“Achieving Outcomes by Building Capability”

An assessment of the economic value of irrigation on the Poverty Bay Flats

Prepared for: Gisborne District Council
and
Horticulture New Zealand

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Executive Summary

Gisborne District Council (GDC) is currently preparing a plan to guide the sustainable management of fresh water resources in the Gisborne District. The plan will include setting water quality standards and water allocation limits for catchments in the District. The standards and limits will be based on a range of freshwater uses and values: ecological, economic and social / cultural. The following is a summary of the assessment of the economic value of fresh water for various irrigation uses on the Poverty Bay flats using irrigation water from groundwater and surface water taken from the Waipaoa and Te Arai Rivers.

The analysis reported here is for the direct impact of the production and immediate post harvest handling of the crops grown. Any indirect or flow on impacts beyond the post harvest handling of the crops will be in addition to those reported here. There is a large amount of data used and in most cases the values were able to be supplied or extrapolated from other sources. In some cases the values for data had to be assumed and the author takes responsibility for any assumptions that have been made.

The periods when water was not available were recorded for both the Waipaoa and Te Arai rivers. This was done by month in which the restriction would occur. They were recorded as the number of days when water would not be available.

Both rivers were analysed at three levels of reliability:

1. Status quo minimum flow: Current GDC minimum levels at 1300 litres/second for the Waipaoa and 15 litres/second for Te Arai;
2. NES default minimum flow: The proposed National Environmental Standards for Ecological Flows and Water Levels at 1600 litres/second for the Waipaoa and 60 litres/second for Te Arai; and
3. Conservative ecology minimum flow: The highest level of protection for ecological values at 2000 litres/second for the Waipaoa and 150 litres/second for Te Arai.

The Waipaoa River is quite benign in terms of the regularity of restrictions but when they do occur they occur for reasonable periods of time. The other point to note is the extreme of the maximum period of restriction. In the 1300 litres/sec scenario the January events only experience restrictions occurring for 12% of the time with a 19 day length. At 1600 litres/sec the restrictions which retain the same level of probability only go out to 26 days. For the 2000 litres/se restrictions the probability of almost all occurrences doubles: while the period of the average event does not get much longer the maximum event becomes very long.

For Te Arai river the gradient between restriction events between the flow regimes is much more extreme in all events. Starting off with the 15 litres / sec flow regime there are very few restrictions. The next step of 60 litres/sec shows a much higher number of events with quite a high average. The lift to 150 litres/sec shows a high number of restrictions occurring in the earlier months with very long periods of restrictions.

There is a range of 21 irrigated crops grown over approximately 2,670 ha of the Poverty Bay flats. The irrigation demand of these crops is quite complicated as they all require differing volumes of water throughout the year and/or the rotation.

Each scenario was tested for its effect on the gross margin return and its impact on employment.

Table 10 shows the impact for the average scenario. As can be seen there is very little change between the 1300 and the 1600 litres/sec flows with the Gross Margin only changing by $0.81 m or 4%. However the step up to the 2000 litres/sec flow shows a much more considerable difference of a change in gross margin of $2.0m or 11 %.

Table 1: Gross Margin analysis of River Flow Regimes (Average) ($ m per annum)

	1300 l/s	1600 l/s	Change	Change %	2000 l/s	Change From 1300	Change %
Gross Revenue	57.61	56.52	1.09	2%	54.69	2.9	5%
Total Costs	38.38	38.11	0.28	1%	37.51	0.9	2%
Gross Margin	19.23	18.42	0.81	4%	17.18	2.0	11%

The changes in labour that would occur from the 1300 litres/sec to the 1600 litres/sec is relatively minor at 10 Full Time Equivalents (FTE) whereas the change to 2000 litres/sec is much larger at 24 FTEs.

However the situation changes considerably when we look at the impact of the maximum event in Table 2. The change in gross margin from the average event is quite significant as are the changes as the flow regime increases to the point where there is an almost complete loss of the gross margin return.

