ANNEXURE G

Updated Civil Engineering Report

93

CIVIL ENGINEERING REPORT

Concept Plan for a Proposed Residential Subdivision and BioBanking Proposal Steve Eagleton Drive, South West Rocks

December 2013

HOPKINS CONSULTANTS
DEVELOPMENT MANAGERS • SURVEYORS • ENGINEERS • PLANNERS

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Appendix D	Concept Sewer Reticulation Strategy

1 Introduction

Hopkins Consultants have been engaged to prepare Civil Engineering Plans to support the intended residential subdivision of land known as "Settler's Ridge" located at Steve Eagleton Drive, South West Rocks.

The development proposal has been determined by the Department of Planning to be a Major Project under the provisions of the Environmental Planning and Assessment Act 1979. Accordingly, the subdivision proposal requires the lodgement of an Environmental Assessment pursuant to State Environmental Planning Policy (Major Development) 2005.

This Civil Engineering Report has been prepared to support the Environmental Assessment and respond to the Director General's Requirements. This report should be referenced against the Environmental Assessment, and associated reports and plans lodged with that Part 3A application.

2 Subject Site

2.1 Locality

South West Rocks is a Coastal Village with a population of 6,500 on the Mid North Coast of NSW. The village is located 40km north-east of Kempsey near the mouth of the Macleay river, and is about 5 ½ hours drive north of Sydney.

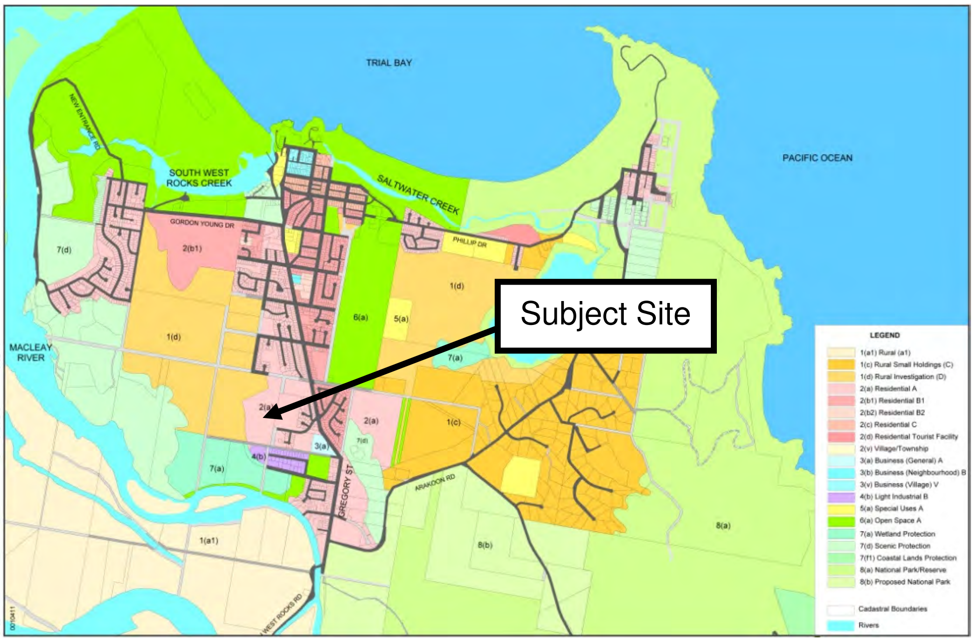
The site has frontage to, and is bound by Gregory Street to the east, Steve Eagleton Drive to the south and the partly formed Keith Andrews Avenue to the north. The land is located between the "old' town of South West Rocks, and more recent residential development that has occurred along Steve Eagleton Drive adjacent 'The Rocks' local shopping centre. The South West Rocks industrial area lies to the south.

The land is undulating and is mostly vegetated. There are no permanent or semi-permanent water-bodies within the study area.

The Real Property description of the subject land is:

- Lot 31 DP 754396 (Lot 31);
- Lot 57 DP 1117398 (Lot 57); &
- Lot 223 DP 754396 (Lot 223).

2.1.1 Locality Map



3 Proposal

The Concept Plan for which approval is sought consists of a number of elements for the purpose of creating a residential subdivision over the site. The proposed civil works associated with the subdivision include:

- Extension of Trevor Judd Avenue providing vehicular access to the land;
- Landscaping/Street tree planting within all road reserves;
- Footpath and Cycleway connections;
- Creation of a bio-retention basin in the site's south abutting the Steve Eagleton Drive extension;
- Extension and augmentation of all associated public infrastructure to provide essential services to the residential neighbourhood.

The concept plan incorporates a variety of allotment sizes, road alignments and widths. The overall plan of subdivision is illustrated in the concept plan contained at **Appendix A**, and the mix of residential lot sizes is summarised in **Table 3.1** below.

Table 3.1 Proposed Residential Lot Sizes

Total No. of residential allotments	**140**
Courtyard allotments 470 – 499m^2	25
Premium courtyard allotments 500 – 599m^2	48
Traditional allotments 600 - 699 m^2	48
Premium traditional allotments 700 m^2 +	19
Balance allotments	1

All lots can be serviced by existing infrastructure with augmentation as necessary. All local infrastructure has been designed to the standards necessary to accommodate this anticipated development which is identified in Council's local DCPs and DSPs, and are commented on in more detail in **Section 4** of this report.

4 Essential Services

4.1 Roads

Trevor Judd Avenue and Steve Eagleton Drive will serve as fully constructed residential streets.

The half-width constructed Keith Andrews Avenue between Bruce Field Street and Rippon Place adjoins part of the north boundary of the site. Widening of Keith Andrews Avenue can be easily and economically provided within the site.

The road and street network is to be constructed as part of the proposed subdivision in accordance with AUSPEC and Kempsey Shire council requirements for public roads. The recommended road reserve widths of Council's DCP 36 for Internal Streets is 16m.

Road longitudinal grades have been kept within normal standards where practicable. Internal streets will have typical cross-falls with kerb and gutter connection to stormwater drainage system via kerb inlet pits and reinforced concrete pipes.

The existing sub-grade conditions will need to be fully investigated by a Geo-technician specifically in relation to California Bearing Ratio prior to a detailed pavement design during the design & documentation phase. Preliminary investigations indicate standard pavement design will be applicable.

Traffic & Access from surrounding streets has been addressed in a separate Traffic Assessment report prepared by Roadnet (also contained with the Technical Papers in support of the EA). This traffic report deems the traffic environment to be capable of accommodating the proposed increase in local traffic volumes.

4.2 Stormwater

An assessment of the drainage characteristics has been carried out & a catchment plan prepared. In addition, a drainage and water quality strategy has been completed for lodgement with the Environmental Assessment.

The development site is not subject to flooding nor has it any permanent or semi permanent watercourses. The site comprises 4 main sub-catchments being:

- Catchment 1 (North-Western Catchment) – 4.82ha:
  - Draining to proposed bio-retention basin located west of the development
- Catchment 2 (Northern Catchment) – 0.70ha :
  - Draining to existing storm water system in Keith Andrews Avenue
- Catchment 3 (North-Eastern Catchment) – 0.67ha:
  - Draining to existing storm water system in Keith Andrews Avenue

- Catchment 4 (Eastern-most Catchment) – 0.33ha:
  - Draining to existing storm water system in Gregory Street
- Catchment 5 (Eastern Catchment) – 1.45 ha:
  - Draining to existing storm water system in Trevor Judd Avenue
- Catchment 6 (South-Eastern Catchment) – 3.51ha:
  - Draining to proposed bio-retention basin located west of Steve Eagleton Drive

It is proposed that the proposed bio-retention basins will be designed and constructed as "dry sand filter" type basin to capture and treat storm water from the development. The basin has been sized to treat and reduce Total Suspended Solids (TSS), Total Phosphorous (TP) and Total Nitrogen (TN). It is proposed that the treatment will reduce these parameters by the current industry standard being:

- TSS = 80%
- TP = 45%
- TN = 45%

A preliminary assessment regarding the proposed bio-retention basins size has been undertaken, however further detailed design and analysis of the basins using the modelling software MUSIC will be required to fine tune the filter media size, filter area, basin size & construction details.

Catchments 2, 3 and 4 connect to existing systems, and as such they will not be incorporated into the detention system.

A plan detailing the proposed drainage strategy, and which illustrates the catchments and proposed bio-retention basin is contained in **Appendix B** to this report.

4.3 Town Water

Town water mains exist in Trevor Judd Avenue, Steve Eagleton Drive and along the full extent of Keith Andrews Avenue (trunk main and local supply mains). Water mains surrounding the site have been previously designed in anticipation of the future site development and will be augmented once the site development proceeds.

