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Dungog Shire Council On-site Sewage Management Technical Manual

Final Report

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June 2015

Dungog Shire Council
On-site Sewage Management Technical Manual

Prepared For:	Dungog Shire Council
Prepared By:	BMT WBM Pty Ltd (Member of the BMT group of companies)

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Title :	Dungog Shire Council On-site Sewage Management Technical Manual
Authors :	Ben Asquith, Jack Sharples, Daniel Williams
Synopsis :	This manual presents a technical justification for the revision of Council policy relating to the planning and approval of on-site sewage management systems in the Dungog Shire Local Government Area (LGA). This includes the unsewered development of land through rezoning and subdivision. Spatial analysis, hazard mapping and catchment modelling have been used to a) classify unsewered land according to the minimum level of technical investigation required for the approval of a development; b) nominate a minimum lot size based on analysis of local development characteristics; and c) evaluate the long-term sustainability of on-site systems for different existing and greenfield areas within the LGA based on the prevention of localised and broader cumulative impacts. This Technical Manual also contains guiding information and useful resources for fulfilling the obligations of the Development Assessment Framework.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

BMT WBM has recently completed a project entitled *Development of On-site Sewage Management Systems for Dungog Shire Council* on behalf of Dungog Shire Council (Council). The project involved a broad scale land capability assessment of the Dungog Shire Local Government Area (LGA) to establish local benchmarks for safe, effective on-site sewage management incorporating issues such as land capability, cumulative impacts (lot density) and minimum lot size. This technical basis for sustainable on-site sewage management was then used in the formation of a Development Assessment Framework (DAF) for the assessment and approval of on-site sewage management systems and unsewered developments generally. The DAF streamlines the approval process for on-site systems located in lower risk areas. It also provides clear guidance on the supporting information and Minimum Standards required for higher risk locations.

1.1 Aims and Objectives

This *On-site Sewage Management Technical Manual* (the Technical Manual) has been prepared to;

- document the broad scale land capability assessment process as a technical basis for on-site sewage management policy development; and
- provide guidance on scientific and engineering principles and techniques that can be used to demonstrate compliance with the DAF (particularly with regard to High and Very High Hazard allotments).

The main objectives of the Technical Manual are as follows.

- Provide a transparent technical rationale for the On-site Sewage Management Hazard Map, minimum allotment size and cumulative impact determinations.
- Describe and demonstrate the use of specific methods / tools in the assessment of on-site sewage management system applications.
- Describe and demonstrate the use of specific methods / tools to undertake cumulative impact assessments for unsewered developments involving an increase in building entitlements and non-domestic systems.

1.2 Use of the Technical Manual

This Technical Manual is designed primarily for use by environmental / engineering consultants completing wastewater management investigations on behalf of applicants for installation of individual on-site systems and unsewered development applications involving an increase in building entitlements. Specifically it may be used to;

- confirm the basis for On-site Sewage Management Hazard Class for a particular lot;
- confirm the basis for minimum allotment sizes / maximum densities included in the DAF;
- undertake more complex assessment and design procedures required for High and Very High Hazard lots; and
- undertake a site specific cumulative impact assessment to determine maximum lot density / minimum lot size.

2 BACKGROUND

The diversity of bio-physical conditions observed across Dungog Shire (and many other LGA's) limits the opportunities for a 'one size fits all' approach to on-site sewage management. Diversity is increased once consideration is given to the variation in the nature and extent of unsewered development. Council have previously investigated ways to standardise approval and regulatory processes for on-site systems in the face of this variation.

Council currently consider the suitability of a proposed on-site system for a site on a case by case basis. Most applications to install or alter an on-site system are required to be supported by a "geotechnical" or site assessment report. These reports (for the purpose of this Study they will be called Wastewater Management Reports) provide a more detailed evaluation of site and soil constraints to on-site sewage management in addition to guidance on selection of an appropriate treatment and land application system. They also typically include calculations to determine the minimum size of land application areas.

There is typically considerable variation in the structure and quality of Wastewater Management Reports (WMR) submitted to Dungog Shire Council. In some cases insufficient supporting information or evidence is provided in the Report to enable Council to approve the proposed system with confidence. NSW legislation (*Local Government Act 1993*) and guidelines (DLG, 2008) effectively apply a performance based approach to preparation of WMRs. The revised *ASNZ1547:2012* does offer more detailed guidance on the key content and assessment requirements for WMRs. However, this document is not an adopted code in NSW and cannot strictly be enforced on its own.

There are limited resources within Council and the community available to complete and assess site and soil assessments and WMRs for on-site systems. As such, opportunities to standardise streamline and justify minimum standards for on-site system approval will offer significant benefits.

This Study presents the outcomes of a detailed broad scale land capability assessment of the Dungog Shire LGA that helps define the likely constraints to sustainable on-site sewage management on a lot by lot basis. It also provides technical justification for establishment of a risk based approach to the assessment and approval of on-site systems. Where risks are low Council may adopt reduced assessment and design standards or potentially offer a "deemed to comply" approach. Where risks are higher or uncertain the outcomes of this Study can be used to support requests for more comprehensive levels of assessment and design.

In commissioning this project, Council identified the need for an assessment framework for on-site systems that balances adaptability to the diverse range of circumstances faced by system owners with the provision of a clear set of requirements for the approval of new and upgraded on-site systems and unsewered development. BMT WBM has utilised a range of best practice tools and information relating to on-site sewage management to complete a revised broad scale land capability assessment and make determinations on sustainable lot sizes and densities for unsewered development. The outcomes of this work have been used to establish a Development Assessment Framework for on-site sewage management that is integrated with Council policies and plans.

3 STRUCTURE OF THE DEVELOPMENT ASSESSMENT FRAMEWORK

The Development Assessment Framework (DAF) has been developed to better integrate the design, approval and construction of On-site Sewage Management Systems (OSMS) into broader development planning requirements and provide a standardised and clear process for applicants, designers and installers. The OSMS DAF incorporates Minimum Standards and Acceptable Solutions for each of the four On-site Sewage Management Hazard Classes. It covers applications to install or alter individual on-site systems (domestic and non-domestic) and Development Applications (DA) that increase building entitlements on unsewered allotments. It is designed as a ready reference for system installers and environmental consultants who design on-site systems. This DAF also refers to other council policy and guideline documents in addition to external technical publications that will assist in meeting Councils Minimum Standards and Acceptable Solutions.

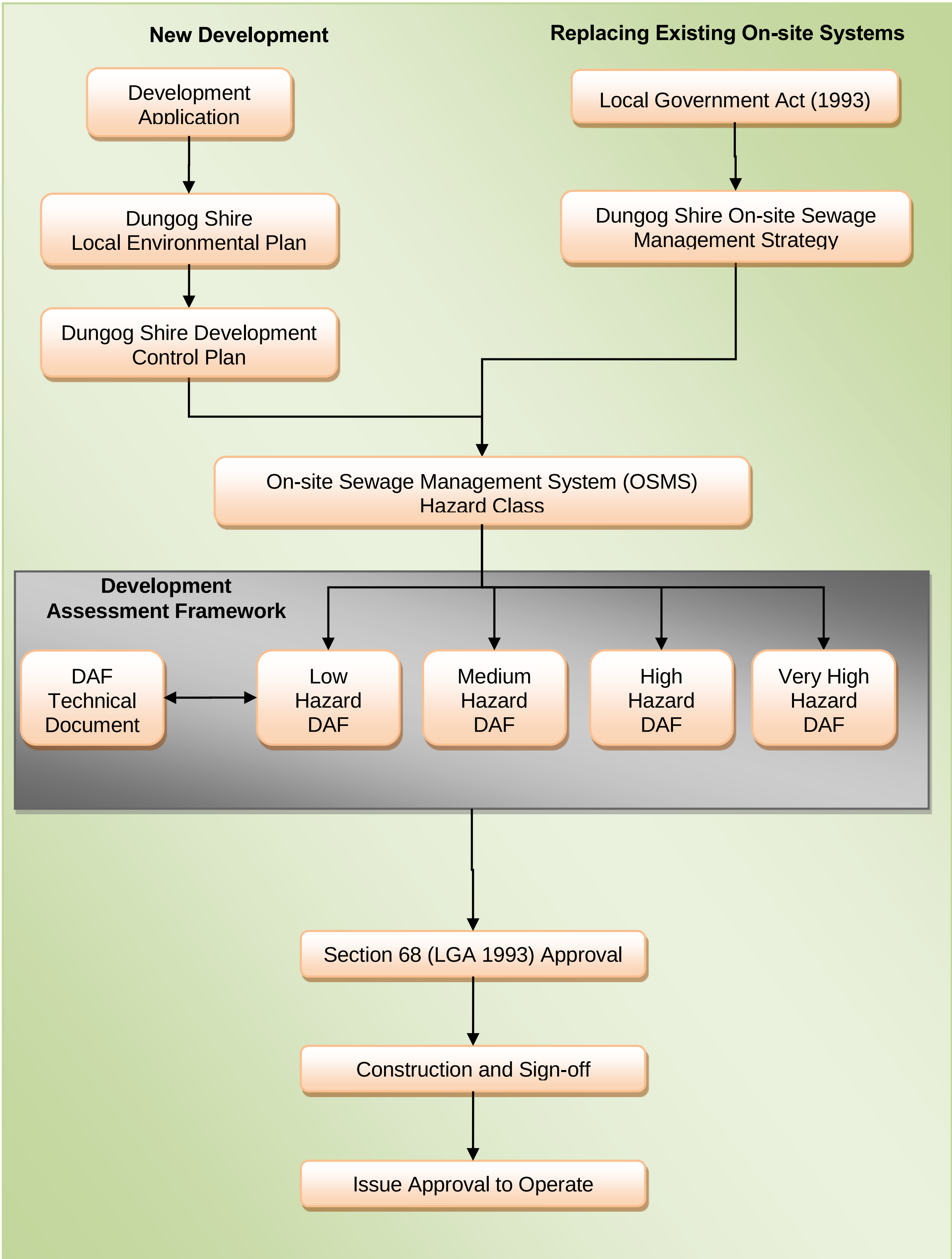
A checklist is provided for each Hazard class that can be used to confirm if the proposed on-site sewage management system or unsewered subdivision meets Councils Minimum Standards and Acceptable Solutions standards. **Where an application meets these standards, approval will be granted promptly. If not, further information will be requested by Council to allow approval.**

Minimum Standards apply to all aspects of the assessment, design and approval process and are divided into the following components.

- Site and Soil Assessment:
- System Selection and Sizing:
- Constructability:
- Increasing Building Entitlements.

The DAF document sets out how applications to install on-site sewage management systems and development applications that increase existing building entitlements can meet Minimum Standards and Acceptable Solutions and recommends resources, tools, standards and guidelines to be used in demonstrating compliance. **An application to install an individual on-site system or unsewered subdivision is unlikely to be approved where an applicant fails to use the recommended resources, tools, standards and guidelines to demonstrate compliance.** Notwithstanding, the DAF does provide flexibility for individual applicants to develop innovative or site specific on-site system designs by allowing for a performance based approach where clear justification is provided and a specific level of assessment and design is undertaken.

In the majority of cases, Councils DAF will reduce the uncertainty associated with how much information is required for approval and streamline / expedite the approval process. However, where specific applications are clearly in contrast to Councils objectives for sustainable and cost appropriate on-site sewage management, the DAF will also make it clear what additional information is required for Council to approve the system / development.


New Development
Replacing Existing On-site Systems
Development Application
Local Government Act (1993)
Dungog Shire Local Environmental Plan
Dungog Shire On-site Sewage Management Strategy
Dungog Shire Development Control Plan
On-site Sewage Management System (OSMS) Hazard Class
Development Assessment Framework
DAF Technical Document
Low Hazard DAF
Medium Hazard DAF
High Hazard DAF
Very High Hazard DAF
Section 68 (LGA 1993) Approval
Construction and Sign-off
Issue Approval to Operate

4 TECHNICAL BASIS FOR THE FRAMEWORK

The technical basis for the DAF is founded in the following key components.

- Assignment of an On-site Sewage Management Hazard Class to unsewered lots in the LGA based on a range of bio-physical and built characteristics. A separate hazard class was assigned for individual on-site sewage management and increases in building entitlements on unsewered lots. These hazard classifications provide a general guide to the potential for hazards to impair the performance of on-site systems.
- Identification of sustainable minimum allotment size(s) that ensure sustainable, safe and efficient sewage management can take place for the life of a development.
- Determination of maximum sustainable on-site system densities for new unsewered developments designed to provide a high level of protection from cumulative impacts on ecosystems and human health.
- Identification of key existing unsewered villages / areas where the capacity for sustainable on-site sewage management is limited and alternative servicing scenarios should be considered.
- A set of Acceptable Solutions for on-site sewage management on Low and Medium Hazard allotments that allow Council to promptly approve systems/developments with confidence that they will deliver long-term sustainability.

Chapters 5 to 8 of this Technical Manual document the rationale, methodology and outcomes of these four elements of the DAF.

5 ON-SITE SEWAGE MANAGEMENT HAZARD MAPPING

The use of Geographical Information System (GIS) analysis has enabled Council to undertake a revised broad scale land capability assessment of all unsewered lots in the LGA. The process is similar to the site and soil assessment process typically undertaken for single lots and unsewered subdivisions as guided by DLG (1998) and *ASNZS1547:2012*. The availability of a wider range of data sets which, in some cases are of greater accuracy has allowed the GIS analysis and mapping process to be vastly improved on initial approaches. Mapping has incorporated a wide range of built and natural features of the LGA into assignment of On-site Sewage Management Hazard Classes for all unsewered allotments.

Derivation of the final On-site Sewage Management Hazard Class involved comprehensive analysis of a range of individual parameters that typically influence the sustainability of on-site systems. This analysis required a range of hazard classes (e.g. low, medium and high) to be assigned to each parameter based on the degree to which general conditions observed on a site influence the design, construction and operation of systems. Hazard class represents a relative assessment of the likelihood and consequence associated with a particular condition. A simple example is provided by slope. Sites with slopes less than 10% typically do not restrict options for the design, construction and operation of on-site systems and as a result a Hazard Class of 1 (Low) is assigned. Sites with slopes greater than 20% severely restrict options for sustainable on-site sewage management and as such a Hazard Class of 3 (High) is applied.

The method for assessing land capability was undertaken in two stages. Initially, a base hazard level was derived using soil, slope and climate inputs. This process has been limited to consideration of these three fundamental parameters for the following reasons:

- Insufficient data was available for the Study Area to enable more detailed parameters to be evaluated:
- Soil (particularly depth to rock or groundwater), slope and climate constraints are the dominant factors influencing land capability for on-site wastewater management in Dungog Shire (and most locations):
- BMT WBM has previously developed a robust, groundtruthed risk assessment matrix using these parameters that has been thoroughly tested in adjacent LGAs.

This base hazard (Stage One) class represents the constraints to design, construction and operation of an effluent land application area (i.e. hazards that influence the relative risk of failure). Stage Two then involved adjustment of this base hazard level based on the proximity to and sensitivity of receiving environments (i.e. the likely consequence of any failure).

Stage one of the process utilised three spatial data layers:

- Soil Landscape Hazard – derived from existing soil landscape mapping and associated soil characteristics. The logic for assignment of soil hazard class is documented in Section 5.1.1 and Appendix A;
- Climate Hazard – derived from the soil parameters and monthly rainfall data. The logic for assignment of climate hazard class is documented in Section 5.1.2; and

- Slope Hazard – derived from the Digital Elevation Model. Areas where slopes are <10% were assigned a low hazard level, 10-15% as a medium hazard, 15-30% as a high hazard and >30% as a very high hazard.

These three layers were combined to assign an initial land capability hazard level using the matrix presented in Table 5-1.

Table 5-1 Stage One Land Capability Assessment Matrix

Soil Hazard	Climate Hazard	Slope Hazard: Low (<10%)	Slope Hazard: Medium (10-15%)	Slope Hazard: High (15-30%)	Slope Hazard: Very High (>30%)
Low	Low	Low	Low	High	Very High
Low	Medium	Low	Medium	High	Very High
Low	High	Medium	Medium	High	Very High
Medium	Low	Low	Medium	High	Very High
Medium	Medium	Medium	Medium	High	Very High
Medium	High	Medium	High	Very High	Very High
High	Low	Medium	High	Very High	Very High
High	Medium	Medium	High	Very High	Very High
High	High	High	High	Very High	Very High

The initial hazard levels from the matrix were then adjusted where an area was within a specified proximity to sensitive receptors. A proximity hazards layer (Stage Two) was derived from the data sources listed in Table 5-2.

Table 5-2 Stage Two Hazard Class Logic – Dungog LGA Wide

Proximity Hazards	Proximity	Hazard Application
Minor Watercourse / Farm Dams	40m	Raise hazard class by 1 for each proximity hazard present. Total hazard capped at 4.
Major Watercourse / Waterbody	100m	
Floodprone Land	Within	
Receiving Environments		
SEPP14 Wetlands	100m	Raise hazard class by 2 for each proximity hazard present. Total hazard capped at 4.
SEPP62 Aquaculture Zones	500m	

For areas in proximity to the intermittent watercourses, permanent waterbodies and flood prone land, the initial land capability hazard was increased by one level. For areas in proximity to SEPP14

Wetlands and SEPP62 Aquaculture Zones, the initial land capability hazard was increased by two levels. Examples of the mapping methodology are presented in Figure 5-1 and Figure 5-2.

The final land capability map provided a hazard level ranging from low to very high for all locations in the Study Area. The land capability map for the Study Area is presented in Figure 5-3. The land capability map (in addition to being a useful output in itself) has been used in the evaluation of available area for effluent management in addition to on-site system performance modelling. The following flow chart summarises the On-site Sewage Hazard Map development process as detailed in the following sections.

In addition, a more conservative range of watercourse proximity hazard buffers was also initially applied within HWC Drinking Water Catchments to account for the greater potential human health risk associated with systems within these catchments. However this resulted in an excessive number of lots being classified as high/very high and hazard variation across the LGA was lost. These additional hazard buffers were therefore not included in the final mapping as the existing mapping logic already sufficiently captures the necessary risks within drinking water catchments. It was identified that placement of an additional layer of hazard effectively double accounted for land capability constraints. Rather, it was determined that additional protection of potable water supply catchments should be achieved through Minimum Standards for unsewered subdivision in the DAF itself.

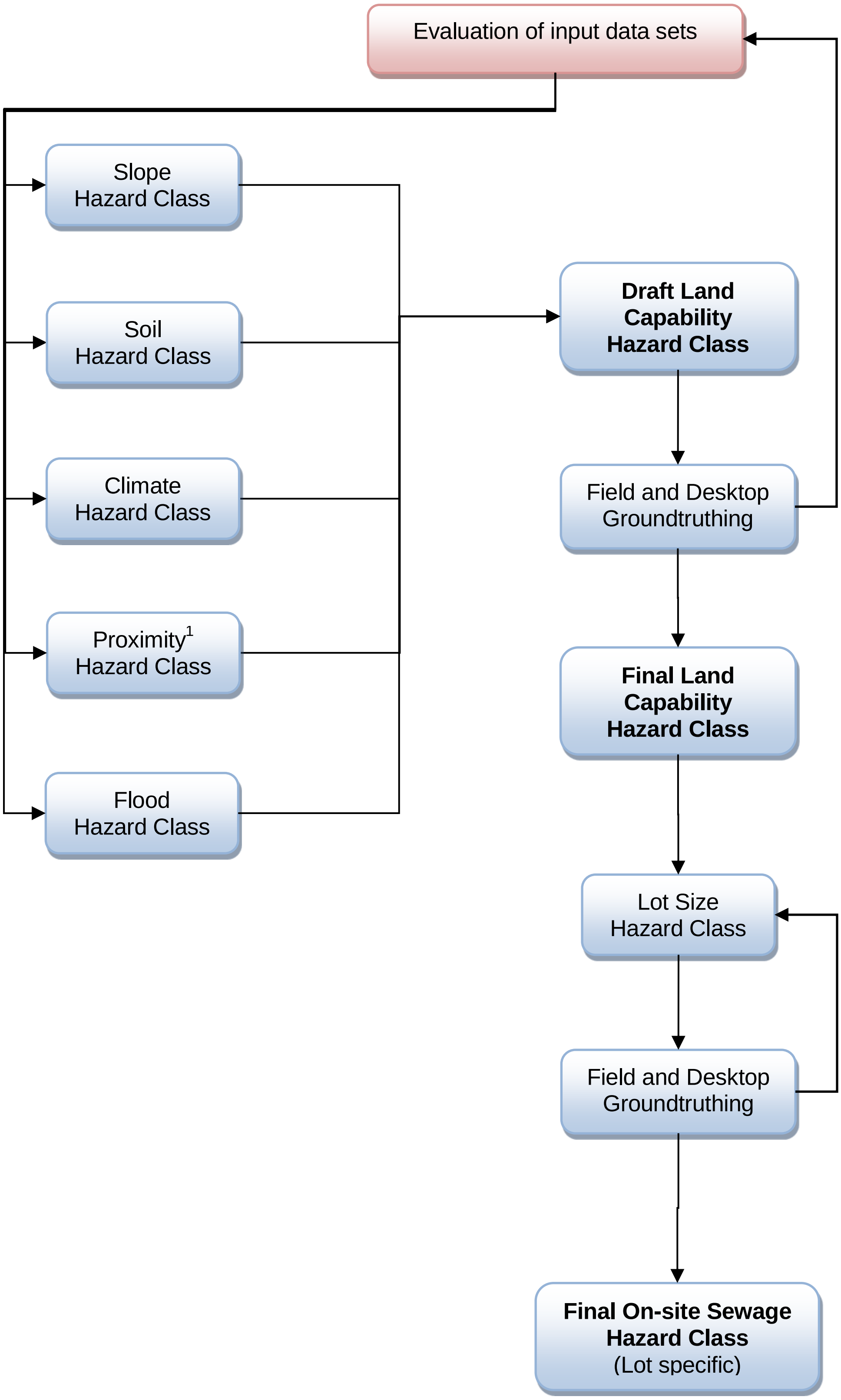
5.1 Input Data for Land Capability Mapping

Eight data sets were used in the creation of the land capability hazard map.

