orientated north. The angle of inclination relative to a particular boundary is determined by the angle on the diagram in Figure 3 adjacent at that boundary.

2.2.4.4.2 Within the Maxwell Hills Zone the angle shall be measured from a starting point 2.3 metres above ground level (x = 2.3 m).

2.2.4.4.3 Except where a site boundary abuts the street or road, no part of any building should exceed a height limit imposed by a line drawn at an angle of 55° from the horizontal and originating and drawn at right angles from a point 2 metres above the boundary of the site where it abuts the street or road.

2.2.4.4.4 Exception for a garage
Any part of the garage building may intrude into a recession plane, until the recession plane reaches 3 metres in height with reference to the boundary level, to enable the garage building to be sited up against or nearer to a side or rear boundary provided that:

(a) The continuous or aggregate length of a building or buildings sited on or near to the boundary and intruding into the recession plane may not exceed 9.0 metres.
(b) The exemption can be applied to only one side boundary and one rear boundary.
(c) Any such building shall be sited at least 5.5 metres from the front boundary. This does not apply to side entry garages, where a 90-percentile vehicle can park between the front boundary and the garage entrance.
(d) The maximum height of the building within 1 metre of the boundary does not exceed 3 metres.

2.2.4.5 Siting Requirements for Garages

A front yard of 5.5 metres depth shall be provided for a garage having vehicular access directly from the road or street.

2.2.4.6 Noise

All activities shall be conducted so as to ensure that noise arising from such activities does not exceed the following noise limits at or within the boundary of any other site zoned Maxwell Hills:

55 dBA L_{10}	0700 hrs - 2200 hrs Monday to Friday and 0700 hrs - 1200 hrs Saturday
45 dBA L_{10}, and 70 dBA L_{max}	At all other times including any public holiday

Provided on any day between 0700 hrs - 2200 hrs the L_{max} limit shall not apply

2.2.5 Heritage

Note:
Notwithstanding any permitted activity status herein, an authorisation from the New Zealand Historic Places Trust is required before any person may destroy, damage or modify the whole or part of any historical, cultural or archaeological site.

2.2.6 Hazards

2.2.6.1 Flood Protection / Riparian Management

2.2.6.1.1 All buildings, structures and trees shall be set back a minimum of 8 metres from the top of any natural river or stream bank, or wetland, or any stopbank.

2.2.6.1.2 No dwelling house(s) shall be sited on the river/stream side of the flood line shown on the Maxwell Hills Zone Outline Development Plan (see Clause 2.8).

2.2.6.1.3 No dwelling house(s) shall be sited within the Hazard overlay area shown on the Outline Development Plan (see Clause 2.8).

2.2.6.1.4 The earth bund shown on the Outline Development Plan in Clause 2.8 must be constructed before any dwellings can be constructed on the north side of Maxwell Creek.

Hazards Register

Note:
The Council maintains a Hazard Register, which provides public information on properties where natural hazards have been specifically identified. (The Register is a 'living' document which is progressively updated). Property developers are advised to consult this register.

2.2.7 Earthworks

2.2.7.1 Excavation

2.2.7.1.1 No excavation shall take place within 8 metres of the landward toe of a stopbank and the depth of any excavation may not exceed 20% of the distance from the stopbank.

Exemptions

Filling or excavation associated with the construction or maintenance of flood protection works. This includes stopbanks or retention basins constructed by or on behalf of the Council.

2.2.7.2 Content

2.2.7.2.1 Material other than rubble, ballast, stones, soil material and demolition material shall not be used as fill or for the filling of land or depressions.

2.2.7.2.2 Fill material shall not contain any putrecible, inflammable or hazardous components.

2.2.7.2.3 Fill material shall contain no more than 5% vegetative material which is not incidental to the cleaning of sites.

2.2.7.3 General

2.2.7.3.1 No woody material of greater than 100 mm diameter shall be left in any permanently flowing river, lake, or wetland as a result of any earthworks.

2.2.7.3.2 All sites subject to excavation or fill are to be stable when subject to a storm event of return frequency of 1 in 10 years or less.

2.2.8 Discharges

2.2.8.1 Domestic Effluent Disposal

2.2.8.1.1 Provision must be made for the satisfactory disposal of all effluent and greywater in accordance with the requirements of this Plan. The requirements of this Plan are deemed to have been met where all domestic effluent and greywater is connected to a public system expressly designed for this purpose.

2.2.8.2 Incineration

2.2.8.2.1 The discharge of contaminants to air from incineration of untreated wood, vegetation newspapers, magazines and cardboard shall be a Permitted Activity provided that:

(a) The waste is generated on the property where incineration occurs.
(b) Any vegetative matter is dry.
(c) The waste being incinerated shall not include:
(i) Car tyres;
(ii) Plastic agrichemical containers;
(iii) Hazardous substances or containers of hazardous substances;
(iv) Oil based products;
(v) Food scraps;
(vi) Aerosol cans;
(vii) Foam products;
(viii) Paper, unless there is a fly ash guard;
(ix) All tyres and rubber, and all plastics.

(d) Weather conditions are such that any nuisance effects from smoke are minimised.

2.2.8.3 Other Discharges to Air

Any discharge of contaminants to air associated with any Permitted Activity is also a Permitted Activity provided:

(a) There shall be no objectionable or offensive odour to the extent that it causes an adverse effect beyond the boundary of the site of the discharge.
(b) The discharger at all times, adopts the best practicable option to avoid, remedy or mitigate any adverse effects on the environment.

2.2.8.4 Discharge of Electro Magnetic Radiation (EMR)

The discharge of EMR (Electric Magnetic Radiation) is a Permitted Activity, provided the level of discharge meets the requirement/limitations of NZS 6609.

2.2.8.5 Application of Agrichemicals

The discharge of a contaminant or contaminants onto land or into air in connection with the spray application of agrichemicals on domestic or residential properties or in domestic quantities on industrial and trade premises is permitted provided that the person responsible for the activity shall:

(a) Apply sprays strictly in accordance with the manufacturers instructions.

(b) Notify the Council immediately in the case of accidental discharge into a water body.

(c) Take all reasonable steps to ensure that no spray drift occurs beyond the boundary of the property.

(d) Apply sprays in a manner which does not cause or is not likely to cause deposition into surface waters.

(e) Apply sprays with hand held equipment only.

2.2.9 Rules Applicable to Temporary Buildings

The following temporary buildings shall be a Permitted Activity:

(a) Temporary buildings ancillary to a building or construction project, provided that any such building does not exceed 40 m^2 in area, or remain on the site for longer than the duration of the project or twelve months, whichever is the lesser.

(b) Temporary buildings or other structures including tents, ancillary to carnivals, bazaars, and public meetings, provided that such activities or buildings shall not remain on site longer than one month.

(c) Where a building is intended for the care of a nominated dependent relative and the maximum site coverage requirement for buildings has already been reached then a building of not more than 80 m^2 will be permitted subject to the building being relocatable. The landowner shall enter into a bond with the Council to ensure that the building is removed when no longer required for the housing of the nominated dependent relative (the bond shall be registered under the Land Transfer Act 1952 against the Certificate of Title to the land and shall be of a covenant running with the land which binds all subsequent owners of the land).

2.3 Limited Discretionary Activities

2.3.1 Application must be made for a resource consent for a limited discretionary activity for the following:

- Wastewater infrastructure that does not meet rule 2.1 and/or 2.2. but meets rule 2.3.1.1.
- Wastewater discharges that do not meet rule 2.1 and/or 2.2. but meet rule rule 2.3.1.2.
- Minor non-compliance with the standards for Permitted Activities to the extent specified in rule 2.3.1.3 below.

2.3.1.1 Reticulated Community Wastewater Treatment Plant and Associated Infrastructure

2.3.1.1.1 A Reticulated Community Wastewater Treatment Plant and associated on-site infrastructure including primary treatment tanks or grinder pump chamber is a Limited Discretionary Activity provided that the activity conforms to the following Standards and Terms.