Table 2: Gross Margin analysis of River Flow Regimes (Maximum) ($ m per annum)

	1300 l/s	1600 l/s	Change	Change %	2000 l/s	Change From 1300	Change %
Gross Revenue	50.77	45.67	5.10	10%	31.73	19	38%
Total Costs	36.08	34.91	1.17	3%	30.87	5	14%
Gross Margin	14.69	10.76	3.93	27%	0.86	14	94%

Some of the irrigators are in a position whereby there is no room for failure or even poor performance of their crops. They are locked into supply agreements which require them to produce the product. Failure to do so could mean the loss of the contract.

As can be seen from Table 13 the impact on employment would be significant and adverse, with 170 FTEs losing employment.

An analysis of flows based on the mean or average flow would indicate that a 1600 litres/sec flow adjustment would not have a significant effect on production values. However when the effect of the maximum restriction period is analysed, the effect would be extreme and adverse for the growers of some crops. Extending the limit up to 2000 litres/sec would be even more extreme and would most likely cause growers to move operations, and the post harvest employment that it supports to somewhere where those operations could access more reliable water.

One way of overcoming this would be to set up a regime which cut off some irrigators but not those that were reliant on their crops performance. The figures on allocative efficiency calculated in this report could provide one basis for calculating which crops were to remain under irrigation. They show that crops that have relatively high gross margin returns and use highly efficient irrigation systems score well on allocative efficiency.

The value of water used for irrigation on the Poverty Bay flats is approximately $11.3 million dollars per annum.

1 Background

Gisborne District Council (GDC) is currently preparing a plan to guide the sustainable management of fresh water resources in the Gisborne District. The plan will include setting water quality standards and water allocation limits for catchments in the District. The standards and limits will be based on a range of freshwater uses and values: ecological, economic and social / cultural.

The first catchment plan to be developed is for the Waipaoa Catchment west of Gisborne City. The catchment has several important fresh water uses and values including: being the sole source of drinking water for Gisborne City , providing the bulk of the Districts water takes for irrigation that support the main horticultural activity in the District: and holds values that are significant to tangata whenua.

The following is a report of the assessment of the economic value of fresh water for various irrigation uses on the Poverty Bay flats.

1.1 Scope

The following scope was provided for this work;

1. Identify the current irrigation activities on the Poverty Bay flats by production enterprises (crop, pasture), irrigation method, and by monthly use and water resource type (surface or groundwater).
2. Model the allocative efficiency of irrigation water use based on reliability of supply for (at least) vine crops (grapes, kiwifruit and frost protection), tree crops (pip fruit and sub tropicals) annual processed and fresh vegetables (broccoli, lettuce, melons, maize, sweet corn, squash, onions and herbs) pasture, forestry (nurseries and value added manufacture) and other nurseries.
3. Any assessment of allocative efficiency would include as a minimum an analysis of gross margins, an assessment of yield change as a result of changes in irrigation levels and an assessment of the value added (in $/ m^3). The three sets of water levels to be used for the assessment are:
    a. Status quo minimum flow: Current GDC minimum levels that trigger irrigation restrictions as per existing water permits (1300 litres / second for the Waipaoa and 15 litres / second for Te Arai);
    b. NES default minimum flow: The proposed National Environmental Standards for Ecological Flows and Water levels (1600 litres / second for the Waipaoa and 60 litres / second for Te Arai); and
    c. Conservative ecology minimum flow: Projected water levels to provide maximum protection for ecological values (2000 litres / second for the Waipaoa and 150 litres / second for Te Arai).
4. Provide some further analysis of the economic benefit to the District from irrigation uses by the significant production enterprises such as GDP, value added and employment generated per hectare. Some analysis of the value of the authorised and permitted water abstractions would also be useful.

1.2 Methodology

The following section briefly describes the methodologies used in determining the results found in this report. There is a large amount of data used and in most cases the values were able to be supplied or extrapolated from other sources. In some cases the values for data had to be assumed and the author takes responsibility for any assumptions that have been made. Wherever assumptions have been made they have been based on similar values for similar types of crops.

It should be pointed out that the analysis reported here is for the direct impact of the production and immediate post harvest handling of the crops grown. Any indirect or flow on impacts beyond the post harvest handling of the crops will be in addition to those reported here.