The highest sections of the parent Lots 223 & 57 may require some pressure boosting to achieve satisfactory pressures. This will be subject to further negotiations with Kempsey Shire Council at the detailed engineering design stage.

Concept plans for the water reticulation of the residential project have been prepared and are contained in **Appendix C**.

4.4 Town Sewer

There are 6 sewer catchments within the proposed development, these are shown on the sewer reticulation plan contained in **Appendix D.**

- Catchment 1 (Western Catchment):
  - Gravity feeds to a pump station west of the development which then pumps via a rising main into the existing sewer system in Keith Andrews Avenue
- Catchment 2 (North-Western Catchment):
  - Gravity feeds to existing sewer system in Keith Andrews Avenue
- Catchment 3 (North-Eastern Catchment):
  - Gravity feeds to existing sewer system in Gregory Street
- Catchment 4 (Middle-Eastern Catchment):
  - Gravity feeds to existing sewer system in Trevor Judd Avenue
- Catchment 5 (South-Eastern Catchment):
  - Gravity feeds to existing sewer system in Mertens Place
- Catchment 6 (South-Western Catchment):
  - Gravity feeds to a pump station west of Steve Eagleton Drive which then pumps via a rising main into the existing sewer system further east along Steve Eagleton Drive

It is anticipated that the new sewer pump station will be designed and constructed to Kempsey Shire Council standards and handed over to council as public assets.

4.5 Electricity

Underground electricity with pad-mount transformers exist adjoining the site in Trevor Judd Avenue and Steve Eagleton Drive. High voltage overhead and low voltage underground supply exists along the Keith Andrews Avenue frontage (northern boundary of the site).

It is proposed to have Country Energy or an Accredited Electrical designer prepare an electrical services plan to extend the power supply into this subdivision. The electrical conduits would be located in the area allocated for services in the footpath.

An electrical servicing plan will be prepared during the detailed design phase.

4.6 Telephone Services

Underground facilities adjoin the site in Trevor Judd Avenue, Steve Eagleton Drive and Keith Andrews Avenue. All services have capacity to be augmented to connect with the residential project. As this development exceeds 100 Lots it will need to be registered with NBN for provisioning.

It is proposed that telecommunications pit & pipe will be designed and constructed under a shared trench arrangement with the electrical supply.

A telecommunications layout plan will be prepared during the detailed design phase.

6 Conclusion

The subject site has been zoned for residential purposes since 1987. In the twenty-four years since, all services infrastructure for residential development of the locality have been completed to the east, south & north. All such works have been designed and co-ordinated to take into consideration the eventual residential development of this site as per Kempsey Shire Council's urban growth strategies for South West Rocks.

Moreover, Kempsey Shire Council has DCPs in place which anticipate this development accordingly, and Kempsey Council's Engineering Guidelines Code DCP 36 has been utilised to design and construct the integrated residential development. Those guidelines will be adhered to within the design plans for the site.

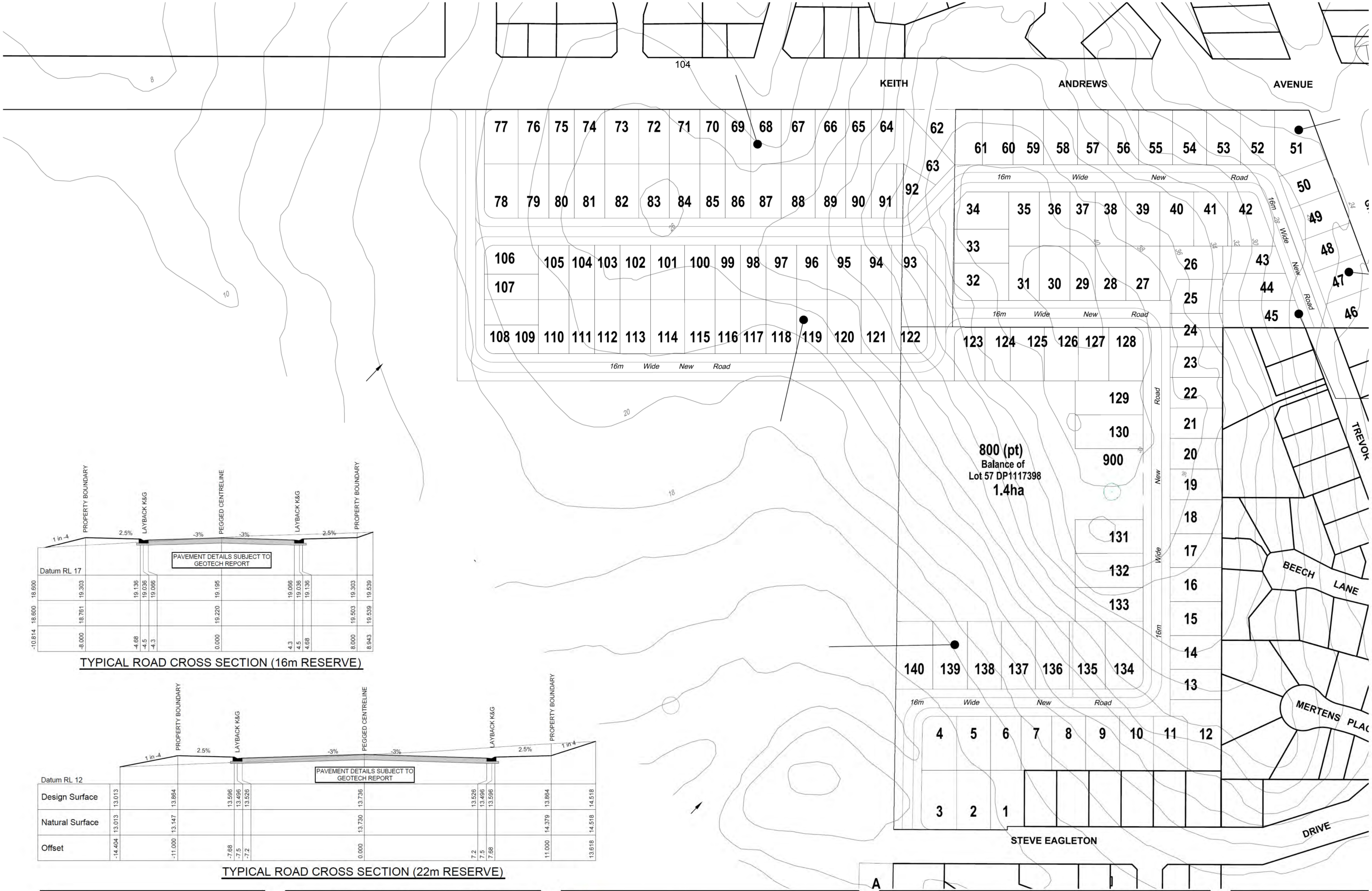
Principal infrastructure components of the concept plan are:

1. Kerbed and sealed sheets;
2. Concrete footpaths;
3. Traffic calming;
4. Stormwater drainage to AR & R specifications;
5. Functional accesses to all lots;
6. Water Sensitive Urban Design and ongoing water quality maintenance infrastructure;
7. Town water, sewer and electricity and telephone services to standard designs and within registered easements where required;
8. Detailed erosion and sediment control strategies during civil construction and construction maintenance.

All such items of infrastructure will be detailed at the Development Application and/or Construction Certificate phase.