(a) All allotments with dwellings have an on-site interceptor tank or grinder pump chamber with a minimum storage capacity of 24 hours.
(b) Secondary treatment shall be by a recirculating textile packed bed reactor treatment plant or similar technology;
(c) The Treatment Plant shall be:
  (i) Located in the utilities area in general accordance with the Outline Development Plan.
  (ii) Monitored by a remote telemetry unit.
  (iii) Of sufficient capacity for emergency storage volume of at least 24 hours at peak flow following any Treatment Plant malfunction.
  (iv) Planted along boundaries to provide screening of the site from the road.

2.3.1.1.2 Matters to which the Council has restricted the exercise of its Discretion:

For a reticulated community wastewater treatment plant that conforms with the standards and terms in rule 2.3.1.1, the Council limits its discretion to, and may impose conditions with respect to:

(a) The location, siting, bulk and design of the plant and associated infrastructure;
(b) Staging of installation of the Treatment Plant and associated infrastructure;
(c) The quality of the effluent to be created;
(d) Screening of the Treatment Plant from the road, including proposed height of plants at time of planting;
(e) Maintenance contracts and management plans;
(f) Monitoring systems, alarms and emergency response;
(g) Systems of reporting to the Council;
(h) Ownership structure for the Wastewater Treatment Plant.

2.3.1.1.3 All applications under rule 2.3.1.1 will not require the written approval of other persons and shall be non-notified. However, the Council may consult with iwi.

2.3.1.2 Discharge of Treated Wastewater

2.3.1.2.1 Discharge of treated wastewater is a Limited Discretionary Activity provided that the discharge is from a wastewater treatment plant that complies with the standards and terms in rule 2.3.1.1.

2.3.1.2.2 Matters to which the Council has restricted the exercise of its Discretion:

For discharge of treated wastewater that complies with rule 2.3.1.2, the Council restricts its discretion to and may impose conditions with respect to:

(a) The location and siting of the discharge areas;
(b) Fencing and barrier planting, and amenity planting;
(c) Vegetation within the land application area/s;
(d) The quality of the effluent to be discharged
(e) The rate of discharge sufficient to avoid slope instability or erosion, and avoid contamination of water;
(f) The design of the land irrigation system;
(g) Systems for monitoring and maintenance;
(h) Emergency and malfunction management systems;
(i) Management Plans;
(j) Systems of reporting to Council;
(k) Ownership structure for the land and for any land application system, where relevant.

2.3.1.2.3 All applications under rule 2.3.1.2 will not require the written approval of other persons and shall be non-notified, however, the Council may consult with iwi.

Note:
Discharge of treated wastewater within the Maxwell Hills Zone is likely to be limited, but could include discharge in the utilities area specified in the Outline Development Plan at Clause 2.9 and/or recycling of high quality effluent to irrigate road berms, landscaped areas and private lawns.

2.3.1.3 Minor Non-compliance with Some Standards for Permitted Activities

2.3.1.3.1 Minor non-compliance with the standards for Permitted Activities to the extent specified below:

- Buildings exceeding the maximum permitted site coverage up to a maximum of 20% of the specified standard.
- Buildings or structures exceeding the maximum permitted height up to a maximum of 20% of the specified standard.
- Buildings encroaching the height envelope created by the recession plane angles by a maximum of 1 metre in any direction.
- Buildings, structures and trees within 8 metres of any drainage channel or landward toe of any stopbank - up to 100% dispensation.
- Parking requirements.
- Access gradients - up to 5%.

2.3.1.3.2 All applications for minor non-compliance shall be non-notified, however, the Council may require the written approval of every person who may in the Council's judgment be adversely affected by the granting of the consent for non-compliance unless it is considered unreasonable in the circumstances to require such approval.

2.3.1.3.3 Matters to which the Council has Restricted the Exercise of its Discretion

In considering any application for minor non-compliance the Council will in the exercise of its discretion have regard to the following matters:

(a) The non-compliance should not diminish the overall residential character of the locality.

(b) The non-compliance should not significantly and adversely obstruct views from nearby residential properties to the surrounding hills and valley
(c) The non-compliance should not adversely affect privacy enjoyed on adjoining residential properties.
(d) The non-compliance should not significantly diminish the daylight available to adjoining properties or cause shading of outdoor living areas, service courts, open space or habitable rooms on adjoining properties.
(e) The non-compliance should not significantly reduce the usability or enjoyment of open space, living courts, or service courts on the applicant's site.
(f) The non-compliance should not put at risk any private property from foreseeable flood hazard.
(g) The non-compliance should not interfere with the protection of any natural or any other floodway. The non-compliance should not adversely affect the hydraulic integrity of any watercourse or stream. The non-compliance should not adversely affect on-site vehicle manoeuvring or car parking areas or affect the safe flow of traffic on adjoining roads.

2.4 Discretionary Activities

2.4.1 Application must be made for a resource consent for a Discretionary Activity for the following:

- Activities listed as Permitted which do not comply with standards and/or conditions or with the provisions for minor non-compliance dealt with as Limited Discretionary Activities. Except that this provision shall not apply to activities listed as Non-Complying or Prohibited Activities.

- Activities provided for under Rules 2.3.1.1 and 2.3.1.2 that do not comply with the standards and terms of those rules.

- Relocated buildings of greater than $36m^2$ in area.

- Visitor accommodation, including camping grounds.

- Community facilities and activities, places of assembly, religious institutions.

- Recreational facilities (other than parks and reserves).

- Retail facilities not provided for as a permitted activity.

- Educational facilities.

- Marae and marae-based activities.

- Hazardous facilities having an effects ratio no greater than 1.0.

- Emergency service activities.

- Development that is not in general accordance with the Outline Development Plan.

2.5 Non-Complying Activities

2.5.1 Application must be made for a resource consent for a Non-Complying Activity for the following:

- Any activity not provided for as a Permitted, Controlled, Limited Discretionary, Discretionary or Prohibited Activity shall be deemed to be a Non-Complying Activity.

- Any non-compliance with Rule 2.2.4.1 (Residential Site Density).

- Within any area identified as a Flood Hazard on the Planning Maps the following are Non-Complying Activities:
  Any building.
  Construction of stopbanks, modification of existing stopbanks or deposition of material in ephemeral channels.
  Construction of impermeable walls, fences or similar structures which would divert water.
  Any excavation.

2.6 Prohibited Activities

2.6.1 The following are Prohibited Activities for which no resource consent shall be granted:

- The disposal of hazardous waste substances to land or water.

- The combustion of:
  Materials associated with the recovery of metals from insulated electrical cables in the open; or
  Materials and metals used in motor vehicles in the open; or
  Any other PVC plastic, or rubber tyres, waste oils, treated timber, or agricultural chemical wastes in the open.

Note:
In the open means other than in an enclosed incineration device with a chimney.

2.7 Subdivision

2.7.1 Permitted Subdivision Activities

The provisions of Chapter 28, Rule 28.1.1 and Rule 28.1.2 shall apply.

2.7.2 Controlled Subdivision Activities

2.7.2.1 Subdivision which complies with the following standards shall be a controlled activity:

(a) Allotment Standards

Zone	Allotment Type	Environmental Assessment Threshold Lot Area m²	Environmental Assessment Threshold Building Platform Shape Factor	Environmental Assessment Threshold Frontage metres	Qualification
Maxwell Hills Zone	Front and rear with sewerage reticulation	2,000 m^2 minimum; and 2,400m^2 average (see note 1 below)	15 metre diameter circle (see note 2 below)[2]	N/A	Access requirements apply, refer Chapter 28, Rule 28.2.3 as for all residential zones.

Notes:

1 Lot areas prescribed are net areas, exclusive of access

2 The minimum building platform shape factor may be applied anywhere within the proposed allotment.

(b) Subdivision in the Maxwell Hills Zone shall be in general accordance with the Outline Development Plan at Clause 2.8.

(c) The General Standards for controlled subdivision activities contained in Chapter 28, Rule 28.2.4 shall apply.

2.7.2.2 Matters over Which the Council will Exercise Control

2.7.2.2.1 The matters for control identified in Chapter 28, Rule 28.2.5 shall apply.

2.7.2.2.2 In addition to the matters identified in rule 28.2.5, the Council will also exercise control over landscape treatment.