1.2.1 River reliability analysis.

For this exercise the resources of groundwater and surface water were combined to represent the one water source. This was at the instruction of GDC as the two sources are believed to be hydraulically linked.

The flow records of the Waipaoa and Te Arai Rivers are held by the GDC. The Waipaoa record has been kept since 1960 and was able to be analysed for 50 irrigation seasons. Te Arai records have been kept since 1986 therefore 25 years data were able to be examined. The three flow regimes were drawn across the record and the periods when the flow went below each was written down from the start date and the end date of each period of restriction.

We were not able to match supply and demand in this study. This would be normally done by calculating by reference to evapotranspiration and the available soil moisture the demand from the crops for irrigation and then matching that with supply from the river. The nature of the rivers means that they are fed by rainfall in the headwaters which are a long way from the place where the water is abstracted for irrigation. This means that although it is generally the case that the periods of low flow coincide with hot and dry conditions, it is possible that weather conditions on the coast are different from in the foot hills. There will be instances when the river is relatively low but the soil moisture conditions at the coast are better than this analysis allows for. It should be considered that the analysis provided here is the worst case scenario.

Lincoln Environmental[1] identified that *"In its broadest sense, reliability of supply of irrigation water describes the restrictions and water availability an enterprise can expect and the subsequent effect of these restrictions on farm profit. It has aspects of timeliness, steadiness, variability, predictability and is related to user expectations. There are four aspects needed to accurately describe restrictions.*

- **Severity** *or the amount of restriction.*
- **Frequency** *or how many times a year that restrictions can be expected and how many years in which they will occur.*
- **Duration** *or how long the restrictions last for.*
- **Timing** *or when in the production season that the restrictions occur."*

[1] Lincoln Environmental: Reliability of Supply for Irrigation in Canterbury. Report No 4465/1, Prepared for Environment Canterbury (June 2001)

Severity

Of importance when determining the reliability of supply is the magnitude of the supply restriction and the duration over which a continuous restriction (either partial or full restriction) occurs. For example, the effects of continuous full restrictions over 5 days may or may not be similar to the effects of continuous 50% restrictions over 10 days. In the case of the rivers analysed the flow characteristics mean that there is a fairly steep deterioration of flow and so the restriction periods were all full restrictions.

Frequency

The frequency or occurrence of events has been calculated and expressed as a probability as a % of years in which an event occurs.

Duration

The duration or length of a continuous event can have a large influence on the impact that the event will have on agricultural production systems. Obviously events of shorter duration will have a minimal impact on production systems as the ability to irrigate after the event can overcome any small soil moisture deficits quickly. However the longer that the event continues, the less likely it is that irrigation can rectify the soil moisture deficits before negative plant growth impacts occur.

The average length of events has been calculated.

Timing

The impact of timing of events is important in the Poverty Bay flats as the range of horticultural crops has quite an extensive range of timing of when water is required or quite beneficial. The data from the river records also shows that the start date of restrictions is quite extensive in terms of period. Because of this the starting date of restrictions was recorded.

1.2.2 Crops Grown

This was put together from a number of sources. These include the data from Statistics NZ on the irrigated area in 2009 and the crops grown in 2009. Several local people helped with estimating the list of irrigated crops grown. In particular Stuart Davis was very helpful in providing information on the area of irrigated crops grown by LeaderBrand. LeaderBrand are by far the biggest growers of irrigated horticultural crops in the Poverty Bay area. Fortuitously this estimate very closely matched the area of irrigation given in the 2009 Statistics NZ survey so this was settled on as the area and range of irrigated crops grown.

1.2.3 Crop Gross Margins

There are a total of 21 crops grown. The gross margin for each crop was compiled. This was done through the help of Trevor Lupton (from Lewis Wright Consultants) who was able to provide a range of crop gross margins and Bill Thorpe (from First Fresh New Zealand) who provided some citrus gross margins. The remainder of the gross margins were put together by reference to a range of sources including work done by The AgriBusiness Group in previous work, the Lincoln Budget Manual and the MAF Farm Monitoring reports.