APPENDIX A

Concept Plan of Residential Subdivision



No.	DATE	REVISIONS	BY

SETTLERS RIDGE

SOUTH WEST ROCKS

HOPKINS CONSULTANTS PTY LTD
Suite 1 / 109 William Street · PO Box 1556 Port Macquarie NSW 2444 · ABN 27 055 060 878
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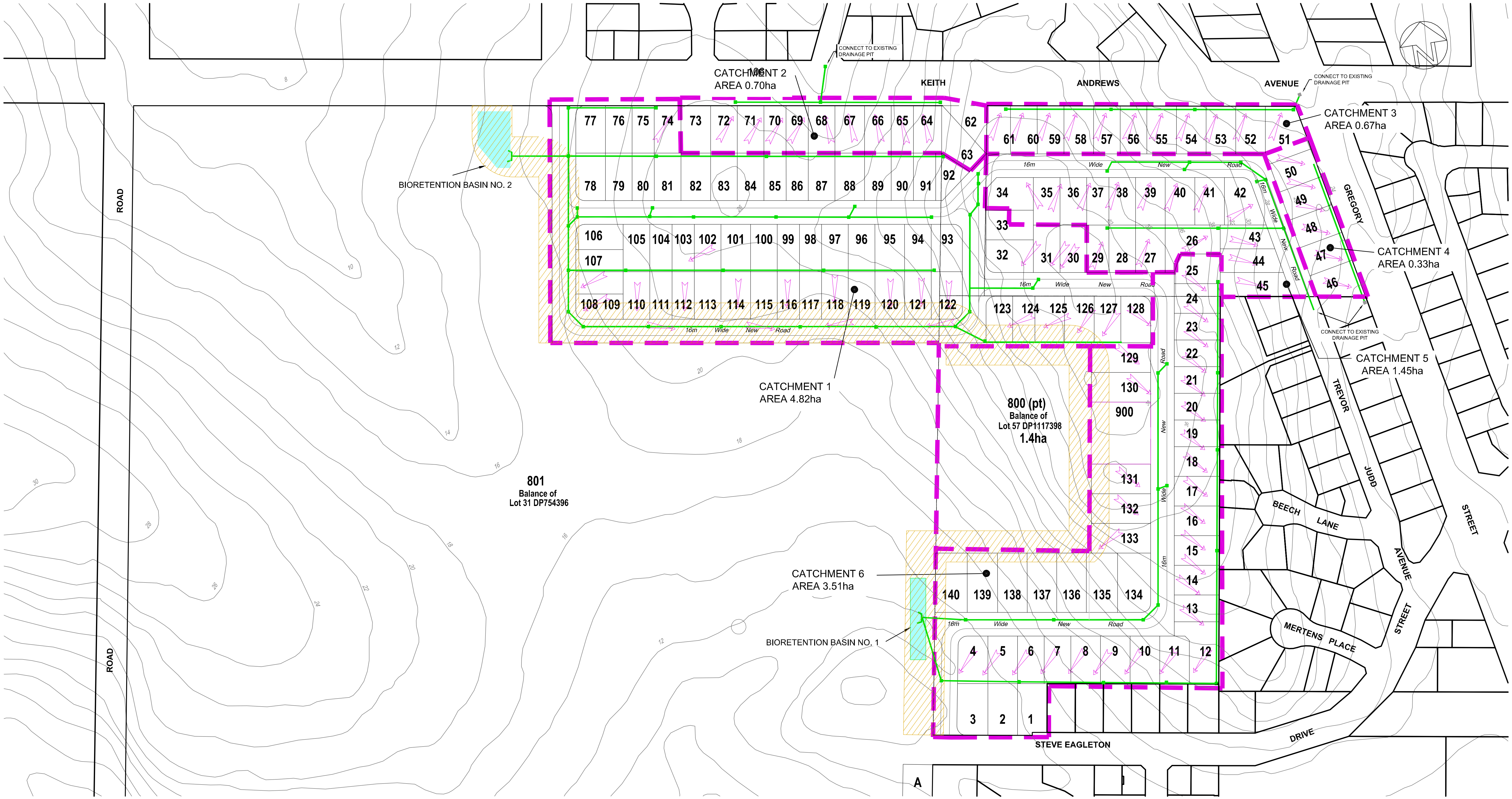
DEVELOPMENT MANAGERS · SURVEYORS · ENGINEERS · PLANNERS

PLAN OF PROPOSED SUBDIVISION
LOT 31 & 223, DP754396 & LOT 57, DP1117398

Drawing number/reference: 6383-0003-01
Drafting: GA
Datum: AHD
Approved: AL
Scale: 1:1000

APPENDIX B

Proposed Drainage Strategy



LEGEND

- ASSET PROTECTION ZONE
- PROPOSED DRAINAGE STRATEGY
- DRAINAGE CATCHMENT AREAS
- BIORETENTION BASIN

NOTE;
ALL DIMENSIONS, AREAS, LOT LAYOUTS & SERVICES DESIGN ARE SUBJECT TO FINAL SURVEY, DETAILED DESIGN WORKS, ENVIRONMENTAL STUDIES & APPROVAL BY PORT MACQUARIE HASTINGS COUNCIL.

BIORETENTION BASIN

- BIORETENTION BASIN
CATCHMENT AREA 2 : 12.54ha
BASIN AREA: 3140m² (APPRX 2.5% OF CATCHMENT)

No.	DATE	REVISIONS	BY
A	17.12.2013	ASSET PROTECTION ZONE & AMENDED BIORETENTION	SR
A	12.12.2013	REVISED STORMWATER	SR

SETTLERS RIDGE

SOUTH WEST ROCKS

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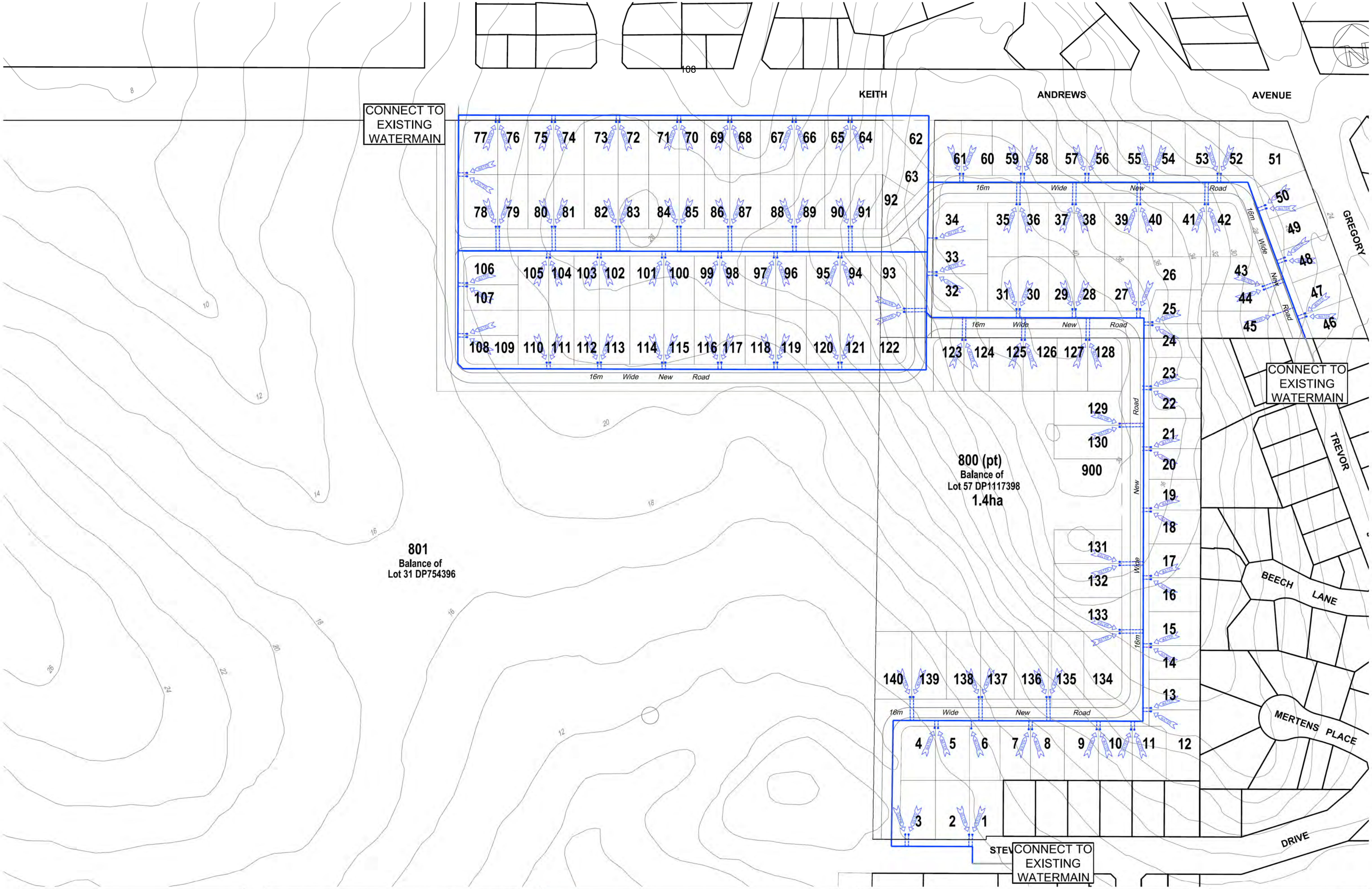
PROPOSED DRAINAGE STRATEGY
LOT 31 & 223, DP754396 & LOT 57, DP1117398

Drawing Number/Reference: 6383-0003-02		Rev: B
Designer: GA	Origin of Levels	Date: 23-5-2013
Surveyor	Height	Sheet Size: A1
Drafting: GA	Datum: AHD	Sheet No: 02
Approved: AL	Scale: 1:1250	Total: 04

APPENDIX C

Concept Water Reticulation Strategy



No	DATE	REVISIONS	BY
-			

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WATER RETICULATION
LOT 31 & 223, DP754396 & LOT 57, DP1117398