2.7.3 Discretionary and Non-Complying Subdivision Activities

Subdivision is a Discretionary Activity where the subdivision does not comply with one or more of the Permitted or Controlled Activity requirements for the Maxwell Hills Zone; except that where the environmental assessment threshold lot area is not met the subdivision activity shall be a non-complying activity.

In assessing a discretionary or non-complying subdivision activity, the Council may take into consideration the matters contained in Chapter 28, Clause 28.3.5 and may impose conditions indicated in Chapter 28, Clause 28.3.6.

2.7.4 Information to be Supplied with All Applications for Subdivision Consent

2.7.4.1 The relevant provisions of Chapter 29.0, Clause 29.1 shall apply to all applications for subdivision consent. In addition the specific information requested below shall be required:

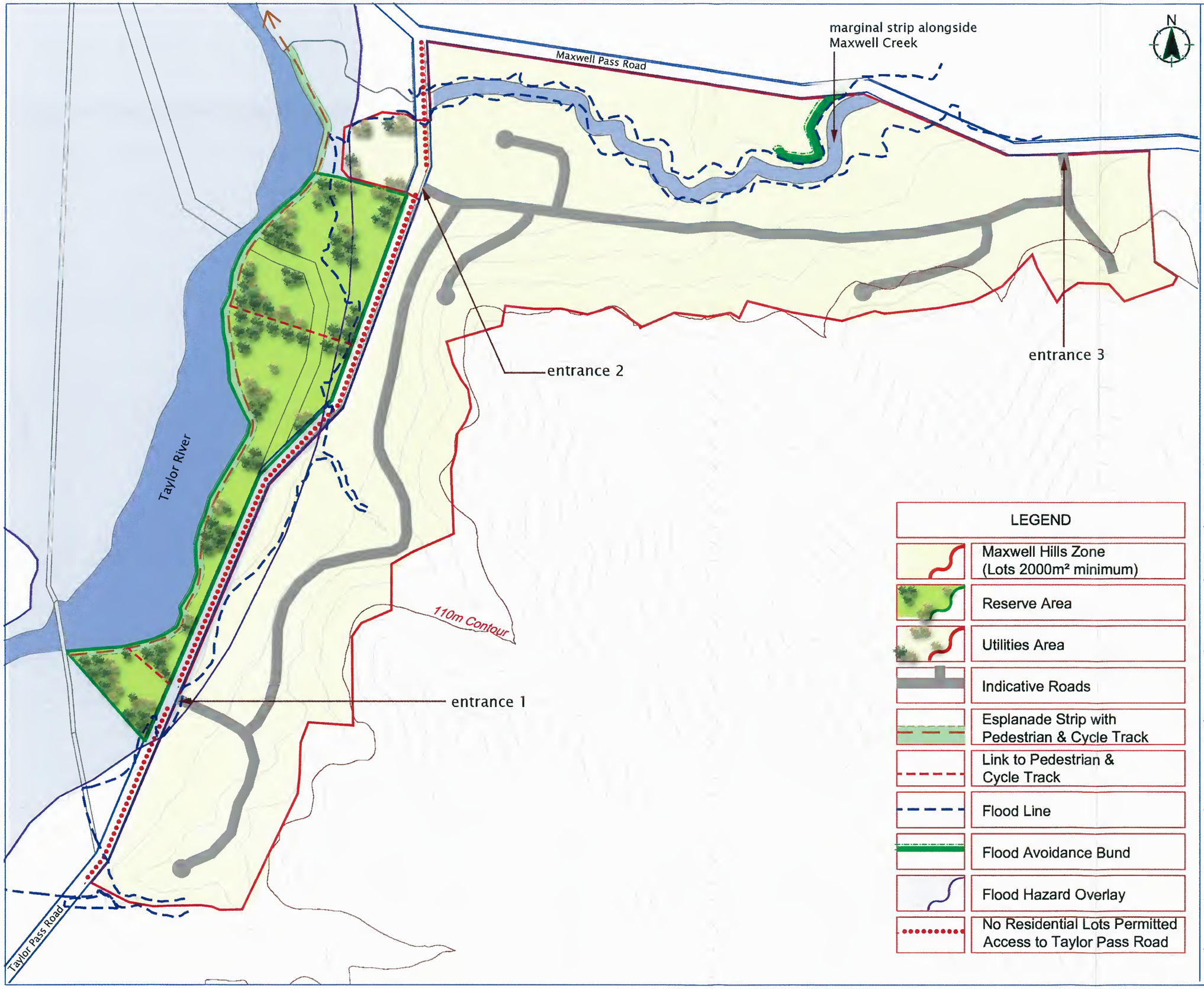
(a) A landscape plan detailing the species, density, planting programme as well as maintenance regime.

2.7.5 Requirements for Subdivision and Development

2.7.5.1 The provisions of Chapter 29.0, Clause 29.2 shall apply. In respect to Clause 29.2.19.4 the amount required for reserve fund contribution shall be as for the Rural Residential Zone.

2.8 Outline Development Plan for Maxwell Hills Zone

[next page]



N

GENERAL NOTES

1. Flood Hazard Overlay boundaries to be confirmed.
2. Lot boundaries, Vegetation, Road & Track positions shown are indicative only.
3. All subdivision lots accommodated within proposed Maxwell Hills Zone.

LEGEND

- Maxwell Hills Zone (Lots 2000m² minimum)
- Reserve Area
- Utilities Area
- Indicative Roads
- Esplanade Strip with Pedestrian & Cycle Track
- Link to Pedestrian & Cycle Track
- Flood Line
- Flood Avoidance Bund
- Flood Hazard Overlay
- No Residential Lots Permitted Access to Taylor Pass Road

B	AMEND LAYOUT	JC	11.11.10
A	INITIAL ISSUE	JC	03.11.10

Revision		App	Date
Surveyed	-		-
Designed	JC		11.11.10
Drawn	NC	MGC (CGLA) 21.02.11 MGC (CGLA) 28.04.11	11.11.10
Reviewed	JC		11.11.10
Approved	JANICE CARTER		11.11.10

Verify all dimensions on site before commencing work. Prioritise figured dimensions over scaling. Refer all discrepancies to the drawing office.

