318324	5854958	Sandy Loam	5.5	4.6
22317603	WS12	WS12. 0-10	0	10	55H	318640	5854958	Sandy Loam	6.2	5.4
22317597	WS13	WS13. 0-10	0	10	55H	318956	5854958	Sandy Loam	6.5	5.9
22317553	WS14	WS14. 0-10	0	10	55H	319272	5854958	Fine Sandy Loam	6.3	5.7
22317551	WS15	WS15. 0-10	0	10	55H	319588	5854958	Clay Loam	6.5	5.9
22317548	WS16	WS16. 0-10	0	10	55H	319904	5854958	Light Sandy Clay Loam	7.1	6.6
22317545	WS17	WS17. 0-10	0	10	55H	320220	5854958	Light Sandy Clay Loam	5.8	5.1
22317543	WS18	WS18. 0-10	0	10	55H	320536	5854958	Clay Loam	5.3	4.6
22317542	WS19	WS19. 0-10	0	10	55H	320852	5854958	Clay Loam	5.9	5.2
22317589	WS21	WS21. 0-10	0	10	55H	318008	5855274	Fine Sandy Loam	5.6	4.7
22317599	WS22	WS22. 0-10	0	10	55H	318324	5855274	Fine Sandy Loam	5.2	4.4
22317601	WS23	WS23. 0-10	0	10	55H	318640	5855274	Sandy Loam	6.0	5.4
22317575	WS24	WS24. 0-10	0	10	55H	318956	5855274	Fine Sandy Loam	6.0	5.4
22317573	WS25	WS25. 0-10	0	10	55H	319272	5855274	Fine Sandy Loam	6.2	5.5
22317571	WS26	WS26. 0-10	0	10	55H	319588	5855274	Fine Sandy Loam	7.1	5.9
22317568	WS27	WS27. 0-10	0	10	55H	319904	5855274	Fine Sandy Loam	5.9	5.1
22317566	WS28	WS28. 0-10	0	10	55H	320220	5855274	Fine Sandy Loam	5.9	5.2
22317563	WS29	WS29. 0-10	0	10	55H	320536	5855274	Fine Sandy Loam	6.6	5.9
22317562	WS30	WS30. 0-10	0	10	55H	320852	5855274	Fine Sandy Loam	6.1	5.4
22318002	WS31	WS31. 0-10	0	10	55H	321168	5855274	Clay Loam	6.3	5.5
22317584	WS32	WS32. 0-10	0	10	55H	318324	5855590	Sandy Loam	5.8	4.5
22317585	WS33	WS33. 0-10	0	10	55H	318640	5855590	Fine Sandy Loam	6.6	5.9
22317577	WS34	WS34. 0-10	0	10	55H	318956	5855590	Fine Sandy Loam	6.0	5.2
22317695	WS35	WS35. 0-10	0	10	55H	319272	5855590	Fine Sandy Loam	6.3	5.7
22317692	WS36	WS36. 0-10	0	10	55H	319588	5855590	Fine Sandy Loam	6.1	5.3
22317690	WS37	WS37. 0-10	0	10	55H	319904	5855590	Fine Sandy Loam	7.1	6.3
23317679	WS38	WS38. 0-10	0	10	55H	320220	5855590	Fine Sandy Loam	6.3	5.7
22317666	WS39	WS39. 0-10	0	10	55H	320536	5855590	Fine Sandy Loam	6.1	5.5
22317668	WS40	WS40. 0-10	0	10	55H	320852	5855590	Fine Sandy Loam	5.7	5.0
22314857	WS41	WS41. 0-10	0	10	55H	321168	5855590	Fine Sandy Loam	5.8	4.9
22317582	WS44	WS44. 0-10	0	10	55H	318640	5855906	Fine Sandy Loam	5.0	4.0
22317559	WS45	WS45. 0-10	0	10	55H	318956	5855906	Fine Sandy Loam	6.0	5.3
22317680	WS47	WS47. 0-10	0	10	55H	319588	5855906	Fine Sandy Loam	6.6	6.1
22317688	WS48	WS48. 0-10	0	10	55H	319904	5855906	Fine Sandy Loam	6.2	5.5
22317677	WS49	WS49. 0-10	0	10	55H	320220	5855906	Fine Sandy Loam	6.3	5.6
22317673	WS50	WS50. 0-10	0	10	55H	320536	5855906	Fine Sandy Loam	6.4	5.7
22317671	WS51	WS51. 0-10	0	10	55H	320852	5855906	Silty Loam	6.2	5.5
22314725	WS52	WS52. 0-10	0	10	55H	321168	5855906	Fine Sandy Loam	5.3	4.7
22314744	WS53	WS53. 0-10	0	10	55H	321484	5855906	Fine Sandy Loam	5.7	4.9
22314746	WS54	WS54. 0-10	0	10	55H	321800	5855906	Light Sandy Clay Loam	6.0	5.2
22317554	WS55	WS55. 0-10	0	10	55H	318640	5856222	Fine Sandy Loam	4.9	4.0
22317557	WS56	WS56. 0-10	0	10	55H	318956	5856222	Fine Sandy Loam	6.0	5.0
22317700	WS57	WS57. 0-10	0	10	55H	319272	5856222	Fine Sandy Loam	5.6	4.9
22317683	WS58	WS58. 0-10	0	10	55H	319588	5856222	Sandy Loam	6.7	6.3
22317685	WS59	WS59. 0-10	0	10	55H	319904	5856222	Fine Sandy Loam	6.6	6.0
22317675	WS60	WS60. 0-10	0	10	55H	320220	5856222	Fine Sandy Loam	9.1	8.1
22314726	WS63	WS63. 0-10	0	10	55H	321168	5856222	Fine Sandy Loam	6.1	5.1
22314724	WS64	WS64. 0-10	0	10	55H	321484	5856222	Clay Loam	5.9	5.0
22324718	WS65	WS65. 0-10	0	10	55H	318640	5856538	Clay Loam	6.7	6.4
22317703	WS66	WS66. 0-10	0	10	55H	318956	5856538	Fine Sandy Loam	5.4	4.4
22317697	WS67	WS67. 0-10	0	10	55H	319272	5856538	Fine Sandy Loam	5.9	5.2
22317654	WS77	WS77. 0-10	0	10	55H	318640	5857802	Sandy Loam	5.1	4.1
22317997	WS78	WS78. 0-10	0	10	55H	318956	5857802	Fine Sandy Loam	5.4	4.4
22317656	WS79	WS79. 0-10	0	10	55H	319272	5857802	Fine Sandy Loam	5.6	4.9
22317658	WS80	WS80. 0-10	0	10	55H	318640	5858118	Fine Sandy Loam	4.7	4.1
22317661	WS81	WS81. 0-10	0	10	55H	318956	5858118	Fine Sandy Loam	5.6	4.5
22317663	WS82	WS82. 0-10	0	10	55H	319272	5858118	Clay Loam	6.2	5.4

