MERIDIAN ENERGY LIMITED

Hunter Downs Irrigation Scheme Drainage Requirements Analysis in and Around the Wainono Lagoon

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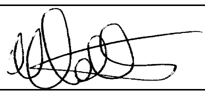
Signature	
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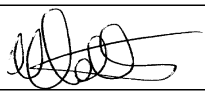
Signature	
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1 INTRODUCTION

1.1 Background to the Study

This study has been prepared for the proposed Hunter Downs Irrigation Scheme (HDIS) to assess the effects of the project on runoff and drainage requirements in and around the Wainono Lagoon.

1.2 Scope of Work

The scope of work for Glasson Potts Fowler Ltd's (GPF) input was as follows:

(i) Analysis of changes in soil moisture over the duration of a rainfall event;
(ii) Analysis of the effect of different soil types on drainage and flooding in the project area;
(iii) Analysis of the likely change in flood flows, and if necessary, the flood carrying capacity of the drainage network, with the change from dryland to irrigated agriculture within the catchment;
(iv) To evaluate before project and after project drainage scenarios to determine the impact of the project on the area's drainage requirements;
(v) To compare the frequency of run-off events in the catchment with and without the project; and,
(vi) Surveying of profiles of the major spring and drainage ditches.

1.3 Objectives

The objectives of this study are:

- To estimate the effect of the proposed HDIS on peak floods and drainage in the study area; and,
- To estimate the effect of HDIS on flooding and drainage in and around the Wainono Lagoon.

This report details the methodology used and provides a discussion of the analyses that were undertaken by GPF to achieve the objectives above.

1.4 Limitations

This report and the information it contains have been prepared solely for the use by Meridian Energy Limited, and any reliance on this report by any other parties shall be at their own risk.

The report is based on the conditions encountered and information reviewed at the time of preparation and is directly relevant only to the points in the catchment area where they were obtained at the time of the assessment.

As catchment and climatic conditions are dynamic, this document and the information contained herein should only be regarded as valid at the time of the investigation unless otherwise explicitly stated in this report.

2 CATCHMENT CHARACTERISTICS AND FLOWS

2.1 Location of the HDIS

The HDIS would potentially irrigate up to 40,000 hectares out of a total area of 60,000 hectares with water from the Waitaki River. The scheme will be spread across six sub-schemes namely Elephant Hill/Waihao Downs, Waimate, Makikihi, Otaio, Pareora and Otipua.

The majority of the scheme area is within a narrow coastal band, ranging from the coast to about 10 - 16 km inland.

The map in Appendix A shows the location and extent of the HDIS.

2.2 The Wainono Lagoon

The Wainono Lagoon is situated on the South Canterbury coastline 35 km south of Timaru, and covers an area of approximately 4.3 km^2. The lagoon acts as a storage area and provides a drainage outfall for farmland via numerous open drains.

The lagoon drains from the south east corner of the Waihao "Dead Arm" depending on water levels in the Lagoon. The Hook River and Waituna Stream flow directly into the lagoon area, while Sir Charles Creek and Waimate Creek enter the Lagoon via the Waihao Dead Arm. This either flows into the Lagoon, or away from it depending on whether the "Box" is open. The Makikihi-Hook Swamp Drain flows into the north end of the lagoon, which runs parallel to the coast.

Surface water from the Waihao River and all catchments northwards to the Makikihi River drain into the coastal strip where the Wainono Lagoon is situated. Direct drainage of these catchments is restricted by coastal processes. The Waihao Box provides discharge from the Waihao River. At times the box fails to maintain an open mouth, for example, during periods of higher sea levels associated with large wave action. The mouth is also opened mechanically when the levels in Wainono Lagoon are considered excessive. At times, there are requests to the Morven-Glenavy Irrigation Scheme to put water into the Waihao River to augment the Lagoon.

Appendices B and C (taken from Pemberton (1980) and Aitchson-Earl *et. al* (2005) respectively) show the location of the Wainono Lagoon and the catchments draining into the lagoon.