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Client
KAPITI VIEWS TRUST

Project Title
MAXWELL HILLS PLAN CHANGE

Sheet Title
OUTLINE DEVELOPMENT PLAN

Scale (A3 Original) 1:5000

50 25 0 50 100 150 m

Project No	Sheet	Revision
009025	130	B

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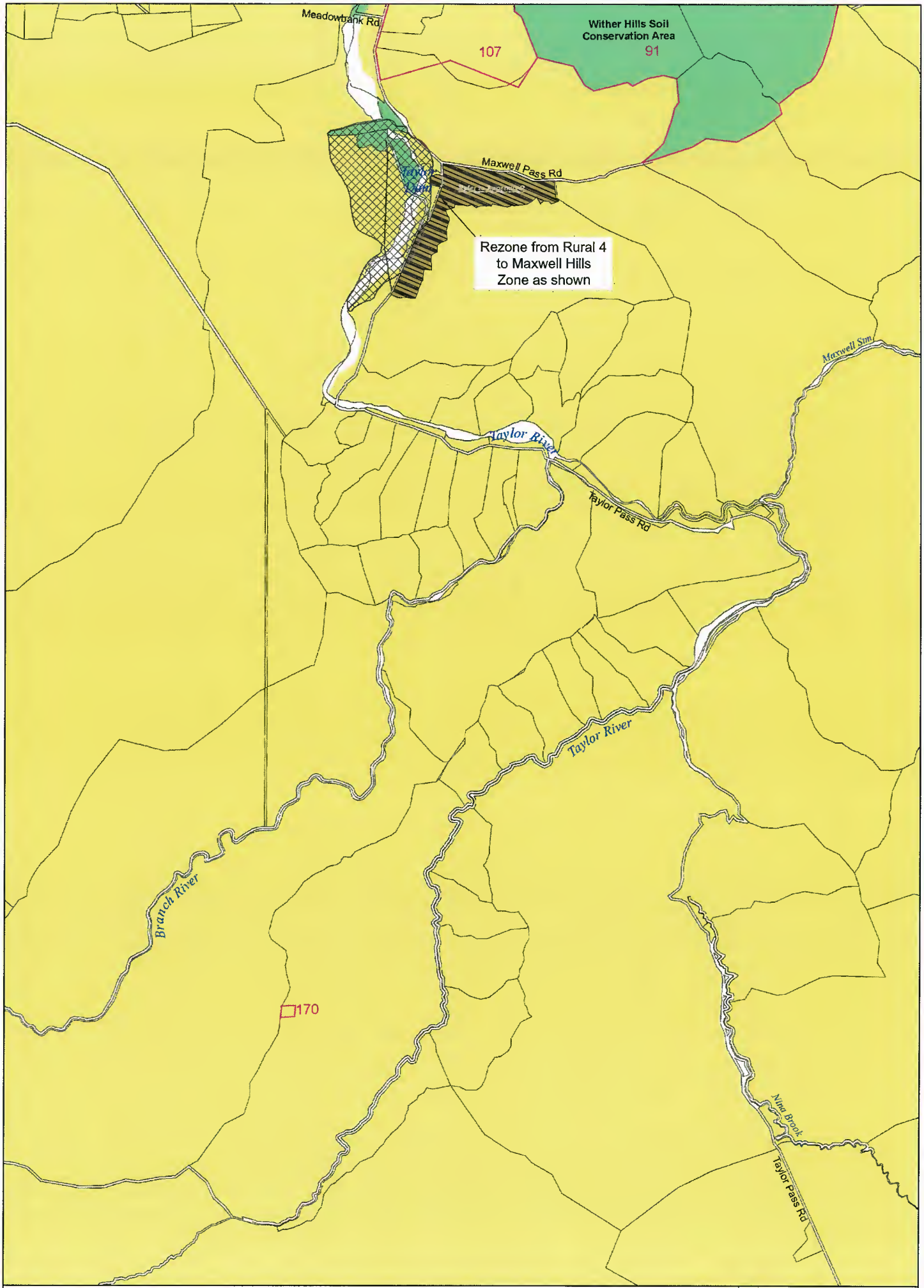
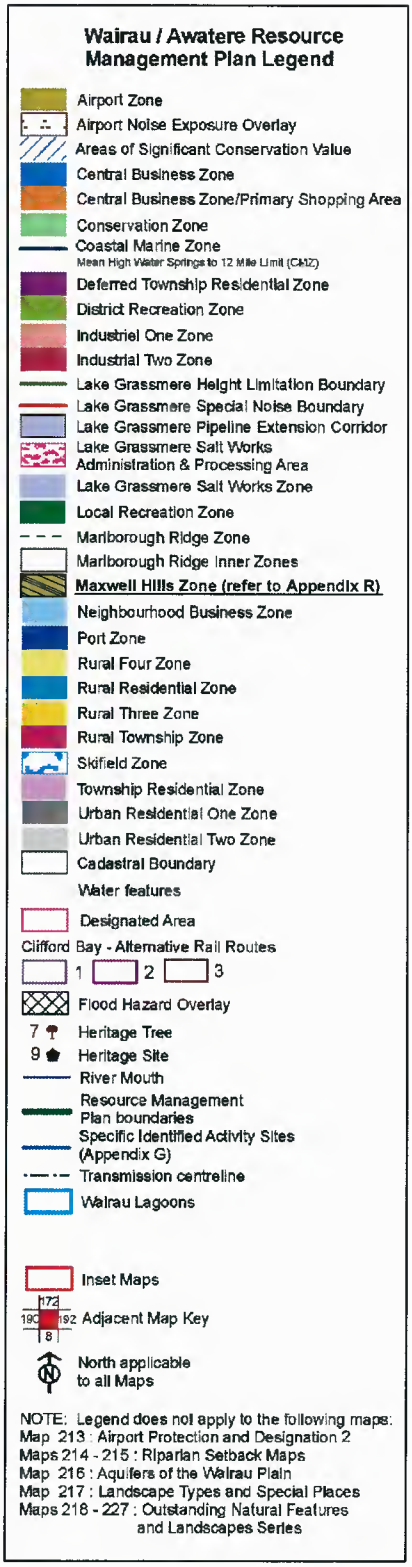


PROPOSED PLAN CHANGE: REZONING FROM RURAL 4 TO MAXWELL HILLS ZONE


Wairau / Awatere Resource Management Plan Legend
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Airport Noise Exposure Overlay
Areas of Significant Conservation Value
Central Business Zone
Central Business Zone/Primary Shopping Area
Conservation Zone
Coastal Marine Zone
Mean High Water Springs to 12 Mile Limit (CMZ)
Deferred Township Residential Zone
District Recreation Zone
Industriel One Zone
Industrial Two Zone
Lake Grassmere Height Limitation Boundary
Lake Grassmere Special Noise Boundary
Lake Grassmere Pipeline Extension Corridor
Lake Grassmere Salt Works Administration & Processing Area
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APPENDIX H
Stormwater Report - Riley Consultants Limited

RILEY CONSULTANTS

MAXWELL HILLS RURAL RESIDENTIAL ZONE PROPOSED PRIVATE PLAN CHANGE STORMWATER REPORT

Engineers and Geologists

MAXWELL HILLS RURAL RESIDENTIAL ZONE
PROPOSED PRIVATE PLAN CHANGE
STORMWATER REPORT

Report prepared for: Kapiti Views Trust

Report prepared by: Jason Budd, Senior Civil Engineer, CPEng

.....

Report reviewed by: Brett Black, Director, CPEng

.....

Report reference: 04819/6SW-A

Date: 15 February 2011

Copies to:

Kapiti Views Trust	1 copy
CPG Global	1 copy 1 electronic copy
Riley Consultants Ltd	1 copy

Issue:	Details:	Date:
1	Stormwater Report	15 February 2011

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MAXWELL HILLS RURAL RESIDENTIAL ZONE
PROPOSED PRIVATE PLAN CHANGE
STORMWATER REPORT

1.0 Introduction

Riley Consultants Ltd (RILEY) has prepared the following stormwater report at the request of Kapiti Views Trust. This report describes a preliminary stormwater assessment to establish the effects of a proposed residential development and to identify the potential constraints for developing the site. This report will also provide methods to manage stormwater run-off from the development area in order to mitigate the effects on the downstream environment. It is intended to support a plan change application to Marlborough District Council (MDC).

The plan change region covers the lower terraced area of the larger lots (Lot 1, DP 9518, Section 2, SO 7014 Lots 1-3, DP357141) held by Kapiti Views Trust.

To ensure that development is sustainable and suitable, an assessment of the engineering aspects has been provided by RILEY. This report should be read in conjunction with the following RILEY documents.

Planning Variation	RILEY Reference Number
Flooding Assessment	04819/6FL-A
Geotechnical Assessment	04819/6GT-A
Wastewater Servicing	04819/6WW-A

2.0 Site Location and Characteristics

The site is located approximately 2.5km south of the existing urban boundary of Blenheim, Marlborough, and is bounded by Maxwell Pass Road and Taylor Pass Road. The Taylor River runs along the western boundary, with the Taylor Dam (a flood detention structure protecting the Blenheim Township) located a few hundred metres from the site's north-western corner. The entire site has an area of approximately 286ha, with the proposed development described as the "rural residential development area" of 49.9ha. It is proposed to develop rural residential lots with an area of typically 0.2ha, which are configured in a conventional type subdivisional layout pattern.

The rural residential development area is located on the lower portion of the site. The topography of the lower areas is relatively gentle with slopes of 0 to 20°, which do not have the same potential for erosion as the steeper areas. The stormwater management network in this area is based around a pipe network that will collect flows from the roads and individual lots where possible. Where this is not possible, soakage pits will be used for individual lots. Water quality ponds will be constructed for each drainage catchment to treat run-off from the proposed development. Catchment characteristics are described in greater detail in Section 5.1.