Table A.5: Wallan South 0-10cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Electrical Conductivity (1:5 water)	Exchangeable Sodium Percentage	Emerson Class	Disp. Index, Loveday/Pyle	Slaking 2Hrs
			dS/m	%			
22314844	WS1	WS1. 0-10	0.15	3.7	7	1	Water Stable
22317529	WS2	WS2. 0-10	0.14	2.4	7	2	Water Stable
22317531	WS3	WS3. 0-10	0.16	3.9	7	1	Water Stable
22317533	WS4	WS4. 0-10	0.31	2.0	7	1	Water Stable
22317537	WS5	WS5. 0-10	0.11	1.6	3	1	Partial
22317538	WS6	WS6. 0-10	0.12	1.1	7	2	Water Stable
22317540	WS7	WS7. 0-10	0.08	1.4	7	1	Water Stable
22317591	WS9	WS9. 0-10	0.10	6.8	7	1	Water Stable
22317593	WS10	WS10. 0-10	0.07	4.0	7	1	Water Stable
22317595	WS11	WS11. 0-10	0.15	10.0	7	1	Water Stable
22317603	WS12	WS12. 0-10	0.10	3.9	7	1	Water Stable
22317597	WS13	WS13. 0-10	0.14	1.8	8	2	Water Stable
22317553	WS14	WS14. 0-10	0.16	2.8	7	0	Water Stable
22317551	WS15	WS15. 0-10	0.14	2.3	8	1	Water Stable
22317548	WS16	WS16. 0-10	0.22	1.8	7	1	Water Stable
22317545	WS17	WS17. 0-10	0.15	1.7	7	1	Water Stable
22317543	WS18	WS18. 0-10	0.13	0.7	7	1	Water Stable
22317542	WS19	WS19. 0-10	0.13	1.1	7	1	Water Stable
22317589	WS21	WS21. 0-10	0.06	2.2	7	1	Water Stable
22317599	WS22	WS22. 0-10	0.11	7.3	7	1	Water Stable
22317601	WS23	WS23. 0-10	0.17	2.4	7	1	Water Stable
22317575	WS24	WS24. 0-10	0.18	2.1	7	0	Water Stable
22317573	WS25	WS25. 0-10	0.20	2.0	7	1	Water Stable
22317571	WS26	WS26. 0-10	0.07	3.0	7	1	Water Stable
22317568	WS27	WS27. 0-10	0.10	3.2	7	1	Water Stable
22317566	WS28	WS28. 0-10	0.13	1.7	7	1	Water Stable
22317563	WS29	WS29. 0-10	0.08	0.7	7	1	Water Stable
22317562	WS30	WS30. 0-10	0.11	1.3	7	1	Water Stable
22318002	WS31	WS31. 0-10	0.07	2.1	8	1	Water Stable
22317584	WS32	WS32. 0-10	0.05	6.2	3	5	Partial
22317585	WS33	WS33. 0-10	0.17	1.6	7	1	Water Stable
22317577	WS34	WS34. 0-10	0.14	3.3	7	1	Water Stable
22317695	WS35	WS35. 0-10	0.16	2.2	7	1	Water Stable
22317692	WS36	WS36. 0-10	0.10	3.4	7	1	Water Stable
22317690	WS37	WS37. 0-10	0.10	4.0	7	1	Water Stable
23317679	WS38	WS38. 0-10	0.11	1.5	8	0	Partial
22317666	WS39	WS39. 0-10	0.15	1.9	7	1	Water Stable
22317668	WS40	WS40. 0-10	0.17	3.3	8	3	Water Stable
22314857	WS41	WS41. 0-10	0.11	3.1	7	1	Water Stable
22317582	WS44	WS44. 0-10	0.05	3.5	7	1	Water Stable
22317559	WS45	WS45. 0-10	0.10	2.6	7	1	Water Stable
22317680	WS47	WS47. 0-10	0.22	0.8	7	0	Water Stable
22317688	WS48	WS48. 0-10	0.14	3.2	7	1	Water Stable
22317677	WS49	WS49. 0-10	0.14	2.2	7	1	Water Stable
22317673	WS50	WS50. 0-10	0.13	2.2	3	1	Partial
22317671	WS51	WS51. 0-10	0.13	2.2	8	0	Water Stable
22314725	WS52	WS52. 0-10	0.19	3.4	7	1	Water Stable
22314744	WS53	WS53. 0-10	0.14	2.9	7	1	Water Stable
22314746	WS54	WS54. 0-10	0.09	2.5	7	1	Water Stable
22317554	WS55	WS55. 0-10	0.05	2.4	7	3	Water Stable
22317557	WS56	WS56. 0-10	0.11	12.0	7	2	Water Stable
22317700	WS57	WS57. 0-10	0.11	3.7	7	3	Water Stable
22317683	WS58	WS58. 0-10	0.23	1.8	7	0	Water Stable
22317685	WS59	WS59. 0-10	0.16	4.3	7	2	Water Stable
22317675	WS60	WS60. 0-10	0.21	4.3	7	1	Water Stable
22314726	WS63	WS63. 0-10	0.07	3.1	3	1	Partial
22314724	WS64	WS64. 0-10	0.10	2.5	7	1	Water Stable
22324718	WS65	WS65. 0-10	0.27	1.7	7	0	Water Stable
22317703	WS66	WS66. 0-10	0.05	5.9	7	1	Water Stable
22317697	WS67	WS67. 0-10	0.11	3.7	7	1	Water Stable
22317654	WS77	WS77. 0-10	0.06	1.4	7	2	Water Stable
22317997	WS78	WS78. 0-10	0.09	7.8	7	1	Water Stable
22317656	WS79	WS79. 0-10	0.12	4.4	7	1	Water Stable
22317658	WS80	WS80. 0-10	0.16	6.2	8	0	Water Stable
22317661	WS81	WS81. 0-10	0.09	9.3	7	2	Water Stable
22317663	WS82	WS82. 0-10	0.11	0.9	8	1	Water Stable