The approximate total aerial extents of the catchments linked to the lagoon as derived from Aitchson Earl et. al. (2005) are given in Table 1 below.

Table 1 – Approximate Areas of Catchments Linked to the Wainono Lagoon

CATCHMENT/STUDY SUB-CATCHMENT	Area (km^2)
Waihao Catchment	541
Buchanans Creek	15
Waimate Catchment	78
Sir Charles Creek	14
Wainono Inflows	24
Hook Catchment	70

2.3 Irrigation Sub-schemes

2.3.1 Area

The HDIS comprises a number of sub-schemes classified according to soil type. The rationale behind the sub-scheme classification is detailed in the HDIS Assessment of Environmental Effects (AEE). The Waimate sub-scheme is the one that is directly linked to the Wainono Lagoon. The sub-scheme has a gross area of 182 km^2. This represents 25% of the total area (742 km^2) shown in Table 1.

2.3.2 Soils

Table 2 summarises the description of the soils, the proportion of the soils based on the profile available water (PAW) classes and the proportion of each PAW class in the Waimate sub-scheme.

The majority of the soils (77%) in the study area have PAW ranging from 75 – 110 mm.

Table 2 – Summary of the Waimate Sub-scheme and its Soil Characteristics

Sub-Area	Typical Soil Descriptions	PAW (mm)	Proportion	Area (ha)
Waimate (18,220 ha)	Willowbridge deep and moderately deep silt loam, Claremont deep silt loam, Morven deep silt loam, Wakanui deep and mod deep silt loam, Waitohi deep silt loam.	<75	4 %	729
		75 – 110	77 %	14,029
		> 110	19 %	3,462

2.4 Land Use and Effects of Land Use Changes

The existing and the most likely land uses for the Waimate sub-area following irrigation development are detailed in the HDIS AEE. One of the most likely land use scenarios is summarised in Table 3 below.

Table 3: Existing and Likely Land Use for the Waimate Sub-area

	Dairy	Pastoral	Arable	Other
Existing				
Proportion	10%	62%	25%	3%
Likely				
Proportion	60%	10%	30%	-

The table above shows that the major change is going to be from general dryland pastoral farming to dairy farming, with minor changes in arable farming. The effect of these land use scenarios on drainage and flooding would be through:

- Changes to land cover and vegetation types;
- Changes to runoff and erosion throughout the catchment; and,
- Effects on the catchment water balance possibly leading to rising water tables.

2.5 Surface Drainage and Streamflows

Streamflow is strongly seasonal, with some of the creeks (for example Sir Charles and Buchanan Creeks) in the project area known to dry out during parts of the year (Aitchison-Earl et al, 2005). This occurs usually in summer but can occur at other times of the year following periods of low rainfall.

2.6 Historical Flooding and Flood Management

2.6.1 Historical Flooding

The Waihao River Floodplain Management Strategy (ECan, 2004) lists a number of historical flood events for the Waihao catchment. Table 4 summarises some of these events.

Table 4: Floods in the Waihao River Floodplain[1]

Year	Rainfall Depth (mm)	Peak Flow (m^3/s)	Duration (hours)	Intensity (mm/hr)
February 1945*	n/a	850 - 1,000	n/a	n/a
July 1961	200	700 - 800	n/a	n/a
March 1986	n/a	1,250	10	20
March 1994	150	900*	12	12.5

n/a – Not Available

** The Lower Waihao Asset Management Plan gives a value of 1120 m^3/s for this flood.*

2.6.2 Existing Flood Infrastructure Management

As part of the flood management strategy, flood protection systems have been implemented. There is limited information available on the design levels of the flood infrastructure. The Waihao Floodplain Management Strategy (WFMS) and some asset management plans provide the little information that can be found. This is presented in Table 5 below.