3.0 Background

3.1 Discussions with MDC

Stormwater from the site will continue as it does presently and discharge into the Taylor River and Maxwell Pass Stream immediately upstream of the Taylor Dam. Under normal flow conditions water passes through a culvert underneath the dam, with the dam filling only when the flow in the Taylor River exceeds the capacity of the culvert. According to MDC, this dam attenuates flood flows of up to $300m^3/s$ from the Taylor River, and is designed to spill at a 1% Annual Exceedance Probability (AEP) event with the crest level set for the Probable Maximum Flood (PMF).

RILEY has previously discussed the issue of stormwater discharge with a MDC Rivers and Drainage Engineer who accepted, in principle, that no stormwater storage or attenuation is necessary within the development due to the Taylor Dam being able to cope with any increase in flow. The following assessment of the development is undertaken on the assumption that stormwater attenuation is not required from the downstream flooding perspective.

In accordance with the proposed Wairau/Awatere Resource Management Plan, measures will be provided prior to construction earthworks commencing, to restrict the transport of sediment laden run-off entering the river. Erosion and sediment control devices will be commissioned that are capable of mitigating sediment laden run-off for up to a 1 in 10 year storm event.

The design should ensure that the natural clarity of the receiving waters shall not be "conspicuously changed" by sediment. "Conspicuously changed" means: greater than 33% reduction in the visual clarity of the receiving water as measured by the horizontal sighting on a black disk; and/or greater than 15% increase in the turbidity of the receiving water as measured in NTU. The measurements are to be taken immediately upstream and below the discharge after reasonable mixing.

3.2 Geotechnical Considerations

A detailed geotechnical description of the site is presented in the accompanying geotechnical report. The upper part of the site is steep, with the loess soils susceptible to erosion, shallow landslides and small slumps. Such hazards may be exacerbated by the uncontrolled discharge of stormwater. Therefore, the focus of stormwater management is not on limiting post-development flows to pre-development levels, but on minimising erosion and instability throughout the site. However, it is noted that the mitigation measures proposed for minimising erosion and instability will, by their nature, result in some attenuation of run-off.

3.3 Design Standards

RILEY has referred to the MDC *Code of Practice for Subdivision and Development* and the New Zealand Standard NZS 4404 *Land Development and Subdivision Engineering* to determine the most appropriate design storms for the present development. The MDC Code of Practice for Subdivision and Land Development indicates that the 2% AEP (1 in 50 years) rainfall event should be used for design of stormwater systems to protect residential property. However, NZS 4404 recommends using a 1% AEP (1 in 100 years) rainfall. A 1% AEP is the minimum standard used for flood protection in most other regions and is recognised as providing an acceptable level of safety for residential developments.

Inundation from the upper catchment is a primary concern for this site as the topography is steep with limited natural vegetation except for grazing pasture. The extended dry periods experienced in this area mean that the natural ground initially behaves similar to an impervious pavement with a high percentage of rainfall transferred as run-off. Run-off will initially be as sheet flow before collecting in the hillside gullies and flowing down to the lower catchments via ephemeral streams. Once the upper catchment has softened (typically in winter) peak run-off rates will be lower. However, as a measure of protection from sudden summer rainfall and the first of the autumn rain, we recommend that the 1% AEP event is used to size overland flowpaths and to design building platforms with an appropriate level of free board protection. As mentioned in our flood assessment report there should be a minimum of 1m free board protection above the 1% AEP event.

As mentioned earlier, water quality ponds will be provided for each drainage catchment. In the latest MDC Code of Practice, these ponds should be designed in accordance with the Auckland Regional Council technical publication TP10, "Stormwater Management Devices: Design guidelines manual", 2nd Edition, May 2003. The ponds will be designed to provide only stormwater treatment for run-off from the developed catchment. No attenuation is necessary due to the Taylor Dam immediately downstream of the site.

4.0 Stormwater Mitigation Measures

A preliminary lot layout has been developed for feasibility purposes. A full concept design for this area has not been undertaken, however, this preliminary layout has been used to develop stormwater management measures to mitigate the effects of stormwater run-off generated from new impervious surfaces. This conceptual plan will highlight the stormwater mitigation measures that will be required to develop the site.

The predominant concern for the rural residential lots is to identify overland flow from the catchment above. The mitigation options discussed below will ensure that overland flow is clearly identified and does not cause potential inundation of rural residential building platforms.

4.1 Individual House Lots

The individual house lots in the rural residential areas can be separated into the following two categories: house sites upslope of a road, and house sites downslope of a road.

Connection to Pipe Network

House sites upslope of a road that have natural fall and will be connected to a reticulated pipe network.

Soakage Pits

House sites downslope of a road should connect into the pipe network where possible. Otherwise, stormwater should be discharged into soakage pits that drain to the free draining gravels underlying the site. Soakage tests will be required on individual lots to determine appropriate sizing of the soak pits in the underlying gravels during building consent stage. It is important that soakage be achieved within the underlying gravels and not within surficial founding soils.

Overland Flow

Stormwater from the upper catchment that is not drained into specific gullies will typically run downslope to the lower parts of the site. Concentrated overland flow has been identified for each catchment with a preliminary lot arrangement created to ensure these flows bypass building platforms. Overland flow should typically occur along lot boundaries.

4.2 Stormwater Conveyance

Primary Flows

Stormwater management shall be via a pipe network, which should be designed for a 10% AEP rain event. The pipe network will collect stormwater run-off from the roads, impervious areas of individual house lots where possible, and sheet flow run-off from areas above the road. All aspects of the MDC Code of Practice and the New Zealand Building Code should be adhered to in the design of the pipe network. A typical cross-section of the road and drainage is presented on RILEY Dwg: 04819/6SW-5.

Secondary Overland Flowpaths

As discussed earlier, the desirable method for conveying stormwater flows within the rural residential area is by a pipe network. This network would be used to convey the primary stormwater flows (up to a 10% AEP event) to water quality ponds as indicated on RILEY Dwgs: 04819/6SW-1 to -4.

Where stormwater run-off exceeds the capacity of the primary pipe network, the roads and designated corridors will become secondary overland flowpaths to convey stormwater run-off flows for up to a 1% AEP event. The use of roads as a secondary overland flowpath has previously been discussed with MDC and is an accepted practice. For all overland flowpaths, it is important to ensure that the designated route remain clear of obstructions that may affect the flow capacity (e.g. fences) and, therefore, it would be preferable that overland flowpaths are not located within individual lots unless an easement is specifically provided.

4.3 Culverts, Discharge Points and Water Quality Ponds

There are three main types of discharge currently within the site: culverts draining the site to the Taylor River; pipes that drain directly to a gully or stream; and pipes that drain directly to Maxwell Pass Stream or the Taylor River.

Culverts

Run-off from the existing gullies that drain to Taylor Pass Road tend to flow across the lower lots and into the roadside drain. There are existing culverts at several points that convey the water to the Taylor River. These culverts appear to be undersized and may provide some attenuation. Gullies that drain to the north have a slightly different pattern, with many draining directly into Maxwell Pass Stream. Where flow is intercepted by Maxwell Pass Road, the culverts are undersized and, again, may provide some attenuation.

The major concern with the culverts that drain directly to a gully or stream is the potential for erosion at the outlet. Culverts will be required at numerous points throughout the development to convey water beneath roads and into gullies. The code of practice does not specify a design event for culverts in the district, during detailed design of the secondary flowpaths it is recommended that each culvert is designed based on specific site constraints, e.g. risk of flooding due to back water effects, acceptability of the roading authority to possible over topping etc.

Discharge Points

The discharge points is a critical aspect of stormwater management as the energy in the water discharging from these points needs to be properly dissipated to reduce the energy of the stormwater flows. An example of the application of energy dissipation structures on steep terrain in loess soils can be seen on the Port Hills in Christchurch, where a combination of structural methods (i.e. concrete channels, rip rap) and vegetative methods (i.e. planting with vegetation and grasses) has been used successfully for several decades. Similar methods of protection are suitable for this development.