Table A.6: Wallan South 0-10cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Cation Exch. Cap.
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg
22314844	WS1	WS1. 0-10	940	460	215	83	18	4.7	3.8	0.55	0.36	0.2	9.5
22317529	WS2	WS2. 0-10	1700	472	164	71	<9.0	8.5	3.9	0.42	0.31	<0.1	13.1
22317531	WS3	WS3. 0-10	1540	484	145	113	<9.0	7.7	4	0.37	0.49	<0.1	12.5
22317533	WS4	WS4. 0-10	1520	532	219	60	<9.0	7.6	4.4	0.56	0.26	<0.1	12.8
22317537	WS5	WS5. 0-10	1680	569	184	53	<9.0	8.4	4.7	0.47	0.23	<0.1	13.8
22317538	WS6	WS6. 0-10	1560	581	223	32	<9.0	7.8	4.8	0.57	0.14	<0.1	13.3
22317540	WS7	WS7. 0-10	360	145	98	14	120	1.8	1.2	0.25	0.06	1.3	4.6
22317591	WS9	WS9. 0-10	780	436	66	143	77	3.9	3.6	0.17	0.62	0.9	9.1
22317593	WS10	WS10. 0-10	620	109	164	46	23	3.1	0.9	0.42	0.2	0.3	4.9
22317595	WS11	WS11. 0-10	500	169	121	117	29	2.5	1.4	0.31	0.51	0.3	5
22317603	WS12	WS12. 0-10	840	157	43	53	<9.0	4.2	1.3	0.11	0.23	<0.1	5.9
22317597	WS13	WS13. 0-10	1960	290	246	55	<9.0	9.8	2.4	0.63	0.24	<0.1	13.1
22317553	WS14	WS14. 0-10	1640	145	227	67	<9.0	8.2	1.2	0.58	0.29	<0.1	10.3
22317551	WS15	WS15. 0-10	1780	339	270	67	<9.0	8.9	2.8	0.69	0.29	<0.1	12.7
22317548	WS16	WS16. 0-10	2600	424	289	74	<9.0	13	3.5	0.74	0.32	<0.1	17.8
22317545	WS17	WS17. 0-10	1540	375	239	46	<9.0	7.7	3.1	0.61	0.2	<0.1	11.6
22317543	WS18	WS18. 0-10	2000	363	254	23	17	10	3	0.65	0.1	0.2	14.2
22317542	WS19	WS19. 0-10	1720	617	258	37	<9.0	8.6	5.1	0.66	0.16	<0.1	14.5
22317589	WS21	WS21. 0-10	520	242	184	28	24	2.6	2	0.47	0.12	0.3	5.5
22317599	WS22	WS22. 0-10	540	194	59	87	40	2.7	1.6	0.15	0.38	0.4	5.2
22317601	WS23	WS23. 0-10	1320	242	211	51	<9.0	6.6	2	0.54	0.22	<0.1	9.3
22317575	WS24	WS24. 0-10	1360	194	215	44	<9.0	6.8	1.6	0.55	0.19	<0.1	9.1
22317573	WS25	WS25. 0-10	1700	242	188	53	10	8.5	2	0.48	0.23	0.1	11.3
22317571	WS26	WS26. 0-10	1060	133	82	48	<9.0	5.3	1.1	0.21	0.21	<0.1	6.9
22317568	WS27	WS27. 0-10	1180	157	43	55	<9.0	5.9	1.3	0.11	0.24	<0.1	7.5
22317566	WS28	WS28. 0-10	880	133	133	23	<9.0	4.4	1.1	0.34	0.1	<0.1	6
22317563	WS29	WS29. 0-10	1240	145	86	14	<9.0	6.2	1.2	0.22	0.06	<0.1	7.6
22317562	WS30	WS30. 0-10	1180	327	152	28	<9.0	5.9	2.7	0.39	0.12	<0.1	9.1
22318002	WS31	WS31. 0-10	1440	387	59	51	<9.0	7.2	3.2	0.15	0.22	<0.1	10.7
22317584	WS32	WS32. 0-10	140	206	152	62	120	0.7	1.7	0.39	0.27	1.3	4.4
22317585	WS33	WS33. 0-10	1180	157	430	30	<9.0	5.9	1.3	1.1	0.13	<0.1	8.4
22317577	WS34	WS34. 0-10	1260	206	285	67	<9.0	6.3	1.7	0.73	0.29	<0.1	9
22317695	WS35	WS35. 0-10	1600	194	137	51	<9.0	8	1.6	0.35	0.22	<0.1	10.2
22317692	WS36	WS36. 0-10	1180	436	74	78	<9.0	5.9	3.6	0.19	0.34	<0.1	9.9
22317690	WS37	WS37. 0-10	1340	194	160	83	<9.0	6.7	1.6	0.41	0.36	<0.1	9
23317679	WS38	WS38. 0-10	1580	375	94	39	<9.0	7.9	3.1	0.24	0.17	<0.1	11.4
22317666	WS39	WS39. 0-10	1800	327	66	53	<9.0	9	2.7	0.17	0.23	<0.1	12.1
22317668	WS40	WS40. 0-10	1080	327	59	64	<9.0	5.4	2.7	0.15	0.28	<0.1	8.4
22314857	WS41	WS41. 0-10	1460	387	125	81	<9.0	7.3	3.2	0.32	0.35	<0.1	11.2
22317582	WS44	WS44. 0-10	160	133	31	28	120	0.8	1.1	0.08	0.12	1.3	3.4
22317559	WS45	WS45. 0-10	1160	145	55	44	<9.0	5.8	1.2	0.14	0.19	<0.1	7.3
22317680	WS47	WS47. 0-10	2400	303	391	30	<9.0	12	2.5	1	0.13	<0.1	16.1
22317688	WS48	WS48. 0-10	1560	351	235	85	<9.0	7.8	2.9	0.6	0.37	<0.1	11.7
22317677	WS49	WS49. 0-10	1300	194	70	41	<9.0	6.5	1.6	0.18	0.18	<0.1	8.5
22317673	WS50	WS50. 0-10	1700	363	168	62	<9.0	8.5	3	0.43	0.27	<0.1	12.2
22317671	WS51	WS51. 0-10	1900	460	90	71	<9.0	9.5	3.8	0.23	0.31	<0.1	13.9
22314725	WS52	WS52. 0-10	840	290	106	58	<9.0	4.2	2.4	0.27	0.25	<0.1	7.2
22314744	WS53	WS53. 0-10	980	363	336	60	<9.0	4.9	3	0.86	0.26	<0.1	9
22314746	WS54	WS54. 0-10	1880	448	63	81	<9.0	9.4	3.7	0.16	0.35	<0.1	13.6
22317554	WS55	WS55. 0-10	60	61	94	18	210	0.3	0.5	0.24	0.08	2.3	3.4
22317557	WS56	WS56. 0-10	700	73	43	138	<9.0	3.5	0.6	0.11	0.6	<0.1	4.9
22317700	WS57	WS57. 0-10	980	133	59	53	<9.0	4.9	1.1	0.15	0.23	<0.1	6.4
22317683	WS58	WS58. 0-10	2400	218	121	58	<9.0	12	1.8	0.31	0.25	<0.1	14.1
22317685	WS59	WS59. 0-10	1640	424	51	122	<9.0	8.2	3.5	0.13	0.53	<0.1	12.3
22317675	WS60	WS60. 0-10	820	278	305	74	<9.0	4.1	2.3	0.78	0.32	<0.1	7.4
22314726	WS63	WS63. 0-10	1240	472	55	76	<9.0	6.2	3.9	0.14	0.33	<0.1	10.7
22314724	WS64	WS64. 0-10	2400	726	94	110	<9.0	12	6	0.24	0.48	<0.1	18.9
22324718	WS65	WS65. 0-10	3600	750	137	99	<9.0	18	6.2	0.35	0.43	<0.1	24.9
22317703	WS66	WS66. 0-10	400	145	39	55	42	2	1.2	0.1	0.24	0.5	4
22317697	WS67	WS67. 0-10	1100	206	74	67	<9.0	5.5	1.7	0.19	0.29	<0.1	7.7
22317654	WS77	WS77. 0-10	260	73	176	14	160	1.3	0.6	0.45	0.06	1.8	4.2
22317997	WS78	WS78. 0-10	260	218	39	85	95	1.3	1.8	0.1	0.37	1.1	4.7
22317656	WS79	WS79. 0-10	1080	278	70	85	19	5.4	2.3	0.18	0.37	0.2	8.4
22317658	WS80	WS80. 0-10	400	218	133	85	120	2	1.8	0.34	0.37	1.4	5.9
22317661	WS81	WS81. 0-10	500	242	74	124	54	2.5	2	0.19	0.54	0.6	5.8
22317663	WS82	WS82. 0-10	3800	1089	430	60	<9.0	19	9	1.1	0.26	<0.1	29.1