- 2 metre resolution Digital Elevation Model (DEM) created from LiDAR data (where available from Hunter Water) and 25 metre broad-scale DEM sourced from other Hunter Water topographic data. These DEM's were re-sampled at a 10m resolution and merged to create a final DEM for mapping purposes in this study.
- Soil hazard map created through desktop and groundtruthing of NSW Government and the Department of Conservation and Land Management (DCLM) soil landscape mapping (refer to Section 5.1.1).
- Climate hazard map created through calculation of gridded monthly water balance for the entire Dungog Shire LGA (refer to Section 5.1.2).
- The following data layers were supplied by Hunter Water Corporation and Dungog Shire Council (or available from state government websites) for use as proximity hazards.
    - Major Waterways.
    - SEPP14 Wetlands.
    - Whole LGA Drainage.
    - Flood Planning Levels.
    - SEPP62 Priority Aquaculture Zones.
    - Farm Dams (point data which was available within HWC Drinking Water Catchments only).

The land capability map was then finalized through the merging of adjacent polygon fragments which shared the same composite hazard class, to create larger continuous polygons of similar hazard class. The final Land Capability Hazard Map is shown in Figure 5-3.

More detailed descriptions of the key input data sets are provided in the following subsections.



Note 1: Includes proximity to watercourses, wetlands, aquaculture, dams and drains.

5.1.1 Soil Hazard Map

Derivation of a single Hazard Class that encapsulates the range of soil characteristics relevant to on-site sewage management requires experienced judgement based on sound soil science principles. A good understanding of soil landscapes and their mapping is also important to ensure the Hazard Class acknowledges the uncertainty associated with broad scale soil landscape mapping. Notwithstanding, this soil Hazard Class is a broad scale parameter that provides a general guide to soil constraints likely to be present. It is accepted that the soil hazard map cannot and should not replace site specific investigations to design effluent land application areas. The DAF simply uses it as a risk based tool to guide the level of detail required for investigation and design of on-site systems.

Published soil landscape mapping from the NSW Government and the Department of Conservation and Land Management (DCLM) was available for this project. Classification of the mapped soil facets was based on existing DCLM soil surveys and NSW Government GIS layers. Consequently, BMT WBM utilised the mapping layers and soil landscape data to complete a manual desktop assessment of each soil facet in the DSC LGA.

There are 86 soil facets in the LGA and assignment of a soil hazard for on-site sewage management was based on good quality information for each facet. The project manager is familiar with the soils of the Dungog Shire region and is confident that the assigned soil hazard classes are broadly applicable (i.e. at 1:100,000 scale). The basis for the soil hazard class is summarised in Table 5-3. A final soil hazard class was then derived using a weighted average score as summarised in Table 5-4. Weightings were based on the relative influence the various parameters have on the design, construction and operation of on-site systems.

Final soil hazard classes for all mapped soil landscapes in the DSC LGA are presented in Appendix A and will be supplied as a GIS layer.

Table 5-3 Parameters Adopted for Derivation of Soil Hazard Class

Hazard Type	Parameter	Hazard Class	Description	
Depth Hazard	Profile Depth	Low	Greater than 2 metres profile depth	Greater depths of unsaturated soil provide increased treatment of effluent and reduced potential for lateral water movement.
		Medium	1 – 2 metres profile depth	
		High	Less than 1 metre profile depth	
Hydraulic Hazard	Texture	Low	Pedal loam to clay loam soils with mid-range permeability and moderate to free drainage.	
	Structure Indicative Permeability	Medium	Generally imperfectly drained, weakly structured clay loams and light clays or deep, rapidly drained sands (e.g. sand hills).	
	Drainage	High	Generally, shallow, structureless clays and sands in either very rapidly or very poorly drained landscapes.	
Pollution Hazard	Nutrient Retention	Low	Generally soils with high cation exchange (CEC) and / or phosphorus sorption capacity, no sodicity potential and good organic content in topsoil.	
	Sodicity	Medium	Generally soils with moderate CEC, phosphorus sorption capacity, minor sodicity potential and moderate organic content in topsoil.	
	Organic Content	High	Generally soils with low CEC, phosphorus sorption capacity, sodicity potential and/or limited organic content.	

Table 5-4 Weighted Average Logic for Soil Hazard Class

Hazard Type	Hazard Scores (HS)	Weighting (w)	Calculation
Profile Depth	Low Hazard = 1 Medium Hazard = 2 High Hazard = 3	1.5	**Final Hazard Class** = [(Depth HS x w) + (Hydraulic HS x w) + (Pollution HS x w)] / 3 **Weighted average hazard classes** 1 – 1.5 = Low Soil Hazard 1.5 – 2.5 = Medium Soil Hazard 2.5 – 3 = High Soil Hazard
Hydraulic		1	
Pollution		0.5	

5.1.2 Soil Moisture Hazard Map (Climate)

The Soil Moisture Hazard Map (SMHM) was developed to provide a more meaningful assessment of the degree to which climate limits or enhances opportunities for the land application of effluent. It was adopted in preference to an assessment of rainfall and evapo-transpiration alone based on the significant variation in soil hydraulic properties observed across the LGA and the importance of soil water storage capacity and moisture content in effluent management.

The SMHM classifies the Dungog Shire LGA based on the number of average climate months where soil moisture is above field capacity. This represents periods where significant deep drainage or surface surcharging of effluent is more likely to occur because evapo-transpiration is providing limited or no assistance in assimilating wastewater. Grid cells with limited or no average months with soil moisture above field capacity represent sites with good evapo-transpiration capacity available for effluent assimilation.

There are two stages in the development of the SMHM. Creation of mean monthly soil moisture grids followed by application of a hazard class to each grid cell based on the number of average months where soil moisture is above field capacity. Soils that are consistently above field capacity will have a higher likelihood of leaching (rapidly draining landscapes) of pollutants or saturation and surcharging of land application areas (slowly draining landscapes).

5.1.2.1 Creation of Mean Monthly Soil Moisture Grids

Mean soil moisture grids represent a continuous 1 year soil water balance

Baseline data layers include;

- 2.5 km^2 grid of mean monthly rainfall (BOM Climate Atlas);
  www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_rain_1961-90.shtml
- 10 km^2 grid of mean monthly areal Potential Evapo-transpiration grid (BOM Climate Atlas); and
  http://www.bom.gov.au/climate/averages/climatology/gridded-data-info/metadata/md_ave_et_1961-90.shtml
- Soil landscape polygon data file (MapInfo table).

The soil data required pre-processing in the form of insertion of the following data as four separate columns against each soil facet.

- Initial soil moisture (ISM) in mm;
- Field capacity (FC) in mm;
- Permanent wilting point (PWP) in mm; and
- Daily recharge rate (DR) as a decimal.

These data were inferred based on Gardner and Davis (1998) and Hazelton and Murphy (2008) based on soil profile descriptions from the NSW Government and the Department of Conservation and Land Management data. The daily recharge rate was adopted from MacLeod (2008) based on indicative hydraulic conductivity and drainage characteristics and represents the proportion of soil water above field capacity that drains following rainfall. The soil landscape vector dataset was converted to a raster format with a cell size of 40m, in order to retain a reasonable level of detail. The rainfall and evapotranspiration data for each month were converted from lat/long co-ordinates to an MGA projection and then interpolated on to the same 40m grid alignment as the soil landscape raster. The soil moisture calculations detailed below were undertaken using these 40m grid inputs.

Firstly, the following calculations were undertaken to produce the mean monthly soil moisture balance (mm).

January Calculation

$SM_{jan} = ISM + Rf_{jan}(1 – [C_v \times 0.8])$

Remaining Months

$SM_{feb.....} = SM_{jan} + Rf_{feb}(1 - [C_v \times 0.8])$ etc...

Where;

SM = Soil moisture for the month (mm);

ISM = Initial Soil Moisture (mm);

Rf = Rainfall (mm/month);

C_v = Runoff Coefficient (obtained from gridded BOM data); and

0.8 = adjustment for baseflow (rainfall that becomes streamflow via subsurface flow).

There are two other conditions / calculations to make depending on the answer to equations 1 and 2.

If SM < PWP then SM = PWP should be applied to each monthly calculation.

If SM > FC then final soil moisture = the greater of (SM x [1-DR]) or FC.

Where;

PWP = Permanent Wilting Point;

FC = Field Capacity; and

DR = Drainage Rate (from MacLeod, 2008).

The final output of this grid analysis was a single soil moisture value (mm) for each month of an average statistical year. The results of these soil moisture calculations were then used to determine an appropriate soil climate hazard level for each soil type.

5.1.2.2 Creation of Final Soil Moisture Hazard Map

The final SMHM (or climate hazard map) was created through classification of grid cells in accordance with the following logic.

Low hazard = 0 months with soil moisture ≥ field capacity.

Medium hazard = 1-3 months with soil moisture ≥ field capacity.

High hazard = 4 or more months with soil moisture ≥ field capacity.

Figure 5-1 to Figure 5-2 show the final climate hazard map and how it integrates with other hazards.

5.2 Derivation of Lot-Based Land Capability

Following the development of the land capability map, it was necessary to determine suitable land capability hazard classes for each lot within the LGA. This was undertaken through the intersection of the land capability map with the Council cadastral boundaries. Average land capability hazard class numbers were then calculated for each lot using an aerial weighted combination of the hazards from the land capability map. Average hazard class numbers were rounded to the nearest integer.

The final mapping output required two hazard maps to be produced – one for a single lot unsewered development and another for unsewered subdivision or rezoning. Critical lot sizes of 4,000 m^2 and 2,000 m^2 were adopted for final hazard class mapping. This is consistent with the outcomes of the *minimum lot* size assessment and maps for Port Stephens, Greater Taree and Great Lakes. These hazard triggers are also generally consistent with the outcomes of cumulative impact assessments for existing unsewered allotments.

5.2.1.1 Single Lot

The following logic was applied to cadastral data to produce the single lot hazard class.

Lots >= 4000 m^2 = Average land capability hazard class number (for each lot).

Lots 2000 – 4000 m^2 = Greater of 3 (high hazard) and the average land capability hazard class.

Lots <2000 m^2 = Very high (4) hazard (regardless of land capability).

5.2.1.2 Multiple Lot

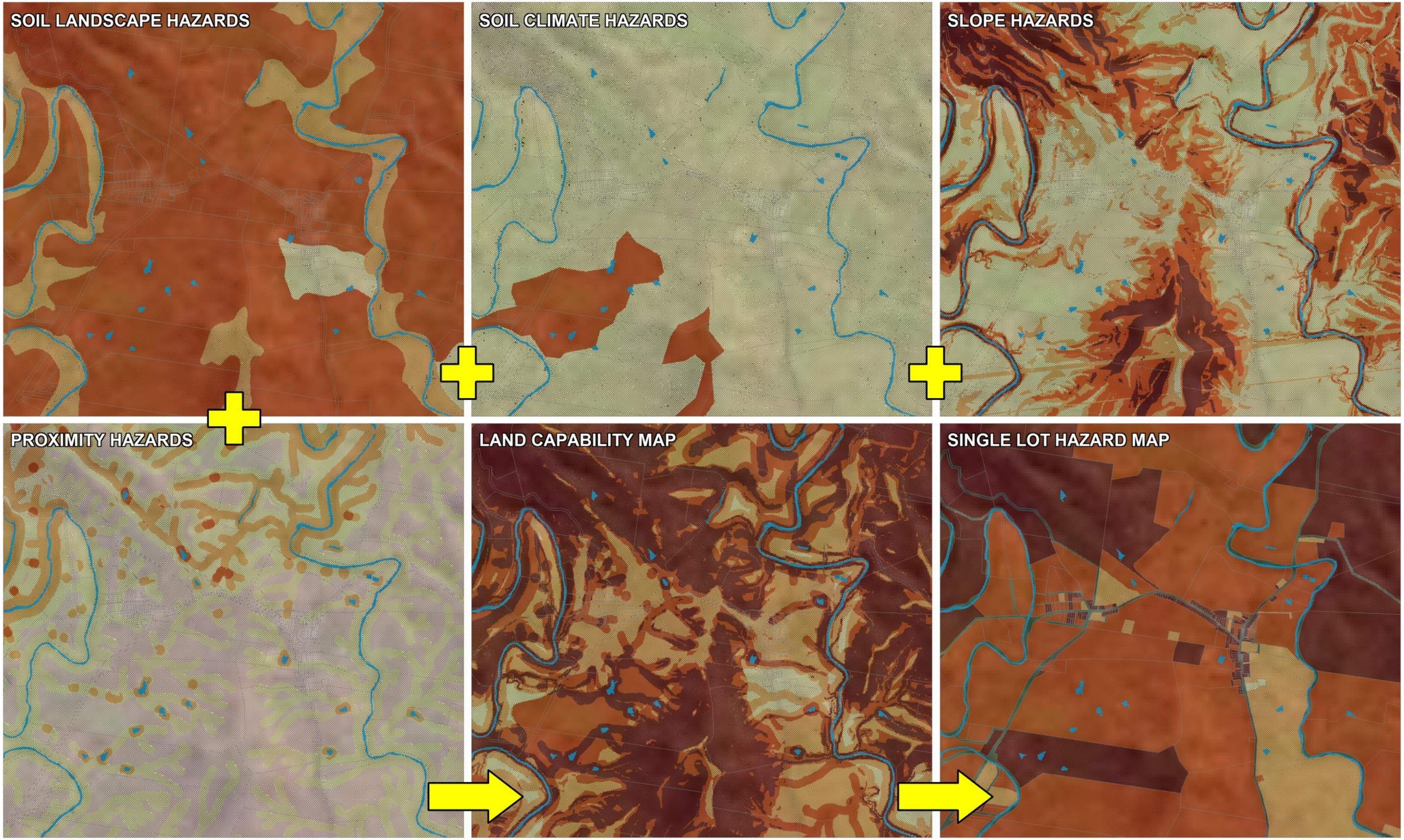
The following logic was applied to cadastral data to produce the multiple lot hazard class.

Lots >= 8000 m^2 = Average land capability hazard class number (for each lot).

Lots 4000 – 8000 m^2 = Greater of 3 (high hazard) and the average land capability hazard class.

Lots <4000 m^2 = Very high (4) hazard (regardless of land capability).

The following figures present the final Land Capability Hazard Map, Final On-site Sewage Management Hazard Maps and two example close ups illustrations of how the individual elements were combined to create the final maps.



LEGEND

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Dungog Shire
Hazard Map Methodology at Gresford

Figure: 5-1

Rev: A

N

0 0.75 1.5km

Approx. Scale

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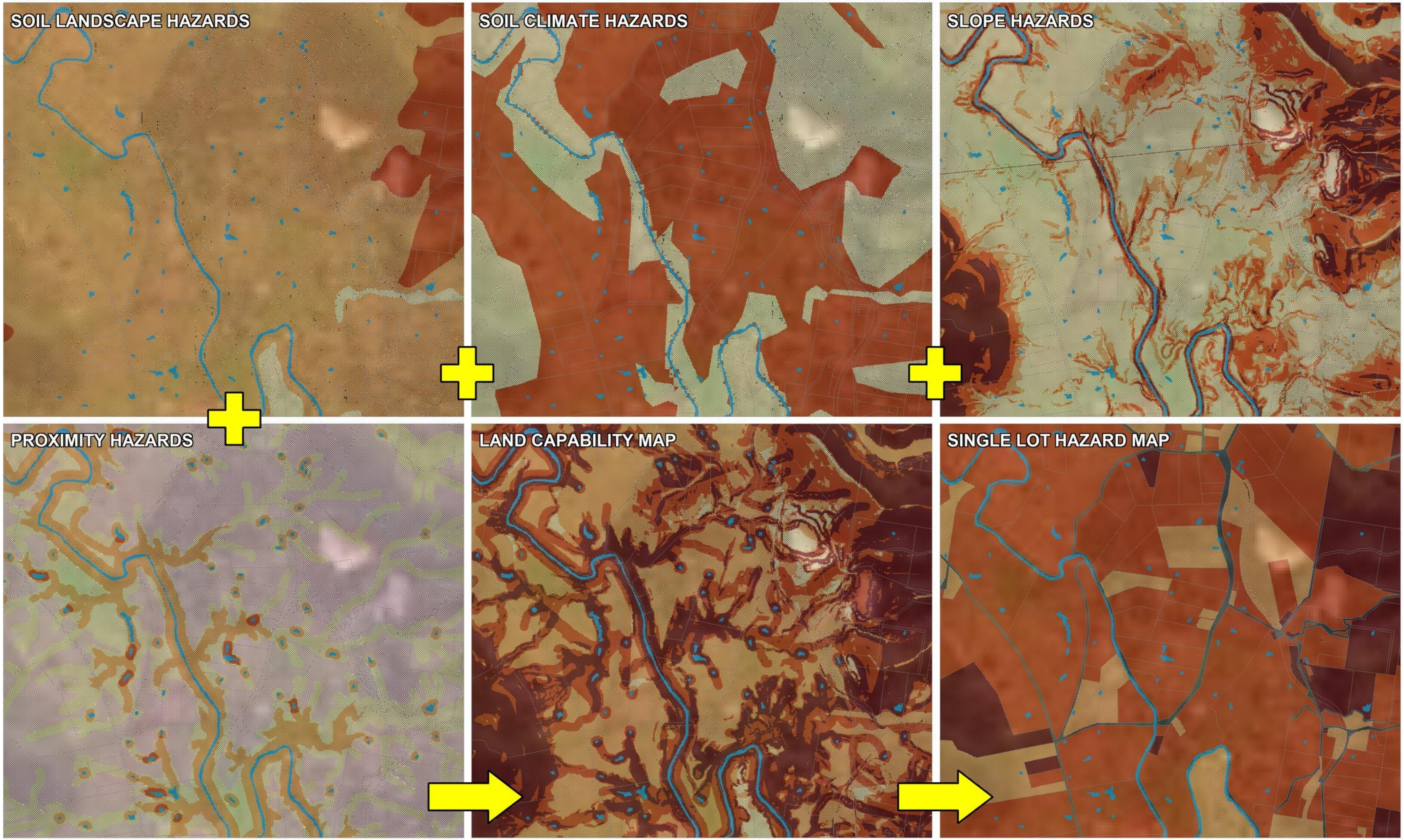

LEGEND

Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Dungog Shire
Hazard Map Methodology at Vacy

Figure: **5-2**

Rev: **A**

N

0 0.75 1.5km
Approx. Scale

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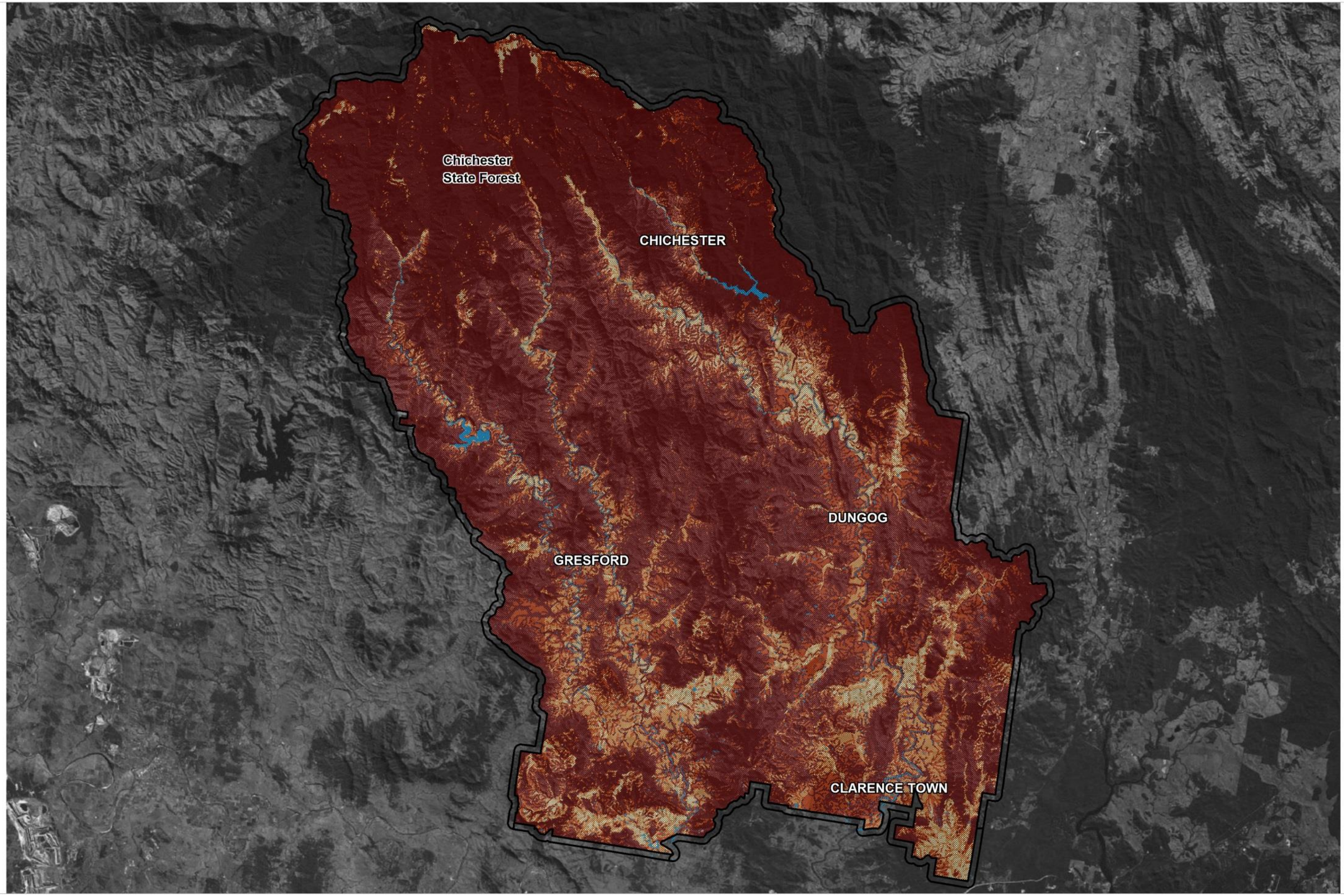

LEGEND

Land Capability Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Water Bodies

Title:

Sustainable On-site Sewage Management in Dungog Shire
Land Capability Hazard Map

Figure: **5-3**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 5 10km

Approx. Scale

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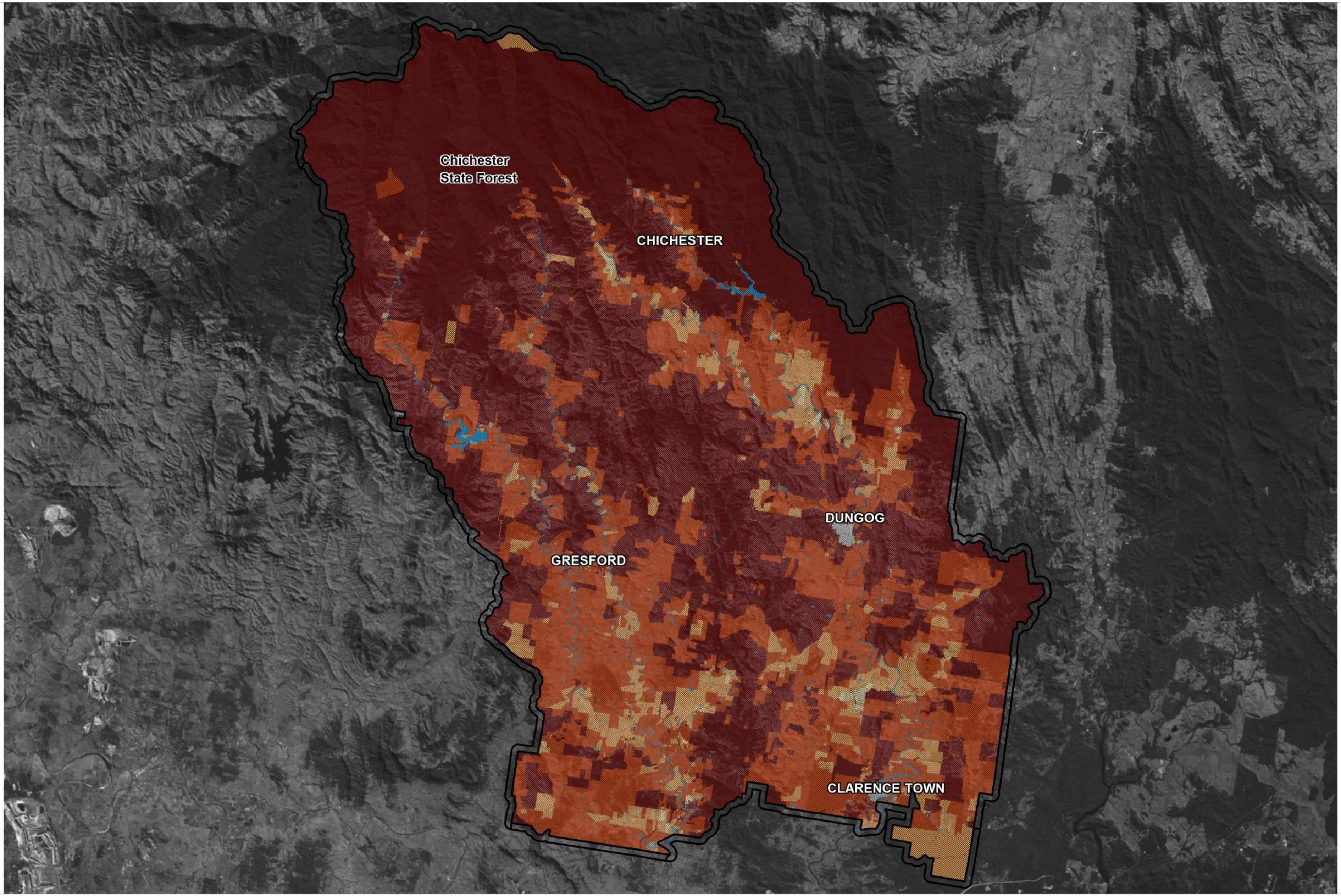

LEGEND

Land Capability Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Sewered Area (No Hazard Class)
- Water Bodies

Title:

Sustainable On-site Sewage Management in Dungog Shire
Final On-site Sewage Hazard Map (Single Lots)

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Figure: 5-4

Rev: A

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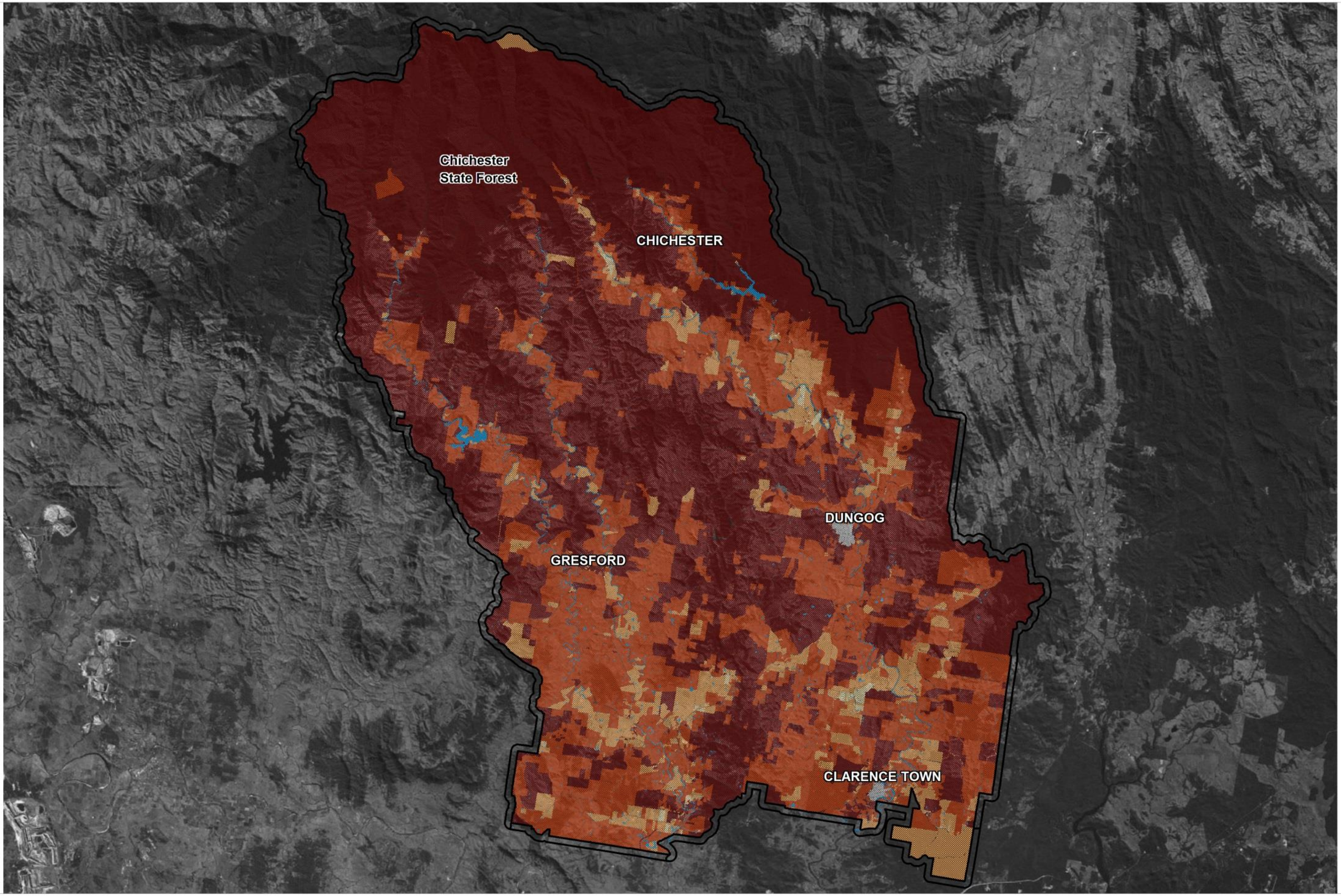

LEGEND

Land Capability Hazard Class

- Low Hazard
- Medium Hazard
- High Hazard
- Very High Hazard
- Sewered Area (No Hazard Class)
- Water Bodies

Title:

Sustainable On-site Sewage Management in Dungog Shire
Final On-site Sewage Hazard Map (Multiple Lots)

Figure: **5-5**

Rev: **A**

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5.4 Groundtruthing

BMT WBM conducted field groundtruthing of the land capability and on-site sewage management hazard maps October 2014. Twenty two sites were assessed based on the risk matrix and hazard classification protocol detailed in Section 5. Sites were selected to maximise benefits of field checking by;

- concentrating on locations where land capability inputs (i.e. the inputs subject to the most uncertainty) had the potential to influence the final Hazard Class;
- identifying sites where there was observed uncertainty in the individual parameters used to assign a hazard class (e.g. near a soil landscape boundary or area of variable slope); and
- concentrating on areas with higher densities of on-site systems or known performance issues.

Groundtruthing involved visual checking of each site against the matrix in Table 5-1 and Table 5-2. It also involved some checking of soil hazard class against key criteria set out in Section 5.1.1. Hazard maps were then checked via a laptop and GPS at each site with results recorded with supporting photography. The location of groundtruthing sites and results are presented in Appendix B.

The results found no significant discrepancies in the On-site Sewage Management Hazard Class. Although mapping of farms dams and other small waterbodies (provided by HWC) only extended across the drinking water catchments, the waterbodies (hydroarea) mapping captured the majority of these across the LGA.

The results found the land capability map represented the actual situation well.

5.5 Cadastral Inaccuracy

During data review and hazard map development a significant spatial error in the location of cadastral boundaries was detected within some areas (e.g. Gresford). In some cases this error was up to 20 metres and could have the potential to influence the final hazard class calculated for a number of lots. A GIS and desktop groundtruthing (i.e. via orthophoto inspection and Google Street View) process was developed that enabled the majority of cadastral errors to be rectified. The process undertaken was as follows.

- A 10 metre grid was created of the variability in Land Capability hazard Class within 50 metres of each grid cell. All lots with <2 hazard classes within 50 metres were excluded from the assessment.
- Lots less than 4,000 m^2 and greater than 10 hectares were excluded given the limited potential for land capability / cadastral error to influence final Hazard Class.
- Remaining lots were assessed via GIS and cadastral errors identified where they had potential to influence final Hazard Class.
- A working cadastral file was set up where these lots were adjusted based on orthophoto and LiDAR inspection to better reflect actual conditions.
- Average Land Capability Hazard Class was then recalculated for these erroneous lots only and the final Hazard Class amended accordingly.

The final On-site Sewage Hazard Class layers were given an adjusted and original Hazard Class. The adjusted class was adopted for mapping and includes corrections.

5.6 Limitations of Hazard Mapping

The final On-site Sewage Management Maps assign a Hazard Class to individual unsewered allotments in the Dungog Shire LGA. It is important to recognise that this site specific Hazard Class was derived using a range of data collected at a range of scales. LiDAR data sourced for creation of slope grids provides a very high level of detail while soil landscape data was mapped at 1:100,000 scale and digitised. Essentially, the Hazard Class assigned to each lot should still be considered a broad scale on-site sewage management hazard. However, this does not preclude the Hazard Maps from being used to at the individual lot scale as long as consideration is given to limitations and uncertainty associated with scale and data source.

It was identified during the course of the Study that cadastral data for certain areas (e.g. Gresford; Paterson) within the LGA were inaccurate. Some allotments showed property boundaries that were misaligned by up to 20 metres. BMT WBM conducted a review of the On-site Sewage hazard Map to determine the degree to which this impacted on hazard class accuracy (refer to Section 5.5 for detail). The final Hazard Class was adjusted where errors altered the hazard class.

The DAF primarily uses the Hazard maps to guide the level of detail required in supporting information for applications to install on-site systems or unsewered development. They have not been used to prescribe site specific conditions of approval relating to system selection, design and construction. They simply establish a Minimum Standard of supporting information to ensure Council can be satisfied that a proposed unsewered development is sustainable. In fact, where broad scale hazard mapping has identified a higher risk, Council will require site specific investigations to be undertaken to confirm conditions. There will be a minority of occasions where these field investigations will identify lots where data scale and accuracy may have resulted in an inaccurate hazard classification.

A number of elements of the hazard mapping were undertaken to minimise the potential for data scale and accuracy to reduce the benefit of the On-site Sewage Hazard Maps.

- Extensive desktop and field based groundtruthing of the Land Capability and Final On-site Sewage Hazard maps throughout the LGA to confirm that land and allotments have been appropriately classified.
- Iterative testing and refinement of the hazard map development protocol based on the outcomes of groundtruthing.
- Adjustment of the final On-site Sewage Management Hazard Class in areas where cadastral data is highly inaccurate to ensure the mapping is based on best available data.

As a result of this study, all known unsewered lots in the Dungog Shire LGA have been assigned an On-site Sewage Management Hazard Class. This Hazard Class provides a technically justifiable basis for setting requirements for supporting information to be submitted with applications for on-site systems and unsewered development.

6 MINIMUM ALLOTMENT SIZE

A review was undertaken of sustainable *minimum* allotment sizes for on-site sewage management within the Dungog Shire LGA. Sustainable minimum lot size was considered to allow for typical levels of site development (based on applicable land use zoning) in addition to a conservatively sized land application system (using a mean monthly water balance) and provision of adequate separation distances from sensitive receptors.

This assessment included consideration of existing allotments and potential future rezoning and subdivision. Sustainable lot size was also compared to typical unsewered allotment sizes within existing areas to provide insight into the sustainability of existing villages.

The intention of this assessment was to establish a conservative lot size (or some other measure) that was considered adequate to provide Council with a high degree of confidence that an effective, safe and sustainable on-site sewage management service can be accommodated (with factors of safety).

6.1 Methodology

For previous studies, a conservative land area requirement for sustainable on-site sewage management has been calculated by the following procedure. The procedure was applied using rainfall and pan evaporation data from stations within the LGA.

1. A design occupancy of 6 persons for a 4 bedroom house (using reticulated water) was adopted to represent the typical design residential development scenario.

2. A typical system configuration of secondary treatment and subsurface irrigation was assumed. This scenario also allowed for primary dosed trenches and beds (discussed further below).

3. A mean monthly water and annual nutrient balance was undertaken based on the above occupancy assuming a Design Loading Rate (DLR) of 3 mm/day (Category 5 – light clays). This DLR was selected on the basis that it strikes an appropriate balance between conservatism and realism. In practical terms this results in an actual loading rate of 1.3 mm/day which is conservative.

The outcomes of these water and nutrient balance calculations were then used to examine minimum Effluent Management Areas (EMA) required for the majority of sites and dwellings likely to be encountered.

Following this, an assessment was undertaken of a sample of allotments within unsewered zones of the LGA. A total of 500 allotments were assessed to determine the capacity to provide available area for sewage management in addition to area occupied by development and separation distances from objects such as;

- building structures;
- driveways and paths;
- swimming pools and other dedicated recreational areas (e.g. tennis courts);

- land occupied by livestock or horses;
- property boundaries; and
- dams, intermittent and permanent watercourses.

The assessment was undertaken through orthophoto investigations and GIS creation of buffers around the abovementioned objects. Statistics on the area of land and proportion of total lot area occupied by each component (inclusive of buffers) were recorded for analysis. The 500 lots assessed were selected to provide a representative sample of typical development in unsewered areas including Gresford, East Gresford, Paterson, Eccleston and Vacy.

Statistics obtained from this assessment were analysed to identify any patterns or relationships between lot size, land use zones and area available for effluent LAA's. Multiple scatter plots of lot size and the proportion of the lot unavailable for effluent management were created. This was completed for a number of allotment size ranges to determine relationships for these allotment ranges that could be applied LGA wide.

Figure 6-4 provides an example of the minimum lot size assessment procedure.

6.2 Results

Based on the outcomes of previous water (checked against annual nutrient balances) balance assessments, an LAA of **450 – 550 m^2** has typically been required. The "design" estimate (outlined in points 1 – 3 above) based on the more conservative climate zone resulted in a minimum land application area of approximately **700 m^2**. Allowing for treatment tanks, required zoning of LAAs and other infrastructure required for an on-site system, a typical Effluent Management Area (EMA) was found to be **~800-1,000 m^2**. Primary dosed trenches and beds (which are not always suitable for observed site and soil conditions) occupy approximately half the land area of a secondary dosed irrigation system. However, allowance for a reserve area must be made for primary dosed subsurface systems which results in a comparable land area requirement to that of a secondary dosed irrigation system.

The larger footprint is considered appropriate for planning purposes and allows for situations where issues such as irregular shaped areas and slope limit the proportion of available land that can actually be occupied by a land application system. It is important to note that the outcomes of this minimum allotment size assessment should not be used in a prescriptive or deterministic fashion. Individual applicants should be able to undertake additional site specific investigations to confirm the appropriateness of Council's general minimum lot size for their site.

A poor relationship between lot size and land area unavailable for effluent management was observed in the total sample data (R^2 = 0.27). The less than optimal correlation can largely be attributed to the reasonable number of lots (regardless of lot size) observed to be severely constricted by the presence of one or more of the following.

- A dam or intermittent watercourse.
- Open stormwater drains or pits.
- Permanent watercourses.

This sub-component of sampled lots appeared (through further orthophoto investigation and groundtruthing) to be typical of Rural and Rural-residential zones throughout the LGA (refer to Figure 6-4 for examples).

Figure 6-1 contains the results of this analysis (sample size = 500).

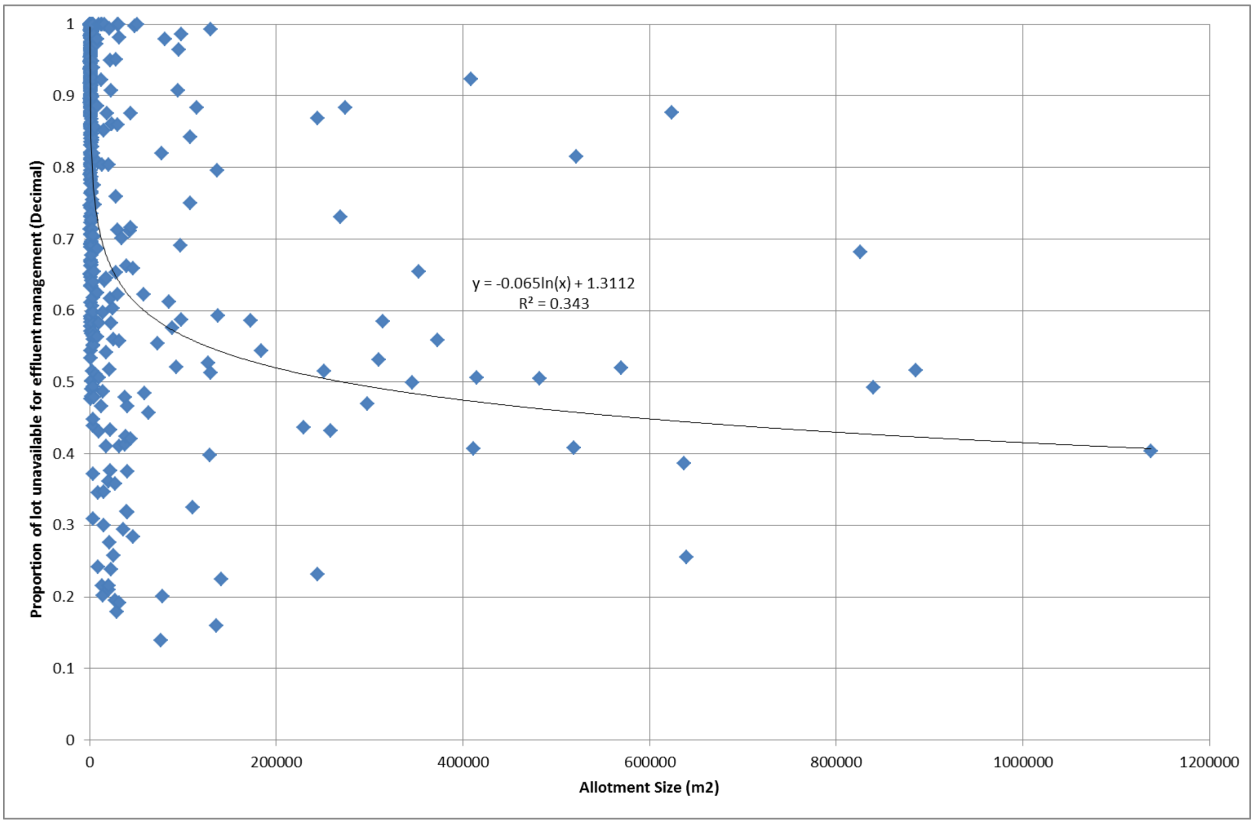


Figure 6-1 Results of Initial Minimum Lot Size Evaluation for Dungog Shire LGA

The relationship was then compared to adoption of an average available area approach which was found to be more applicable and more adaptable to the broader study area. This involved determining the relationship between average unavailable area and allotment size at allotment size ranges. Figure 6-2 contains the results of this analysis.