It should be pointed out that because of confidentiality reasons LeaderBrand were not able to give us their gross margins. This is understandable because of their position in a relatively small and specialised market. Therefore the results reported here will not necessarily match those that actually occur. Nevertheless the results reflect our estimate of what is occurring. Where there are comparisons between river flow options the same factors will affect each option therefore the relativity of each option will stay the same.

Each gross margin is set up as follows:

Gross Revenue

Wages Permanent
Harvest
Post harvest
Packaging
Growing Costs

Total Costs

Gross Margin

The total costs include wages split up between Permanent, Harvest and Post Harvest wages, packaging costs and general growing costs. Therefore it was possible to calculate the impact of a reduced yield on the gross margin by deducting the savings in the various categories that are related to yield.

Trevor Lupton was also able to provide tremendous help in providing the hours contributed / ha for a range of options. This also included the immediate post harvest information on labour involvement. We were also able to refer to a previous piece of work done on the labour requirement of the New Zealand Horticulture industry. In some instance it was necessary to estimate the labour demand. This was done by choosing the labour demand from a crop which was most like the one in terms of labour requirements. Where appropriate we adjusted these to better reflect the crop in terms of yield requirements.

1.2.4 Crop Yield Impacts

The impact on horticultural crops of poor reliability of water take the form of both quantity impacts and impacts on the quality of the crop. In most horticultural crops this has a significant effect on the returns that can be made. For many growers the reaction to water restrictions will be to try and manage the crop to ensure that they maintain the quality of the crop while reducing the yield. In some crops this is a very difficult exercise.

The impacts of the three flow regimes (for each river) were estimated by presenting them to the reference group. They were each able to provide estimates of the reduction in yield for each flow regime across a range of crops. In some cases the same reductions were used across a range of similar crops.

These yield reductions expressed as a percentage of the full potential yield were fed into the gross margins to allow for the reductions in expenditure that would occur and these were then translated into a new gross margin outcome and the corresponding reduction in both harvest and post harvest labour requirements.

1.2.5 Allocative Efficiency

Allocative efficiency relates to the value generated from the use of the water resource. This is generally measured as dollars generated per cubic meter of water used ($ / m3). This was calculated by deducting the gross margin from the dryland crop from the gross margin from the irrigated crop and dividing by the amount of irrigation water used. In some cases where it was indicated that the crop would not be grown without irrigation the dryland crop of maize was used as the next best alternative.

1.2.6 The Value of Irrigation

In order to calculate the value of irrigation water the gross margin return from the total area under irrigation (gross margin x area of each crop) was calculated as was the gross margin for the total area of the dryland crop. The one was deducted from the other to give the value of irrigation on the Poverty Bay flats.

2 Results

2.1 River Reliability

The following tables represent the theoretical flow restrictions that would occur if each of the minimum flow levels were adopted on the two major rivers in the Gisborne District.

They are listed according to the month in which the restriction starts. The "number out of" column shows the number of times that a restriction would have occurred during the time scale of the record. For the Waipaoa River the record was for 50 seasons and in the Te Arai case it was for 25 seasons. The occurrence % column represents the % of seasons in which they would occur.

The events are then listed according to their length in days of continuous restrictions. This is listed as the average period then the maximum period on record and then the minimum period on record that a restriction would occur for.

For the first table the row that represents January can be interpreted as follows. In the Waipaoa River using 2000 litres/sec as the level of restriction a restriction would occur in 11 out of the 50 years or 22% of the time. The average event would last for 26 days with the maximum being for 101 days and the minimum for 2 days.