Table A.7: Wallan South 0-10cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Aluminium Saturation	Calcium/Magnesium Ratio	ESP% + EPP% Calculation	Organic Carbon (W&B)	Organic Matter (W&B * 1.72)
			%	%	%	%		SESW Calculation	%	%
22314844	WS1	WS1. 0-10	49	39	5.8	2.1	1.2	9.5	3.2	5.5
22317529	WS2	WS2. 0-10	65	30	3.2	<1.0	2.2	5.6	3.8	6.6
22317531	WS3	WS3. 0-10	62	32	3	<1.0	1.9	6.9	4.0	6.8
22317533	WS4	WS4. 0-10	60	34	4.4	<1.0	1.7	6.4	3.3	5.7
22317537	WS5	WS5. 0-10	61	34	3.4	<1.0	1.8	5.0	3.0	5.2
22317538	WS6	WS6. 0-10	59	36	4.3	<1.0	1.6	5.4	2.9	5.0
22317540	WS7	WS7. 0-10	39	26	5.5	28	1.5	6.9	1.8	3.0
22317591	WS9	WS9. 0-10	43	39	1.9	9.4	1.1	8.7	4.8	8.2
22317593	WS10	WS10. 0-10	64	18	8.5	5.3	3.4	12.5	3.1	5.3
22317595	WS11	WS11. 0-10	49	28	6.2	6.4	1.8	16.2	2.6	4.4
22317603	WS12	WS12. 0-10	71	23	1.9	<1.0	3.2	5.8	1.7	2.9
22317597	WS13	WS13. 0-10	75	18	4.8	<1.0	4.1	6.6	2.9	5.0
22317553	WS14	WS14. 0-10	80	12	5.7	<1.0	6.8	8.5	2.9	5.0
22317551	WS15	WS15. 0-10	70	22	5.4	<1.0	3.2	7.7	2.6	4.5
22317548	WS16	WS16. 0-10	74	20	4.1	<1.0	3.7	5.9	2.9	5.0
22317545	WS17	WS17. 0-10	67	26	5.3	<1.0	2.5	7.0	3.3	5.7
22317543	WS18	WS18. 0-10	73	21	4.6	1.4	3.3	5.3	4.0	6.9
22317542	WS19	WS19. 0-10	59	35	4.6	<1.0	1.7	5.7	3.2	5.5
22317589	WS21	WS21. 0-10	48	37	8.6	4.8	1.3	10.8	3.0	5.2
22317599	WS22	WS22. 0-10	51	30	2.9	8.5	1.7	10.2	2.8	4.8
22317601	WS23	WS23. 0-10	71	21	5.8	<1.0	3.3	8.2	3.5	6.0
22317575	WS24	WS24. 0-10	74	18	6	<1.0	4.3	8.1	3.4	5.9
22317573	WS25	WS25. 0-10	75	18	4.2	1	4.3	6.2	3.5	6.1
22317571	WS26	WS26. 0-10	78	16	3	<1.0	4.8	6.0	2.4	4.2
22317568	WS27	WS27. 0-10	78	17	1.4	<1.0	4.5	4.6	2.3	4.0
22317566	WS28	WS28. 0-10	74	19	5.8	<1.0	4	7.5	1.7	3.0
22317563	WS29	WS29. 0-10	81	15	2.9	<1.0	5.2	3.6	2.1	3.5
22317562	WS30	WS30. 0-10	65	29	4.3	<1.0	2.2	5.6	2.3	3.9
22318002	WS31	WS31. 0-10	67	30	1.4	<1.0	2.3	3.5	2.2	3.7
22317584	WS32	WS32. 0-10	16	39	8.9	30	0.4	15.1	1.1	1.9
22317585	WS33	WS33. 0-10	70	15	13	<1.0	4.5	14.6	3.0	5.2
22317577	WS34	WS34. 0-10	70	18	8.1	<1.0	3.7	11.4	3.7	6.3
22317695	WS35	WS35. 0-10	79	16	3.4	<1.0	5	5.6	3.4	5.8
22317692	WS36	WS36. 0-10	59	36	1.9	<1.0	1.6	5.3	2.7	4.6
22317690	WS37	WS37. 0-10	74	18	4.5	<1.0	4.2	8.5	2.1	3.6
23317679	WS38	WS38. 0-10	70	27	2.1	<1.0	2.5	3.6	2.8	4.8
22317666	WS39	WS39. 0-10	74	23	1.4	<1.0	3.3	3.3	3.3	5.6
22317668	WS40	WS40. 0-10	63	31	1.8	<1.0	2	5.1	2.3	3.9
22314857	WS41	WS41. 0-10	65	29	2.8	<1.0	2.3	5.9	3.9	6.7
22317582	WS44	WS44. 0-10	23	33	2.3	38	0.7	5.8	3.5	6.0
22317559	WS45	WS45. 0-10	79	16	1.9	<1.0	4.8	4.5	2.7	4.7
22317680	WS47	WS47. 0-10	77	16	6.3	<1.0	4.8	7.1	4.1	7.1
22317688	WS48	WS48. 0-10	67	25	5.1	<1.0	2.7	8.3	3.8	6.6
22317677	WS49	WS49. 0-10	77	19	2.1	<1.0	4.1	4.3	2.6	4.4
22317673	WS50	WS50. 0-10	70	24	3.5	<1.0	2.8	5.7	3.2	5.4
22317671	WS51	WS51. 0-10	69	28	1.7	<1.0	2.5	3.9	3.7	6.3
22314725	WS52	WS52. 0-10	59	34	3.7	<1.0	1.8	7.1	2.8	4.8
22314744	WS53	WS53. 0-10	54	33	9.6	<1.0	1.6	12.5	3.0	5.2
22314746	WS54	WS54. 0-10	69	27	1.2	<1.0	2.5	3.7	3.5	6.1
22317554	WS55	WS55. 0-10	8.7	14	7.1	68	0.6	9.5	1.8	3.0
22317557	WS56	WS56. 0-10	73	13	2.3	<1.0	5.6	14.3	1.9	3.3
22317700	WS57	WS57. 0-10	77	17	2.3	<1.0	4.5	6.0	3.8	6.5
22317683	WS58	WS58. 0-10	83	13	2.2	<1.0	6.7	4.0	3.9	6.7
22317685	WS59	WS59. 0-10	66	28	1	<1.0	2.3	5.3	2.8	4.9
22317675	WS60	WS60. 0-10	55	31	10	<1.0	1.8	14.3	3.0	5.1
22314726	WS63	WS63. 0-10	58	37	1.4	<1.0	1.6	4.5	2.8	4.8
22314724	WS64	WS64. 0-10	64	32	1.3	<1.0	2	3.8	4.9	8.5
22324718	WS65	WS65. 0-10	72	25	1.4	<1.0	2.9	3.1	5.3	9.2
22317703	WS66	WS66. 0-10	50	30	2.4	12	1.7	8.3	2.4	4.1
22317697	WS67	WS67. 0-10	72	22	2.5	<1.0	3.2	6.2	2.8	4.7
22317654	WS77	WS77. 0-10	31	15	11	42	2	12.4	3.3	5.7
22317997	WS78	WS78. 0-10	28	39	2.2	22	0.7	10.0	3.2	5.5
22317656	WS79	WS79. 0-10	64	27	2.1	2.5	2.3	6.5	5.2	8.9
22317658	WS80	WS80. 0-10	34	31	5.8	23	1.1	12.0	5.2	9.0
22317661	WS81	WS81. 0-10	42	35	3.2	10	1.3	12.5	3.5	6.1
22317663	WS82	WS82. 0-10	64	31	3.7	<1.0	2.1	4.6	5.8	10.0

Table A.8: Wallan South 30-40cm Sample Analytical Results.