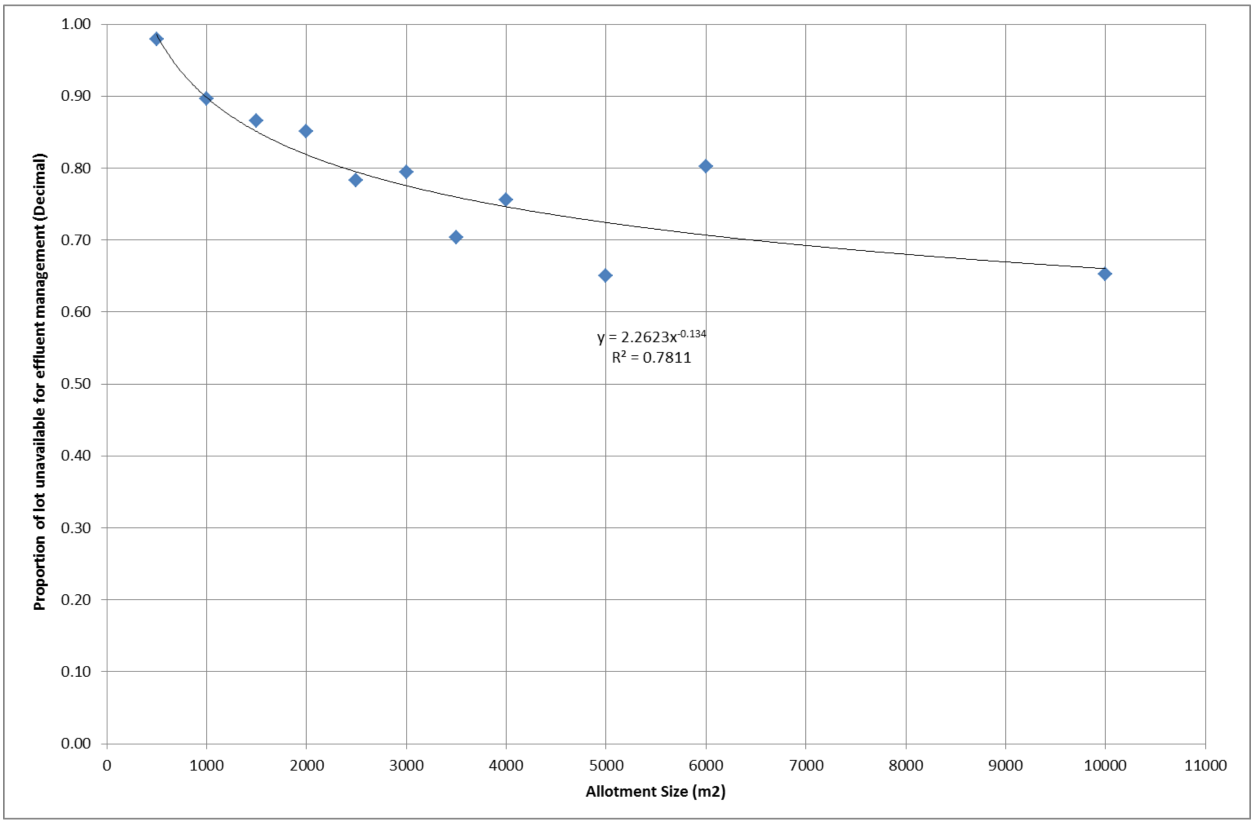


Figure 6-2 Average Unavailable Area and Allotment Size Evaluation

The relationship of this analysis was observed to have much greater correlation (R^2 = 0.78). This relationship equation was consequently utilised to calculate available area estimation curves outlined in Figure 6-3. The relationship between standard deviation / average unavailable area ratio and the allotment size was utilised to calculate upper and lower available area estimates.

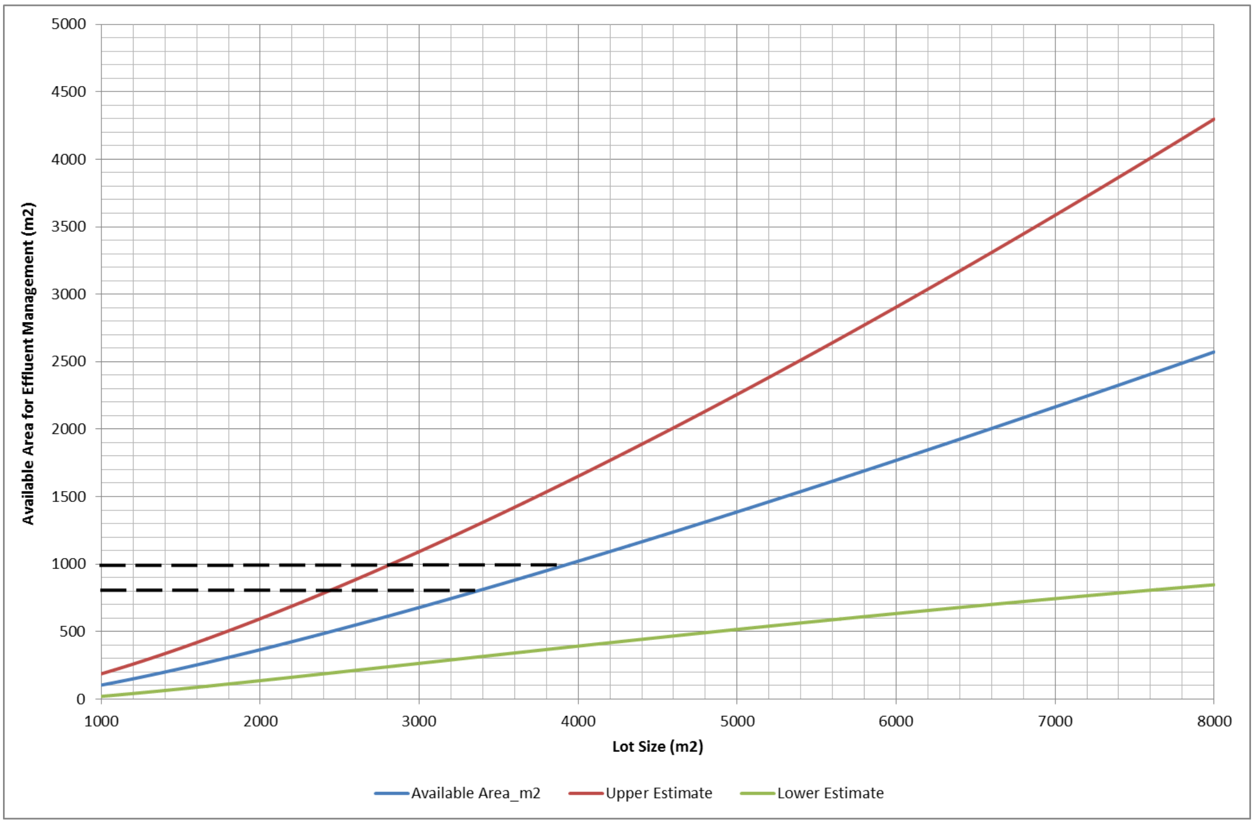


Figure 6-3 Effluent Management Available Area Curves for Dungog Shire LGA

The resulting equation in Figure 6-3 was used to calculate a “typical” lot size required to provide sufficient land area (Effluent Management Area or EMA) for sustainable on-site sewage management. The size of this EMA was estimated to be 800 – 1,000m^2 (as described above). The size of this EMA was estimated broadly for the LGA based on water balances, climate data and a clay loam to clay design soil horizon. This assessment was not intended to produce a worst case or most conservative LAA sizing; rather it represented a typical situation experienced within the LGA under design load conditions (i.e. four bedrooms at an occupancy of six people). Cumulative impact modelling of existing systems within the LGA has confirmed that actual occupancy and LAA performance is likely to be significantly underestimated by mean monthly water balances so results are still suitably conservative.

The resulting equation (see Figure 6-3) from the minimum lot size assessment was then used to estimate the typical lot size required to ensure a minimum of 800 to 1,000 m^2 is available for an EMA. This minimum lot size was calculated to be **3,500 to 4,000 m^2** which is the range of values observed from previous DAF studies. However, it is important to acknowledge the moderate correlation between lot size and available land for an EMA and the significant influence on available area posed by watercourses, dams and other major natural features. Residual errors from cadastre misalignment also affected the results.

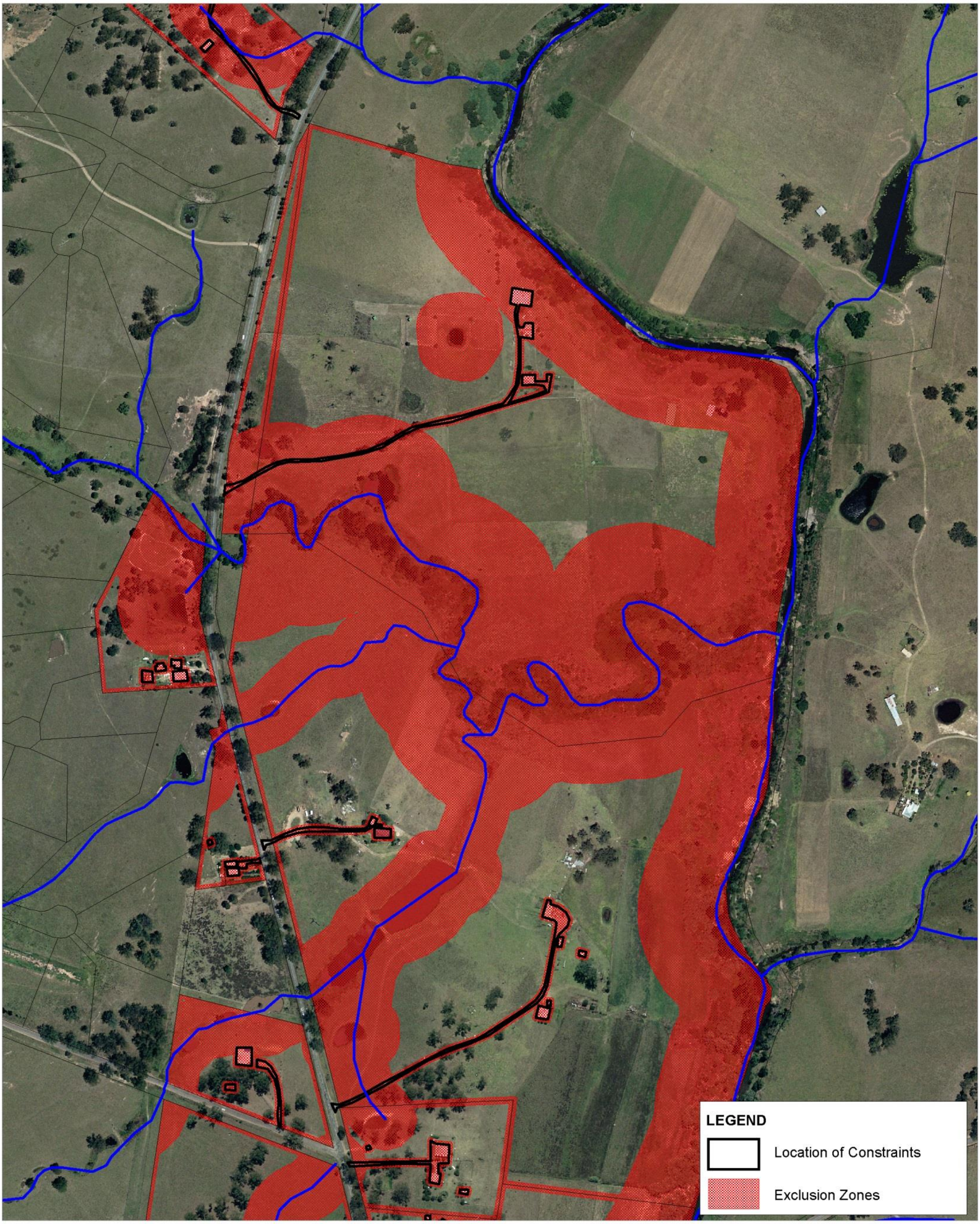
6.3 Outcomes

For the purpose of development planning, lot sizes greater than 4,000 m^2 are likely to be capable of fitting a sustainable on-site sewage management system within the allotment assuming native vegetation protection can be managed through site specific design and communication between relevant Council staff. However, based on the relatively small sample size and the major influence of watercourses, dams and other receiving environments, it is recommended that 4,000 m^2 of *useable land should be considered a minimum criterion*. Useable land (for the purpose of on-site sewage management) can be considered to be;

Total allotment area excluding dams, intermittent and permanent watercourses and open stormwater drains and pits in addition to the relevant buffer distances prescribed in the DSC On-site Sewage Management DAF for those objects.

This number needs to be considered in conjunction with lot sizes for prevention of unacceptable cumulative impacts (see Section 7). In the case of DSC, planning restrictions are likely to prevent lot size becoming a constraint to unsewered development for new subdivisions and rezoning's. However, development within and immediately surrounding existing village zones may have the potential to trigger lot size concerns.

An additional advantage of adopting the Useable Land classification is that it eliminates the need to alter or interfere with minimum allotment sizes as set out in the LEP. The application of Useable Land is significantly more flexible and will allow site specific opportunities (e.g. a small site with few constraints and limited development) and constraints (e.g. a significant intermittent watercourse running through the middle of a smaller site) to be considered.



Title:

Example of Minimum Allotment Size Assessment Procedure

Figure: 6-4

Rev: A

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7 CUMULATIVE IMPACTS (ON-SITE SYSTEM DENSITY)

The previous chapter summarised the process followed to establish a *minimum allotment size* based on ensuring lots have sufficient usable land to contain a sustainable on-site sewage management service. In addition, consideration should also be given to on-site system density. The range of natural and built environments throughout the LGA display different capacities to receive and safely assimilate effluent loads from on-site systems. Dungog LGA specific cumulative impact modelling was not within the scope of this project. However, applicable outcomes from previous adjacent Development Assessment Framework (DAF) projects have been reviewed for incorporation into the Dungog DAF.

Local Councils are faced with a great deal of uncertainty when assessing and predicting the long-term performance of existing and proposed decentralised (on-site and cluster) wastewater management systems. Financial resources are rarely available for collection of sufficient field data to isolate and quantify the magnitude and frequency of impacts from existing systems with adequate certainty. In the case of *proposed* decentralised systems, there is no field data to collect. These limitations have led to the development of a range of water cycle modelling tools to assist in decision making by shedding some light on areas of uncertainty. When used in conjunction with realistic amounts of field data, modelling tools can greatly assist in reducing or defining uncertainty in a working environment consistently and indefinitely constrained by available financial resources.

Affordable modelling tools that can practically be applied to on-site and cluster wastewater management system assessment are available that can be drawn from fields such as hydrology, catchment modelling, groundwater assessment and water sensitive urban design in addition to wastewater management. This chapter presents a summary of previous cumulative impact assessments and recommendations on how they should be applied to policy development regarding on-site system density for both new unsewered development and risks posed by existing unsewered villages.

Procedures for completion of risk based cumulative impact assessments have also been incorporated into the DAF. In developing a procedure for Cumulative Impact Assessment (CIA) from on-site systems the following principles were applied.

- The CIA procedure(s) should utilise models and tools that are economically and practically viable for use in assessing typical unsewered development applications.
- CIA procedure(s) should be adaptable to varying levels of risk.
- Performance targets for CIA's need to be meaningfully measurable and proportionate to targets for non-wastewater pollution sources (e.g. urban stormwater).
- CIA procedure(s) should not be expected to be deterministic tools but rather indicative tools to provide guidance on the potential risk of impacts (i.e. likelihood, consequence and uncertainty).

Two broad aims were identified for CIA assessments for Dungog Shire.

- Evaluation of sustainable on-site system densities for new unsewered development.
- Evaluation of the sustainability of existing high risk unsewered villages.

7.1 Sustainable Unsewered Development

Based on previous CIA work undertaken for Port Stephens, Greater Taree and Great Lakes Councils, BMT WBM considers 1 ha to be a suitably conservative minimum lot size for future unsewered subdivision. Council planning staff also advised BMT WBM that very few unsewered subdivisions or rezoning's were included in long-term strategic plans for Dungog Shire.

Reference should be made to the detailed methodologies and results of greenfield cumulative impact modelling for Port Stephens (BMT WBM, 2011), Greater Taree (BMT WBM, 2012), Great Lakes (BMT WBM, 2013) and Lake Macquarie (BMT WBM 2014) for a comprehensive background to the following summary.

7.1.1 Key Results and Discussion

Final minimum Useable Land requirements to manage cumulative impacts for key case studies from previous DAF work are summarised below. The table presents results based on greenfield CIA loads for both nitrogen and phosphorus. Phosphorus loads were typically the limiting sizing factor.

Table 7-1 Minimum Useable Land Requirements from Previous Greenfield CIA's

LGA	Greenfield Site	Minimum Useable Land Required	
		Nitrogen Loads	Phosphorus Loads
Port Stephens	Butterwick	4,000 m^2	4,000 m^2
	Salt Ash	4,000 m^2	1.1 ha
Greater Taree	Bohnock	-	2,800 m^2
Great Lakes	Coomba Park	-	6,800 m^2
Lake Macquarie	Martinsville	-	1,000 m^2

Critical lot density was determined based on achievement of long-term nutrient and pathogen protection targets. A suitable long-term nutrient target for on-site systems was identified as the point where combined on-site system and undeveloped background pollutant loads result in no more than a 10% increase in undeveloped background loads. This target has initially been carried through from the DAF that has been adopted for all four other councils for consistency. This target was adopted because a) it is unlikely to be possible to develop land without increasing long-term nutrient loads; b) the relatively small contribution to catchment nutrient loads made by on-site systems and c) there is sufficient uncertainty in the modelling process to warrant allowance for a +/-10% error.

It was agreed that new on-site systems should deliver full pathogen removal prior to receiving waters under average long-term conditions. As such the target for cumulative impacts was set at <1 MPN/100ml virus concentration at the receiving water as an annual average. In terms of residual health risks (i.e. risks associated with in-situ surcharging of effluent off-site), all systems were sized to limit surface hydraulic surcharge to 5% of the total wastewater volume generated over the life of the system.

Modelled on-site systems were found to have minimal contribution to nitrogen loads produced from the site as the existing background loads were identified as the chief sources. The critical lot size identified at which the combined developed and existing phosphorus loads were equivalent to the existing phosphorus loads (+10% error) varied between 1.1 ha and 1,000 m^2. It has also been consistently observed that existing on-site systems in all case study subcatchments were a relatively minor contributor to total catchment loads based on model results. This is consistent with other research into cumulative impacts from contemporary best practice on-site systems where development is located at conservative setback distances to sensitive receiving environments.

It should be noted that these hypothetical assessments ignored available area (i.e. the capacity of smaller lots to fit a land application area sized to modern standards). In reality, lots less than 4,000 m^2 would typically not be able to fit such an LAA.

The results of previous Cumulative Impact Assessments have consistently confirmed previous research and monitoring of on-site systems that found systems sized to prevent frequent hydraulic failure are unlikely to generate off site impacts. It also confirmed that planned minimum allotment sizes for land use zonings likely to involve unsewered development will be more than adequate to prevent cumulative impacts. Given the limited risk of cumulative impacts occurring as a result of Greenfield development, these results were considered sufficient to support planning policy.

Risks of cumulative impact may occur in cases where setback distances to receiving environments are significantly less than the Minimum Standard in the DSC DAF. The results of this assessment are based on achievement of the DAF Minimum Standard buffer distances for all new development. In these cases, site specific CIAs must be undertaken and in some particularly sensitive environments a CIA would need to be accompanied by effluent plume modelling.

7.2 Sustainability of Existing High Risk Villages

Like many Councils along the NSW coast, DSC face significant challenges in the management of environmental and health risks associated with on-site systems in existing unsewered villages. Some villages were developed many decades before on-site sewage management was any form of consideration for planning and land development. Allotment sizes and site constraints create severe restrictions on the design, construction and operation of on-site systems. Often there is insufficient land available for the application of full effluent loads under current design standards. These hazards are compounded in a number of areas in the DSC LGA by the close proximity to sensitive receiving environments such as water supply catchments.

It can be challenging to determine the most appropriate long-term strategy for improving wastewater servicing for such high risk villages. Ideally, some form of community wastewater management (decentralised or conventional reticulated sewerage) should be adopted where risks warrant investment of this level. However, limited funding is available for provision of a sewerage scheme to most high risk villages in Dungog Shire.

Preliminary high level advice is provided in this document on the sustainability of long-term on-site sewage management in comparison to other potential wastewater servicing scenarios for four existing high risk villages.

Gresford, East Gresford, Paterson and Vacy were selected on the basis of existing small lot sizes, site and soil constraints and observed impacts / failure of systems. Gresford and East Gresford have been considered in combination given their close proximity and likelihood that any strategies for improved wastewater servicing would be undertaken as a single project.

These four villages were selected in consultation with Council and it was envisaged that this indicative assessment will provide initial guidance to Council, Hunter Water and NSW Office of Environment and Heritage (OEH) on preferred long-term wastewater servicing strategies for high risk villages in Dungog Shire.

Previous Cumulative Impact Assessment (CIA) modelling undertaken for existing high risk villages in Port Stephens, Great Lakes, Greater Taree and Lake Macquarie was utilised for four high risk villages in Dungog and the results have been evaluated in terms of;

- risks to receiving environments, public health and local (in village) health risks associated with the existing on-site systems; and
- relative environmental and health protection benefits likely to be achieved through implementation of some form of improved wastewater servicing strategy.

The wastewater servicing strategies referred to in the following assessments are broadly defined in Table 7-2.

Table 7-2 Broad Description of Potential Wastewater Servicing Scenarios

Scenario	Description
Existing	Baseline situation for comparison to possible alternatives. Assumes upgrade only occurs once a system reaches its design life or comes to the attention of council due to potential impacts. Costs include annual operation and maintenance and upgrades every 10-20 years (15 average).
Upgraded On-site Systems	Assumes Council enforcement of upgrades to on-site systems to best practicable option (as close to compliant as possible). Also assumes systems are operated in accordance with approval to operate. Sites where prevention of hydraulic failure from effluent land application areas is not feasible would be converted to pump out (see below).
Pump Out	Under an on-site sewage management scenario effluent pump out systems would be installed on sites where prevention of hydraulic failure from effluent land application areas is not feasible. Pump out costs assume an average 3 person family on reticulated water.
Managed Decentralised	Involves retention of best practicable on-site sewage management where this can meet regulatory requirements (prevent hydraulic failure, manage health and environmental impact). Where land application of between 50-100% of wastewater loads is achievable on site, this would be retained with excess discharging to a small diameter sewer to be conveyed to a community sewage treatment plant and irrigation scheme. Sites where <50% of wastewater loads can be managed on site will be replaced with low pressure (grinder or STEP/STEG) sewers conveying sewage to a community sewage treatment plant and irrigation scheme.
Conventional Sewerage	All properties connected to a Hunter Water (or private service provider) gravity sewer to be conveyed to a conventional sewage treatment plant for irrigation or discharge to waters under licence.

The tables below present the indicative findings of the high risk village analysis. Life cycle costs are based on a 30 year Net Present Value (NPV) assessment adopting a 7% discount rate. Cost rates have been obtained from previous Priority Sewerage Program cost estimates from Hunter Water (HWA, 2010), additional work conducted by BMT WBM on the PSP program for Hunter Water (BMT WBM, 2011) and recent work undertaken as part of the Park Orchards Trial Project for Yarra Valley Water (http://www.yvw.com.au/parkorchardsbacklog).