Table 5 – Existing Floodplain Management Design Parameters

Catchment	Source	Total Catchment Area (km^2)	Design Period	Design Flow (m^3/s)	Freeboard (mm)
Waihao	WFMS[1]	541	1:50 Yr	975	300
Waimate	WFMS/ LHAMP[2]	78	1:10 Yr	42	n/a
Hook	LHAMP	70.2	1: 5 Yr	32	150

1- WFMS – Waihao Floodplain Management Strategy
2. LHAMP - Lower Hook Asset Management Plan ([2]Environment Canterbury, 2004*)*
3. n/a – Not Available

[1] Environment Canterbury. 2004. Waihao River Floodplain Management Strategy. ECan Report No R03/13

[2]Environment Canterbury. 2004. Canterbury Regional Council, Lower Hook Asset Management Plan. River Engineering

3 METHODOLOGY

The approaches and methods adopted for this study were influenced by the quality and quantity of available data and generally accepted practices.

Four types of analyses were done to achieve the objectives of the study. These were:

- Preliminary analysis comprising of a soil moisture balance;
- Hydrologic analysis;
- Hydraulic analysis; and,
- Estimation of runoff event frequency.

3.1 Available Data

Data and information used in the study included:

- Local knowledge of the study area from past visits;
- Consultation with local landowners and interest groups;
- Catchment demarcations from Environment Canterbury reports;
- High Intensity Rainfall Design Systems Version 2 (HIRDS 2) which is a rainfall intensity programme developed by NIWA;
- Historical data for the Poingdestres rainfall station near the Wainono Lagoon;
- Catchment topographical maps to extrapolate key hydrological parameters such as slopes;
- Soil infiltration tests undertaken by GPF;
- Various technical papers for the project area prepared by Environment Canterbury (as referenced throughout this report); and
- River cross sections from a field survey undertaken by GPF.

3.2 Data Analysis and Interpretation

A rainfall/runoff approach of linking hydrologic and hydraulic models and calibrating them to historical data is not possible due to the lack of suitable historical rainfall/runoff information linked in time with river flow data and flooding inundation data.

However inferences have been made on the relationship between rainfall and runoff based on the data available. This approach provides a way of achieving the objectives and scope of the study in the absence of the detailed historical data described above.

A sensitivity analysis was also undertaken to ascertain the effects of changes in the adopted model parameters.

During the course of this study GPF consulted with various stakeholders. This comprised:

- Consultation with local landowners including the Chairman of the Hunter Downs Irrigation Scheme committee, Mr Ian Moore and the Chairman of the Wainono Drainage District, Mr Mick Laming. This was helpful in understanding the historical nature of flood and drainage issues in the study area;
- Discussions were also held with ECan staff to provide a better understanding of the operation of the Waihao Box and the various variables affecting its operation; and,
- Community meetings, in particular the Hunter Downs Stakeholder Workshop in January 2007 and the Lower Waihao River Management Group in April 2007.

4 SOIL MOISTURE WATER BALANCE ANALYSIS

A simple water balance equation was used to model changes in soil moisture after a rainfall event. The water balance equation is given below:

$R = P - PET - I_n - S$

Where;

R = surface runoff water (mm);
P = rainfall/irrigation or snowmelt (mm);
PET = potential crop evapotranspiration (mm);
I_n = soil moisture infiltration and includes deep percolation (mm); and
S = changes in soil water storage (mm).

4.1.1 Rainfall

Rainfall data was derived from HIRDS V2, developed by NIWA. This provides rainfall depths for Average Recurrence Intervals (ARI) of various durations. The rainfall data used for this study and the resultant intensities are given in Appendix D.

4.1.2 Climate Change

Climate change has been assessed for the study area based on the methods proposed by the Ministry for the Environment (MfE, 2004; Gluckman & Boyle, 2003). The Canterbury Region's temperatures and rainfall are expected to change by 0.4 to 3.4 ^{0}C and -12 to + 13% respectively between 1990 and 2080. For this study we have assumed medium changes (2.5 ^{0}C temperature rise and a 1 % increase in rainfall between 2007 and 2050) in making the climate change adjustments. These adjustments have been applied to the rainfall depth and intensity data in Appendix D.