DRAWING NUMBER/REFERENCE: 6383-0003-03		REV.
DESIGNED: GA	ORIGIN OF LEVELS	DATE: 23-5-2013
SURVEYOR	HEIGHT	SHEET SIZE: A1
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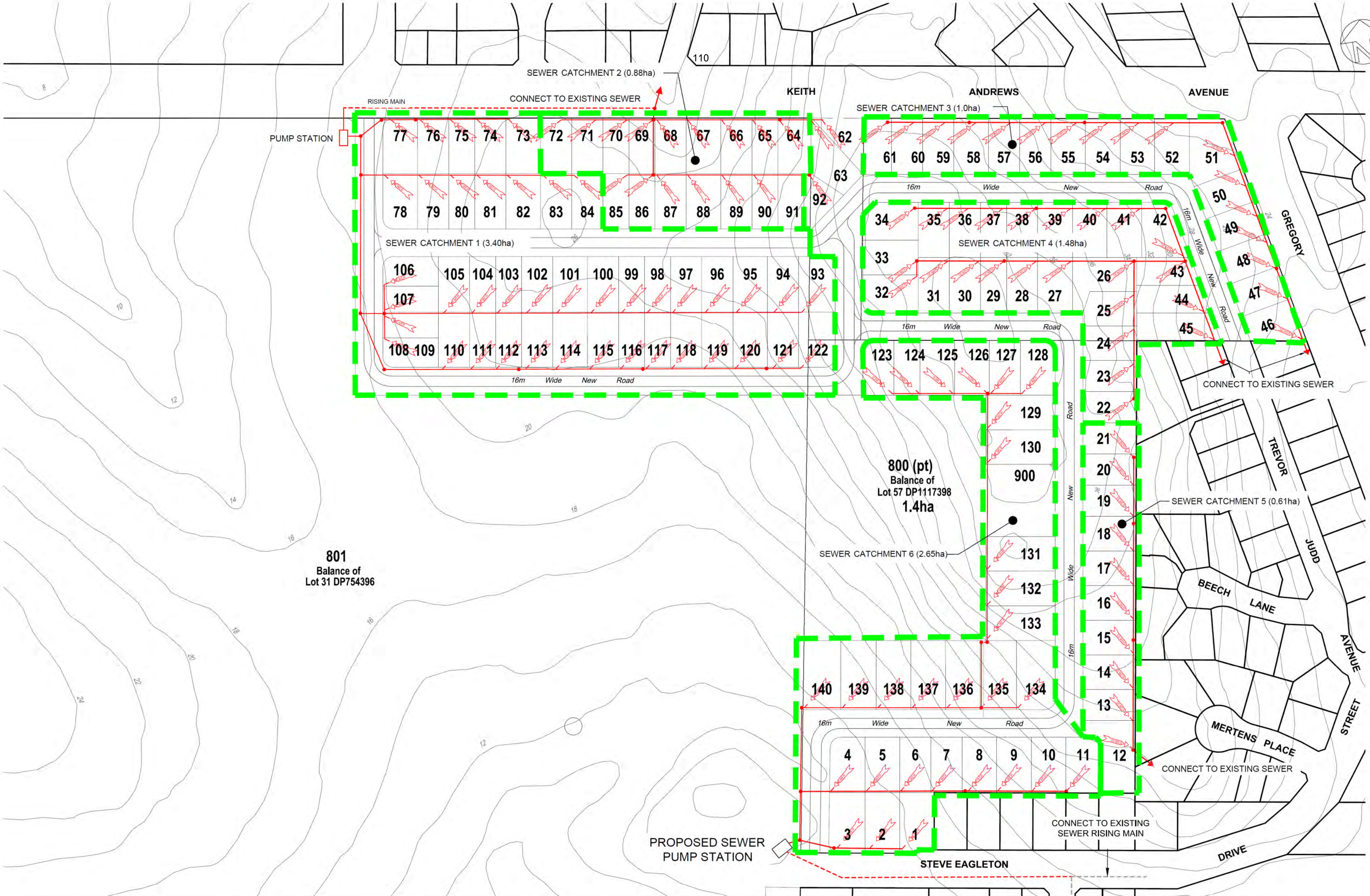
APPROVED: AL	SCALE: 1:1000	TOTAL: 04

APPENDIX D

Concept Sewer Reticulation Strategy



No.	DATE	REVISIONS	BY
A	12.12.2013	REVISED SEWER RETICULATION	SR

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SEWER RETICULATION
LOT 31 & 223, DP754396 & LOT 57, DP1117398

DRAWING NUMBER/REFERENCE: 6383-0003-04		REV: A
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SURVEYOR	HEIGHT	SHEET SIZE: A1
DRAFTING: GA	DATUM: AHD	SHEET NO: 04
APPROVED: AL	SCALE: 1:1000	TOTAL: 04

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PTY LTD

WINNER 2009

Directors

MICHAEL S MOWLE
B E Civ (Hons)
Chartered Engineer

GEOFFREY E HILL
B Surv
Registered Land Surveyor

DANIEL J BAKER
B Surv
Registered Land Surveyor

DARREN J BOOTH
B Surv
Registered Land Surveyor

17th February 2014

Our Ref: 6383
Your Ref:

Steve Connelly
Planners North
PO Box 538
LENNOX HEAD NSW 2478

Dear Steve,

RE: 6383 – Settlers Ridge General Services Layout Agreement

With regards to the proposed sub-division in South West Rocks referred to as Settlers Ridge.

Michael Mowle and I met with members of Kempsey Shire Council (KSC) on the 21st of January 2014, namely Kate Albury and Tony Castle.

During this meeting the drawings 6383-0003-01 to 04 were shown. The general engineering design concepts were proposed and discussed.

KSC agreed that the drawings were satisfactory for lodgement for DA purposes and appear to generally conform with Councils requirements.

Should you have any queries, please do not hesitate to contact the undersigned.

Yours faithfully,
HOPKINS CONSULTANTS Pty Limited

Jonathon Rounsley
BEng(Civil)/BSc(Geology & Management)
Civil Engineer

ABN 27 055 060 878
Suite 1, 109 William St
PO Box 1556, Port Macquarie 2444 NSW
Telephone: 02 6583 6722 Facsimile: 02 6584 9009
Email: mail@hopcon.com.au

TYPICAL ROAD CROSS SECTION (16m RESERVE)

TYPICAL ROAD CROSS SECTION (22m RESERVE)

No.	DATE	REVISIONS	BY

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Drawing Number/Reference: 6383-0003-01
Designer:
Origin of Levels:
Surveyor:
Height:
Drafting: GA
Datum: AHD
Approved: AL
Scale: 1:1000

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LOT 31 & 223, DP754396 & LOT 57, DP1117398

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REV.	B
DESIGNER	GA
ORIGIN OF LEVELS	
DATE	23-5-2013
SURVEYOR	
HEIGHT	
SHEET SIZE	A1
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Designer: GA	Origin of Levels	Date: 23-5-2013
Surveyor	Height	Sheet Size: A1
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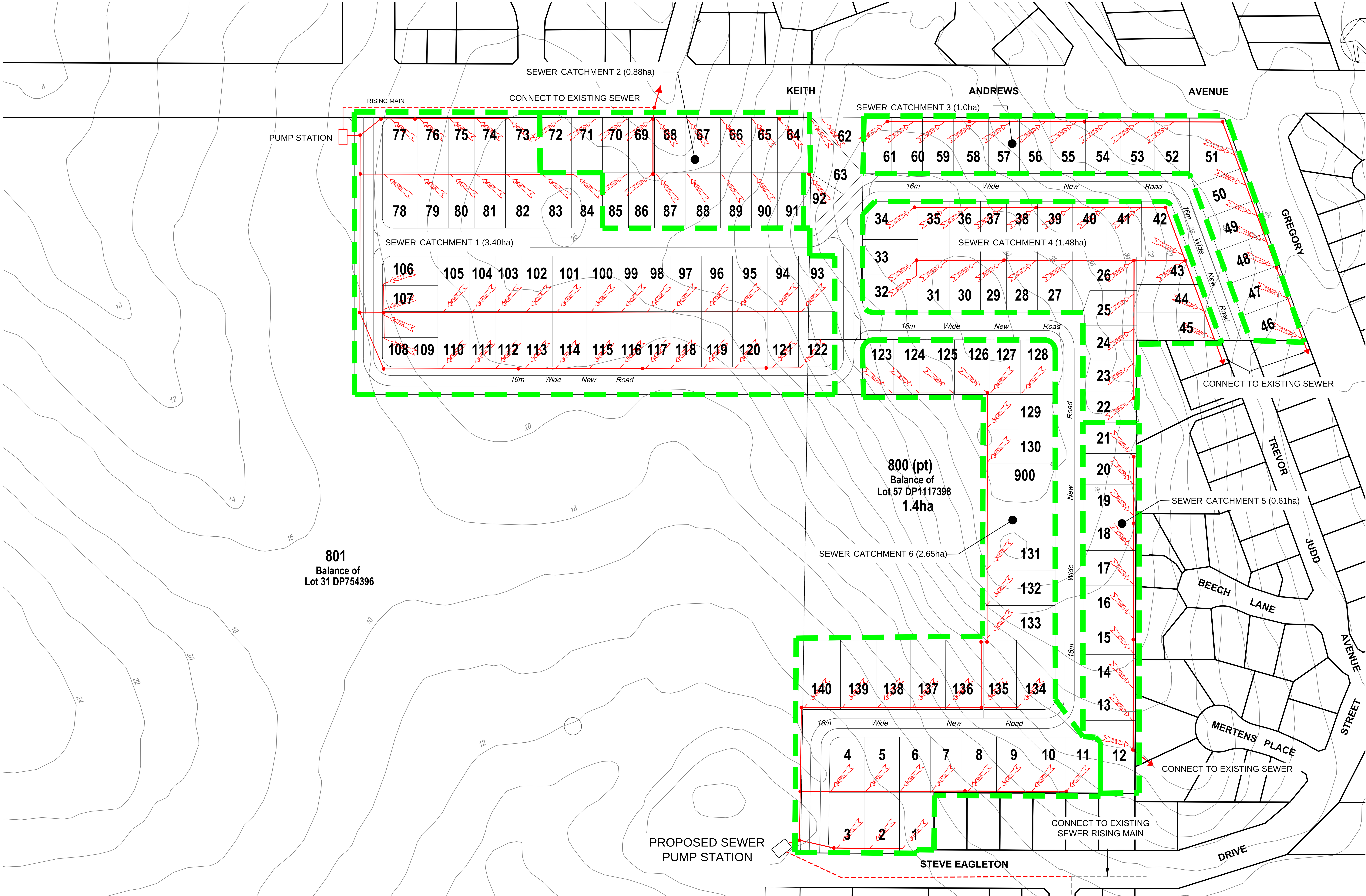