Table 7-3 Indicative High Risk Village Assessment: Gresford/East Gresford

Servicing Option	Feasibility	Life Cycle Cost	Environmental Protection	Public Health Protection
Existing	n/a	$20k/lot	High non-compliance	High non-compliance
Upgraded On-site systems	Long-term sustainability only feasible for 40-50 (25%) lots	$30k/lot	Non-compliant for ~160-170 properties	Non-compliant for ~160-170 properties
Pump out	Feasible	$70-80k/lot	Subject to strict oversight	Subject to strict oversight
Managed decentralised	Feasible	$35k-$45k/lot	Yes	Yes
Conventional Sewerage	Challenging but achievable	$50-60k/lot	Yes	Yes

Table 7-4 Indicative High Risk Village Assessment: Paterson

Servicing Option	Feasibility	Life Cycle Cost	Environmental Protection	Public Health Protection
Existing	n/a	$20k/lot	High non-compliance	High non-compliance
Upgraded On-site systems	Compliance not feasible for 90%+ lots	n/a	Non-compliant	Non-compliant
Pump out	Feasible	$70-80k/lot	Subject to strict oversight	Subject to strict oversight
Managed decentralised	Feasible	$40k-$50k/lot	Yes	Yes
Conventional Sewerage	Feasible	$50-60k/lot	Yes	Yes

Table 7-5 Indicative High Risk Village Assessment: Vacy

Servicing Option	Feasibility	Cost	Environmental Protection	Public Health Protection
Existing	n/a	$20k/lot	High non-compliance	High non-compliance
Upgraded On-site systems	Compliance not feasible for 90% lots	n/a	Non-compliant	Non-compliant
Pump out	Feasible	$70-80k/lot	Subject to strict oversight	Subject to strict oversight
Managed decentralised	Feasible	$35k-$45k/lot	Yes	Yes
Conventional Sewerage	Feasible	$50-60k/lot	Yes	Yes

7.3 Outcomes

7.3.1 Greenfield Unsewered Development

The results of cumulative impacts analysis were analysed in conjunction with outcomes of the Minimum Lot Size assessment (Section 6) in order to make a final 'most limiting' determination on ***Useable Land*** for unsewered development.

Under *average* conditions a minimum of 4,000 m^2 of Useable Land was estimated based on the Minimum Lot Size assessment. In some cases, the useable land value varied from 1,000 - >6,000 m^2 was identified (due to phosphorus export) with respect to cumulative impacts from new systems approved under contemporary standards. However, as discussed in Section 6.3 and apparent from Figure 6-1, significant variation in available area for on-site sewage management was observed across the LGA. The following guiding observations have been drawn.

- Cumulative impacts are unlikely to be significant from new unsewered development where the following are achieved;
  - a Land Application Area (LAA) is sized based on the Design Loading Rates (DLRs) in *ASNZS 1547:2012*;
  - at least 4,000 m^2 of Useable Land is available within each lot; and
  - standard setback distances (presented in Section 6.9 of the DSC DAF) are achieved for all sites.
- Whilst 4,000 m^2 of Useable Land *typically* enables installation of a sustainable on-site sewage management service, there were a number of notable exceptions identified.
- The previous DAF's adopted 4,000 m^2 of Useable Land as the Minimum Standard for low risk (Acceptable Solution) unsewered subdivision to include a factor of safety.

Given the relatively simplistic nature of the cumulative impact assessment approach and the observed variability in minimum lot size / Useable Land, a conservative approach was adopted here.

It was concluded that the provision of a minimum of 4,000 m^2 of Useable Land (as defined in the DAF) is an appropriate deemed to comply criterion to enable construction and design of a robust on-site sewage management system and provide a high level of protection with respect to cumulative impacts on heath and ecosystems.

The Useable Land concept was found to be critical to effective on-site sewage management as the shape of allotments and/or presence of intermittent / permanent water bodies or floodprone land had the ability to prevent construction of a sustainable system on lots up to 2 hectares. Identification of Useable Land has been previously incorporated into DAF procedures for all unsewered developments proposing to increase accessible building entitlements.

Under a DAF, failure to achieve this Useable Land requirement would trigger the need for higher levels of assessment and design. Useable land should be considered in conjunction with setback distances as these two criteria have been identified as critical for preventing cumulative / off-site impacts.

It should also be noted that this Useable Land target has only been assigned to Acceptable Solution development under the DAF. In other words, developments that meet Acceptable Solution criteria of;

- **4,000 m^2 of Useable Land per lot;**
- **achievement of setback distances to sensitive receptors;**
- **classified by Council as Low or Medium On-site Sewage Management Hazard; and/or**
- **being residential development;**

will be considered to adequately manage cumulative impacts without the need for site specific assessment or modelling. Individual applicants are able to complete their own site specific CIA using procedures that are summarised in this Technical Manual.

7.3.2 Existing Villages

On-site sewage management is neither a sustainable (human health and ecosystem protection) nor cost effective wastewater servicing scenario for the four villages selected for evaluation by DSC. This is based on the experience of BMT WBM on previous and current similar investigations in adjacent LGAs and for water utilities including Hunter Water.

The majority of properties are highly unlikely to be capable of containing wastewater loads on-site (prevent hydraulic failure) and would therefore require installation of an effluent pump out system. These systems are the most expensive wastewater management option available and historically it has proven challenging and expensive to regulate timely pump out of holding tanks to prevent overflow to the environment. Councils also report regular cases of deliberate discharge to the environment to reduce costs incurred for removal by tanker truck.

Previous investigations by Hunter Water have identified high capital and operating costs for provision of conventional reticulated sewerage to Gresford, Paterson and Vacy (HWA, 2010). BMT WBM subsequently evaluated opportunities for provision of decentralised servicing approaches on behalf of Hunter Water in 2011 (BMT WBM, 2011). It was identified that all three villages had potential for a more cost effective sewerage solution through adoption of decentralised technologies (whilst still being delivered by Hunter Water). Costs provided in the previous tables are based on the delivery of a decentralised system by Hunter Water.

However, strong opportunities exist for implementation of a hybrid servicing strategy that seeks to maximise management of effluent within individual properties where it is safe and cost effective to do so (the "Managed Decentralised" option in the above tables). Under this scenario, on-site systems are managed by a central entity (with specific services delivered by specialists under contract) in conjunction with operation of a small diameter sewerage system and local package treatment system and effluent management scheme (such as irrigation of open space). Utilisation of land application capacity on properties significantly reduces the need for downstream infrastructure, land purchase and in turn reduces risks and potential for impacts.

Table 7-6 provides an indicative comparison of total 30 year costs to deliver the various wastewater servicing scenarios considered. Please note these are high level estimates with further investigation required to enable decision making.

Table 7-6 Indicative 30 Year Costs for Potential Servicing Scenarios

Scenario	Gresford/East Gresford	Paterson	Vacy
Existing	$4.2M[1]	$4.3M[1]	$1.2M[1]
Upgraded On-site systems (incl. Pump Out)	$13.7M	$16M	$3.9M
Managed decentralised	$8.3M	$9.6M	$2.1M
Conventional Sewerage	$11.4M	$11.7M	$2.9M

Note 1: Cost requires acceptance of elevated risks to human health and impacts on environment.

Based on current lot sizes these villages are well suited to a Managed Decentralised approach due to the potential to utilise significant portions of wastewater within properties (also providing an alternative irrigation source water thereby reducing potable demand). Gresford and Vacy are particularly well suited and such an approach offers 30% savings over 30 years on a more conventional sewerage scheme. Based on experience as part of the Park Orchards Trial, capital costs savings are expected to be more significant.

Whilst a managed decentralised approach still appears to be the most cost effective for Paterson, the larger proportion of very small residential lots does improve the viability of conventional sewerage. Depending on the location of any STP and effluent management options available, conventional sewerage may enable greater infill development (increased density) within a village which may be of interest for Paterson.

Hunter Water identified significant challenges and some uncertainty in the feasibility and costs associated with providing a conventional sewerage solution to Vacy due to it's small size, remote location and challenging topography. Adoption of a managed decentralised approach would most likely reduce community treatment and irrigation sizing requirements to enable management immediately adjacent to the village rather than several kilometres to the north.

8 RATIONALE FOR ACCEPTABLE SOLUTION TABLES

As part of the Development Assessment Framework (DAF), a series of Acceptable Solution tables were developed comprising minimum sustainable land application areas (LAA) required for five common on-site system types. These Acceptable Solution tables have been provided in Section 5 and Appendix A of the DAF as a system selection and design option for Low and Medium Hazard allotments. The tables present minimum land application area sizes (in m^2 basal area) for a wide range of common residential development scenarios possible throughout the LGA. A total of 600 possible combinations were modelled using an annual water and nutrient balance varying the following broad characteristics:

- Two climate zones;
- Six soil types;
- Two water supply system types;
- Number of bedrooms (1-5);
- Five wastewater system types.

Figure 8-2 illustrates the range of on-site system configurations considered in the Acceptable Solution tables.

8.1 Inputs for Minimum Land Application Areas

The Dungog Shire LGA was broken down into two climate zones (northern and southern) as shown in Figure 8-1. The division between climate zones were assigned using gridded average annual rainfall data from the BOM Climate Atlas by identifying the spatial mid-point in average rainfall between stations. Each climate zone was assigned monthly values for rainfall, evaporation and crop factor based on climate data from two BoM stations, with the northern climate zone adopting climate data from the Chichester Dam gauge and the southern zone adopting climate data from the Paterson (Tocal AWS) gauge. The monthly values for the two BoM gauges are shown in Table 8-1 and Table 8-2. These climate zones correlate adequately with those adopted for MUSIC modelling of stormwater impacts.

Table 8-1 Chichester Dam Climate Data

Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Rainfall	162	184	171	99	94	103	54	60	62	91	108	124	**1,312**
Evaporation	140	109	93	69	47	33	40	59	87	112	123	149	**1,059**
Crop Factor	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	**0.59**

Table 8-2 Paterson (Tocal AWS) Climate Data

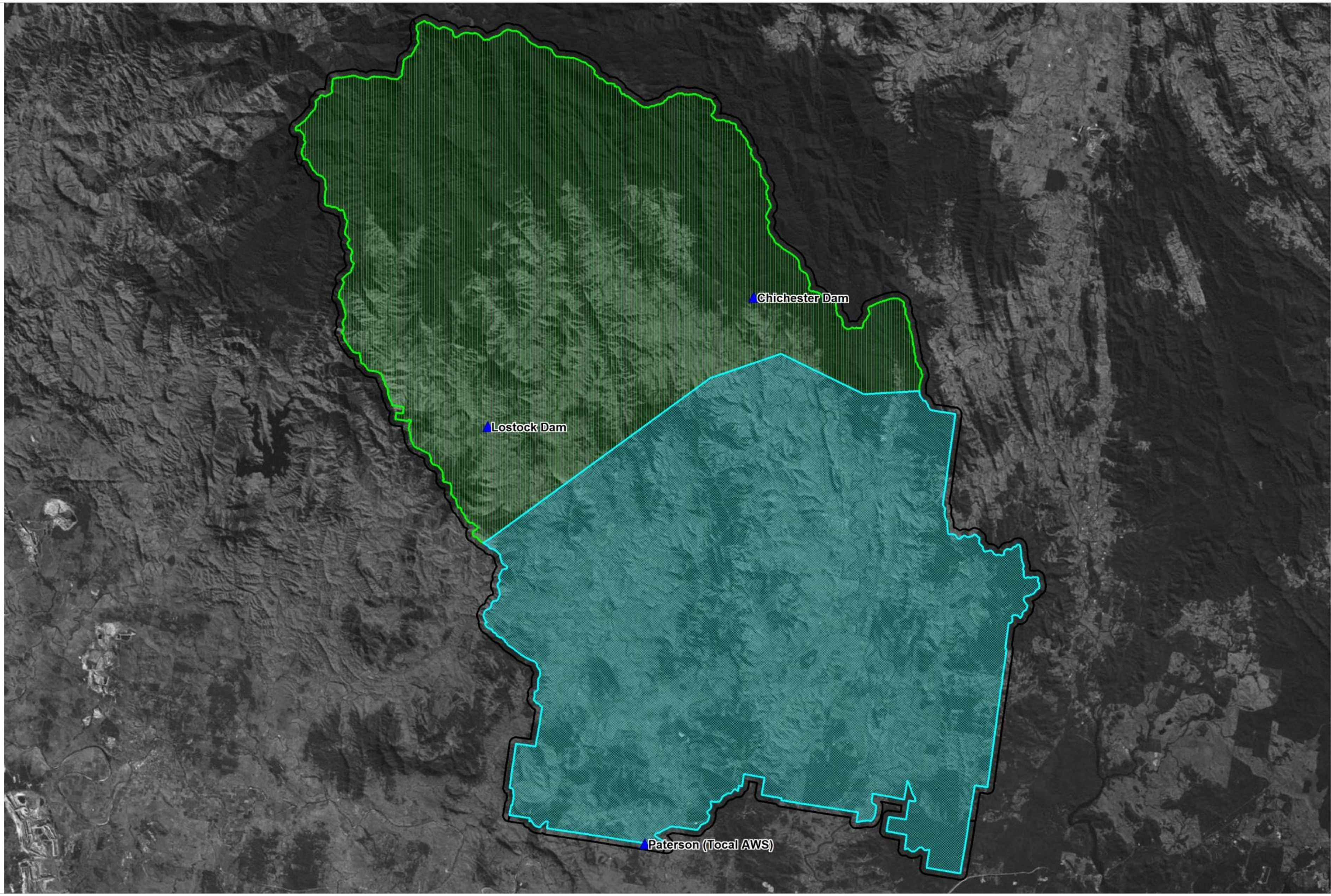
Parameter	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
Rainfall	103	122	116	80	73	77	41	37	49	66	87	78	**929**
Evaporation	192	148	130	96	74	63	74	105	132	161	174	208	**1,570**
Crop Factor	0.7	0.7	0.7	0.6	0.5	0.45	0.4	0.45	0.55	0.65	0.7	0.7	**0.59**

Six general design soil categories were considered ranging from sand to medium/heavy clays. Each soil type was assigned a value for phosphorous sorption (mg/kg) and DLR (mm/day) as shown in Table 8-3. These soils were considered as 'design' soils (i.e. the most limiting soil horizon used to design an on-site system land application area). DLRs were adapted from *ASNZS1547:2012* and phosphorus sorption values were adopted based on local experience conducting site and soil assessments.

Table 8-3 Soil Types and Adopted Parameter Values

Soil Type	Soil P-Sorption (mg/kg)	DLR (mm/day)		
		Primary Trenches/Beds	Secondary Trenches/Beds	Irrigation
Sand	100	20	50	5
Sandy loams	150	15	30	5
Loams	200	10	30	4
Clay loams	300	6	20	3.5
Light clays	350	5	8	3
Medium / heavy clays	400	5	5	2

The daily design wastewater flow was estimated based upon the number of bedrooms per dwelling (1-5) and type of water supply (reticulated or tank). The design wastewater flow values are shown in Table 8-4. It can be seen that occupancy and per capita wastewater generation were based on *ASNZS1547:2012*.



LEGEND

Climate Zones

- Northern Rainfall Zone (adopts Chichester Dam rainfall data)
- Southern Rainfall Zone (adopts Paterson (Tocal AWS) rainfall data)
- Rainfall Gauge Location

Title:

Dungog Shire On-site Sewage Management Climate Zones for Acceptable Solutions

Figure: **8-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N

0 5 10km

Approx. Scale

BMT WBM

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Table 8-4 Design Wastewater Flow

Number of Bedrooms	Number of Occupants	Design Wastewater Flow (L/d)	
		Reticulated Supply	Tank Supply
1	2	300	240
2	4	600	480
3	5	750	600
4	6	900	720
5	7	1,050	840

Five wastewater system types were considered including primary and secondary trench systems; primary and secondary Evapo-transpiration / Absorption (ETA) bed systems; and (subsurface) irrigation systems. Given that the Acceptable Solution tables will only be used for proposed systems on Low and Medium Hazard lots, more traditional primary dosed trenches and beds have been included. However, it is acknowledged that opportunities for adoption of primary dosed trenches and beds are limited and in some cases, may not be as cost effective as secondary treatment and subsurface irrigation. A value for void space ratio, Total Nitrogen (TN) and Total Phosphorous (TP) effluent concentrations, maximum depth of storage in trenches/beds, and percentage of nitrogen lost to soil processes were assigned for each system type as shown in Table 8–6.

Table 8-5 Wastewater System Types

System Type	Void Space	Max. Depth (mm)	Effluent TN (mg/L)	Effluent TP (mg/L)	%N Soil
Primary Trench	0.3	450	60	18	0.4
Secondary Trench	0.3	450	30	12	0.2
Primary ET Bed	0.3	300	60	18	0.4
Secondary ET Bed	0.3	300	30	12	0.2
Irrigation	1	0	30	12	0.2

8.2 Assignment of Minimum Land Application Areas

The input parameters summarised above were compiled into a macro enabled land application area hydraulic sizing spreadsheet. The macro enabled hydraulic sizing calculations (utilising Equation 1 outlined in Section 9.2) to be completed for each of the 600 possible combinations of on-site system scenario and the 1200 results output into a table. Results were then assessed and reduced through consideration of a number of practical and design limitations associated with the various land application system types. Values were also rounded up to the nearest practical value (i.e. an installer is unlikely to vary sizes by small increments). This is considered acceptable given the relative accuracy of design procedures. Further justification for not using a monthly water balance is provided in Section 9.

It is important to recognise that the Acceptable Solutions have been offered as a conservative standard design option for applicants on Low and Medium Hazard lots who wish to fast track their approval whilst providing Council with confidence that their proposal is sustainable. They will not be permitted for adoption on High and Very High Hazard lots, commercial / industrial development or any lot with constraints not identified through the hazard mapping process.

The following points summarise how raw outputs from modelling were reduced and simplified. Further details can be found in the DAF.

- Limitations were placed on maximum allowable slope for trenches and beds to be considered an Acceptable Solution.
- Limitations were placed on allowance of gravity dosing of trenches and beds where even distribution of effluent could prove difficult.
- A minimum of 600mm of soil must be present between the base of any land application system and any limiting layer or water table.
- Limitations were placed on the maximum basal area allowable for trenches and beds considered an Acceptable Solution based on construction challenges associated with achieving level bases across large areas.

8.3 Outcomes

A set of Acceptable Solution tables have been included in the DAF for use as a 'deemed to comply' option for system selection and design on Low and Medium Hazard lots. The minimum land application system sizes are considered conservative for a range of possible development scenarios. Applicants are however free to complete site specific design calculations to derive their own sizing.

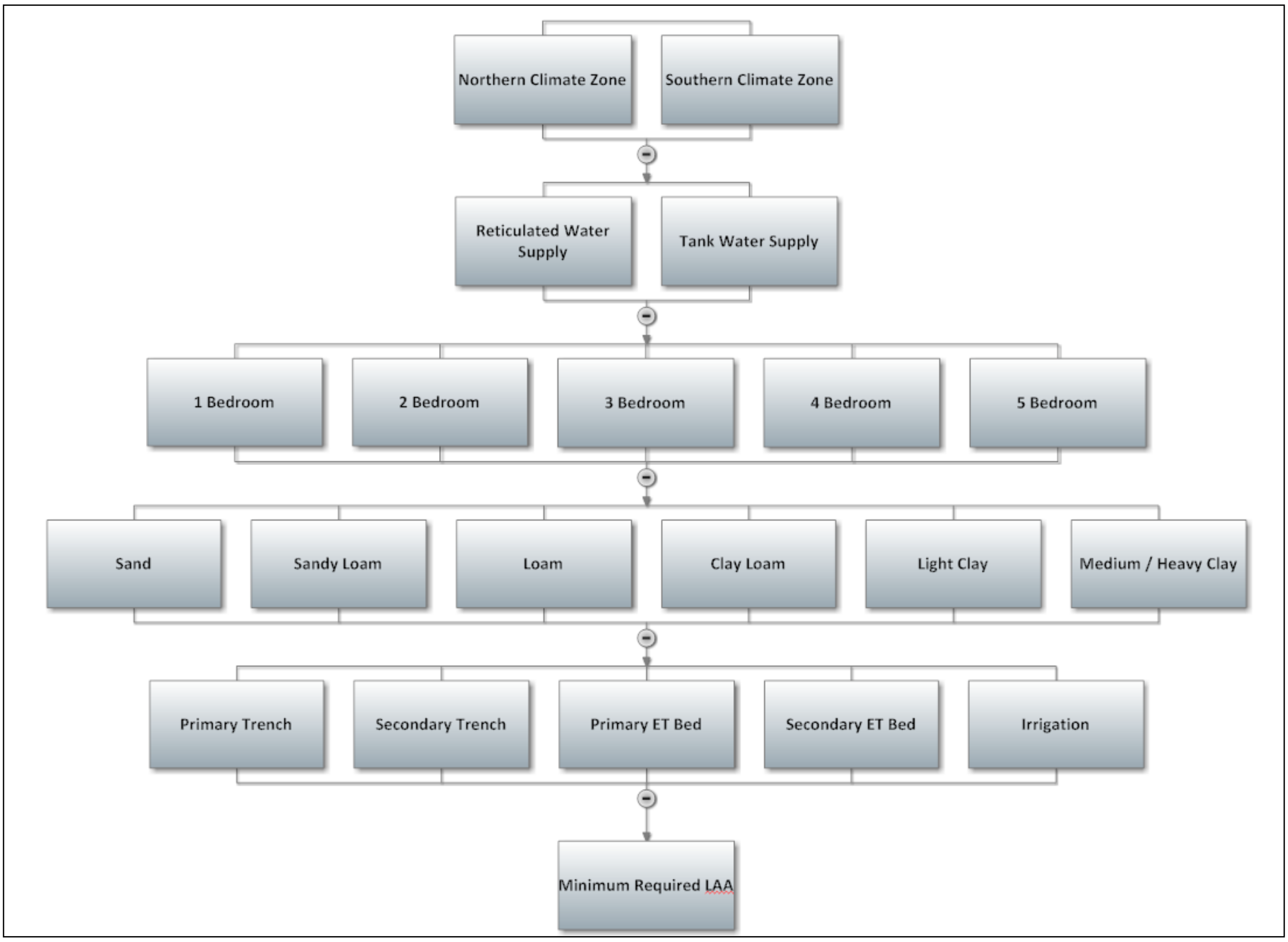

Figure 8-2 Decision Tree for Selection of Acceptable Solutions

9 DAF DESIGN PROCEDURES

The Development Assessment Framework (DAF) sets out a number of design procedures that vary in complexity and information requirements depending on relative risk. Some procedures are already a requirement of on-site sewage management system design. Others are more advanced procedures often limited in use to larger, non-domestic wastewater management systems. Since the implementation of Councils On-site Sewage Management Strategy, it has become apparent that traditional assessment and design procedures associated with domestic on-site systems are not always capable of a) ensuring a system will be capable of managing design loads or b) demonstrating a proposed system will not pose an unacceptable risk to ecosystems and human health. Particular issues have arisen on smaller allotments that feature one or a number of bio-physical constraints to sustainable on-site sewage management. Larger non-residential on-site systems can also require more comprehensive design and assessment procedures.