4.1.3 Potential Evapotranspiration

The monthly evapotranspiration (PET) rate for Waimate in January (the highest) was used. Daily ET was assumed to take place at a constant rate over a 24 hour period. This assumption potentially reduces the evapotranspiration component, thus increasing potential runoff, since in reality ET occurs primarily during the day time hours.

4.1.4 Infiltration Capacities of the Soil in the Study Area

Soil infiltration tests were undertaken at seven sites on representative soil types across the study area. At two sites with known fragipans, the top soil was removed and the tests were done on the fragipan surface. At all the other sites, the infiltration tests were done on the ground surface.

The initial infiltration rate for all the soils tested (top and subsoil) ranged from 12 – 84 mm/hr reflecting the antecedent soil moistures. The infiltration tests were carried out over a two day period. On the evening of Day 1, 22 mm of rainfall was recorded in the area. As a result, the tests undertaken on Day 2 had much lower initial infiltration rates.

The final infiltration rates at the measured sites ranged from 1 – 16 mm/hr for all soils. As expected the lower infiltration rates were observed at sites where the soils were underlain by a thick dense subsurface horizon or fragipans.

Typical infiltration rates for silt loams range from initial rates of 20 - 40 mm/hr to final rates of 10 – 17 mm/hr for Soil Intake Curves types[3] 0.2 and 0.3 respectively. Soil Intake curves were used to simulate the change in soil moisture during an irrigation event.

Based on Soil Intake Curves 0.2 and 0.3, an average initial infiltration rate of 15 mm/hr was used for dry soils and this then reduced to an average final infiltration rate of 3.4 mm/hr to simulate the soil infiltration close to saturation.

4.1.5 Runoff Assessments

The water balance was used to calculate the runoff from soils under three different antecedent soil moisture conditions:

(i) Dry Soil –Soil is dry when its moisture content is less than or equal to 25% of PAW;
(ii) Field Capacity - Soil is at field capacity when moisture content is 75% of PAW; and,
(iii) Saturated Soil - The soil is completely saturated when soil moisture is greater than field capacity. In this condition, the soil infiltration approximates the final infiltration rate. Rainfall is lost mostly through PET and runoff.

[3] Irrigation New Zealand. 2006. Irrigation Code of Practice and Irrigation Design Standards.

5 HYDROLOGIC ANALYSIS

5.1 Peak Discharge

Peak design discharge for each sub-catchment has been derived using the Rational Method. The peak flows calculated on an Average Return Interval (ARI) of 50 years are shown in Appendix E.

For each sub-catchment, three flow scenarios have been presented based on the antecedent soil moisture conditions discussed earlier.

This model shows that long duration storms become effective in contributing to total runoff once field capacity has been reached. In reality, however, some runoff is observed on dry soils even during low intensity storms. This is attributed to localised effects such as soil surface crusting. The model therefore underestimates runoff for low duration storms on dry soils.

Saturated soils represent the worst case scenario. The soil is fully saturated or waterlogged. In this situation it can normally be assumed that most rainfall contributes to the total runoff volume. Saturated hydraulic conductivity values were used to represent the soil infiltration rate.

5.2 Storm Duration

The time of concentration (Tc) is the time required for a drop of water to travel from the most hydrologically remote point in the sub-catchment to the point of collection was estimated using the Ramsey Method. The time of concentration varied from 1 - 5 hours for the smaller catchments and was approximately 10 hours for the Waihao Catchment.

From Table 4, the durations of two of the storms in the Waihao sub-catchment that caused flooding in recent years (1986 and 1994) are 10 hours and 12 hours. In hydrological terms, these two durations approximate the Tc of 10 hours that was calculated above for the sub-catchment. For this study a Tc of 12 hours was adopted to estimate peak discharges for the Waihao sub-catchment.

5.3 Comparison of Peak Discharges Existing Literature Values

Where available, the design flows in this study are compared with the results of the previous studies undertaken by ECan or the Waimate DC.

Table 6 below compares the calculated data with data from previous studies.