Water Quality Ponds

Previous stormwater assessments for the development did not require stormwater quality or quantity considerations. Recent discussions with MDC representatives are that the council now requires stormwater treatment within the development in accordance with proposed council standards.

As a result of the new standards, stormwater treatment measures have been incorporated to mitigate the effects of the development on the environment. This assessment has designated areas of land for mitigation measures and stormwater management within the development.

Due to the site constraints, stormwater quality ponds at discharge points are considered to be the most efficient method to provide the necessary treatment and erosion control. Other treatment options were considered (swales, structural filtration devices, etc) however, in order to maintain a 'traditional' subdivision development and with allowance for site constraints such as the erosion potential of the underlying soils, water quality ponds were considered the best management practice for stormwater treatment. This has enabled conventional construction of roads and stormwater reticulation within the development.

As shown on the RILEY Dwgs: 04819/6SW-1 to 4, five water quality ponds (labelled A to E) have been included in the stormwater network. The ponds have been designed in accordance with Auckland Regional Council Technical Publication No.10, 'Stormwater Treatment Devices Design Guidelines Manual', Second Edition, May 2003 (TP10), as prescribed in the MDC Code of Practice. The preliminary pond sizing has been calculated for the proposed development as shown Dwgs: 04819/6SW-1 to 4 (i.e. site coverage of impervious areas: roof, roading, paved) and is summarised below.

Note: Creation of further development area within each catchment will mean the proposed pond sizes will need to be re-calculated. The proposed locations for a number of the ponds are within the subdivision itself; further increases in pond size may not be possible at these locations. Alternative locations may need to be considered for increases in development area.

Table 4.1: Preliminary Stormwater Water Quality Pond Assessment

Development Catchment Reference	Catchment Area (ha)	Approximate Pond Dimensions	
		Surface Area (m^2)	Live Storage Volume (m^3)
A	7.0	1,500	300
B	6.1	1,500	300
C	14.9	2,600	800
D	8.8	1,800	400
E	5.5	1,200	300
Totals	**42.3**	**8,600**	**2,100**

As mentioned in Section 2.0, the total rural residential development area is 49.9ha. The remaining development areas that do not drain to the ponds located in Catchments A to E drain directly to either on-site soakage pits or to Maxwell Creek. Further detailed design will optimise the pond sizes and locations.

5.0 Hydrological Assessment

5.1 Site Description

A detailed description of the site is presented in the accompanying geotechnical report. The description includes the catchments above the development area to highlight the major features from a stormwater perspective. The catchments are made up of a series of ridges with steep slopes down to distinct and well-defined gullies. Ground elevation varies between approximately RL 70m and RL 400m, with slopes in the upper catchments typically less than 30°, but up to 40°. The site has two main drainage patterns: ridges and gullies orientated west-east with stormwater draining directly into the Taylor River in the west; and ridges and gullies orientated north-south with stormwater draining directly into the Maxwell Pass Stream in the north. These gullies are ephemeral watercourses that only flow in times of heavy rainfall. For the purposes of stormwater assessment the site can effectively be divided into seven catchments consisting of distinct gullies, plus one catchment making up the area between Maxwell Pass Stream and Maxwell Pass Road. For the design of the water quality ponds and impact of overland flow into the rural residential development areas, these seven catchments have been amalgamated into five catchments to direct water to the five main discharge points from the proposed development. The catchments are defined as follows.

Catchment A (27.4ha) is a narrow catchment consisting of a well-defined gully draining two steep ridges and flows north to an existing culvert under Maxwell Pass Road into Maxwell Pass Stream. A sub-catchment to the east drains the slope between Catchments A and the neighbouring catchment. Run-off will be directed back towards Pond A at the base of Catchment A, however, only the impervious areas from the rural residential development area will drain to the pond. Overland flow from the catchment above the development will bypass the pond as shown on Dwg: 04819/6SW-1.

Catchment B (23.5ha) is a combination of two narrow catchments that drain to the north, flowing into Maxwell Pass Stream. At this location Maxwell Pass Stream is within the boundary of the development. As for Catchment A, overland flow from the catchment above will bypass the pond.

Catchment C (22.1ha) drains into Taylor Pass Road to the west and Maxwell Pass Stream to the North. This catchment includes the largest number of rural residential lots for the development. Again, overland flow from the catchment above will bypass the pond.

Catchment D (44.8ha) is one of two major catchments draining to the Taylor River in the west. This catchment is drained by a substantial gully with steep sided slopes both north and south. As the stream nears Taylor Pass Road it drops down to a terrace of the Taylor River floodplain, where it becomes a deeply incised gully through an existing culvert, into the Taylor River. A smaller catchment to the south drains the slope between catchments D and E, with half of this catchment included as part of D. The management regime for overland flow is the same as above.

Catchment E (80.1ha) is the largest catchment, and the second major catchment that drains the site to the Taylor River in the west. This catchment consists of two major gullies that drain the high slopes and join together before discharging into the Taylor River. The management regime for overland flow is the same as above.

5.2 Stormwater Run-off

There is no gauged data of flows within the catchment and, therefore, the analysis of flows is for an ungauged catchment. Assessment of the pre and unmitigated post-development flows was undertaken using the Rational Method for determining peak flows. This method was considered the most suitable and conservative given that the catchment is rural and less than 3km². Catchments draining the site were assessed using topographic data and aerial photographs of the site. HIRDS v2 was used to develop a design storm for a 2 year (50% AEP), 10 year (10% AEP) and 100 year (1% AEP) event.

The pre and post-development flows were estimated by assessment of topographical information and aerial photographs. HIRDS v2 was used to develop a design storm for each of the following return periods:

- 2 year (50% AEP)
- 10 year (10% AEP)
- 100 year (1% AEP)

The design depths and durations used for the modelling presented in this report are given in Table 5.1.

Table 5.1: Design Storms and Depths

Storm Frequency	Depth for Given Duration (mm)							
	10 minute	20 minute	30 minute	1 hour	2 hour	6 hour	12 hour	24 hour
50% AEP	4.1	6.6	8.7	14	20.3	36.4	52.6	76.1
10% AEP	6.4	10.2	13.4	21.3	30	51.4	72.3	101.6
1% AEP	14.5	22.7	29.5	46.3	61.7	97.3	129.6	172.8

As discussed above, the development was assessed for 50% AEP, 10% AEP and 1% AEP events, which have been used to compare pre and unmitigated post-development flows. HIRDS v2 rainfall data has also been used to size the water quality ponds.

The pre-development flows have been assessed using the following parameters:

- Time of concentration (Tc) 10 minutes
- Run-off coefficient (C) 0.40
- Rainfall intensity (50% AEP) 24.6 mm/hour
- Rainfall intensity (10% AEP) 38.4 mm/hour
- Rainfall intensity (1% AEP) 87 mm/hour

The value for the run-off coefficient (C) is taken from Tables 1 and 2 of the New Zealand Building Code Clause E1 Surface Water[1] document assuming a medium soakage soil type (C = 0.30) and a slope correction due to the steepness of the site (C + 0.1).

The proposed development has a lot and roading layout that has been developed for feasibility purposes and preliminary design. This layout will become more refined as the design process continues; however we consider that any changes to the layout will not significantly alter the flows assessed herein.

Based on this preliminary layout, the unmitigated post-development flows have been assessed using the following parameters:

- Time of concentration (Tc) 10 minutes
- Averaged run-off coefficient (C) 0.42
- Rainfall intensity (50% AEP) 24.6 mm/hour
- Rainfall intensity (10% AEP) 38.4 mm/hour
- Rainfall intensity (1% AEP) 87 mm/hour

The averaged run-off coefficient (C) for the unmitigated post-development condition was calculated using the sub-catchment areas detailed in Section 5.1 and Table 5.2 below. This increase in the run-off coefficient is due to the increase in impervious area within the catchments.