This leaves Council in a position where they must either request additional information from an applicant or make a determination on an application without confidence. This chapter summarises general guideline information for undertaking key on-site system design procedures required under the DAF. It is not however a design manual and consultants are still expected to use the recommended resources provided below to develop their own procedures and tools to meet Councils Minimum Standards.

9.1 Wastewater Characterisation

When designing domestic on-site sewage management systems, use of standard published guideline values (e.g. *ASNZS1547:2012*) for wastewater flow and constituent loads is normally adequate. However, this is not always the case on highly constrained sites or for non-domestic systems. In some cases the sensitivity of the receiving environment may make the inevitable inaccuracies of typical published values critical to performance. Alternatively, the unique site activities associated with non-domestic facilities may limit the suitability of typical published values. **Guiding information** and recommended data sources are provided in the following chapter. There are two occasions within the DAF where wastewater flow and constituent load generation rates beyond *ASNZS1547:2012, AS1546:2008* and NSW Health (2001 and 2005) are required.

9.1.1 Very High Hazard Domestic On-site Systems

The presence of significant constraints to sustainable on-site sewage management on Very High Hazard lots increases the level of detail and accuracy needed during design procedures to ensure a robust system is installed that is capable of managing these constraints. In the case of new developments, existing water consumption or wastewater generation data are not typically available. In these cases it is important to adopt conservative design wastewater generation rates. Notwithstanding, care should also be taken to not be over conservative resulting in oversizing of treatment and/or land application systems to the point where they do not receive sufficient loads to enable adequate biological activity.

In the case of applications to upgrade or replace an on-site system servicing an existing facility, design wastewater flows and loads should be validated or derived from actual site data wherever possible. The following table provides a summary of guiding information on calculation of design wastewater flows and loads for Very High Hazard domestic on-site systems.

Table 9-1 Calculation of Design Wastewater Flows and Loads: Very High Hazard Domestic

Scenario	Calculation Process	Resources
New Dwelling	**Wastewater Flow**	
	Occupancy calculated at minimum 1.6 persons per bedroom. No allowance for water reduction fixtures/facilities.	(Appendix H Table H1of *AS1547*).
	Seasonal variation to be considered for intermittently occupied / holiday homes (design for peak daily/weekly occupancy).[1]	
	Constituent Loads	
	Published domestic loads (e.g. g/day) with conservative allowance made for any non-domestic activities (e.g. hairdressing, cheesemaking).	*AS1646*, NSW Health (2001, 2005).
Existing Dwelling	**Wastewater Flow**	
	Analyse existing water consumption data (or wastewater flow data) and use to validate adopted design flow profile. Consideration should be given to seasonal / monthly variation shown in data.[1]	As above. Consideration should be given to permanently or temporarily installing a Smart Meter to collect detailed water use data where significant variation is likely.
	Constituent Loads	
	Published domestic loads (e.g. g/day) will normally be sufficient. Existing wastewater quality sampling may be warranted where specific non-domestic activities (e.g. hairdressing, cheesemaking) are occurring.	As above.

Note 1: Flow balancing / equalisation may be of benefit where uncertainty exists around peak and average wastewater generation rates.

9.1.2 Non-domestic On-site Systems

Non-domestic facilities commonly produce wastewater that varies in quantity and quality over time. They can involve mixed use facilities where domestic wastewater is generated in combination with commercial, industrial or agricultural wastewater. Adoption of domestic wastewater generation rates and constituent loads (e.g. from *AS1547, AS1546*, NSW Health guidelines) should not be undertaken without confirmation that they are applicable to the specific site. As a minimum, typical published wastewater flow and load generation rates should be sourced from industry recognised, applicable sources. It must be recognised however that even these values are generalised average values obtained from sites with a wide range of activities and unique characteristics. Wherever possible, site specific data should be collected for all non-domestic systems and larger flow domestic systems (>10 kL/day).

There is no NSW guideline document available that relates specifically to non-domestic / package wastewater treatment system applications. There are however a small number of nationally and internationally recognised texts and guidelines that should be used for any non-domestic wastewater management system design process. **Applications for non-domestic on-site systems that propose to "scale up" an off the shelf domestic wastewater treatment plant without supporting justification (process design) will not typically be accepted.** The following technical and guidelines documents are recommended for guidance in the design of non-domestic on-site wastewater management systems.

- Crites and Tchobanoglous (1998) *Small and Decentralised Wastewater Management Systems*. McGraw-Hill.

- Asano *et al* (2007) *Water Reuse: Issues, Technologies and Applications*. Metcalf and Eddy.
- Tchobanoglous *et al* (2003) *Wastewater Engineering: Treatment and Reuse*. 4th Edition. Metcalf and Eddy.

Locally, selected components of the following document may be useful.

- EPA Victoria (1997) *Code of Practice for Small Wastewater Treatment Plants*. EPA Victoria Publication 500.

In particular, Crites and Tchobanoglous (1998) and Asano *et al* (2007) are internationally recognised, comprehensively peer reviewed design manuals and planning guidelines that cover a substantial amount of the necessary processes encountered within the Dungog Shire LGA. Chapter 4 of Crites and Tchobanoglous (1998) and Chapter 13-3 of Asano *et al* (2007) emphasise the need for a wastewater characterisation process for larger systems rather than simply an adoption of standard values.

Table 9-2 Calculation of Design Wastewater Flows and Loads: High/Very High Non-domestic

Scenario	Calculation Process	Resources
New Facility	**Wastewater Flow**[1] Development of a seasonal/monthly/daily time series (time step applicable to nature of temporal variation) of design wastewater flow. This flow profile should be developed using site specific occupancy / process information e.g. • Anticipated seasonal variation in occupation in a tourist facility. • Anticipated seasonal / monthly / daily variation in production in an industrial facility. • Predicted customer numbers / turnover for a proposed commercial facility. Where site specific information is not available, data should be sourced from similar facilities, preferably local ones. **Constituent Loads**[1] At least the average, minimum and maximum concentrations should be obtained and used to calculate design loads. Local data from similar facilities should be sourced where possible. Published constituent loads (e.g. g/day) may be acceptable where data not available.	**Non-domestic** Section 4: Crites and Tchobanoglous (1998) Section 13-3: Asano *et al* (2007) Lesikar *et al* (2006) EPA Victoria (1997) **Domestic (>10kL/day)** Appendix H of *AS1547* *AS1646*, NSW Health (2001, 2005).
Existing Facility	**Wastewater Flow**[1] Development of a seasonal/monthly/daily time series (time step applicable to nature of temporal variation) of design wastewater flow. This flow profile should be developed using site specific monitoring data from the existing facility. Analyse existing water consumption data (or wastewater flow data) and use to validate adopted design flow profile. **Constituent Loads**[1] At least the average, minimum and maximum concentrations should be obtained through monitoring of existing facility operation and used to calculate design loads. Local data from similar facilities should be sourced where significant deviation from existing conditions expected.	As above. Consideration should be given to permanently or temporarily installing a Smart Meter to collect detailed water use data where significant variation is likely. Composite or grab sampling of raw wastewater is strongly recommended to assist in wastewater characterisation.

Note 1: In the case of Low/Medium Hazard Non-domestic systems (and domestic systems 2-10 kL/day), a single, conservative design value for wastewater flows and constituent loads may be acceptable if it can be demonstrated that there is <10% variation in that parameter over 12 months or sufficient flow equalisation is provided to attenuate peaks.

9.2 Hydraulic Design of Land Application Areas

NSW on-site sewage management guidelines (DLG, 1998) currently recommend the use of monthly water balance (in conjunction with annual nutrient balances) to size land application areas (LAA)). Historically, ASNZS1547:1994 also included a recommended procedure for completion of monthly water balance calculations. However, ASNZS1547:2000 and recently ASNZS1547:2012 do not specify the use of a monthly water balance and rather make more general informative statements. In essence, ASNZS1547:2012 adopts a risk based approach, recommending consideration of water balance where it is possible that climate may play an important role in performance.

The DAF specifies the use of a steady state (essentially annual) water balance calculation for Low, Medium and High Hazard residential system designs. It was concluded that a simplified hydraulic sizing approach would be adopted for on-site systems on Low, Medium and High Hazard allotments. This relates to limitations on the useability and applicability of monthly water balance calculations in moderate to high rainfall areas. It also relates to the limited purpose of monthly water balance calculations for design sizing of subsurface irrigation systems or mounds (the two dominant modern land application options).

Monthly water balance calculations for ***irrigation*** land application areas should not include any cumulative storage allowance in the soil. Daily continuous modelling is required to do this with any accuracy. The DLG (1998) method commonly adopted in NSW only uses the “wettest” month of the year (the month with the smallest difference between retained rainfall and crop evapo-transpiration) to size a Land Application Area (LAA). Monthly water balance calculations do allow an estimate of any wet weather storage tanks proposed. However, these are not advocated for residential systems within the DSC DAF or amongst other NSW Councils.

It is acknowledged that monthly water balance calculations do enable consideration of storage capacity within a primary dosed trench or bed (i.e. where effluent is draining from a saturated body of gravel controlled by a biomat). However the use of a Climate Adjustment Factor (CAF) as presented below achieves the equivalent outcome through a simpler method of calculation with reduced potential for error or manipulation. Reference should be made to Asquith *et al* (2012) for more justification on this approach.

Hydraulic sizing of land application areas shall be undertaken using Equation 1 below.

$$\boldsymbol{LAA = \frac{Q}{(DLR - CAF)}} \qquad \text{Equation 1}$$

Where;

LAA = Land Application Area (basal area in m^2)

Q = Design Wastewater Generation Rate (L/day)

DLR = Design Loading Rate (mm/day)

CAF = Climate Adjustment Factor (mm/day)

Detailed land application system modelling was used to support design experience in the sizing of land applications within the LGA. The Climate Adjustment Factor (CAF) enables design loading rates to be adjusted to reflect the degree to which climate influences hydraulic performance. They have been determined based on analysis of the frequency and magnitude of hydraulic failure for a range of on-site system types in different climate regions (consistent with the climate zones adopted for the Acceptable Solutions).

In very wet climates the CAF reduces the daily DLR to reflect the limitation placed of hydraulic capacity by consistently high soil moisture. In dry climates the CAF may increase the DLR based on a higher evapo-transpiration output of applied effluent. The result is comparable to a monthly water balance with respect to rigour of design (resulting LAAs are typically <10% larger or smaller). However, it is a simpler approach that requires limited time to calculate. As previously mentioned it also removes significant potential for unnecessary error or artificial manipulation of results.

Climate adjustment factors can be found in Table 9-3 below for trenches/beds or irrigation LAAs in two broad climate zones. The climate zones applicable to these CAFs are presented in Figure 8-1. These CAF values have been tested and are suitable for the variation in site specific climate observed within each of these zones. Design loading rates should be obtained from *ASNZS1547:2012*.

Table 9-3 Climate Adjustment Factors for Hydraulic Design Equation 1

Climate Zones	Climate Adjustment Factor (CAF)
Chichester Dam (Northern)	1
Paterson (Tocal AWS) (Southern)	0

These CAFs were calculated based on an average annual water balance utilising the inputs summarised in Table 9-4.

Table 9-4 Summary of Input Data for CAF Calculations

Parameter	North	South
Average Annual Rainfall	1,312 mm	929 mm
Volumetric Runoff Coefficient	0.75	0.83
Pan Evaporation	1,059 mm	1,570 mm
Average Crop Factor	0.59	

In the case of trenches and beds, allowance should ***not*** be made for sidewalls in addition to basal area where Design Loading Rates (DLRs) from *ASNZS1547:2012* are adopted. DLRs are purely a best estimate of the long-term hydraulic capacity of land application systems. It is not a physically measurable parameter like Long Term Acceptance Rate (LTAR) as measured by Laak (1973 and 1986). Work undertaken by Tyler and Converse (1994), Beal *et al* (2006) and others has shown that hydraulic pathways from trenches and beds typically oscillate between equilibrium of sidewall and basal area discharge. The dominant flow path at any point in time depends on a number of factors including biomat thickness, effluent quality, hydraulic head and soil hydraulic conductivity. DLR is not a physical measurement of these processes but a general long-term estimate of ***total*** hydraulic output from a LAA (whether sidewall or basal area discharge).

Given the relative accuracy of any hydraulic design equations, rounding of minimum LAA sizes is acceptable to the nearest $10m^2$.

9.3 Annual Nutrient Balance

DLG (1998) also advocate the use of annual nutrient balance calculations in sizing LAAs for domestic on-site systems. The DSC DAF requires annual nutrient balance calculations to be completed in some circumstances, depending on relative risk. Outcomes of lot density modelling (Section 7) supported the assumption that nutrients will be adequately assimilated where the following conditions are achieved.

- LAAs are sized to prevent hydraulic failure in average climate conditions.
- LAAs are located in accordance with DSC buffer distances.
- LAAs are contained within an allotment containing 4,000 m^2 of Useable Land.

As such site specific nutrient balance calculations are not required on Low, Medium and *some* High Hazard allotments that meet the above conditions.

Council recognise the conservatism associated with some elements of the DLG (1998) nutrient balance process and advocate use of a slightly modified method as described and demonstrated in the Municipal Association of Victoria's *Model Land Capability Assessment Report – February 2006* (MAV 2006). The reader is directed to nutrient balance elements contained on pages 18-19, 25 and 35-37 of that document. MAV (2006) can be downloaded from http://www.mav.asn.au/policy-services/environment/water/domestic-wastewater/Pages/default.aspx. DLG (1998) also provides ***nominal*** plant nutrient uptake rates purely to demonstrate use of the nutrient balance procedure. These nominal values are very conservative and underestimate the level of plant uptake occurring in most cases. Council strongly recommend consultants seek more appropriate nutrient uptake values from Table 4.2 of DECCW (2004) *Use of Effluent by Irrigation*. In order to allow for the reduced efficiency in crop production (grass growth) associated with a typical domestic lawn, Council recommend adoption of 50% of published nutrient uptake rates in DECCW (2004). In most cases, use of data for kikuyu will be appropriate and example calculations of nutrient uptake rate are provided below.

Kikuyu Nutrient Uptake

Average dry matter yield (t/ha/year) = 20 TN = 2.6% TP=0.3% (From Table 4.2 of DECCW 2004)

TN = 0.026 x 20,000 = 520 kg/ha/year x 0.5 (conservative allowance for domestic lawn harvesting)

*TN = **260** kg/ha/year = 71 mg/m^2/day.*

TP = 0.003 x 20,000 = 60 kg/ha/year x 0.5

*TP = **30** kg/ha/year = 16 mg/m^2/day.*

Where a vegetation cover that is clearly different to kikuyu is being adopted, site specific nutrient uptake rates should be calculated following the above procedure. Where harvesting and removal of vegetation is not going to occur, limited nutrient uptake can be assumed.

9.4 Continuous Daily On-site System Modelling

The DAF requires a higher level of on-site system water, nutrient and pathogen modelling in circumstances where risks to ecosystem and human health are elevated. Lots with a Very High On-site Sewage Hazard Class warrant this more comprehensive analysis for two key reasons.

- Availability of suitable land for siting of an effluent land application area is often highly limited. Continuous daily on-site system modelling maximises potential to achieve a sustainable design.
- Continuous daily on-site system modelling provides a higher level of accuracy when assessing potential impacts on what are typically sensitive receiving environments.

Continuous daily soil water, nutrient modelling has been included as an assessment tool to simulate performance of land application systems on Very High Hazard lots and for larger non-domestic systems. One dimensional viral dieoff modelling (Cromer *et* al, 2001) is also required as a method for estimating pathogen export potential. This approach is widely considered current best practice in land application system design, particularly effluent irrigation design. There are two commercially available tools that can be used to complete this modelling or alternatively, consultants may construct their own in spreadsheet form (subject to review and endorsement by Council).

9.4.1 Rationale

Continuous daily on-site system modelling does require more data and a higher level of understanding of soil water, nutrient and pathogen dynamics. As such, it cannot be justified in the context of lower hazard on-site systems. However, on severely constrained sites and in the case of non-domestic facilities, monthly water balance spreadsheets such as that advocated in DLG (1998) are not capable of answering key questions about a systems performance. Prior to the availability of computers with sufficient processing capacity to undertake long-term daily modelling, the monthly spreadsheet approach was an acceptable, practical (albeit conservative) method that allowed climatic influences on crop growth to be incorporated into design. However, daily continuous soil water modelling has been a recognised standard for at least the last 10 years. Some of the limitations of a monthly lumped approach are as follows.

Monthly water balances calculate soil water balance for each month in isolation. While cumulative storage is calculated for the gravel void space in trenches or a wet weather storage tank, this is limited to a twelve month period and the assumption is made that the storage volume returns to zero prior to the next winter. This means the method cannot account for antecedent soil moisture or rainfall conditions over the design life of a system. This occurs on an intra-annual basis and between years. Continuous daily modelling simulates soil/plant water dynamics over decades on a daily basis. This ensures both inter-annual and intra-annual variation in a wide range of conditions (beyond rainfall and cumulative storage volume) is accounted for in the design. Essentially, it simulates wet and dry periods in climate history.

The Monthly method assumes infinite soil water storage with no sound method to quantify water lost to deep drainage prior to evapo-transpiration. As a result, it is assumed that all excess water drains at the end of each month and is not carried over (particularly during winter). Continuous daily models dynamically calculate infiltration, soil water storage, plant uptake, deep drainage and runoff for multiple soil horizons on a daily basis. They then carry water in soil storage over to the next day, month and year to ensure antecedent conditions are accounted for.

As previously stated, the most obvious advantage of a daily model is its ability to identify and quantify dry periods within what may be a 'wet' month. Continuous daily modelling enables opportunities for irrigation within wetter months to be identified and taken where appropriate.

At the time of original publication of DLG (1998), lumped monthly water balances did represent best practice for the time and computing power readily available to stakeholders. However, environmental modelling has progressed dramatically in the proceeding 15 year period. Selected models utilise scientifically validated algorithms that have been extensively tested and peer reviewed. Reference should be made to Gardner and Davis (1998) and Martens (1999b) for further description and justification of continuous daily modelling approach for higher risk sites.

9.4.2 Available Modelling Tools

Two commercially available modelling packages are summarised below that can be used to complete continuous daily modelling in accordance with the DAF.

- Model for Effluent Disposal by Land Irrigation (MEDLI).
- Land Application Mass Balance (LAM).

MEDLI is a proprietary software package that needs to be purchased from the Queensland Department of Environment and Resource Management (DERM). LAM is a freely available program under subscription arrangement or as an enhanced version for purchase from BMT WBM. A brief summary of each model is provided below with further detail available from the individual software supplier.

Pathogen (vial die-off) modelling can be completed using a spreadsheet application of the method advocated by Cromer *et al*, (2001).

9.4.2.1 MEDLI

MEDLI is a water and nutrient mass balance model developed by the Queensland Department of Natural Resources and Mines (now DERM) and the CRC for Waste Management and Pollution Control (Gardner and Davis, 1998). It is capable of simulating storage pond dynamics, irrigation scheduling, plant growth, transpiration and nutrient uptake, soil water and nutrient dynamics and salinity on a daily time step over long periods (up to 100 years). The structure of MEDLI is shown in Figure 9-1.

MEDLI currently represents the most sophisticated and technically robust modelling tool for designing effluent irrigation schemes available in Australia and has been in the public domain for over ten years. However, it is less suited to on-site sewage management system modelling as a result of its strong reuse / agronomic focus. The MEDLI Technical Manual (Gardner and Davis, 1998) provides a comprehensive description of the algorithms and modules which have been extensively peer reviewed and validated. Importantly, MEDLI is a process based mass balance model that includes dynamic, daily calculation of infiltration (rainfall and effluent), plant growth, transpiration, deep drainage, runoff and soil profile water. There is limited benefit in repeating small elements of the comprehensive Technical Manual (Gardner and Davis, 1998) here. Readers can obtain a copy of the software (or possibly at least the Technical Manual) from the Queensland Department of Environment and Resource Management (http://www2.dpi.qld.gov.au/environment/5721.html).

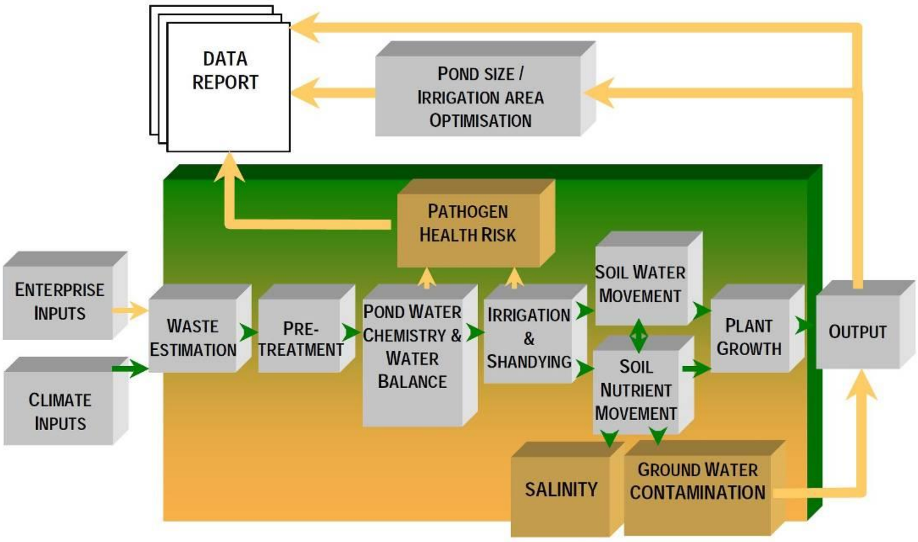

Figure 9-1Structure of MEDLI (Source: MEDLI Technical Description, Queensland DNR)

9.4.2.2 LAM

LAM is a daily soil water, nutrient and pathogen mass balance model developed by BMT WBM specifically for the design and assessment of domestic and non-domestic on-site wastewater land application systems. Algorithms from the Decentralised Sewage Model (See Section 10.3) have been tailored to suit a single site application. In contrast to other tools, LAM focuses on common approaches to effluent land application at domestic and medium scale non-domestic settings such as subsurface irrigation, raised (mound) systems, trenches and beds. A description of LAM is available from BMT WBM (newcastle@bmtwbm.com.au). The structure of the model is depicted in the following figure.