Table 6 – Comparison of Flood Design Parameters

Catchment	Calculated Parameters		Data From Previous Studies		
	Peak Flow (m^3/s)	**Design ARI**	**Flood Design Flow (m^3/s)**	**Design ARI**	**Observed Flood Peak (m^3/s)**
Waihao	946.5	50	975	50	900 (Mar '94)
Buchanans	26.2	50	-	-	-
Waimate	46.7	10	42	10	-
Sir Charles	24.5	50	-	-	-
Wainono Inflows	42	50	-	-	-
Hook	122	50	-	-	-

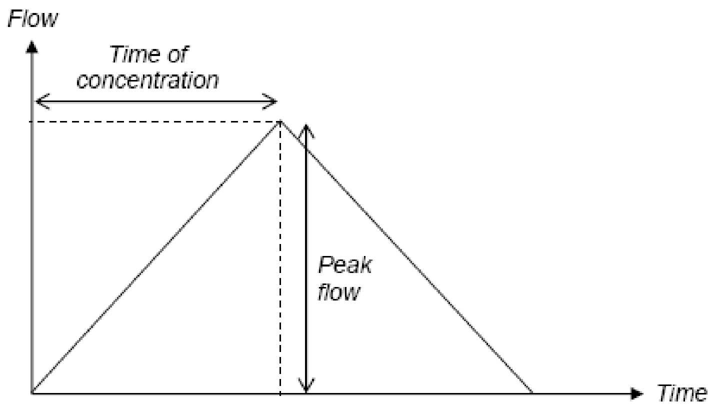
– Not Available

The calculated peak discharge for the worst case scenario from a 50 year, 12 hour duration storm for the Waihao Catchment is 947 m^3/s. This compares well with the Waihao stop bank design flow of 975 m^3/s summarised in Table 5. These flows also confirm that a Tc of around 12 hours is likely to be the critical duration for the Waihao Catchment.

5.4 Hydrograph Generation

Using the runoff depths generated from the water balance model and the calculated time of concentrations, hydrographs were created based on the generic diagram in Figure 1 below.

Figure 1 – Generic Diagram of the Unit Hydrograph



5.5 Conclusion

An analysis of the peak design discharge using the Rational Method suggests that HDIS sub-schemes will be able to cope with flood flows in a manner that is very similar to the status quo.

On average the increase in flow rate and volume is expected to be 0 - 6%. The severity of the increase in flow and volume is related to:

- Soil moisture conditions at the start of a rainfall event; and,
- The nature of the rainfall event, for example (i) long duration storms will not increase run-off as much as shorter duration storms because of their low intensities and (ii) short return period storms will have a less severe impact on increases in flow and volume compared to long return period storms.

The implications of this are otherwise discussed at the end of this report.