Sample ID	Site	Sample Name	Sample Start Depth	Sample End Depth	Zone	GPS Easting	GPS Northing	Texture	pH (1:5 Water)	pH (1:5 CaCl2)
			cm	cm				SESW Field Classification		
22314845	WS1	WS1. 30-40	30	40	55H	321168	5854326	Medium-Heavy Clay	6.3	5.1
22317530	WS2	WS2. 30-40	30	40	55H	319272	5854642	Heavy Clay	6.4	5.4
22317532	WS3	WS3. 30-40	30	40	55H	319588	5854642	Heavy Clay	6.6	5.5
22317534	WS4	WS4. 30-40	30	40	55H	319904	5854642	Heavy Clay	6.5	5.2
22317536	WS5	WS5. 30-40	30	40	55H	320220	5854642	Heavy Clay	6.5	5.2
22317539	WS6	WS6. 30-40	30	40	55H	320536	5854642	Heavy Clay	6.7	5.6
22317590	WS9	WS9. 30-40	30	40	55H	317692	5854958	Sandy Loam	5.4	4.3
22317592	WS10	WS10. 30-40	30	40	55H	318008	5854958	Sandy Loam / Weathered Rock	6.1	4.9
22317594	WS11	WS11. 30-40	30	40	55H	318324	5854958	Sandy Loam	6.6	5.1
22317602	WS12	WS12. 30-40	30	40	55H	318640	5854958	Light Sandy Clay Loam	6.4	5.5
22317580	WS13	WS13. 30-40	30	40	55H	318956	5854958	Medium-Heavy Clay	5.3	4.6
22317598	WS14	WS14. 30-40	30	40	55H	319272	5854958	Sandy Clay Loam	5.3	4.5
22317552	WS15	WS15. 30-40	30	40	55H	319588	5854958	Medium-Heavy Clay	6.0	5.1
22317549	WS16	WS16. 30-40	30	40	55H	319904	5854958	Medium-Heavy Clay	5.9	4.7
22317546	WS17	WS17. 30-40	30	40	55H	320220	5854958	Heavy Clay	6.9	5.7
22317544	WS18	WS18. 30-40	30	40	55H	320536	5854958	Heavy Clay / Wethered Rock	7.4	6.4
22317541	WS19	WS19. 30-40	30	40	55H	320852	5854958	Heavy Clay	7.5	6.4
22317588	WS21	WS21. 30-40	30	40	55H	318008	5855274	Sandy Loam	6.0	4.5
22317596	WS22	WS22. 30-40	30	40	55H	318324	5855274	Fine Sandy Loam	5.4	4.5
22317600	WS23	WS23. 30-40	30	40	55H	318640	5855274	Sandy Loam	6.0	4.8
22317574	WS24	WS24. 30-40	30	40	55H	318956	5855274	Fine Sandy Loam	6.2	5.2
22317572	WS25	WS25. 30-40	30	40	55H	319272	5855274	Sandy Loam	5.4	4.4
22317570	WS26	WS26. 30-40	30	40	55H	319588	5855274	Sandy Loam	6.1	4.7
22317567	WS27	WS27. 30-40	30	40	55H	319904	5855274	Fine Sandy Loam	5.9	4.8
22317565	WS28	WS28. 30-40	30	40	55H	320220	5855274	Fine Sandy Loam	6.6	5.7
22317564	WS29	WS29. 30-40	30	40	55H	320536	5855274	Sandy Loam	6.6	5.6
22317561	WS30	WS30. 30-40	30	40	55H	320852	5855274	Fine Sandy Loam	6.8	5.7
22318001	WS31	WS31. 30-40	30	40	55H	321168	5855274	Clay Loam	6.2	5.1
22317586	WS32	WS32. 30-40	30	40	55H	318324	5855590	Sandy Loam	5.3	4.2
22317583	WS33	WS33. 30-40	30	40	55H	318640	5855590	Sandy Loam	5.9	4.6
22317576	WS34	WS34. 30-40	30	40	55H	318956	5855590	Sandy Loam	5.7	4.5
22317694	WS35	WS35. 30-40	30	40	55H	319272	5855590	Fine Sandy Loam	5.9	4.7
22317691	WS36	WS36. 30-40	30	40	55H	319588	5855590	Fine Sandy Loam	5.6	4.3
22317689	WS37	WS37. 30-40	30	40	55H	319904	5855590	Fine Sandy Loam	6.6	5.4
22317678	WS38	WS38. 30-40	30	40	55H	320220	5855590	Heavy Clay	5.7	4.5
22317665	WS39	WS39. 30-40	30	40	55H	320536	5855590	Sandy Clay Loam	5.7	4.6
22317667	WS40	WS40. 30-40	30	40	55H	320852	5855590	Fine Sandy Loam	6.7	5.8
22314858	WS41	WS41. 30-40	30	40	55H	321168	5855590	Fine Sandy Loam	6.0	4.9
22317581	WS44	WS44. 30-40	30	40	55H	318640	5855906	Sandy Loam	6.3	4.8
22317558	WS45	WS45. 30-40	30	40	55H	318956	5855906	Fine Sandy Loam	6.3	4.9
22317681	WS47	WS47. 30-40	30	40	55H	319588	5855906	Fine Sandy Loam	6.0	5.1
22317687	WS48	WS48. 30-40	30	40	55H	319904	5855906	Fine Sandy Loam	5.7	4.5
22317676	WS49	WS49. 30-40	30	40	55H	320220	5855906	Medium-Heavy Clay	6.0	4.7
22317672	WS50	WS50. 30-40	30	40	55H	320536	5855906	Light Sandy Clay Loam	6.0	4.9
22317670	WS51	WS51. 30-40	30	40	55H	320852	5855906	Silty Loam	5.9	4.8
22314723	WS52	WS52. 30-40	30	40	55H	321168	5855906	Heavy Clay	5.7	4.5
22314722	WS53	WS53. 30-40	30	40	55H	321484	5855906	Heavy Clay	6.1	4.7
22314755	WS54	WS54. 30-40	30	40	55H	321800	5855906	Clay Loam	6.2	5.1
22317698	WS55	WS55. 30-40	30	40	55H	318640	5856222	Sandy Loam	5.4	4.2
22317556	WS56	WS56. 30-40	30	40	55H	318956	5856222	Fine Sandy Loam	5.9	4.8
22317701	WS57	WS57. 30-40	30	40	55H	319272	5856222	Fine Sandy Loam	5.4	4.3
22317682	WS58	WS58. 30-40	30	40	55H	319588	5856222	Sandy Loam	5.5	4.6
22317684	WS59	WS59. 30-40	30	40	55H	319904	5856222	Heavy Clay	6.0	5.5
22317674	WS60	WS60. 30-40	30	40	55H	320220	5856222	Fine Sandy Loam	5.6	4.8
22314727	WS63	WS63. 30-40	30	40	55H	321168	5856222	Medium Clay	6.5	5.1
22313928	WS64	WS64. 30-40	30	40	55H	321484	5856222	Medium Clay / Weathered Rock	5.9	4.8
22317702	WS66	WS66. 30-40	30	40	55H	318956	5856538	Fine Sandy Loam	5.5	4.2
22317696	WS67	WS67. 30-40	30	40	55H	319272	5856538	Sandy Clay Loam	6.0	4.6
22318003	WS77	WS77. 30-40	30	40	55H	318640	5857802	Sandy Loam	5.0	4.3
22318008	WS78	WS78. 30-40	30	40	55H	318956	5857802	Fine Sandy Loam	6.1	4.6
22317655	WS79	WS79. 30-40	30	40	55H	319272	5857802	Sandy Loam	5.6	4.3
22317657	WS80	WS80. 30-40	30	40	55H	318640	5858118	Sandy Clay Loam	5.6	4.4
22317660	WS81	WS81. 30-40	30	40	55H	318956	5858118	Fine Sandy Loam	6.2	4.9
22317662	WS82	WS82. 30-40	30	40	55H	319272	5858118	Heavy Clay	7.7	6.7

Table A.9: Wallan South 30-40cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Electrical Conductivity (1:5 water)	Exchangeable Sodium Percentage	Emerson Class	Disp. Index, Loveday/Pyle	Slaking 2Hrs
			dS/m	%			
22314845	WS1	WS1. 30-40	0.10	6.3	2	14	Partial
22317530	WS2	WS2. 30-40	0.14	8.0	2	13	Partial
22317532	WS3	WS3. 30-40	0.13	7.8	2	14	Partial
22317534	WS4	WS4. 30-40	0.08	5.9	2	10	Partial
22317536	WS5	WS5. 30-40	0.07	5.8	2	6	Partial
22317539	WS6	WS6. 30-40	0.09	3.8	2	2	Partial
22317590	WS9	WS9. 30-40	0.05	5.9	2	4	Partial
22317592	WS10	WS10. 30-40	0.04	5.4	2	10	Partial
22317594	WS11	WS11. 30-40	0.04	9.7	3	5	Partial
22317602	WS12	WS12. 30-40	0.05	8.0	8	9	Water Stable
22317580	WS13	WS13. 30-40	0.19	4.7	7	0	Water Stable
22317598	WS14	WS14. 30-40	0.10	5.2	3	3	Considerable
22317552	WS15	WS15. 30-40	0.10	4.0	3	7	Partial
22317549	WS16	WS16. 30-40	0.08	5.2	8	11	Water Stable
22317546	WS17	WS17. 30-40	0.10	9.1	1	16	Partial
22317544	WS18	WS18. 30-40	0.08	6.0	2	5	Partial
22317541	WS19	WS19. 30-40	0.09	6.3	2	14	Partial
22317588	WS21	WS21. 30-40	0.03	9.0	2	7	Partial
22317596	WS22	WS22. 30-40	0.06	7.4	3	2	Partial
22317600	WS23	WS23. 30-40	0.04	4.2	2	12	Partial
22317574	WS24	WS24. 30-40	0.03	3.5	7	6	Water Stable
22317572	WS25	WS25. 30-40	0.07	6.4	2	10	Partial
22317570	WS26	WS26. 30-40	0.05	10.0	2	13	Partial
22317567	WS27	WS27. 30-40	0.02	1.0	3	4	Partial
22317565	WS28	WS28. 30-40	0.04	4.9	3	4	Partial
22317564	WS29	WS29. 30-40	0.03	2.0	3	4	Considerable
22317561	WS30	WS30. 30-40	0.05	4.8	2	12	Partial
22318001	WS31	WS31. 30-40	0.04	2.8	2	10	Partial
22317586	WS32	WS32. 30-40	0.06	4.0	3	1	Partial
22317583	WS33	WS33. 30-40	0.10	12.0	8	5	Water Stable
22317576	WS34	WS34. 30-40	0.06	7.4	2	11	Partial
22317694	WS35	WS35. 30-40	0.05	9.3	1	16	Partial
22317691	WS36	WS36. 30-40	0.04	7.0	2	14	Considerable
22317689	WS37	WS37. 30-40	0.05	10.0	2	11	Partial
22317678	WS38	WS38. 30-40	0.08	5.8	8	3	Water Stable
22317665	WS39	WS39. 30-40	0.07	6.8	2	10	Partial
22317667	WS40	WS40. 30-40	0.06	2.0	3	6	Considerable
22314858	WS41	WS41. 30-40	0.05	4.3	3	7	Partial
22317581	WS44	WS44. 30-40	0.04	25.0	3	8	Partial
22317558	WS45	WS45. 30-40	0.06	18.0	1	16	Considerable
22317681	WS47	WS47. 30-40	0.08	7.3	3	4	Partial
22317687	WS48	WS48. 30-40	0.06	9.8	8	8	Water Stable
22317676	WS49	WS49. 30-40	0.10	13.0	1	16	Partial
22317672	WS50	WS50. 30-40	0.06	5.7	2	8	Partial
22317670	WS51	WS51. 30-40	0.05	3.9	2	6	Considerable
22314723	WS52	WS52. 30-40	0.07	5.5	1	16	Considerable
22314722	WS53	WS53. 30-40	0.07	7.7	8	8	Water Stable
22314755	WS54	WS54. 30-40	0.04	1.9	3	4	Partial
22317698	WS55	WS55. 30-40	0.07	9.4	3	9	Partial
22317556	WS56	WS56. 30-40	0.04	10.0	3	8	Considerable
22317701	WS57	WS57. 30-40	0.06	8.0	2	8	Partial
22317682	WS58	WS58. 30-40	0.07	12.0	2	8	Partial
22317684	WS59	WS59. 30-40	0.94	19.0	6	0	Partial
22317674	WS60	WS60. 30-40	0.24	18.0	8	5	Water Stable
22314727	WS63	WS63. 30-40	0.07	7.9	2	14	Partial
22313928	WS64	WS64. 30-40	0.03	4.4	2	10	Partial
22317702	WS66	WS66. 30-40	0.03	6.2	3	8	Partial
22317696	WS67	WS67. 30-40	0.09	19.0	1	16	Considerable
22318003	WS77	WS77. 30-40	0.25	18.0	8	1	Water Stable
22318008	WS78	WS78. 30-40	0.04	13.0	3	5	Partial
22317655	WS79	WS79. 30-40	0.04	5.3	3	8	Partial
22317657	WS80	WS80. 30-40	0.06	7.0	2	11	Partial
22317660	WS81	WS81. 30-40	0.04	10.0	2	9	Considerable
22317662	WS82	WS82. 30-40	0.10	1.8	7	0	Water Stable