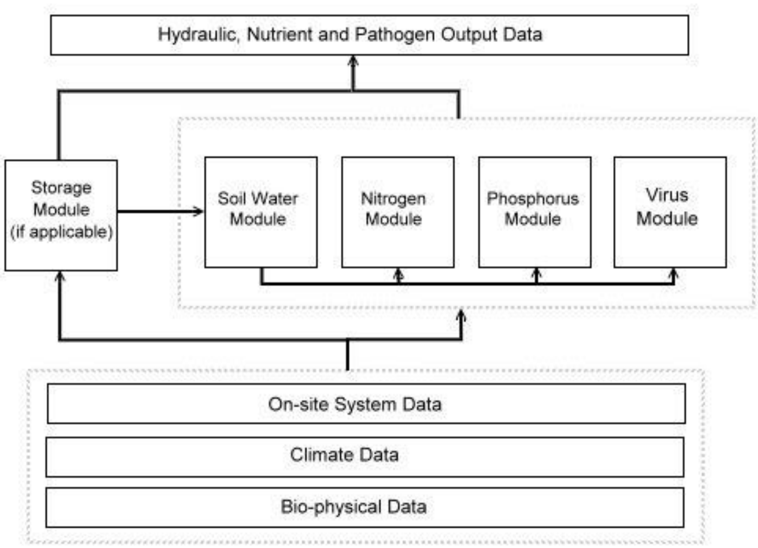

Figure 9-2 Structure of the LAM Model

9.4.2.3 Spreadsheet Based Models

It is possible to construct continuous daily on-site system models in standard spreadsheet software such as MS Excel™. However, both authors and users require significant expertise and experience in soil water, nutrient and pathogen dynamics. Approval from Council will be required should individual consultants wish to build and use their own daily soil water, nutrient and pathogen models. Approval will typically involve some level of peer review of algorithms and testing of the model.

9.4.3 Data Inputs and Outputs

Data requirements and professional resources required for building and running of continuous daily soil water, nutrient and pathogen mass balance models are inevitably greater than current typical practice. However, the experience of many Councils and practitioners supports an increased level of scrutiny in the design and assessment of systems in highly constrained environments. Similarly, poor operational performance can be reduced through the application of a daily modelling approach for non-domestic systems. All of the example modelling tools described in Section 9.4.2 can be operated using readily obtainable field and desktop data whilst producing a meaningful result.

Continuous daily modelling enables a more comprehensive design and assessment process for on-site systems and provides Council with a higher level of assurance that a system is sustainable. The following list is a guide to how daily modelling can be used under the DAF for Very High Hazard and non-domestic systems.

- A more accurate calculation of minimum land application area size that ensures the occurrence of hydraulic failure (surface surcharge) is restricted to extreme climate events. This increased accuracy can sometimes allow smaller land application area sizes in comparison to monthly calculations.
- Realistic sizing of any wet weather storage facilities for non-domestic systems. Monthly calculations should never be used to size wet weather storage facilities. Council do not advocate wet weather storage for domestic systems.
- More realistic estimate of hydraulic, nutrient and pathogen loads leaching into subsurface environments as deep drainage to enable a more detailed assessment of potential impacts.
- Derivation of long-term hydraulic, nutrient and pathogen loads leaching via deep drainage and discharging to the ground surface for input into Cumulative Impact Assessment modelling.

9.5 Hydraulic and Process Design

The DAF recognises that there are a number of circumstances in on-site sewage management where "off the shelf" design and technology options cannot provide a sustainable solution. Furthermore, there are circumstances where a more rigorous engineering and design process should be undertaken and provided to Council to enable a decision. Historically, there has been limited input to NSW on-site sewage management guidelines and legislation from hydraulic and process engineering disciplines. This is not the case in other jurisdictions and countries where designs for on-site systems are expected to follow engineering principles of design including the preparation of specifications and design drawings.

In creating the DAF, Council acknowledge that there is limited need for higher level engineering input to proposals for domestic on-site systems on Low and Medium Hazard lots. However, as the nature and extent of constraints increase, so does the need for a sound, engineered system capable of being taken from concept to reality. There have been occurrences of on-site system designs being submitted to Council that "on paper" are capable of meeting performance objectives. However, the ability to convert a conceptual sketch to a final constructed system is either limited or cost prohibitive. This can be prevented through the submission of engineering calculations, specifications and drawings that demonstrate that a system is feasible.

The technical resources listed in Table 9-6 are a sample of key information and guidance available to allow engineering design of on-site systems. "Black Box" technologies put forward without supporting process design information and performance data for non-domestic systems will not be accepted. The references provide a plethora of design procedures, data and guidance to enable sound designs to be developed.

Table 9-5 Different Stages of the Engineering Process

Engineering Stage	Description	DAF Requirement
Feasibility Study	High level identification of potential options. "Rule of thumb" design calculations based on limited, predominantly desktop data. Multi criteria analysis of shortlisted options.	Increase in building entitlements on Low / Medium Hazard lots. First phase of a project involving a non-domestic system >10 kL/day.
Concept Design	Limited field data collected to enable development of conceptual layout (footprint of each major component) and key sizing calculations for critical system elements such as land application / effluent management systems. Typically used to define site performance targets, undertake an initial environmental assessment and prepare a high level cost estimate (e.g. +/-20%). Will usually be sufficient for domestic systems on Low/Medium Hazard lots.	Domestic systems on Low / Medium Hazard lots. Increase in building entitlements on High/Very High Hazard lots.
Preliminary Design	Design stage bridging the gap between concept and detail. Commonly completed to develop specifications for Design and Construct (D&C) contracts intended for technology providers with in-house detailed design capabilities. Preliminary designs contain sufficient detail to prepare a performance specification and confirm that the conceptual design can be taken through to construction with confidence. Usually involve preliminary site surveys, detailed site and soil assessment and hydraulic / process design. Enables cost estimate (+/-15%)	Domestic systems on High / Very High Hazard lots. Non-domestic systems on Low / Medium Hazard lots (<10 kL/day).
Detailed Design	Comprehensive investigation, survey and design calculations/modelling to produce CAD design drawings and specifications sufficient to enable construction. Hydraulic, treatment process, structural/civil engineering design of all components. Enables preparation of a schedule of quantities.	Non-domestic systems on High / Very High Hazard lots or >10 kL/day.

Table 9-6 Recommended Resources for Hydraulic/Process Engineering of On-site Systems

Resource	Drainage / Collection	Pre-treatment / Flow Balancing	Treatment	Disinfection and Storage	Land Application	Water Reuse
Crites and Tchobanoglous (1998) *Small and Decentralised Wastewater Management Systems*. McGraw-Hill	✓	✓	✓	✓	✓	
Tchobanoglous and Burton (2003) *Wastewater Engineering: Treatment and Reuse.* Metcalf and Eddy.		✓	✓	✓		
Asano *et al* (2007) *Water Reuse: Issues, Technologies and Applications.* Metcalf and Eddy.			✓	✓	✓	✓
Crites *et al* (2006) *Natural Wastewater Treatment Systems.* Taylor and Francis.			✓	✓	✓	
Water Environment Federation (2008) *Alternative Sewer Systems: Manual of Practice FD-12.* 2nd Edition. McGraw-Hill.	✓	✓				
USEPA (1991) *Alternative Collection Systems Design Manual*.	✓	✓				
Consortium of Institutes for Decentralized Wastewater Treatment *University and Practitioners Curricula.* www.onsiteconsortium.org	✓	✓	✓	✓	✓	
Converse and Tyler (2000) *Wisconsin Mound Soil Absorption System: Siting, Design and Construction Manual*. http://www.soils.wisc.edu/sswmp/online_publications.htm provides a range of other useful publications.					✓	
DECCW (2004) *Environmental Guidelines: Use of Effluent by Irrigation*.					✓	✓
USEPA (2006) *Process Design Manual: Land Treatment of Municipal Wastewater Effluent.*					✓	
The Water Environment Research Federation provide a range of information. http://www.decentralizedwater.org/	✓	✓	✓	✓	✓	✓
Netafim provide a design manual, hydraulic design software, standard drawings and checklists to assist in design of drip irrigation systems. http://www.netafim.com.au/index.php?sectionid=165					✓	✓
Geoflow provide a range of material (including a hydraulic design spreadsheet) to assist in design of drip irrigation systems http://www.geoflow.com/design_w.html					✓	✓
Orenco Systems Incorporated have a comprehensive engineering library applicable to a range of systems. http://www.orenco.com/corporate/technical_resources/	✓	✓	✓	✓	✓	✓

10 CUMULATIVE IMPACT ASSESSMENT PROCEDURES

There is no 'one size fits all, black box' tool for undertaking this type of assessment. However, effective use of available models and tools is possible through establishment of a Minimum Standard for assessment of risks associated with proposed increases in unsewered building entitlements. The level of detail and complexity can be varied to reflect the potential risk (a function of the likelihood and/or consequence of failure) a specific proposal poses to human and ecosystem health. The DAF has used the outcomes of hazard mapping, minimum lot size and maximum lot density assessments to develop an adaptable Cumulative Impact Assessment (CIA) procedure. Reference should be made to the DAF for guidance on the circumstances in which CIA is required.

In order to maintain simplicity in CIA procedures, the following indicative performance objective has been adopted.

No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) from existing undeveloped loads

Average virus concentrations in effluent (following attenuation) of <1 MPN/100ml.

All land application areas sized to ensure hydraulic failure (surcharging) accounts for only 5% of total wastewater generated (i.e. 95% containment via evapo-transpiration and deep drainage).

It is readily acknowledged that these targets are arbitrary values. It has been adopted after careful consideration of a range of alternatives. Other more conventional targets immediately require significantly more detailed investigations to be undertaken that were disproportionate to potential risk. They also require holistic, integrated assessment of pollutant loads from a development (e.g. stormwater pollutants) which is currently not required for most developments in Dungog Shire. Based on the outcomes of lot density modelling (Section 7), the adopted target will strike an effective balance between protection of ecosystems and human health and the need to undertake detailed technical investigations.

Health impacts will be considered to be adequately managed where all land application areas are sized in accordance with Section 9.2 ***and*** the daily water balance modelling indicates no change in surcharge frequency on existing conditions. This assumption is appropriate for environments where subsurface pollutant export is minimal. In other circumstances, the Detailed CIA will be completed which models pathogen export explicitly.

10.1 Standard Cumulative Impact Assessment Procedure

The Standard CIA procedure involves daily water and nutrient balance modelling of the proposed range of on-site systems in addition to use of standard background pollutant loads and pollutant attenuation rates to evaluate the potential for the increase in on-site systems to significantly alter nutrient loads or pathogen export risks within a subcatchment. It draws on standard data for NSW (background loads) and locally applicable parameters derived as part of the *Sustainable On-site Sewage Management* Study (attenuation rates). An example methodology and case study demonstrating how a Standard CIA should be undertaken is provided below. Alternative methodologies will be considered but must meet or exceed the Minimum Standards listed below in order to be approved by Council.

Table 10-1 Minimum Standard for Standard Cumulative Impact Assessments

Risk Assessment Component	Minimum Standard
On-lot Land Application Area (LAA) Assessment	• Daily water and nutrient mass balance modelling for each general on-site system LAA type within the subject site used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. Also used to estimate frequency of hydraulic failure (surcharge).
Rainfall-Runoff	• Average annual estimate of runoff volume using a volumetric coefficient of rainfall. Recommend use of Figure 2.3 (and subsequent equations) from Fletcher *et al* (2004).[1] See web link below.
Surface and Subsurface Pollutant Export	• Application of catchment attenuation factor (provided in Table 10-7 of the Technical Manual) to combined surface and subsurface on-site loads based on broad characteristics of the receiving environment.[2] • Mass balance combining attenuated on-site system flows and loads with catchment inputs.
Background Pollutant Loads / Concentrations	• Sourced from Tables 2.44 - 2.45 or Figures 2.15 – 2.23 of Fletcher *et al* (2004).[1] • Acceptable export rates / concentrations sourced from published local studies.
Environment and Health Protection Targets[3]	• No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) based on existing undeveloped background loads. • Average virus concentrations <1 MPN/100ml after application of attenuation rates. • All land application areas sized to ensure hydraulic failure (surcharging) accounts for only 5% of total wastewater generated (i.e. 95% containment via evapo-transpiration and deep drainage).

Note 1: Fletcher et al (2004) available from http://www.catchment.crc.org.au/pdfs/technical200408.pdf.
Note 2: Refer to Section 10.2.1 for explanation of attenuation factor derivation.
Note 3: Site specific targets can be developed and justified on a case by case basis. Outcomes must meet or exceed those achieved by the above targets.

In the case of Standard CIA procedure it is sufficient to complete daily modelling of the anticipated range of general system types, wastewater generation rates (e.g. maximum) and soil characteristics. Results can then be extrapolated based on an assumed breakdown of system types and dwelling sizes / design flows. Development of a site specific daily water, nutrient and pathogen model for every proposed allotment is not necessary.

The Standard CIA is intended to be able to be completed relatively quickly (0.5 to 2 days following field work) for a typical residential subdivision or commercial development. Necessary information for completion is largely provided in this Technical Manual or Fletcher *et al* (2004) with the exception of the daily water, nutrient and pathogen modelling. Refer to Section 9.4 for guidance on daily modelling.

10.1.1 Example Standard Cumulative Impact Assessment

An example Standard CIA is provided below for the following hypothetical unsewered subdivision.

- An existing 5 ha site is proposed to be subdivided into 10 rural living or rural residential lots.
- The hazard class is Medium due to moderate soil constraints and the presence of an intermittent watercourse through the site.
- The proposed subdivision plan indicates a number of the lots would contain between 2,000 – 4,000 m^2 of Useable Land.
- The developer wishes to locate two proposed Effluent Management Areas (EMAs) 30 metres from the intermittent watercourse (i.e. 50-100% achievement of DSC setback distances in Table 6-8 of the DAF.
- The developer wishes to retain the option to install absorption / evapo-transpiration beds on the higher lots where deeper, structured soils were observed during site and soil investigations.

Reference to Table 2-13 in the DSC DAF confirms that the proposed subdivision requires a Standard CIA to be completed.

10.1.1.1 On-lot Land Application Area (LAA) Assessment

Daily LAA water, nutrient and pathogen modelling was undertaken using LAM for two broad system types.

- Four bedroom house (reticulated water supply), secondary treatment system to subsurface irrigation.
- Four bedroom house (reticulated water supply), primary treatment to evapo-transpiration / absorption beds.

One soil type was identified during field investigations and site and soil assessment which was a residual mid-slope profile generally consisting of;

- moderately structured loam topsoil overlying;
- moderately structured clay loam B_1 horizon overlying;
- strongly structured light clay.

Total soil depth of 1.2 metres and a typical root depth of 600mm. Phosphorus sorption was moderate to high. The site is on a mid to lower slope.

Key input parameters are summarised in the following table.

Table 10-2 Summary of Daily LAA Modelling Inputs

Parameter	Unit	System 1	System 2
System Characteristics			
LAA Type		**Conventional Trenches / Beds**	**Sub-surface Irrigation**
Effluent Volume per Working Day	m3	0.9	0.9
Total Phosphorous	mg/L	15	12
Total Nitrogen	mg/L	60	35
Virus	MPN/L	1000	100
Crop Characteristics			
Crop P Uptake	kg/ha/yr	20	20
Crop N Uptake	kg/ha/yr	200	200
Crop Factor		Grass	Grass
Parameter	**Unit**	**Trench / Bed**	**AWTS**
		Light Clay	**Light Clay**
LAA Type		Conventional Trenches / Beds	Sub-surface Irrigation
DLR (from ASNZS1547:2012)	mm/d	8	3.5
LAA	m2	115	260
System Type		**Sub-surface Irrigation**	**Conventional Trenches / Beds**
Soil Type		**Light Clay**	**Light Clay**
Parameter	**Unit**		
Effective Saturation	mm	390	170
Permanent Wilting Point	mm	160	30
Field Capacity	mm	300	65
Saturated Hydraulic Conductivity	mm/day	100	40
Bulk Density	kg/m3	1400	1400
Soil Depth for P Sorption	m	1.25	1.25
INF	mm/day	225	225
Exp 1	-	1.5	1.5
A1	-	240	240
B1	-	0.20	0.20
B2	-	0.10	0.10

LAM produced the following average annual outputs for surface and subsurface hydraulic, nutrient and pathogen (virus) loads.

Table 10-3 Average Annual Loads from On-site System Types

Average Annual Output (per system)	Secondary Treatment Subsurface Irrigation	Primary Treatment ETA Bed
Mean Annual Overflow (m3) =	0	0
Mean Annual Overflow N (kg) =	0	0
Mean Annual Overflow P (kg) =	0	0
Mean Annual Overflow V (MPN) =	0	0
Mean Annual Surface Runoff (m3) =	0	16
Mean Annual Surface N (kg) =	0	0.05
Mean Annual Surface P (kg) =	0	0.66
Mean Annual Surface V (MPN) =	0	455525
Mean Annual Deep Drainage (m3) =	252	287
Mean Annual Deep Drainage N (kg) =	0.17	1.39
Mean Annual Deep Drainage P (kg) =	2.21	3.24
Mean Annual Deep Drainage V (MPN) =	512975	410518

The proposed 260 m^2 irrigation LAA resulted in 100% containment of average annual wastewater generated by the household as deep drainage / evapo-transpiration (i.e. 0% hydraulic surcharging), and as such met the DAF criteria for health protection. The proposed 115 m^2 ETA bed resulted in 95% containment of average annual wastewater generated (i.e. 5% hydraulic surcharging), and thus also met the DAF Minimum Standard.

10.1.1.2 Surface and Subsurface Pollutant Export

Reference was then made to Table 10-7 to select the appropriate catchment attenuation rate for the proposed development. This attenuation rate represents the loss and assimilation of *wastewater* loads (discharging as deep drainage or surface surcharge) as it moves from the land application areas to receiving environments. The attenuation rates were then applied to the average annual wastewater system loads for the proposed development as decay factors. Three primary dosed ETA bed systems were assumed with the remaining seven being secondary dosed subsurface irrigation systems.

Table 10-4 Summary of Final On-site System Loads at Receiving Water

Parameter	Attenuation	Average Loads	Average Concentration
Hydraulic	40%	1.6 ML/year	
Total Nitrogen	90%	0.6 kg/year	0.38 mg/L
Total Phosphorus	98%	0.5 kg/year	0.3 mg/L
Virus	99%	61,000 MPN/year	<1 MPN/100ml

10.1.1.3 Rainfall-Runoff

The equation from Fletcher *et al* (page 8) was used to estimate the annual volume of runoff from the proposed development for the existing case. An Effective Impervious Area (EIA) of zero was adopted making the equation;

$C = 0.0013R^{0.8} – 0.095.$

Average annual rainfall for the site was 1247 mm which equates to a volumetric runoff coefficient (C_v) of 0.29.

Average annual runoff therefore equals 362 mm which equates to 18 ML/year.

10.1.1.4 Background Pollutant Loads / Concentrations

Tables 2.4.4 and 2.4.5 in Fletcher *et al* (2004) were then used in conjunction with runoff volume to estimate background pollutant concentrations and loads. A land use of rural was adopted for the semi-cleared, unimproved pasture site. It is reasonable to apply dry weather concentrations for 20% of the runoff volume and wet weather concentrations to the remaining 80%.

Table 10-5 Summary of Background Pollutant Loads / Concentrations

Parameter	Average Loads	Average Concentrations
Total Nitrogen (TN)	32 kg/year	1.8 mg/L
Total Phosphorus (TP)	3.2 kg/year	0.18 mg/L

10.1.1.5 Environment and Health Protection Targets

Average annual on-site system and background flows and loads were combined in a mass balance to provide an estimate of long-term catchment loads from the proposed on-site systems.

Table 10-6 Results of Site Mass Balance for Cumulative Impact Assessment

Parameter	Average Loads	Percent Increase	Average Concentrations
Flow	20 ML	9%	
Total Nitrogen (TN)	32.6 kg/year	2%	1.63 mg/L
Total Phosphorus (TP)	3.7 kg/year	16%	0.19 mg/L
Virus	N/A		<1 MPN/100ml

The results indicate greater than 10% increase in Total Phosphorus loads as a result of the proposed mix of on-site sewage management system. All other targets were met. Options to bring TP loads down to compliance include;

- eliminating the option for primary effluent dosed trenches and beds (this alone doesn't meet the target);
- improving effluent quality at the treatment system;
- increasing the LAA size to reduce the nutrient loading rate;
- reducing the number of lots to nine; or
- undertaking a Detailed CIA including site specific calculation of attenuation rates which may demonstrate compliance.

In this case, the proponent chose to eliminate the option of primary dosed beds and proposed to increase the minimum subsurface irrigation area to 300 m^2 which enabled the development to meet the DAF Minimum Standards.

10.1.2 Minimum Outputs for Standard CIA's

As advised in the relevant Minimum Standards tables in the DAF, it is envisaged that Simple Cumulative Impact Assessments (CIA) will typically be contained in 5-10 pages within the Wastewater Management Report. The following elements should be provided to enable Council to assess the CIA.

- Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Table 10-1.
- Methodology documenting the basis and source of input data including reference to site specific data, published information or the Technical Manual to justify use.
- Results of daily water balance and annual nutrient balances to demonstrate minimum land application system sizing.
- Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Section 10.1.1.5.
- Brief discussion of long-term risks to health and environment and recommended management measures to address impacts.