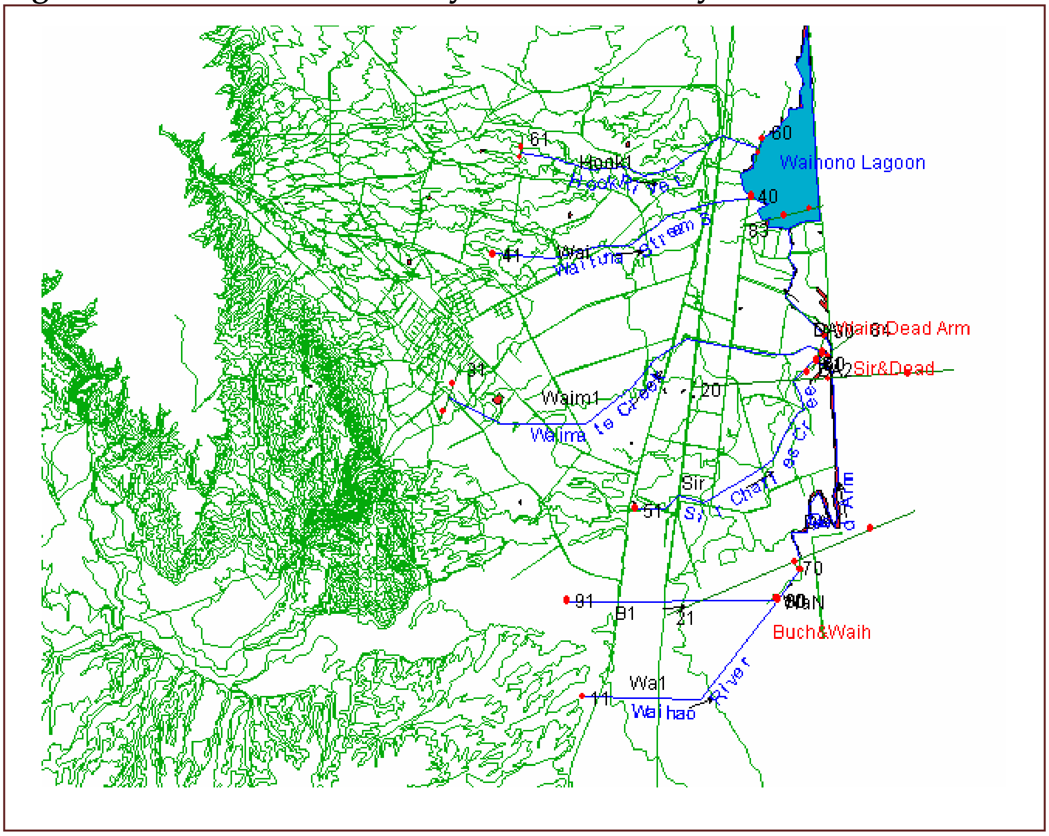
6 HYDRAULIC ANALYSIS

6.1 Modelling

The HEC-RAS programme, a one-dimensional steady and unsteady flow water surface model, was used for modelling.

The plan for the model is shown in Figure 2 below.

Figure 2 – HEC-RAS Model Layout for the Study Area



6.2 Model Inputs

6.2.1 Cross-Section Data

Surveyed cross-section information was collected for most of the major channels linked to the Wainono Lagoon to capture the geometry of the stream channel and floodplain. Appendix F shows some of the cross sections.

6.2.2 River and Channel Delineation

The stream channel was differentiated from the floodplain by manually locating the left and right channel banks for each cross-section. Where the location of the left and right channel banks cross-sections were unclear from the channel geometry, they were estimated.

6.2.3 Upper Boundary Conditions

The upper boundary conditions for each catchment were estimated from the basic inflow hydrograph. The derivation of this hydrograph is described in Section 5.

6.2.4 Lower Boundary Conditions

The lower boundary of the study area is the Wainono Lagoon. GPF assumed water levels from literature (Aitchson-Earl, 2005; Hall, 2003)

6.2.5 Floodplain and Channel Roughness

Manning's 'n' was used to estimate channel and floodplain roughness for each of the cross-sections. Different Manning's values were used for the channels and berms. These values are given in Table 7.

Table 7 - Roughness Coefficients Used for Modelling and Calculation of Tc

Channel Condition	Channel	Berms
Clean	0.05 - 0.005	0.15
Heavily Obstructed	0.1 – 0.15	0.15

Results of a sensitivity analysis of the roughness coefficients are summarised in Section 8.

6.3 Results of the Modelling

Based on this modelling it is not expected that the Hunter Downs Irrigation Scheme will significantly affect the hydrology, the extent and magnitude of the flood hazard risk.

6.4 Assumptions and Limitations

- On some streams, slope variation was more pronounced than that allowed for in the model;

- Lack of historical flood levels, as discussed in Section 3.2, precluded the calibration of the model against historical data;

- Outflows to sea through the Waihao Box and the beach barrier were ignored during the modelling. Ignoring outflow from the Waihao Box, replicates the situation that would exist if the box was closed. However, flow through the beach barrier would remove an estimated 800 L/s (Hall, 2003) or 730 L/s in autumn (Mulgor Consulting, 2006). This outflow would have a significant effect (especially after small events) on the period of inundation in and around the lagoon, even if the box was closed;

- In running the model, focus was on the main drainage channels. A number of smaller creeks and on-farm drainage systems exist, which will also assist in conveying flood water in each sub-catchment. However, a key question that still needs to be addressed, with or without HDIS, is how best to improve the operation of the Waihao Box to remove the water coming from the total catchment; and,

- Some problems were encountered with the model stability because of the complex relationship between the Wainono Lagoon, the Dead Arm, seepage through the Dead Arm barrier and the Waihao Box.