Table A.10: Wallan South 30-40cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Cation Exch. Cap.
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg
22314845	WS1	WS1. 30-40	940	980	59	200	<9.0	4.7	8.1	0.15	0.87	<0.1	13.8
22317530	WS2	WS2. 30-40	1040	1041	164	276	<9.0	5.2	8.6	0.42	1.2	<0.1	15.4
22317532	WS3	WS3. 30-40	1560	1210	180	345	<9.0	7.8	10	0.46	1.5	<0.1	19.9
22317534	WS4	WS4. 30-40	1620	1452	86	299	<9.0	8.1	12	0.22	1.3	<0.1	22.1
22317536	WS5	WS5. 30-40	1380	1331	86	253	<9.0	6.9	11	0.22	1.1	<0.1	19.1
22317539	WS6	WS6. 30-40	2400	1694	145	230	<9.0	12	14	0.37	1	<0.1	27.4
22317590	WS9	WS9. 30-40	140	157	78	58	160	0.7	1.3	0.2	0.25	1.8	4.2
22317592	WS10	WS10. 30-40	260	194	63	46	43	1.3	1.6	0.16	0.2	0.5	3.7
22317594	WS11	WS11. 30-40	220	157	51	62	<9.0	1.1	1.3	0.13	0.27	<0.1	2.8
22317602	WS12	WS12. 30-40	200	157	23	48	<9.0	1	1.3	0.06	0.21	<0.1	2.6
22317580	WS13	WS13. 30-40	1020	1198	188	182	35	5.1	9.9	0.48	0.79	0.4	16.6
22317598	WS14	WS14. 30-40	460	484	47	85	48	2.3	4	0.12	0.37	0.5	7.2
22317552	WS15	WS15. 30-40	920	799	94	110	<9.0	4.6	6.6	0.24	0.48	<0.1	12
22317549	WS16	WS16. 30-40	680	762	86	129	14	3.4	6.3	0.22	0.56	0.2	10.7
22317546	WS17	WS17. 30-40	980	1452	121	391	<9.0	4.9	12	0.31	1.7	<0.1	19
22317544	WS18	WS18. 30-40	920	871	66	175	<9.0	4.6	7.2	0.17	0.76	<0.1	12.7
22317541	WS19	WS19. 30-40	1600	1815	106	368	<9.0	8	15	0.27	1.6	<0.1	24.6
22317588	WS21	WS21. 30-40	60	109	23	44	63	0.3	0.9	0.06	0.19	0.7	2.1
22317596	WS22	WS22. 30-40	240	73	12	39	33	1.2	0.6	0.03	0.17	0.4	2.3
22317600	WS23	WS23. 30-40	340	278	27	44	20	1.7	2.3	0.07	0.19	0.2	4.5
22317574	WS24	WS24. 30-40	220	109	82	18	<9.0	1.1	0.9	0.21	0.08	<0.1	2.2
22317572	WS25	WS25. 30-40	220	182	74	55	61	1.1	1.5	0.19	0.24	0.7	3.7
22317570	WS26	WS26. 30-40	220	315	16	104	23	1.1	2.6	0.04	0.45	0.3	4.5
22317567	WS27	WS27. 30-40	300	315	27	9	13	1.5	2.6	0.07	0.04	0.1	4.4
22317565	WS28	WS28. 30-40	220	169	20	30	<9.0	1.1	1.4	0.05	0.13	<0.1	2.6
22317564	WS29	WS29. 30-40	200	182	23	14	<9.0	1	1.5	0.06	0.06	<0.1	2.7
22317561	WS30	WS30. 30-40	500	726	55	101	<9.0	2.5	6	0.14	0.44	<0.1	9.1
22318001	WS31	WS31. 30-40	560	508	39	46	<9.0	2.8	4.2	0.1	0.2	<0.1	7.3
22317586	WS32	WS32. 30-40	220	133	231	48	200	1.1	1.1	0.59	0.21	2.2	5.3
22317583	WS33	WS33. 30-40	360	1077	90	368	110	1.8	8.9	0.23	1.6	1.2	13.7
22317576	WS34	WS34. 30-40	220	399	51	92	37	1.1	3.3	0.13	0.4	0.4	5.4
22317694	WS35	WS35. 30-40	200	266	39	87	33	1	2.2	0.1	0.38	0.4	4.1
22317691	WS36	WS36. 30-40	180	303	20	74	71	0.9	2.5	0.05	0.32	0.8	4.5
22317689	WS37	WS37. 30-40	180	218	35	74	<9.0	0.9	1.8	0.09	0.32	<0.1	3.1
22317678	WS38	WS38. 30-40	840	1331	113	253	130	4.2	11	0.29	1.1	1.4	18.4
22317665	WS39	WS39. 30-40	520	545	51	129	42	2.6	4.5	0.13	0.56	0.5	8.3
22317667	WS40	WS40. 30-40	500	605	27	37	<9.0	2.5	5	0.07	0.16	<0.1	7.8
22314858	WS41	WS41. 30-40	660	266	12	58	<9.0	3.3	2.2	0.03	0.25	<0.1	5.8
22317581	WS44	WS44. 30-40	40	61	4	60	<9.0	0.2	0.5	0.01	0.26	<0.1	1
22317558	WS45	WS45. 30-40	140	242	16	140	14	0.7	2	0.04	0.61	0.2	3.5
22317681	WS47	WS47. 30-40	260	194	31	53	<9.0	1.3	1.6	0.08	0.23	<0.1	3.2
22317687	WS48	WS48. 30-40	220	230	20	85	31	1.1	1.9	0.05	0.37	0.4	3.8
22317676	WS49	WS49. 30-40	240	1174	98	391	80	1.2	9.7	0.25	1.7	0.9	13.8
22317672	WS50	WS50. 30-40	580	387	23	85	<9.0	2.9	3.2	0.06	0.37	<0.1	6.6
22317670	WS51	WS51. 30-40	640	399	16	62	<9.0	3.2	3.3	0.04	0.27	<0.1	6.8
22314723	WS52	WS52. 30-40	700	1065	106	186	120	3.5	8.8	0.27	0.81	1.4	14.8
22314722	WS53	WS53. 30-40	780	1162	63	276	42	3.9	9.6	0.16	1.2	0.5	15.3
22314755	WS54	WS54. 30-40	1560	532	20	55	<9.0	7.8	4.4	0.05	0.24	<0.1	12.5
22317698	WS55	WS55. 30-40	60	278	59	122	220	0.3	2.3	0.15	0.53	2.4	5.7
22317556	WS56	WS56. 30-40	120	85	4	37	15	0.6	0.7	0.01	0.16	0.2	1.6
22317701	WS57	WS57. 30-40	160	121	23	55	80	0.8	1	0.06	0.24	0.9	3
22317682	WS58	WS58. 30-40	120	85	20	58	46	0.6	0.7	0.05	0.25	0.5	2.1
22317684	WS59	WS59. 30-40	740	1815	82	1081	<9.0	3.7	15	0.21	4.7	<0.1	23.9
22317674	WS60	WS60. 30-40	200	351	63	207	14	1	2.9	0.16	0.9	0.2	5.1
22314727	WS63	WS63. 30-40	920	1029	43	253	<9.0	4.6	8.5	0.11	1.1	<0.1	14.4
22313928	WS64	WS64. 30-40	1960	1077	55	196	<9.0	9.8	8.9	0.14	0.85	<0.1	19.6
22317702	WS66	WS66. 30-40	60	73	35	28	70	0.3	0.6	0.09	0.12	0.8	1.9
22317696	WS67	WS67. 30-40	200	387	27	253	38	1	3.2	0.07	1.1	0.4	5.8
22318003	WS77	WS77. 30-40	40	194	39	177	140	0.2	1.6	0.1	0.77	1.6	4.2
22318008	WS78	WS78. 30-40	80	121	23	62	22	0.4	1	0.06	0.27	0.2	2
22317655	WS79	WS79. 30-40	180	218	47	83	330	0.9	1.8	0.12	0.36	3.7	6.9
22317657	WS80	WS80. 30-40	220	194	133	74	110	1.1	1.6	0.34	0.32	1.3	4.6
22317660	WS81	WS81. 30-40	220	133	23	67	21	1.1	1.1	0.06	0.29	0.2	2.8
22317662	WS82	WS82. 30-40	3800	2662	113	177	<9.0	19	22	0.29	0.77	<0.1	42.2