No.	DATE	REVISIONS	BY
A	12.12.2013	REVISED SEWER RETICULATION	SR

SETTLERS RIDGE

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LOT 31 & 223, DP754396 & LOT 57, DP1117398

DRAWING NUMBER/REFERENCE: 6383-0003-04		REV.: A
DESIGNER: GA	ORIGIN OF LEVELS	DATE: 23-5-2013
SURVEYOR	HEIGHT	SHEET SIZE: A1
DRAFTING: GA	DATUM: AHD	SHEET No.: 04
APPROVED: AL	SCALE: 1:1000	TOTAL: 04

ANNEXURE H

Updated Geotechnical Report

Planners North

Proposed Subdivision, Settlers Ridge, South West Rocks

Slope Stability Assessment

Report No. RGS20027.1-AE

25 November 2013

REGIONAL GEOTECHNICAL SOLUTIONS

Manning-Great Lakes
Port Macquarie
Coffs Harbour

RGS20027.1-AE

25 November 2013

Planners North
PO Box 538
6 Byron Street
LENNOX HEAD NSW 2478

Attention: Mr Stephen Connelly

Dear Stephen,

RE: Proposed Subdivision, Settlers Ridge, South West Rocks

Slope Stability Assessment

As requested, Regional Geotechnical Solutions Pty Ltd (RGS) has undertaken a geotechnical slope stability assessment at the site of the proposed urban subdivision at Settlers Ridge, South West Rocks.

RGS has previously undertaken a geotechnical investigation of the site, Report RGS20027.1-AC, which includes surface and subsurface descriptions of the site and should be referred to as required.

The slope stability assessment was undertaken to reflect the recently revised lot layout. Provided the recommendations within this report are adopted and good engineering practices are followed, the development would be considered to have an overall **Low** risk of slope instability.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Tim Morris

Senior Engineering Geologist

Table of Contents

Figures

Appendices

1 INTRODUCTION

This report presents the results of a geotechnical slope stability assessment undertaken by Regional Geotechnical Solutions Pty Ltd (RGS) for the proposed Settlers Ridge subdivision located at South West Rocks.

RGS has previously undertaken a geotechnical investigation of the site, Report RGS20027.1-AC. That report includes a surface and subsurface description of the site and should be referred to as required.

The proposed subdivision will comprise:

- 137 low density residential lots;
- Two lots for on-site biodiversity offsetting;
- One active open space lot; and
- Internal road network layout and associated civil infrastructure.

The purpose of the work described herein was to address conditions outlined by the Department of Planning & Infrastructure that need to be met before development applications can be submitted. This includes Condition C11 (Geotechnical Assessments) which comprises:

1. *A geotechnical map of the site clearing showing ground surface contours, geotechnical engineering soil types and any geotechnical hazards. The delineation of hazards should include hazard locations and possible hazard impact areas. The map should be accompanied by explanatory text describing the nature and delineation of soil types and hazard types. The map and text should be prepared by a suitably qualified geotechnical practitioner; and;*
2. *A synthesis site plan clearly showing ground surface contours and the location of all test pits, boreholes and monitoring wells drilled on to the site to date*.

The risk of slope instability at the site was reassessed to reflect the lot layout which has been revised since the original geotechnical investigation. The assessment was undertaken using the principles and protocols of the Australian Geomechanics Society publication *Practice Note Guidelines for Landslide Risk Management, 2007*.

2 PROPOSED DEVELOPMENT

For the purpose of this report it is anticipated that the proposed residential subdivision development will be for single to double storey residential buildings and will include associated civil infrastructure works. The proposed lot layout is shown on Figure 1. It is expected that some excavations (up to about 1 to 2m) may be undertaken across the site although exact details are not yet known.

3 FIELD WORK

Field work for the original assessment was undertaken in 2009 and included excavation of 15 test pits by a mini-excavator. Test pits were logged and sampled by an Engineering Geologist. Test pit logs, laboratory testing results and a description of the site conditions is provided in Report RGS20027.1-AC.

Field work for the recent assessment was undertaken on 7 November 2013 by an Engineering Geologist and comprised a site walkover with observation of geotechnical conditions on the site, including measurement of slope angles and assessment of the topographic setting in relation to the slopes.

4 SITE CONDITIONS

4.1 Surface conditions

The site is situated in moderately undulating topography to the north east of Spencers Creek, a tributary of the Macleay River. It is bounded by Keith Andrews Drive to the north, an unformed Crown Road to the west, Spencers Creek road to the south and residential subdivisions to the east adjacent to Steve Eagleton Drive, Trevor Judd Avenue and Gregory Street.

The proposed residential subdivision will comprise 137 residential allotments, access roads and areas of open space as shown in Figure 1.

The dominant landforms within the site comprise the following;

- North-north-west trending ridge in the east of the site. The ridge has a broad crest with slopes of 1° to 3°, while the upper ridge slopes have slope angles ranging from 7° to 15°. A spur extends to the north west from the ridge linking to an isolated knoll located in the north of the site opposite Pisces Place. Surface elevations across the ridge range from 12m AHD on the lower slopes to 40m AHD on the crest;
- North-west trending ridge located in the south west corner of the site outside the area of the proposed development. The upper slopes face north-east and south-west and slope angles range from 3° to 7°. Surface elevations range from 10m AHD to 28m AHD;
- A broad gently sloping saddle orientated north east is located between the two ridges and separates the local water catchments present on the site. The elevation of the saddle at its low point is approximately 18mAHD;
- An isolated sandy knoll is present in the south east corner of the site with slope angles of up to 7° on the upper slopes, grading down to less than 2° on the lower slopes. Surface elevations range from 16m AHD on the crest of the knoll to 4m AHD on the lower slopes;
- Intermittent drainage lines and depressions are present in low lying areas and drain either north west or to the south.

An image of the site taken from the NSW Department of Property Information website is reproduced below.

Settlers Ridge site boundary outlined in red. Approximate extent of proposed residential subdivision outlined in blue.

The site is thickly vegetated with mature eucalypts and a thick understory of shrubs and native grasses. Paperbark trees were present in the drainage depressions in the north and south of the site.

4.2 Subsurface Conditions

The 1:25,000 Kempsey Quaternary Geology Map indicates the site is underlain by greywacke, siltstone and conglomerate of the Kempsey Beds in the elevated areas in the west of the site, residual soils overlying the Smoky Cape Adamellite (granite) in the east of the site and Pleistocene aeolian sand deposits overlying the lower slopes in the centre of the site.

The South West Rocks 1:25,000 Acid Sulfate Soils (ASS) Risk Map indicates that the aeolian sand deposits present in the north of the site have a low risk of ASS at a depth of greater than 3m from surface.