Table 5.2: Determination of the Average Run-off Coefficient (C)

Land Type	Area (ha)	Run-off coefficient (C)
Sealed roads and hardstand areas (300m²/lot)	6.9	0.9
Undeveloped subdivision area	198	0.40

Table 5.3 presents the catchment characteristics and approximate areas for the pre-development, unmitigated post-development, and mitigated post-development scenarios. These preliminary figures are included to show how effective mitigation measures are at reducing post-development flows. As mentioned earlier, the water quality ponds are not intended to provide any attenuation.

[1] Building Industry Authority, 2001. New Zealand Building Code Clause E1 Surface Water.

Table 5.3: Catchment Characteristics and Approximate Areas

Cover Description	Area (ha)					
	Pre-development		Post-development (unmitigated)		Post-development (mitigated)	
	Impervious	Pervious	Impervious	Pervious	Impervious	Pervious
Sealed roads	-	-	2.7	-	2.7	-
Hardstand areas (300 m^2/lot)	-	-	4.4	-	3.2	1.2*
Trees (planted)	-	-	-	-		55+
Undeveloped subdivision area	-	198	-	190.9		135.9
Total area (ha)	198		198		198	

* Hardstand areas are mitigated by soakage for some of the rural residential lots.
\+ Additional planting will reduce run-off.

If run-off quantities from the total site could be concentrated at one location, the peak flow rates presented in Table 5.4 would be generated for the pre-development, unmitigated post-development and mitigated post-development scenarios.

Table 5.4: Catchment Flow Rates

	Pre-development		Post-development (unmitigated)		Post-development (mitigated)	
	Storm 1	Storm 2	Storm 1	Storm 2	Storm 1	Storm 2
AEP (%)	10%	1%	10%	1%	10%	1%
Peak Flow Rate (m^3/s)	8.6	19.0	9.2	20.0	9.1	19.8

The figures presented above show an increase in run-off quantities from the catchment. The increase in peak flows is a result of the increase in impervious area in the unmitigated post-development scenario. If the appropriate mitigation measures outlined above are adopted for the present development, the increase in run-off for the mitigated post-development scenario will be reduced. A more detailed assessment of individual catchments and stages of development should be undertaken during detailed design.

6.0 Effects of Stormwater Disposal

The main effect that normally arises from construction of roads and developments such as this is the concentration of run-off from the site. For this particular development the presence of the Taylor Dam immediately downstream, which is able to cope with any increase in flows, has shifted focus from limiting post-development flows to minimising erosion and instability throughout the site. However, a consequence of these mitigation measures has seen only a slight increase in stormwater run-off.

The stormwater run-off from the proposed development will drain via a reticulated network into water quality ponds provided for development within each catchment, before discharging to the Taylor River or Maxwell Pass Stream. The run-off flows from the rural residential areas will either be collected in a pipe network or disposed of into soakage pits, which effectively stops run-off draining over the erosion prone loess soils. As a result of the proposed development and the associated stormwater mitigation measures, run-off generated from impervious surfaces will be collected and discharged via the ponds to minimise erosion and maintain water quality in the receiving environment.

7.0 Conclusions and Recommendations

A stormwater assessment to accompany a plan change application for a rural residential development has been completed at the site. In our opinion the proposed development is considered feasible from a stormwater perspective. The mitigation measures discussed above will adequately deal with the design storm conditions. This assessment has recognised that the main focus for the mitigation measures is on minimising erosion of the loess soils and maintaining downstream water quality. A consequence of these measures is that attenuation of peak flows will reduce post-development flows close to pre-development levels.

This assessment is based on the following recommendations:

- Without mitigation measures the additional stormwater run-off generated from the proposed development will have potential adverse effects on the receiving environment, such as increasing the risk of erosion or flooding events.
- Stormwater mitigation measures will therefore be required to provide management of run-off generated from the proposed development and ensure impacts on the surrounding environment are minimised.
- The water quality ponds will provide treatment of run-off from the impervious areas of the development.
- If appropriate stormwater mitigation measures are adopted, the proposed development will avoid erosion of the loess soils.
- Further development above that shown on Dwgs: 04819/6SW-1 to 4 will mean the proposed ponds will need to be re-sized. Increases in pond size may not be possible in their current locations.
- The designated routes for overland flow should remain clear of obstructions.
- It is preferable that overland flowpaths are not located within individual lots unless an easement is specifically provided.

8.0 Limitation

This report has been prepared solely for the benefit of Kapiti Views Trust as our client with respect to the brief and Marlborough District Council in processing the plan change. The reliance by other parties on the information or opinions contained in the report shall, without our prior review and agreement in writing, be at such parties' sole risk.

The hydraulic and hydrological analyses and recommendations contained in this report are based on our understanding and interpretation of the available information. The recommendations are, therefore, subject to the accuracy and completeness of the information available at the time of the study. Should any further information become available, the analyses and findings of this report should be reviewed accordingly.

APPENDIX A

Calculations

RILEY CONSULTANTS

Engineers and Geologists

MAXWELL HILLS RURAL RESIDENTIAL ZONE
PROPOSED PRIVATE PLAN CHANGE
STORMWATER REPORT

DESIGN CALCULATIONS

Calculations prepared for: Kapiti Views Trust

Calculations prepared by: Jason Budd, Senior Civil Engineer, CPEng

Calculations reviewed by: Rachel Kelly, Civil Engineer

Project reference: 04819/6SW-A

Date: 15 February 2011

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Riley Consultants Limited

Runoff Parameters and Time of Concentration
(from ARC's TP108)

Project Title: Maxwell Hills **By:** JEB

Project Number: 04819/6 **Checked:** RK 15/2/11

Catchment: A - Rural residential zone **Date:** 15-Feb-11

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Pre Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	Pasture	P	74	7	518
* from Appendix B, TP108 (ARC, 1999)				Totals =	7	518

CN (Weighted) = 74.0

Ia (Weighted) = 5.0 mm

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Post Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	Roof, paving	Im	98	1.3	127.4
	Group C	Grass	P	74	5.7	421.8
* from Appendix B, TP108 (ARC, 1999)				Totals =	7	549.2

CN (Weighted) = 78.5

Ia (Weighted) = 4.1 mm

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	A - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Pre Development		

1. Data

Catchment Area	A =	0.07	km^2
Runoff curve number....	CN =	74.0	
Initial Abstraction....	Ia =	5.0	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 89.2 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.27	0.34	0.48
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	31.5	50.2	109.5
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	2207	3515	7668

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title: Maxwell Hills **By:** JEB

Project Number: 04819/6 **Checked:** RK 15/2/11

Catchment: A - Rural residential zone **Date:** 15-Feb-11

Scenario: Post Development

1. Data

Catchment Area	A =	0.07 km^2
Runoff curve number....	CN =	78.5
Initial Abstraction....	Ia =	4.1 mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 69.7 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.33	0.40	0.54
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	36.6	56.9	119.4
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	2562	3981	8357

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JW
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	A - Rural residential zone	**Date:**	15-Feb-11

1. Data

Catchment Area	A =	0.07	km^2
Runoff curve number....	CN =	78.5	
Initial Abstraction....	Ia =	4.1	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 69.7 mm

	Storm #4	Storm #5
3. Average Recurrence Interval, ARI (yr)	Wqevent	ED
4. 24-hour Rainfall Depth, P_{24} (mm)	25.36667	34.5
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.11	0.16
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	5.0	9.2
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	300	600

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	A - Rural residential zone	**Date:**	15-Feb-11

Attenuation Volume Summary

Average Recurrence Interval, ARI (yr)	WQ	ED	2	10	100
24-hour Rainfall Depth, P24 (mm)	25.366667	34.5	76.1	101.6	172.8
Pre Development Runoff Volume (m^3)	N/A	N/A	2207	3515	7668
Post Development Runoff Volume (m^3)	N/A	N/A	2562	3981	8357
Attenuation Volume (m^3)	**300**	600	**355**	**466**	**689**

Riley Consultants Limited

Runoff Parameters and Time of Concentration
(from ARC's TP108)