10.2 Catchment Pollutant Attenuation

10.2.1 Standard CIA

In the case of Standard CIAs reference can be made to the following table to select and apply catchment attenuation rates. These rates should be applied to the wastewater flows and loads only (i.e. not the background loads) prior to calculating the site mass balance. They have been derived through a series of modelling processes (using the Domenico steady state equation) and on the back of previous experience. They correlate reasonably well with previous studies. However it should be noted that they are generalised estimates only. More accurate determination requires comprehensive site monitoring and modelling processes that will only be justified for proposed systems in highly sensitive environments where risks are high.

Table 10-7 Catchment Pollutant Attenuation Rates for Standard CIA

	Hydraulic	Nitrogen	Phosphorus	Pathogen
Inland / Rolling Hills Rolling hills of residual, colluvial and erosional soils predominantly in the western portion of the LGA with bedrock creating relatively shallow episodic perched water tables that discharge to local ephemeral drainage lines and creeks.				
DSC Setbacks[1] Achieved	60%	95%		
50% DSC Setbacks	40%	90%	98%	99%
<50% DSC Setbacks[2]	20%	80%		
Coastal / Estuarine Lower lying alluvial, sandy or estuarine environments underlain by shallow unconfined aquifers.				
DSC Setbacks[1] Achieved	40%	90%		
50% DSC Setbacks	30%	80%		99%
<50% DSC Setbacks[2]	20%	60%		
Attenuation factors should be applied to combined surface/subsurface average annual on-site system loads (kg/year) as an inverse (decay) decimal (i.e. 1-AF)				

Note 1: DSC Setbacks as follows – open drainage, intermittent and permanent watercourses, groundwater bores and farm dams.

Note 2: Sites where any land application system is proposed within 20 metres of a natural or artificial watercourse will require site specific determination of pollutant attenuation.

10.2.2 Detailed CIA

Site specific modelling using the Domenico steady state approach must be undertaken for Detailed CIAs. This approach involves spreadsheet application of the above equations using parameters readily obtained of inferred to a sufficient level of accuracy through site and soil and desktop evaluations. A freely available spreadsheet model that includes this equation can be obtained from the United Kingdom EPA (http://www.environment-agency.gov.uk/research/planning/40373.aspx).

10.3 Detailed Cumulative Impact Assessment Procedure

The Detailed CIA procedure set out below and in the DAF is based on the approach adopted for the on-site system density assessment documented in Section 7. It involves daily simulation of individual on-site systems using mass balance calculations for water, nutrients and (in specific circumstances) pathogens. Wastewater discharge into surface and groundwater is then input into a continuous catchment water quality and runoff model to simulate surface runoff and groundwater recharge. The attenuation of pollutants derived from on-site systems as they move down the catchment is also incorporated based on the outcomes of lot density modelling. The modelling is designed to simulate long-term average conditions but incorporates dynamic conditions on a daily time step to improve accuracy. It also allows assessment of intra-annual variation in results where conditions vary (e.g. areas with holiday homes or highly variably climate).

The models utilised in the Detailed CIA (DSM and MUSIC) do represent current best practice tools for water quantity and quality modelling. However, alternative models do exist and will be considered by Council subject to an initial peer review. As an example, modelling of long-term catchment water quantity and quality can be completed using a number of proprietary models including MUSIC and MIKE NAM. There are no known proprietary models for the simulation of multiple on-site systems on a daily time step other than the DSM. However, it can be done using excel spreadsheet models where the user has expertise in on-site system bio-physical processes and mass balance modelling. It can also be completed using single site models such as MEDLI and LAM (see Section 9.4.2). The development of a 'Minimum Standard' specification for risk assessment modelling will provide control over the quality of any non-proprietary modelling tools.

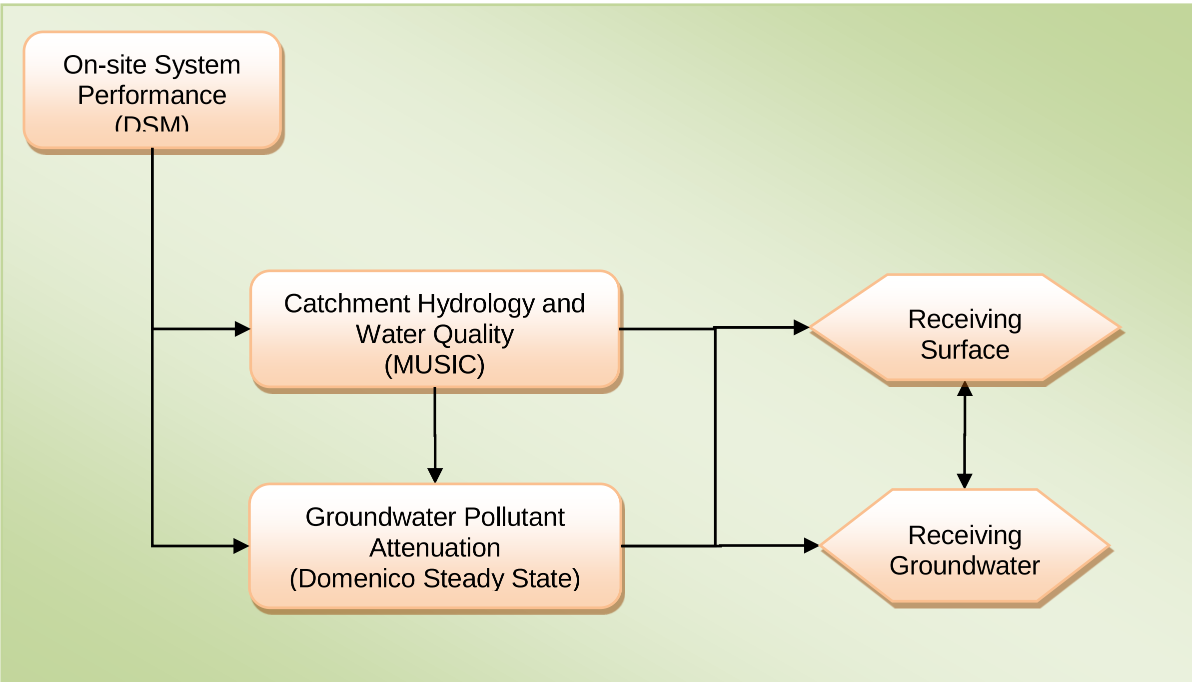

Figure 10-1 Structure of the Detailed CIA Modelling Procedure

The DAF requires a Detailed CIA to be completed in the following circumstances.

- Unsewered increases in building entitlements with any lot containing <2000m^2 Useable Land.
- Unsewered increases in building entitlements on Very High Hazard lots.
- Unsewered increases in building entitlements on High Hazard lots where buffer distances for open drainage, intermittent and permanent watercourses, groundwater bores and farm dams are less than 50% of those documented in the DAF.
- Non-domestic systems that do not meet buffer distances as above.
- Non-domestic systems High and Very High Hazard lots where sufficient Useable Land for the proposed system cannot be demonstrated.

Provided in this section are a set of Minimum Standards for completion of a Detailed CIA and catchment attenuation factors derived through the lot density assessment process. It is acknowledged that the Detailed Risk Assessment Procedure adopted for the lot density assessment represents only one methodology for undertaking this type of work. Alternative methodologies put forward by consultants / developers should meet or exceed these Minimum Standards.

Table 10-8 Minimum Standards for Detailed Cumulative Impact Assessment Procedure

Risk Assessment Component	Minimum Standard
On-lot Land Application Area (LAA) Assessment	• Daily water and nutrient mass balance modelling on a site specific basis used to derive average annual hydraulic and pollutant loads to surface and subsurface export routes. Viral die-off modelling.
Rainfall-Runoff and Groundwater Recharge	• Continuous daily rainfall-runoff, nutrient and pathogen mass balance modelling using MUSIC (or equivalent) used to derive average annual values.
Background Pollutant Loads / Concentrations	• Sourced from Chapter 2 of Fletcher *et al* (2004). • Acceptable export rates / concentrations sourced from published local studies. • Site specific data where available or necessary.
Surface and Subsurface Pollutant Export	• Site specific calculation of catchment attenuation factors for both surface and subsurface on-site loads based on data obtained through desktop and field site and soil investigations and representative of the characteristics of the receiving environment.[2] • Mass balance combining attenuated on-site system flows and loads with catchment inputs.
Environment and Health Protection Targets[3]	• No more than 10% increase in average annual nitrogen and phosphorus loads (kg/year) based on existing undeveloped background loads. • Average virus concentrations <1 MPN/100ml after application of attenuation rates. • All land application areas sized to ensure hydraulic failure (surcharging) accounts for only 5% of total wastewater generated (i.e. 95% containment via evapo-transpiration and deep drainage).

Note 1: Fletcher et al (2004) available from http://www.catchment.crc.org.au/pdfs/technical200408.pdf.
Note 2: Refer to Section 10.2.1 for explanation of attenuation factor derivation.
Note 3: Site specific targets can be developed and justified on a case by case basis. Outcomes must meet or exceed those achieved by the above targets.

This assessment will require more comprehensive skills and experience in catchment modelling and the modelling of on-site system performance. As such it is only required for very high risk proposals. Nonetheless it is consistent with assessment and modelling approaches for stormwater impact assessment and other potentially polluting activities.

10.3.1 Minimum CIA Outputs to be Provided

As advised in the relevant Minimum Standards tables in the DAF, it is envisaged that Detailed Cumulative Impact Assessments (CIA) will typically be contained in 10-20 pages within the

Wastewater Management Report. The following elements should be provided to enable Council to assess the CIA.

- Summary of approach taken and confirmation of compliance with the Minimum Standards documented in Table 10-8.
- Methodology documenting the basis and source of input data including reference to site specific data, published information or the *Technical Manual* to justify use.
- Summary of results of daily modelling for adopted on-site system types including (as a minimum):
    - Average annual nutrient loads and concentrations:
    - Average annual surface surcharge and deep drainage volumes:
    - Average annual pathogen concentration in deep drainage (where applicable): and
    - Average annual frequency of surface failure (surcharge) of land application systems.
- Summary results of viral dieoff modelling or any other groundwater modelling undertaken.
- Mean annual outputs from the MUSIC (or similar) model.
- Results demonstrating compliance with local water quality objectives and adequate management of health risk as defined and demonstrated in Table 10-6.
- Brief discussion of long-term risks to health and environment and recommended management measures to address impacts.

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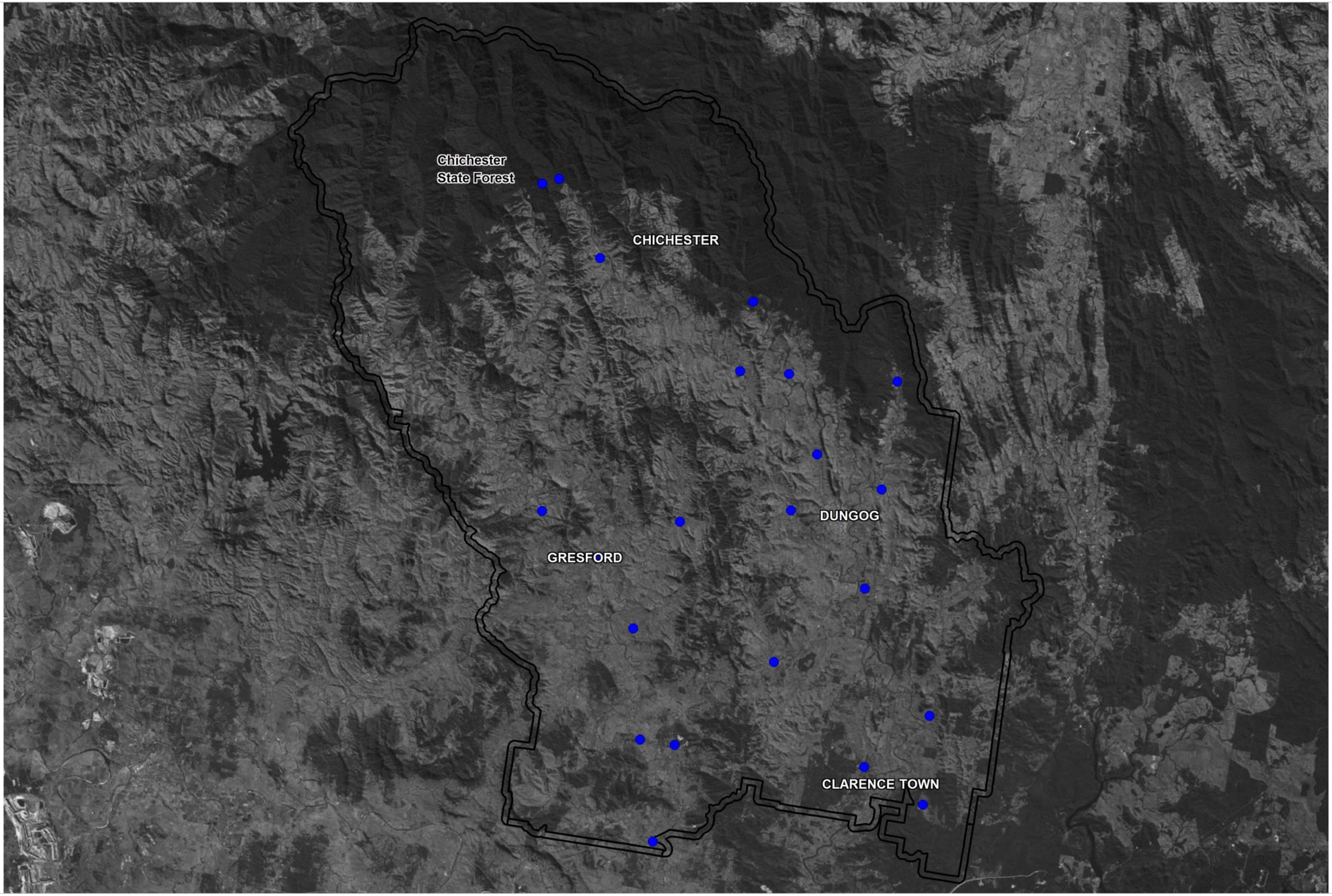
APPENDIX A: SOIL HAZARD CLASSES

CODE	NAME	SOURCE_SET	LANDSCAPE	FINAL SOIL HAZARD	ISM	PWP	FC	DR
bt	BARRINGTON TOPS	Singleton		Low	147.5	99	196	0.5
bi	BIRDSVIEW	Dungog	CObi	High	123.0	80	166	0.75
bia	BIRDSVIEW variant a	Newcastle	ERbia	High	123.0	80	166	0.75
bib	BIRDSVIEW variant b	Newcastle	ERbib	High	123.0	80	166	0.75
bc	BLACK CAMP CREEK	Dungog	STbc	Medium	245.0	100	390	0.25
bh	BOLWARRA HEIGHTS	Newcastle	ERbh	Medium	153.0	108	198	0.25
bn	BONNINGTON	Dungog	ERbn	High	114.5	75	154	0.5
br	BRECON	Dungog	REbr	Medium	158.0	138	178	0.25
bra	BRECON variant a	Newcastle	ERbra	Medium	397.5	251	544	0.75
bg	BRIDGELANDS	Singleton		Medium	147.5	105	190	0.5
cm	CAMBERWELL	Singleton		Low	145.5	102	189	0.5
ci	CHICHESTER	Dungog	COci	Low	300	218	382	0.75
cr	CHICHESTER RIVER	Dungog	ALcr	Low	225	180	270	0.4
cra	CHICHESTER RIVER variant a	Dungog	ALcra	Low	225	180	270	0.4
cia	CHICHESTER variant a	Dungog	COcia	Low	300	218	382	0.75
cib	CHICHESTER variant b	Dungog	COcib	High	98.0	68	128	0.4
cl	CLARENCETOWN	Dungog	ERcl	High	97	50	144	0.1
ch	CLAY HILL	Dungog	COch	High	123.0	80	166	0.75
cha	CLAY HILL variant a	Dungog	ERcha	High	123.0	80	166	0.75
cc	COCKLE CREEK	Newcastle	ALcc	High	160.0	100	220	0.2
cn	COLONEL	Singleton		High	169.5	132	207	0.5
xx	**DISTURBED TERRAIN**	**Newcastle**	**DTxx**	High				
du	DUNGOG	Dungog	ERdu	High	168.0	120	216	0.25
dua	DUNGOG variant a	Dungog	ERdua	High	168.0	120	216	0.25
dub	DUNGOG variant b	Dungog	TRdub	High	168.0	120	216	0.25
gr	GARDINERS ROAD	Dungog	COgr	High	156.0	121	191	0.75
gt	GEORGE TRIG	Newcastle	VEgt	High	78.0	45	111	0.5
gi	GILMORE HILL	Dungog	COgi	High	162.5	102	223	0.25
gia	GILMORE HILL variant a	Dungog	COgia	High	162.5	102	223	0.25
gw	GLEN WILLIAM	Newcastle	ERgw	Medium	158.5	61	256	0.25
gwa	GLEN WILLIAM variant a	Newcastle	TRgwa	Medium	158.5	61	256	0.25
gl	GLENURIE HILL	Newcastle	ERgl	High	114.5	75	154	0.5
gp	GLOUCESTER TOPS	Dungog	REgp	Low	323	237	409	0.75
gpa	GLOUCESTER TOPS variant a	Dungog	REgpa	Medium	323.0	237	409	0.75
gpb	**GLOUCESTER TOPS variant b**	**Dungog**	**SWgpb**	High	1.5	1	2	0.1
gd	GRESFORD	Dungog	ERgd	High	114.0	88	140	0.5
gda	GRESFORD variant a	Dungog	ERgda	High	114.0	88	140	0.5
hb	HALF MOON BRUSH	Dungog	COhb	High	98.0	68	128	0.4
hba	HALF MOON BRUSH variant a	Dungog	ERhba	Medium	165.0	108	222	0.4
hi	HILLDALE	Dungog	ERhi	Medium	97.0	50	144	0.5
hh	HUNGRY HILL	Newcastle	COhh	Medium	273.5	200	347	0.25
hu	HUNTER	Newcastle	ALhu	Low	425	270	580	0.5
ig	INGAR	Singleton		High	217.0	147	287	0.2
im	IRONSTONE MOUNTAIN	Newcastle	COim	High	98.0	68	128	0.75
ima	IRONSTONE MOUNTAIN variant a	Newcastle	ERima	Medium	144.0	90	198	0.75
lb	LAMBS VALLEY	Singleton		High	118.0	68	168	0.25
lr	LAWLERS RANGE	Dungog	COlr	High	98.0	68	128	0.75
ls	LOSTOCK	Singleton		Medium	187.5	147	228	0.5
ma	MARSHDALE	Dungog	ERma	High	114.0	88	140	0.25
maa	MARSHDALE variant a	Dungog	ERmaa	High	114.0	88	140	0.25
me	MEDOWIE	Newcastle	REme	Medium	226.0	198	254	0.5
ml	MERRILONG	Singleton		High	173.0	128	218	0.5
mi	MIDDLEHOPE	Newcastle	ERmi	High	114.0	88	140	0.5
mo	MONKERAI	Dungog	ERmo	High	114.0	80	148	0.4
mb	MOONABUNG	Singleton		Medium	118.0	68	168	0.25
md	MOUNT DOUGLAS	Newcastle	Remd	Low	505	430	580	0.75
mj	MOUNT JOHNSTONE	Newcastle	COmj	Medium	153.0	99	207	0.75
ne	NORTH EELAH	Newcastle	ERne	Medium	191.5	150	233	0.5
ng	NUNGRA	Newcastle	TRng	Medium	90.0	32	148	0.1
pa	PATERSON RIVER	Dungog	ALpa	Medium	257.0	118	396	0.75
rt	RATTLY GROUND	Singleton		Low	300	218	382	0.75
ri	RIVERMEAD	Dungog	REri	Low	323	237	409	0.5
sa	SALISBURY	Dungog	ALsa	Low	257	118	396	0.75
saa	SALISBURY variant a	Dungog	REsaa	Low	257	118	396	0.75
sab	SALISBURY variant b	Dungog	TRsab	Low	257	118	396	0.75
sc	SANDY CREEK	Dungog	ALsc	Low	285	120	450	0.5
se	SEAHAM	Newcastle	ERse	Medium	172.0	135	209	0.5
sea	SEAHAM variant a	Newcastle	COsea	High	172.0	135	209	0.75
st	STANHOPE	Singleton		Medium	182.5	131	234	0.5
tm	TEN MILE ROAD	Dungog	ERtm	Medium	88.5	46	131	0.5
tma	TEN MILE ROAD variant a	Newcastle	ERtma	Medium	88.5	46	131	0.5
tb	THE BRANCH	Newcastle	REtb	Medium	177.0	78	276	0.1
ti	TILLEGRA	Dungog	ERti	Medium	161.5	120	203	0.4
tia	TILLEGRA variant a	Dungog	ERtia	Medium	161.5	120	203	0.4
va	VACY	Newcastle	TRva	Medium	118.0	68	168	0.25
wg	WALLALONG	Newcastle	REwg	High	217.0	147	287	0.2
wt	WANGAT	Dungog	COwt	High	82.0	56	108	0.75
wta	WANGAT variant a	Dungog	ERwta	High	82.0	56	108	0.75
wtb	WANGAT variant b	Dungog	COwtb	High	82.0	56	108	0.75
WATER	**WATER**	**Dungog**	**WATER**					
we	WELSHMANS CREEK	Dungog	ERwe	Medium	150.5	119	182	0.75
wea	WELSHMANS CREEK variant a	Dungog	COwea	Medium	143.0	113	173	0.75
wi	WILLIAMS RANGE	Dungog	COwi	High	80.0	52	108	0.75
wia	WILLIAMS RANGE variant a	Dungog	COwia	High	80.0	52	108	0.75
wib	WILLIAMS RANGE variant b	Dungog	COwib	High	80.0	52	108	0.75
wr	WILLIAMS RIVER	Dungog	ALwr	Low	257	118	396	0.5
wra	WILLIAMS RIVER variant a	Dungog	ALwra	Low	257	118	396	0.5
wm	WOOLOOMA	Singleton		Low	505	430	580	0.75

APPENDIX B: GROUNDTRUTHING



LEGEND

Groundtruthing Site Point

Title:

Dungog Shire Land Capability Hazard Map Groundtruthing

Figure: **A-1**

Rev: **A**

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

N 0 7.5 15km
Approx. Scale

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Filepath : K:\N20168_Dungog_OSSMPlanning\MI\Workspaces\DWG_006_241114_DSC_Groundtruthing.wor

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