Site observations and investigations revealed four distinctly different geological profiles on the site associated with topographical features. On the basis of the surface conditions and subsurface profiles encountered, the site was divided into four geotechnical terrains as summarised in the following sections and shown on Figure 1. Detailed descriptions of the geological profiles encountered are provided in Report RGS20027.1-AC.

4.2.1 Terrain A: Alluvial Drainage Depressions

Located in intermittent drainage lines and drainage depressions the soil profile typically consisted of organic silts and clays overlying alluvial sandy clays and clayey sands. Ground water levels were high at the time of the original investigation. This terrain is situated outside of the proposed residential subdivision.

4.2.2 Terrain B: Aeolian Dunes

Located in gently to moderately undulating terrain in the south east corner of the site the soil profile typically consisted of thin sandy topsoil overlying ancient aeolian sand dunes.

4.2.3 Terrain C: Lower to Middle Ridge Slopes

Located on the lower to middle ridge slopes with surface slope angles of 3 to 7° the soil profile typically consisted of colluvial clayey sands overlying residual clay soils that graded into extremely weathered granite clays.

4.2.4 Terrain D: Ridge Crest and Upper Ridge Slopes

Located on the broad ridge crests and upper ridge slopes with surface slope angles of 7 to 15°. Granite cobbles and boulders were typically present on the surface. The soil profile typically consisted of shallow colluvial soils overlying extremely weathered granite clays that included large granite corestone boulders.

Selected images of the Terrain D landscape are presented below.

Terrain D - Granite boulders on surface of upper ridge slope.

Granite boulder on surface of existing subdivision at Mertens Place.

5 SLOPE STABILITY ASSESSMENT

5.1 Risk Assessment

The risk of slope instability has been assessed using the principles and protocols of the Australian Geomechanics Society publication *Practice Note Guidelines for Landslide Risk Management, 2007*. This methodology represents the currently accepted state of practice for landslide risk assessment.

The slope risk assessment process involves identification of a potential slope failure event, or hazard, followed by an estimation of the likelihood of the event occurring, and the potential consequences should the event occur.

The terms used in the risk assessment process are defined below:

Hazard: A condition with the potential for causing an undesirable consequence.

Likelihood: The estimated probability that the hazardous event will occur.

Consequence: Loss or damage resulting from a hazard event.

Risk: A term combining the likelihood and consequence of an event in terms of adverse effects to property or the environment.

5.2 Hazard Identification

The following potential slope stability hazards were assessed in relation to the site and the proposed development:

Hazard 1: Deep seated rotational or translational failure caused by sliding of the site soil profile over a plane of weakness such as a clay seam or zone of water concentration within the underlying soil or rock mass on the upper ridge slopes (Terrain D). Should such a failure occur it could potentially cause extensive structural damage and require large scale, costly repairs, and possibly temporary evacuation of the building until repairs are complete;

Hazard 2: Small scale rotational failure (<10m^3) in Terrain B, C or D due to destabilisation of slope by un-retained excavations. Such a failure could cause minor damage to structures and impact the ongoing utility of the site until repairs are undertaken;

Hazard 3: Small scale toppling failure of large granite boulder in Terrain D due to destabilisation of slope by un-retained excavations. Such a failure could cause minor damage to structures and impact the ongoing utility of the site until repairs are undertaken;

Hazard 4: Soil creep. Creep is an imperceptibly slow movement that takes place on sloping soil sites such as Terrains B, C and D. It is an ongoing, natural slope process involving the progressive downslope movement of soils over the underlying rock profile. Creep will occur within the upper sandy profile above the underlying granite boulders, and will require management by undertaking good hillside construction practice as recommended in this report.

Potential hazard areas are summarised on Figure 1.

5.3 Risk Evaluation for Existing Site Conditions

Table 1 summarises the factors affecting slope stability in relation to each of the hazards identified and assesses the risk of slope instability for each using the risk assessment matrix provided in Appendix C of the Australian Geomechanics Society (AGS) publication *Practice Note Guidelines for Landslide Risk Management, 2007*. A copy of the risk matrix from the AGS document is provided in Appendix A.

Table 1: Slope Risk Assessment Based on AGS2007 method

Hazard	H1 Deep failure	H2 Localised failure of unsupported cuts	H3 Small scale toppling failure of granite boulders	H4 Soil Creep
Slope height	N/A	Approx. 2m	Approx. 2m	N/A
Cause or trigger	Slope deterioration followed by extreme weather (1in 10000yr event)	Cut steeper than angle of repose, unsupported, high rainfall (1 in 10yr event)	Granite boulder destabilised by excavation works	Ongoing process of imperceptibly slow soil movement
Proportion of slope affected	0.1	0.01	0.01	1
Estimated annual probability	10^{-5}	10^{-2}	10^{-2}	10^{-1}
Likelihood	Rare	Likely	Likely	Almost Certain
Consequence	Major	Minor	Minor	Insignificant
Risk	Low	Medium	Medium	Low

5.4 Evaluation of Risk Level

It is noted that the assessment presented in Table 1 indicates a **Medium** risk of slope instability affecting potential unsupported cuts on this site. This risk can be reduced to **Low** by adopting the recommendations of the previous Report RGS20027.1-AC, regarding maximum unsupported cut heights, batter angles, and retaining wall design.

Provided the recommendations within this report are adopted and good engineering practices are followed, the development would be considered to have an overall **Low** risk of slope instability. This risk rating would normally be considered acceptable in Australia for hillside residential construction.

6 GEOTECHNICAL DESIGN CONSIDERATIONS

The Australian Geomechanics Society published a series of documents providing guidelines for Landslide Risk Management in 2007. The documents included recommendations on Good Hillside Practice. It is recommended that development at this site be undertaken in accordance with good hillside practice as summarised on the documents reproduced in Appendix B, and the specific recommendations of this report.

The following recommendations are made with regard to development at this site:

- All excavations exceeding 1.0m depth should be supported by engineer designed retaining walls.
- In the residual sandy clays, temporary batters of 1H:1V would be appropriate. Permanent batters in these materials should not exceed 2H:1V. In the aeolian sands temporary batters of 2H:1V would be appropriate and permanent batters should not exceed 3H:1V.
- Building types that accommodate the existing slope and reduce the need for cutting and filling would be preferred in Terrain D. Options include split level developments designed to terrace up the slope, pier and beam construction, or pole house style construction.
- Use of vegetation to reduce soil moisture and bind the soil structure. (Care should be taken with regards to planting near foundations, as soil moisture changes can significantly affect some types of foundation).
- Use and maintenance of drainage structures that direct rainfall and surface water downslope from the items at risk. In particular runoff water should be directed downslope of all fill and retaining structures. These should be 'self flushing' where possible, to reduce blockages from leaves and other debris.
- Maintenance of retaining structures – including reduction of vegetation growing within retaining walls, and regular maintenance of groundwater weep structures.
- Regular observation of the site conditions noting changes to surface water regime and changes in shape to retaining structures.

7 LIMITATIONS

The findings presented in the report and used as the basis for recommendations presented herein were obtained using normal, industry accepted geotechnical design practises and standards. To our knowledge, they represent a reasonable interpretation of the general condition of the site. Under no circumstances, however, can it be considered that these findings represent the actual state of the site at all points. If site conditions encountered during construction vary significantly from those discussed in this report, Regional Geotechnical Solutions Pty Ltd should be contacted for further advice.

This report alone should not be used by contractors as the basis for preparation of tender documents or project estimates. Contractors using this report as a basis for preparation of tender documents should avail themselves of all relevant background information regarding the site before deciding on selection of construction materials and equipment.

If you have any questions regarding this project, or require any additional consultations, please contact the undersigned.