Table A.11: Wallan South 30-40cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Aluminium Saturation	Calcium/Magnesium Ratio	**ESP% + EPP% Calculation**
			%	%	%	%		**SESW Calculation**
22314845	WS1	WS1. 30-40	34	59	1.1	<1.0	0.6	7.4
22317530	WS2	WS2. 30-40	34	56	2.7	<1.0	0.6	10.7
22317532	WS3	WS3. 30-40	39	51	2.3	<1.0	0.8	10.1
22317534	WS4	WS4. 30-40	36	57	1	<1.0	0.7	6.9
22317536	WS5	WS5. 30-40	36	57	1.2	<1.0	0.6	7.0
22317539	WS6	WS6. 30-40	42	53	1.3	<1.0	0.9	5.1
22317590	WS9	WS9. 30-40	17	30	4.7	42	0.5	10.6
22317592	WS10	WS10. 30-40	35	42	4.2	13	0.8	9.6
22317594	WS11	WS11. 30-40	40	46	4.6	<1.0	0.9	14.3
22317602	WS12	WS12. 30-40	39	50	2.5	<1.0	0.8	10.5
22317580	WS13	WS13. 30-40	31	59	2.9	2.3	0.5	7.6
22317598	WS14	WS14. 30-40	31	55	1.6	7.3	0.6	6.8
22317552	WS15	WS15. 30-40	39	55	2	<1.0	0.7	6.0
22317549	WS16	WS16. 30-40	32	59	2	1.5	0.5	7.2
22317546	WS17	WS17. 30-40	26	63	1.6	<1.0	0.4	10.7
22317544	WS18	WS18. 30-40	36	57	1.4	<1.0	0.6	7.4
22317541	WS19	WS19. 30-40	33	60	1.1	<1.0	0.5	7.4
22317588	WS21	WS21. 30-40	15	40	2.9	33	0.4	11.9
22317596	WS22	WS22. 30-40	51	25	1.3	16	2.1	8.7
22317600	WS23	WS23. 30-40	37	52	1.6	4.9	0.7	5.8
22317574	WS24	WS24. 30-40	48	39	9.4	<1.0	1.3	12.9
22317572	WS25	WS25. 30-40	30	40	5.1	18	0.7	11.5
22317570	WS26	WS26. 30-40	25	58	0.83	5.8	0.4	10.8
22317567	WS27	WS27. 30-40	35	59	1.6	3.3	0.6	2.6
22317565	WS28	WS28. 30-40	40	53	1.8	<1.0	0.8	6.7
22317564	WS29	WS29. 30-40	39	57	2.1	<1.0	0.7	4.1
22317561	WS30	WS30. 30-40	28	66	1.5	<1.0	0.4	6.3
22318001	WS31	WS31. 30-40	38	58	1.4	<1.0	0.7	4.2
22317586	WS32	WS32. 30-40	21	21	11	43	1	15.0
22317583	WS33	WS33. 30-40	13	65	1.7	9.1	0.2	13.7
22317576	WS34	WS34. 30-40	21	62	2.4	7.8	0.3	9.8
22317694	WS35	WS35. 30-40	26	54	2.4	8.9	0.5	11.7
22317691	WS36	WS36. 30-40	19	56	1.1	18	0.3	8.1
22317689	WS37	WS37. 30-40	29	58	3	<1.0	0.5	13.0
22317678	WS38	WS38. 30-40	23	62	1.6	7.9	0.4	7.4
22317665	WS39	WS39. 30-40	32	54	1.6	5.6	0.6	8.4
22317667	WS40	WS40. 30-40	32	65	0.88	<1.0	0.5	2.9
22314858	WS41	WS41. 30-40	57	38	0.44	<1.0	1.5	4.7
22317581	WS44	WS44. 30-40	22	53	1	<1.0	0.4	26.0
22317558	WS45	WS45. 30-40	20	57	1	4.6	0.4	19.0
22317681	WS47	WS47. 30-40	41	50	2.4	<1.0	0.8	9.7
22317687	WS48	WS48. 30-40	28	51	1.3	9.1	0.6	11.1
22317676	WS49	WS49. 30-40	8.7	71	1.8	6.5	0.1	14.8
22317672	WS50	WS50. 30-40	45	49	0.84	<1.0	0.9	6.5
22317670	WS51	WS51. 30-40	48	48	0.56	<1.0	1	4.5
22314723	WS52	WS52. 30-40	24	60	1.8	9.3	0.4	7.3
22314722	WS53	WS53. 30-40	25	63	1	3.1	0.4	8.7
22314755	WS54	WS54. 30-40	62	35	0.41	<1.0	1.8	2.3
22317698	WS55	WS55. 30-40	4.4	41	2.7	43	0.1	12.1
22317556	WS56	WS56. 30-40	36	43	1	11	0.9	11.0
22317701	WS57	WS57. 30-40	27	34	2	29	0.8	10.0
22317682	WS58	WS58. 30-40	29	32	2.5	25	0.9	14.5
22317684	WS59	WS59. 30-40	16	64	0.88	<1.0	0.3	19.9
22317674	WS60	WS60. 30-40	20	57	3.1	3	0.3	21.1
22314727	WS63	WS63. 30-40	32	59	0.74	<1.0	0.5	8.6
22313928	WS64	WS64. 30-40	50	45	0.73	<1.0	1.1	5.1
22317702	WS66	WS66. 30-40	16	33	4.5	40	0.5	10.7
22317696	WS67	WS67. 30-40	17	56	1.3	7.3	0.3	20.3
22318003	WS77	WS77. 30-40	3.8	38	2.5	37	0.1	20.5
22318008	WS78	WS78. 30-40	19	52	3.1	12	0.4	16.1
22317655	WS79	WS79. 30-40	13	27	1.8	53	0.5	7.1
22317657	WS80	WS80. 30-40	25	34	7.3	27	0.7	14.3
22317660	WS81	WS81. 30-40	39	41	2.2	8.2	1	12.2
22317662	WS82	WS82. 30-40	46	51	0.69	<1.0	0.9	2.5

Table A.12: Wallan South >40cm Sample Analytical Results.