7 RUNOFF FREQUENCY ESTIMATION

The first phase of the study showed that the scheme has the potential to increase peak flows and volumes by 0 - 6% depending on antecedent soil moisture. The next phase of the study assesses whether the introduction of the HDIS would result in more frequent flood events.

7.1 Water Balance Model

GPF developed a spreadsheet model to simulate runoff in the area draining to the Wainono Lagoon. The spreadsheet was a water balance model based on 5 years of historical data (June 2001 to September 2006) for the catchment area.

Two scenarios were modelled. The first scenario assumed that the whole HDIS area would have the same antecedent soil moisture (AMC) at any given time. In the second scenario, the area within HDIS was divided into five sectors, effectively assuming a 5-day irrigation cycle. Each sector was assumed to have different AMC depending on the position in the irrigation cycle. In other words, 20 % of the area would be at or close to field capacity, 20 % would be close to the maximum depletion point and the remaining 60% would fall in between.

7.2 Model Assumptions

The following assumptions were made in the model:

- Allowable Depletion (AD) was set as a user defined variable. For this study it was set at 75% of PAW;
- If soil moisture falls below PAW x AD, irrigation occurs;
- Rainfall was considered to be effective if it was greater than 5 mm;
- A Saturation Factor (SF) has been included. This accounts for storage above field capacity. For the soils in this area, this factor was set at 5%;
- The SF is applied to HDIS soils only. Assumption is that the soils in HDIS have better structure and are thus able to take in slightly more moisture above field capacity;
- Proper irrigation management means the SF is not required to account for irrigation water;
- Irrigation is applied to 75% of PAW, i.e. 50% of PAW is applied from 25 to 75% PAW. This ensures that no unnecessary runoff occurs from the HDIS;
- Runoff occurs if the soil moisture is greater than PAW x SF; and,
- Runoff coefficient of 0.6 was assumed.

7.3 Results of the Model

A total of 507 rainfall events were recorded in the rainfall data at the Poingdestres Station. Of these, 112 events were effective, i.e. rainfall was greater than 5 mm.

7.3.1 Scenario 1 – All of HDIS with the Same AMC

Table 8 summarises the number of runoff events with and without the HDIS for Scenario 1.

Table 8 – Runoff Events when Soils Have the Same AMC

	With HDIS	**Without HDIS**
Total Events	20	10
Events > 2 m^3/s	18	9
Events > 10 m^3/s	11	7
Events > 30 m^3/s	4	4

The model indicates double the number of runoff events (20 compared to 10) over the 5 year period of analysis. What is of interest is that these runoff events are not large (compared to floods) as can be seen when the event rates are reviewed:

- If events below 2 m^3/s are ignored, then this ratio does not change (18 runoff events compared to 9).
- If events below 10 m^3/s are ignored this ratio reduces to 11 runoff events compared to 7.
- If events below 30 m^3/s are ignored, then there is no difference in runoff events (4 with and without HDIS).

7.3.2 Scenario 2 – Area Divided into 5 AMC Sectors

Table 9 summarises the number of runoff events with and without the HDIS for Scenario 2.

Table 9 - Runoff Events when Soils have 5 Different Moisture Contents

	With HDIS	Without HDIS
Area 1	20	10
Area 2	20	10
Area 3	20	10
Area 4	20	10
Area 5	20	10

Accounting for different AMCs does not necessarily give lower run off rates than Scenario 1. The reason for this is that the sectors into which the irrigated area is broken are a small percentage of the total area. As discussed earlier, the HDIS Waimate sub-scheme is 182 km^2 and this is approximately 25% of the total catchment likely to contribute to the flows in the lagoon. Each sector is only approximately 5 % of the total catchment.