For and on behalf of

Regional Geotechnical Solutions Pty Ltd

Tim Morris

Senior Engineering Geologist

Figure

RGS20027.1 – Geotechnical Terrain Summary

Terrain*	Name	Topography	Subsurface Profile	Slope Hazards**
A	Drainage Depressions	Poorly drained alluvial depressions present below approximately 10m AHD.	Organic silts and clays overlying alluvial sands/clays	H2 – Localised failure of unsupported cuts
B	Aeolian Dunes	Undulating dunes with slope angles from 0 to 7°	Thin sandy topsoil horizon overlying aeolian sands	H2 – Localised failure of unsupported cuts H4 - Creep
C	Residual Slopes	Lower to middle ridge slopes with slope angles from 0 to 7°	Topsoil and sandy slopewash overlying residual clays grading to extremely weathered granite	H2 – Localised failure of unsupported cuts H4 - Creep
D	Ridge Crest and Upper Slopes	Broad, near flat ridge crests grading down onto upper ridge slopes, uneven in places with slope angles from 7 to 15°.	Granite cobbles/boulders on surface, thin topsoil and colluvial soils overlying extremely weathered granite clay soils that include high strength granite core stone boulders.	H1 – Deep failure H2 – Localised failure of unsupported cuts H3 – Granite boulder destabilised by excavation works H4 - Creep

*Refer Report RGS20027.1-AC for detailed terrain description
**Refer Report RGS20027.1-AE for detailed hazard description

Based on supplied drawing titled "Proposed Layout", dated 30 October 2013

REGIONAL GEOTECHNICAL SOLUTIONS

Client	PLANNERS NORTH	Job No.	RGS20027.1
Project:	SETTLERS RIDGE SUBDIVISION	Drawn By:	TLM
	SOUTH WEST ROCKS	Date:	25-November-2013
Title:	GEOTECHNICAL TERRAINS AND SLOPE HAZARDS	Drawing No.	[illegible] 1

Appendix A

Risk Matrix – AGS 2007

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: LANDSLIDE RISK ASSESSMENT

QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY

QUALITATIVE MEASURES OF LIKELIHOOD

Approximate Annual Probability		Implied Indicative Landslide Recurrence Interval		Description	Descriptor	Level
Indicative Value	**Notional Boundary**					
10^{-1}	$5x10^{-2}$	10 years	20 years	The event is expected to occur over the design life.	ALMOST CERTAIN	A
10^{-2}	$5x10^{-3}$	100 years	200 years	The event will probably occur under adverse conditions over the design life.	LIKELY	B
10^{-3}	$5x10^{-4}$	1000 years	2000 years	The event could occur under adverse conditions over the design life.	POSSIBLE	C
10^{-4}	$5x10^{-5}$	10,000 years	20,000 years	The event might occur under very adverse circumstances over the design life.	UNLIKELY	D
10^{-5}	$5x10^{-6}$	100,000 years	200,000 years	The event is conceivable but only under exceptional circumstances over the design life.	RARE	E
10^{-6}		1,000,000 years		The event is inconceivable or fanciful over the design life.	BARELY CREDIBLE	F

Note: (1) The table should be used from left to right; use Approximate Annual Probability or Description to assign Descriptor, not *vice versa*.

QUALITATIVE MEASURES OF CONSEQUENCES TO PROPERTY

Approximate Cost of Damage		Description	Descriptor	Level
Indicative Value	**Notional Boundary**			
200%	100%	Structure(s) completely destroyed and/or large scale damage requiring major engineering works for stabilisation. Could cause at least one adjacent property major consequence damage.	CATASTROPHIC	1
60%	40%	Extensive damage to most of structure, and/or extending beyond site boundaries requiring significant stabilisation works. Could cause at least one adjacent property medium consequence damage.	MAJOR	2
20%	10%	Moderate damage to some of structure, and/or significant part of site requiring large stabilisation works. Could cause at least one adjacent property minor consequence damage.	MEDIUM	3
5%	1%	Limited damage to part of structure, and/or part of site requiring some reinstatement stabilisation works.	MINOR	4
0.5%		Little damage. (Note for high probability event (Almost Certain), this category may be subdivided at a notional boundary of 0.1%. See Risk Matrix.)	INSIGNIFICANT	5

Notes: (2) The Approximate Cost of Damage is expressed as a percentage of market value, being the cost of the improved value of the unaffected property which includes the land plus the unaffected structures.

(3) The Approximate Cost is to be an estimate of the direct cost of the damage, such as the cost of reinstatement of the damaged portion of the property (land plus structures), stabilisation works required to render the site to tolerable risk level for the landslide which has occurred and professional design fees, and consequential costs such as legal fees, temporary accommodation. It does not include additional stabilisation works to address other landslides which may affect the property.

(4) The table should be used from left to right; use Approximate Cost of Damage or Description to assign Descriptor, not vice versa

PRACTICE NOTE GUIDELINES FOR LANDSLIDE RISK MANAGEMENT 2007

APPENDIX C: – QUALITATIVE TERMINOLOGY FOR USE IN ASSESSING RISK TO PROPERTY (CONTINUED)

QUALITATIVE RISK ANALYSIS MATRIX – LEVEL OF RISK TO PROPERTY

LIKELIHOOD		CONSEQUENCES TO PROPERTY (With Indicative Approximate Cost of Damage)				
	Indicative Value of Approximate Annual Probability	1: CATASTROPHIC 200%	2: MAJOR 60%	3: MEDIUM 20%	4: MINOR 5%	5: INSIGNIFICANT 0.5%
A – ALMOST CERTAIN	10^{-1}	VH	VH	VH	H	M or L (5)
B - LIKELY	10^{-2}	VH	VH	H	M	L
C - POSSIBLE	10^{-3}	VH	H	M	M	VL
D - UNLIKELY	10^{-4}	H	M	L	L	VL
E - RARE	10^{-5}	M	L	L	VL	VL
F - BARELY CREDIBLE	10^{-6}	L	VL	VL	VL	VL

Notes: (5) For Cell A5, may be subdivided such that a consequence of less than 0.1% is Low Risk.
(6) When considering a risk assessment it must be clearly stated whether it is for existing conditions or with risk control measures which may not be implemented at the current time.

RISK LEVEL IMPLICATIONS

Risk Level		Example Implications (7)
VH	VERY HIGH RISK	Unacceptable without treatment. Extensive detailed investigation and research, planning and implementation of treatment options essential to reduce risk to Low; may be too expensive and not practical. Work likely to cost more than value of the property.
H	HIGH RISK	Unacceptable without treatment. Detailed investigation, planning and implementation of treatment options required to reduce risk to Low. Work would cost a substantial sum in relation to the value of the property.
M	MODERATE RISK	May be tolerated in certain circumstances (subject to regulator's approval) but requires investigation, planning and implementation of treatment options to reduce the risk to Low. Treatment options to reduce to Low risk should be implemented as soon as practicable.
L	LOW RISK	Usually acceptable to regulators. Where treatment has been required to reduce the risk to this level, ongoing maintenance is required.
VL	VERY LOW RISK	Acceptable. Manage by normal slope maintenance procedures.

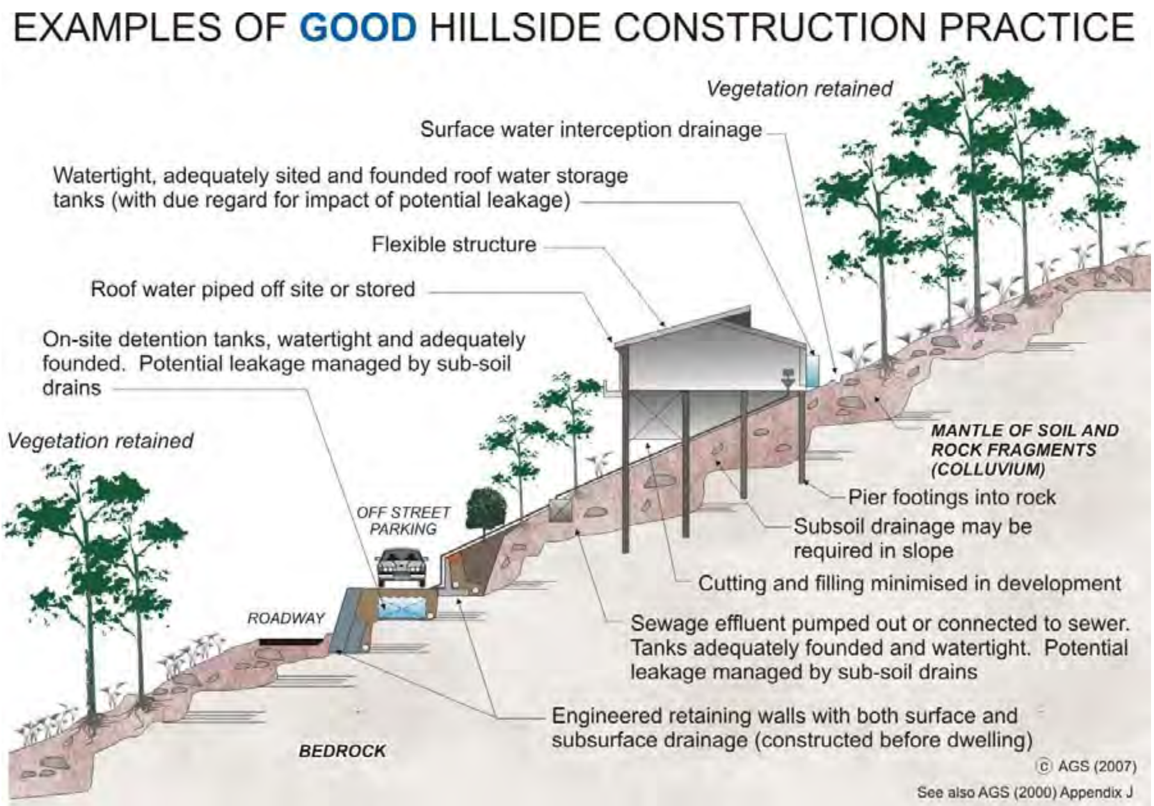
Note: (7) The implications for a particular situation are to be determined by all parties to the risk assessment and may depend on the nature of the property at risk; these are only given as a general guide.