Project Title: Maxwell Hills **By:** JEB

Project Number: 04819/6 **Checked:** RK 15/2/11

Catchment: B - Rural residential zone **Date:** 15-Feb-11

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Pre Development

Soil Name	Soil Classification	Cover Description	Pervious, impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	Pasture	P	74	6.1	451.4
* from Appendix B, TP108 (ARC, 1999)				Totals =	6.1	451.4

CN (Weighted) = 74.0

Ia (Weighted) = 5.0 mm

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Post Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	roofs, pavement	Im	98	0.81	79.38
	Group C	Grass	P	74	5.29	391.46
* from Appendix B, TP108 (ARC, 1999)				Totals =	6.1	470.84

CN (Weighted) = 77.2

Ia (Weighted) = 4.3 mm

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	B - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Pre Development		

1. Data

Catchment Area	A =	0.061	km^2
Runoff curve number....	CN =	74.0	
Initial Abstraction....	Ia =	5.0	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 89.2 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.27	0.34	0.48
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	31.5	50.2	109.5
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	1923	3063	6682

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	B - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Post Development		

1. Data

Catchment Area	A =	0.061	km^2
Runoff curve number....	CN =	77.2	
Initial Abstraction....	Ia =	4.3	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 75.1 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.31	0.38	0.52
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	35.1	54.9	116.5
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	2139	3349	7109

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	B - Rural residential zone	**Date:**	15-Feb-11

1. Data

Catchment Area	A =	0.061	km^2
Runoff curve number....	CN =	77.2	
Initial Abstraction....	Ia =	4.3	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 75.1 mm

	Storm #4	Storm #5
3. Average Recurrence Interval, ARI (yr)	Wqevent	ED
4. 24-hour Rainfall Depth, P_{24} (mm)	25.36667	34.5
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.10	0.15
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	4.6	8.6
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	300	500

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	B - Rural residential zone	**Date:**	15-Feb-11

Attunation Volume Summary

Average Recurrence Interval, ARI (yr)	WQ	ED	2	10	100
24-hour Rainfall Depth, P24 (mm)	25.366667	34.5	76.1	101.6	172.8
Pre Development Runoff Volume (m^3)	N/A	N/A	1923	3063	6682
Post Development Runoff Volume (m^3)	N/A	N/A	2139	3349	7109
Attenuation Volume (m^3)	**300**	500	**216**	**286**	**427**

Riley Consultants Limited — **Runoff Parameters and Time of Concentration** (from ARC's TP108)

Project Title: Maxwell Hills — **By:** JEB

Project Number: 04819/6 — **Checked:** RK 15/2/11

Catchment: C - Rural residential zone — **Date:** 15-Feb-11

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Pre Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	Pasture	P	74	14.9	1102.6
* from Appendix B, TP108 (ARC, 1999)				Totals =	14.9	1102.6

CN (Weighted) = 74.0

Ia (Weighted) = 5.0 mm

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Post Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	roofs, pavement	Im	98	2.89	283.22
	Group C	Grass	P	74	12.01	888.74
* from Appendix B, TP108 (ARC, 1999)				Totals =	14.9	1171.96

CN (Weighted) = 78.7

Ia (Weighted) = 4.0 mm

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RIC 15/2/11
Catchment:	C - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Pre Development		

1. Data

Catchment Area	A =	0.149 km^2
Runoff curve number...	CN =	74.0
Initial Abstraction....	Ia =	5.0 mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 89.2 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.27	0.34	0.48
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	31.5	50.2	109.5
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	4698	7482	16322

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	C - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Post Development		

1. Data

Catchment Area	A =	0.149 km^2
Runoff curve number....	CN =	78.7
Initial Abstraction....	Ia =	4.0 mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 68.9 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.33	0.40	0.54
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	36.8	57.2	119.8
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	5489	8519	17855

Riley Consultants Limited — **Graphical Peak Flow Method** (from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	C - Rural residential zone	**Date:**	15-Feb-11

1. Data

Catchment Area	A =	0.149	km^2
Runoff curve number....	CN =	78.7	
Initial Abstraction....	Ia =	4.0	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 68.9 mm

	Storm #4	Storm #5
3. Average Recurrence Interval, ARI (yr)	Wqevent	ED
4. 24-hour Rainfall Depth, P_{24} (mm)	25.36667	34.5
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.11	0.16
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	5.0	9.3
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	800	1400

Riley Consultants Limited

Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	C - Rural residential zone	**Date:**	15-Feb-11

Attunation Volume Summary

Average Recurrence Interval, ARI (yr)	WQ	ED	2	10	100
24-hour Rainfall Depth, P24 (mm)	25.366667	34.5	76.1	101.6	172.8
Pre Development Runoff Volume (m^3)	N/A	N/A	4698	7482	16322
Post Development Runoff Volume (m^3)	N/A	N/A	5489	8519	17855
Attenuation Volume (m^3)	**800**	1400	**791**	**1038**	**1533**

Riley Consultants Limited — Runoff Parameters and Time of Concentration (from ARC's TP108)

Project Title: Maxwell Hills — **By:** JEB

Project Number: 04819/6 — **Checked:** RK 15/2/11

Catchment: D - Rural residential zone — **Date:** 15-Feb-11

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Pre Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	Pasture	P	74	8.8	651.2
* from Appendix B, TP108 (ARC, 1999)				Totals =	8.8	651.2

CN (Weighted) = 74.0

Ia (Weighted) = 5.0 mm

1. Runoff Curve Number (CN) and Initial Abstraction (Ia) - Post Development

Soil Name	Soil Classification	Cover Description	Pervious, Impervious	CN*	Area (Ha)	Product of CN x Area
Colluvium	Group C	roofs, pavement	Im	98	1.205	118.09
	Group C	Grass	P	74	7.595	562.03
* from Appendix B, TP108 (ARC, 1999)				Totals =	8.8	680.12

CN (Weighted) = 77.3

Ia (Weighted) = 4.3 mm

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Graphical Peak Flow Method
(from ARC's TP108)

Project Title:	Maxwell Hills	**By:**	JEB
Project Number:	04819/6	**Checked:**	RK 15/2/11
Catchment:	D - Rural residential zone	**Date:**	15-Feb-11
Scenario:	Pre Development		

1. Data

Catchment Area	A =	0.088	km^2
Runoff curve number....	CN =	74.0	
Initial Abstraction....	Ia =	5.0	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 89.2 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.27	0.34	0.48
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	31.5	50.2	109.5
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	2774	4419	9640

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Graphical Peak Flow Method
(from ARC's TP108)

Project Title: Maxwell Hills **By:** JEB

Project Number: 04819/6 **Checked:** RK 15/2/11

Catchment: D - Rural residential zone **Date:** 15-Feb-11

Scenario: Post Development

1. Data

Catchment Area	A =	0.088	km^2
Runoff curve number....	CN =	77.3	
Initial Abstraction....	Ia =	4.3	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 74.6 mm

	Storm #1	Storm #2	Storm #3
3. Average Recurrence Interval, ARI (yr)	2	10	100
4. 24-hour Rainfall Depth, P_{24} (mm)	76.1	101.6	172.8
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.31	0.38	0.52
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	35.2	55.0	116.8
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	3097	4844	10274

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Graphical Peak Flow Method
(from ARC's TP108)

Project Title: Maxwell Hills **By:** JEB

Project Number: 04819/6 **Checked:** RK 15/2/11

Catchment: D - Rural residential zone **Date:** 15-Feb-11

1. Data

Catchment Area	A =	0.088	km^2
Runoff curve number....	CN =	77.3	
Initial Abstraction....	Ia =	4.3	mm

2. Calculate Storage, S = (1000/CN - 10)25.4 = 74.6 mm

	Storm #4	Storm #5
3. Average Recurrence Interval, ARI (yr)	Wqevent	ED
4. 24-hour Rainfall Depth, P_{24} (mm)	25.36667	34.5
5. Compute $c^* = (P_{24}-2Ia)/(P_{24}-2Ia+2S)$	0.10	0.15
6. Runoff Depth, $Q_{24} = (P_{24}-Ia)2/(P_{24}-2Ia)+S$ (mm)	4.6	8.7
7. Runoff Volume, $V_{24} = 1000Q_{24}A$ (m^3)	400	800