Sample ID	Site	Sample Name	Sample Start Depth	Sample End Depth	Zone	GPS Easting	GPS Northing	Texture	pH (1:5 Water)	pH (1:5 CaCl2)	Electrical Conductivity (1:5 water)	Exchangeable Sodium Percentage	Emerson Class	Disp. Index, Loveday/Pyle	Slaking 2Hrs
			cm	cm				SESW Field Classification			dS/m	%			
22317535	WS4	WS4. 100-110	100	110	55H	319904	5854642	Heavy Clay	8.3	7.4	0.28	11.0	3	7	Partial
22317579	WS13	WS13. 110-120	110	120	55H	318956	5854958	Heavy Clay	5.4	4.5	0.33	15.0	2	12	Considerable
22317550	WS16	WS16. 130-140	130	140	55H	319904	5854958	Heavy Clay	5.5	4.5	0.16	11.0	2	14	Considerable
22317547	WS17	WS17. 60-70	60	70	55H	320220	5854958	Heavy Clay	8.1	6.8	0.18	13.0	1	16	Partial
22317587	WS21	WS21. 110-120	110	120	55H	318008	5855274	Medium-Heavy Clay	5.8	4.6	0.19	19.0	8	11	Water Stable
22317569	WS26	WS26. 120-130	120	130	55H	319588	5855274	Heavy Clay	6.8	5.9	0.32	29.0	1	16	Considerable
22317560	WS30	WS30. 130-140	130	140	55H	320852	5855274	Medium Clay	7.5	6.4	0.27	30.0	1	16	Considerable
22318000	WS31	WS31. 120-130	120	130	55H	321168	5855274	Heavy Clay	6.7	5.6	0.12	9.3	1	16	Partial
22317693	WS35	WS35. 130-140	130	140	55H	319272	5855590	Medium-Heavy Clay	7.3	6.2	0.20	33.0	1	16	Partial
22317664	WS39	WS39. 120-130	120	130	55H	320536	5855590	Heavy Clay	7.3	6.7	0.53	23.0	1	16	Partial
22317578	WS44	WS44. 110-120	110	120	55H	318640	5855906	Heavy Clay	6.9	5.7	0.26	32.0	1	16	Partial
22317686	WS48	WS48. 130-140	130	140	55H	319904	5855906	Heavy Clay	5.4	4.7	0.54	22.0	3	1	Considerable
22317669	WS51	WS51. 120-130	120	130	55H	320852	5855906	Heavy Clay	7.6	6.2	0.08	11.0	1	16	Considerable
22317555	WS56	WS56. 120-130	120	130	55H	318956	5856222	Sandy Clay	7.9	6.8	0.33	33.0	1	16	Considerable
22317699	WS57	WS57. 130-140	130	140	55H	319272	5856222	Heavy Clay	5.5	4.6	0.42	33.0	3	1	Considerable
22318028	WS78	WS78. 120-130	120	130	55H	318956	5857802	Heavy Clay	6.7	5.5	0.31	33.0	1	16	Partial
22317659	WS81	WS81. 120-130	120	130	55H	318956	5858118	Heavy Clay	5.8	4.5	0.14	18.0	1	11	Considerable

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Sodium (Amm-acet.)	Aluminium (KCl)	Cation Exch. Cap.
			mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg	cmol(+)/kg
22317535	WS4	WS4. 100-110	1940	1936	113	736	<9.0	9.7	16	0.29	3.2	<0.1	29.2
22317579	WS13	WS13. 110-120	760	1452	149	713	99	3.8	12	0.38	3.1	1.1	19.8
22317550	WS16	WS16. 130-140	720	980	86	368	47	3.6	8.1	0.22	1.6	0.5	14.1
22317547	WS17	WS17. 60-70	1200	2057	137	805	<9.0	6	17	0.35	3.5	<0.1	26.9
22317587	WS21	WS21. 110-120	100	1077	180	575	76	0.5	8.9	0.46	2.5	0.9	13.1
22317569	WS26	WS26. 120-130	280	1053	82	966	<9.0	1.4	8.7	0.21	4.2	<0.1	14.5
22317560	WS30	WS30. 130-140	400	980	90	1035	<9.0	2	8.1	0.23	4.5	<0.1	14.8
22318000	WS31	WS31. 120-130	1060	1162	98	368	<9.0	5.3	9.6	0.25	1.6	<0.1	16.7
22317693	WS35	WS35. 130-140	160	1137	82	1173	<9.0	0.8	9.4	0.21	5.1	<0.1	15.6
22317664	WS39	WS39. 120-130	1020	1815	117	1403	<9.0	5.1	15	0.3	6.1	<0.1	26
22317578	WS44	WS44. 110-120	40	1186	55	1081	<9.0	0.2	9.8	0.14	4.7	<0.1	14.8
22317686	WS48	WS48. 130-140	340	1936	129	1196	66	1.7	16	0.33	5.2	0.7	23.4
22317669	WS51	WS51. 120-130	800	1174	90	391	<9.0	4	9.7	0.23	1.7	<0.1	15.7
22317555	WS56	WS56. 120-130	120	1041	70	1058	<9.0	0.6	8.6	0.18	4.6	<0.1	13.9
22317699	WS57	WS57. 130-140	40	908	51	943	57	0.2	7.5	0.13	4.1	0.6	12.6
22318028	WS78	WS78. 120-130	140	1210	78	1242	<9.0	0.7	10	0.2	5.4	<0.1	16.4
22317659	WS81	WS81. 120-130	40	1077	59	552	140	0.2	8.9	0.15	2.4	1.5	13.1

Table A.13: Wallan South >40cm Sample Analytical Results (Continued).

Sample ID	Site	Sample Name	Calcium (Amm-acet.)	Magnesium (Amm-acet.)	Potassium (Amm-acet.)	Aluminium Saturation	Calcium/Magnesium Ratio
			%	%	%	%	
22317535	WS4	WS4. 100-110	33	55	0.98	<1.0	0.6
22317579	WS13	WS13. 110-120	19	58	1.9	5.5	0.3
22317550	WS16	WS16. 130-140	25	58	1.6	3.7	0.4
22317547	WS17	WS17. 60-70	22	63	1.3	<1.0	0.4
22317587	WS21	WS21. 110-120	3.4	68	3.5	6.5	0.1
22317569	WS26	WS26. 120-130	10	60	1.4	<1.0	0.2
22317560	WS30	WS30. 130-140	13	55	1.6	<1.0	0.3
22318000	WS31	WS31. 120-130	32	58	1.5	<1.0	0.6
22317693	WS35	WS35. 130-140	5.3	60	1.3	<1.0	0.1
22317664	WS39	WS39. 120-130	20	56	1.2	<1.0	0.3
22317578	WS44	WS44. 110-120	1.1	66	0.93	<1.0	0
22317686	WS48	WS48. 130-140	7.1	66	1.4	3.1	0.1
22317669	WS51	WS51. 120-130	26	62	1.5	<1.0	0.4
22317555	WS56	WS56. 120-130	4.4	62	1.3	<1.0	0.1
22317699	WS57	WS57. 130-140	1.6	60	1	5	0
22318028	WS78	WS78. 120-130	4.3	62	1.2	<1.0	0.1
22317659	WS81	WS81. 120-130	1.4	68	1.2	12	0

Table A.14: Soil colors/ranges and interpretation

Exchangeable Sodium Percentage (ESP) Interpretation

Colour	ESP Range	Interpretation
	<6%.	Non-sodic.
	6.1-10%.	Moderately Sodic
	10.1-15.0%	Strongly Sodic
	>15.1%	Very Strongly Sodic

Emerson Dispersion Class Interpretation.

Colour	Emerson Class	Interpretation
	4, 5, 6, 7, 8	Non-dispersive.
	3	Partial Dispersion after remoulding
	2	Partial Dispersion
	1	Complete Dispersion

Loveday & Pyle (L&P) Score Interpretation.

Colour	L&P Score	Interpretation
	0, 1, 2, 3, 4	Low to moderate. Nil to slight gypsum resonse expected where dispersive.
	5, 6, 7, 8	Moderate to high. Gypsum response expected to control dispersion.
	9, 10, 11, 12	High. Gypsum response expected to control dispersion. High rates required.
	13, 14, 15, 16	Very high. Very high rates required to control dispersion.

Slaking Class Interpretation.

Colour	Slaking Class	Interpretation
	Water Stable	Aggregate stable when wetted, nil or minimal breakdown in structure.
	Partial	Low aggregate stability. Partial breakdown in structure when wetted.
	Considerable	Unstable. High or significant loss of structure when wetted.

Organic Carbon Interpretation

Colour	Organic Carbon %	Interpretation
	<1.0	Low to deficient. Low or poor aggregate stability expected.
	1.0-1.9	Slightly low. Aggregates expected to be unstable, or partially stable.
	2.0-2.9	Acceptable. Variable water stability expected.
	3.0-3.9	Optimal. Water stable aggregates expected.
	4.0+	Optimal to high. Aggregate stability likely.