Appendix B

Good Hillside Construction Practice - AGS 2007

HILLSIDE CONSTRUCTION PRACTICE

Sensible development practices are required when building on hillsides, particularly if the hillside has more than a low risk of instability (GeoGuide LR7). Only building techniques intended to maintain, or reduce, the overall level of landslide risk should be considered. Examples of good hillside construction practice are illustrated below.



WHY ARE THESE PRACTICES GOOD?

Roadways and parking areas - are paved and incorporate kerbs which prevent water discharging straight into the hillside (GeoGuide LR5).

Cuttings - are supported by retaining walls (GeoGuide LR6).

Retaining walls - are engineer designed to withstand the lateral earth pressures and surcharges expected, and include drains to prevent water pressures developing in the backfill. Where the ground slopes steeply down towards the high side of a retaining wall, the disturbing force (see GeoGuide LR6) can be two or more times that in level ground. Retaining walls must be designed taking these forces into account.

Sewage - whether treated or not is either taken away in pipes or contained in properly founded tanks so it cannot soak into the ground.

Surface water - from roofs and other hard surfaces is piped away to a suitable discharge point rather than being allowed to infiltrate into the ground. Preferably, the discharge point will be in a natural creek where ground water exits, rather than enters, the ground. Shallow, lined, drains on the surface can fulfil the same purpose (GeoGuide LR5).

Surface loads - are minimised. No fill embankments have been built. The house is a lightweight structure. Foundation loads have been taken down below the level at which a landslide is likely to occur and, preferably, to rock. This sort of construction is probably not applicable to soil slopes (GeoGuide LR3). If you are uncertain whether your site has rock near the surface, or is essentially a soil slope, you should engage a geotechnical practitioner to find out.

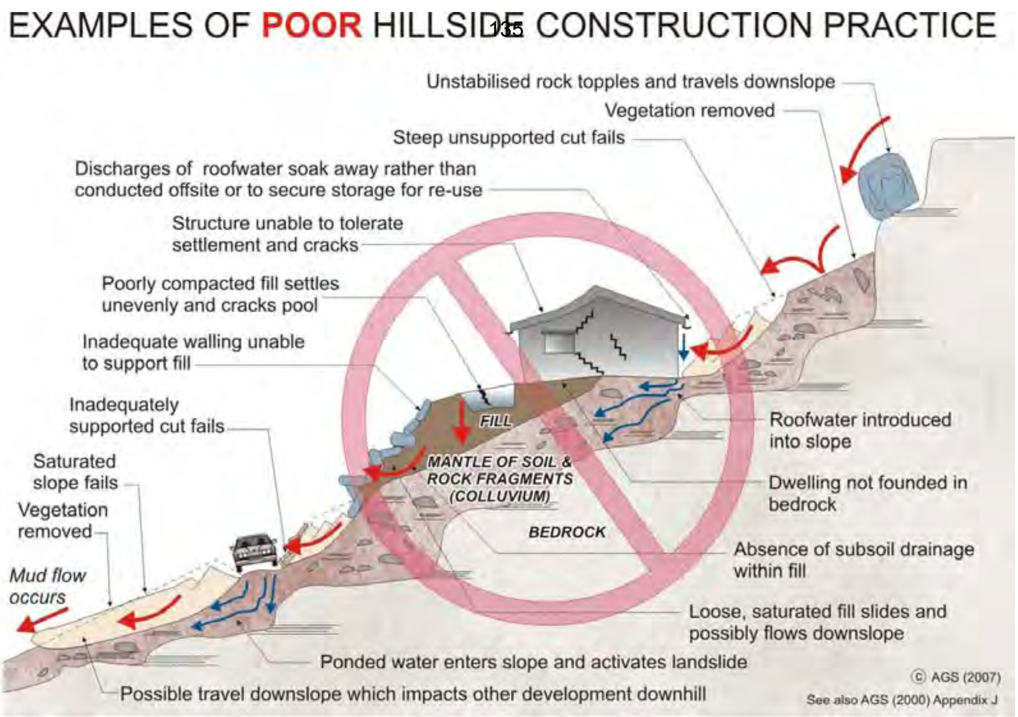
Flexible structures - have been used because they can tolerate a certain amount of movement with minimal signs of distress and maintain their functionality.

Vegetation clearance - on soil slopes has been kept to a reasonable minimum. Trees, and to a lesser extent smaller vegetation, take large quantities of water out of the ground every day. This lowers the ground water table, which in turn helps to maintain the stability of the slope. Large scale clearing can result in a rise in water table with a consequent increase in the likelihood of a landslide (GeoGuide LR5). An exception may have to be made to this rule on steep rock slopes where trees have little effect on the water table, but their roots pose a landslide hazard by dislodging boulders.

Possible effects of ignoring good construction practices are illustrated on page 2. Unfortunately, these poor construction practices are not as unusual as you might think and are often chosen because, on the face of it, they will save the developer, or owner, money. You should not lose sight of the fact that the cost and anguish associated with any one of the disasters illustrated, is likely to more than wipe out any apparent savings at the outset.

ADOPT GOOD PRACTICE ON HILLSIDE SITES

AUSTRALIAN GEOGUIDE LR8 (CONSTRUCTION PRACTICE)



WHY ARE THESE PRACTICES POOR?

Roadways and parking areas - are unsurfaced and lack proper table drains (gutters) causing surface water to pond and soak into the ground.

Cut and fill - has been used to balance earthworks quantities and level the site leaving unstable cut faces and added large surface loads to the ground. Failure to compact the fill properly has led to settlement, which will probably continue for several years after completion. The house and pool have been built on the fill and have settled with it and cracked. Leakage from the cracked pool and the applied surface loads from the fill have combined to cause landslides.

Retaining walls - have been avoided, to minimise cost, and hand placed rock walls used instead. Without applying engineering design principles, the walls have failed to provide the required support to the ground and have failed, creating a very dangerous situation.

A heavy, rigid, house - has been built on shallow, conventional, footings. Not only has the brickwork cracked because of the resulting ground movements, but it has also become involved in a man-made landslide.

Soak-away drainage - has been used for sewage and surface water run-off from roofs and pavements. This water soaks into the ground and raises the water table (GeoGuide LR5). Subsoil drains that run along the contours should be avoided for the same reason. If felt necessary, subsoil drains should run steeply downhill in a chevron, or herring bone, pattern. This may conflict with the requirements for effluent and surface water disposal (GeoGuide LR9) and if so, you will need to seek professional advice.

Rock debris - from landslides higher up on the slope seems likely to pass through the site. Such locations are often referred to by geotechnical practitioners as "debris flow paths". Rock is normally even denser than ordinary fill, so even quite modest boulders are likely to weigh many tonnes and do a lot of damage once they start to roll. Boulders have been known to travel hundreds of metres downhill leaving behind a trail of destruction.

Vegetation - has been completely cleared, leading to a possible rise in the water table and increased landslide risk (GeoGuide LR5).

DON'T CUT CORNERS ON HILLSIDE SITES - OBTAIN ADVICE FROM A GEOTECHNICAL PRACTITIONER

More information relevant to your particular situation may be found in other Australian GeoGuides:

- GeoGuide LR1 - Introduction
- GeoGuide LR2 - Landslides
- GeoGuide LR3 - Landslides in Soil
- GeoGuide LR4 - Landslides in Rock
- GeoGuide LR5 - Water & Drainage
- GeoGuide LR6 - Retaining Walls
- GeoGuide LR7 - Landslide Risk
- GeoGuide LR9 - Effluent & Surface Water Disposal
- GeoGuide LR10 - Coastal Landslides
- GeoGuide LR11 - Record Keeping

The Australian GeoGuides (LR series) are a set of publications intended for property owners; local councils; planning authorities; developers; insurers; lawyers and, in fact, anyone who lives with, or has an interest in, a natural or engineered slope, a cutting, or an excavation. They are intended to help you understand why slopes and retaining structures can be a hazard and what can be done with appropriate professional advice and local council approval (if required) to remove, reduce, or minimise the risk they represent. The GeoGuides have been prepared by the Australian Geomechanics Society, a specialist technical society within Engineers Australia, the national peak body for all engineering disciplines in Australia, whose members are professional geotechnical engineers and engineering geologists with a particular interest in ground engineering. The GeoGuides have been funded under the Australian governments' National Disaster Mitigation Program.