Again, the runoff events are not large (compared to floods) as can be seen when the event flow rates are reviewed:

- If events below 2 m^3/s are ignored this ratio reduces to 13 runoff events compared to 9.
- If events below 5 m^3/s are ignored there is no difference in runoff events (9 with and without HDIS).

7.3.3 Comment on limitations

As a check on the assumptions, the irrigation trigger was changed from 25% to 50% and the replenishment trigger was changed from 75% to 100%. Of interest this generated more runoff events below 10 m^3/s (15 compared to 6), but did not increase the number of events over 30 m^3/s.

7.3.4 Conclusion

The results indicate that the antecedent moisture content of the HDIS area is inconsequential to runoff as this area represents a small fraction of the total catchment area.

Where the HDIS does effect a change, ~~it~~ is only in the situation where the rest of the catchment is dry and the soils within the scheme are at saturation at the start of a rainfall event. In this situation the presence of the scheme has potential to generate runoff in a rainfall event that under current dryland conditions would not occur. The first phase of this study found that the runoff rates in this situation will not be at flood levels.

The analysis shows limited runoff events in total over the analysis period.

In summary:

- HDIS may result in more runoff events than currently might occur. These additional runoff events are small, less than 30 m^3/s, and thus will not cause flooding;
- In larger storms, the extra soil moisture associated with the HDIS is inconsequential due to the small area that the scheme covers within the total catchment;
- On a catchment by catchment basis, there would be 10 additional runoff events but the magnitude of the events is smaller. For example, if events less than 2 m^3/s are ignored, the Wainono Catchment will have the same runoff events with or without HDIS. In the larger Hook Catchment, ignoring events less than 9 m^3/s produces the same number of runoff events with or without HDIS; and,
- Table 5 gave the design parameters of the existing flood protection infrastructure. While there would have been more runoff events, the design flood flows for both the Wainono and Hook Catchments would not have been exceeded if the HDIS was in operation during the period assessed.

8 SENSITIVITY ANALYSIS

A range of sensitivity analyses were undertaken to determine the potential variation in the study results due to different assumptions in the key model parameters adopted.

The following scenarios were considered to represent the envelope of likely parameter values:

(i) 20% decrease in the amount of PET (provides high runoff potential);
(ii) Reduce soil infiltration by 20% (low infiltration, high runoff potential); and,
(iii) Change in Manning's 'n' value.

The results from the sensitivity analyses can be summarised as follows:

(i) A 20% decrease in PET results in a change in runoff of less than 1.5 %;
(ii) A 20% reduction in infiltration produces a corresponding 3% to 27% increase in peak flood volumes. However, this is unlikely to happen as saturated hydraulic conductivity values have been used for saturated soils and these have been measured; and,
(iii) A decrease in the Manning's 'n' value from 0.055 to 0.050 for overland flow paths generally resulted in increases in peak flows of up to 10%.

9 CONCLUSIONS

From the foregoing, the proposed Hunter Downs Irrigation Scheme will increase the likelihood of runoff in the area. The number of runoff events is expected to be approximately double. However, not all runoff will produce flooding. The analysis shows that the with-HDIS and without-HDIS scenarios will produce a similar number of runoff with flows above 30 m^3/s.

If part of the portion of the catchment under HDIS is all ready close to saturation, a 12 hour duration rainfall will result in 0 - 6 % increase in flow, than if that same portion was at or below field capacity.

HEC-RAS was the hydraulic model used for the modelling of unsteady flows to the Wainono Lagoon. The results of the hydraulic modelling show that:
(i) All the existing water channels will be able to handle the extra runoff within their sub-catchments for design levels of up to 10 % AEP; and (ii) Some of these channels will be able to handle design flows of up to 2 % AEP. In other words, the existing infrastructure will be able to handle the average 0 – 6% increase in runoff flows within the existing flood protection design limits.

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