Table 3: Waipaoa River Restrictions at 2000 litres/sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct	1	2	36	36	36
Nov	3	6	29	60	7
Dec	3	6	23	56	4
Jan	11	22	26	101	2
Feb	13	26	22	70	4
March	2	4	13	16	10

Table 4: Waipaoa River Restrictions at 1600 litres/sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct	1	2	28	28	28
Nov	2	4	6	6	6
Dec	3	6	12	25	3
Jan	6	12	26	86	7
Feb	3	6	14	15	14
March	2	4	5	7	2

Table 5: Waipaoa River Restrictions at 1.300 litres/sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct	1	2	17	17	17
Nov	1	2	4	4	4
Dec	1	2	7	7	7
Jan	6	12	19	81	2
Feb	2	4	4	6	2
March	1	2	17	17	17

As can be seen from the tables above the Waipaoa River is quite benign in terms of the regularity of restrictions but when they do occur they occur for reasonable periods of time. The other point to note is the extreme of the maximum period of restriction. Obviously the level of restrictions lift significantly from the present 1300 litres/sec record. In the following discussion we concentrate on the record for January. In the 1300 litres/sec scenario it only experiences restrictions occurring in January for 12% of the time with a 19 day length. At 1600 litres/sec the restrictions only go out to 26 days but for the 2000 litres/sec restrictions the probability of almost all occurrences doubles while the period of the average event doesn't get much longer the maximum event becomes very long.

Table 6: Te Arai River Restrictions at 150 l / sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct	3	12	56	90	33
Nov	4	16	37	76	23
Dec	23	92	49	179	2
Jan	4	16	24	44	9
Feb	9	36	35	88	8
March					

Table 7: Te Arai River Restrictions at 60 l / sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct	1	4	7	7	7
Nov					
Dec	3	12	27	31	23
Jan	4	16	40	65	25
Feb	2	8	28	33	23
March					

Table 8: Te Arai River Restrictions at 15 litres/sec

Start Month	No out of 50	Occurrence %	Average	Maximum	Minimum
Oct					
Nov					
Dec					
Jan					
Feb	2	8	23	24	22
March					

For Te Arai river the gradient between restriction events between the flow regimes is much more extreme in all events. Starting off with the 15 litres/sec flow regime there are very few restrictions. The next step of 60 litres/sec shows a much higher number of events with quite a high average. The lift to 150 litres/sec shows a high number of restrictions occurring in the earlier months with very long periods of restrictions.

Growers of high return crops that are locked into a market for supply have indicated that they would stop growing the crops with water supplied from Te Arai River if the reliability of supply deteriorated as the risk of failure would be too great.

2.2 Crops Grown

The irrigated crops grown are dominated by squash at just over 1,000 ha with a big drop back to the next crop. Some crops such as lettuce (4), cabbage (2), broccoli (3) and mesculin (7) are grown multiple times in the one season.

Table 9: Irrigated crops grown.

Crop	Ha	Crop	Ha
Squash (conventional)	1,055	**Onions**	50
Sweet Corn Fresh	275	**Maize Seed**	50
Kiwifruit Green	191	**Mandarins**	31
Apples	190	**Persimmons**	30
Sweet Corn Process	185	**Lettuce**	18
Tomatoes	170	**Lemons**	12.7
Squash (plastic mulch)	125	**Cabbage**	7
Kiwifruit Gold	93	**Tangelos**	5
Broccoli	70	**Grapefruit**	1.5
Water melons	59	**Mesclun**	1.5
Oranges	50	**Total**	**2,670**

The irrigation demand of these crops is quite complicated as they all have differing water requirements at differing times of the year.

2.3 Testing River Flows

The area of each crop times the gross margin times the crop yield impact have been multiplied to calculate the impact of each of the flow regimes. All figures are presented on an annual basis.

Table 10 shows the impact for the average scenario. As can be seen there is very little change between the 1300 and the 1600 litres/sec flows with the Gross Margin only changing by $0.81 m or 4%. However the step up to the 2000 litres/sec flow shows a much more considerable difference of a change in gross margin of $2.0m or 11 %.

Table 10: Gross Margin analysis of River Flow Regimes (Average) ($ m per annum)

	1300 l/s	1600 l/s	Change	Change %	2000 l/s	Change From 1300	Change %
Gross Revenue	57.61	56.52	1.09	2%	54.69	2.9	5%
Total Costs	38.38	38.11	0.28	1%	37.51	0.9	2%
Gross Margin	19.23	18.42	0.81	4%	17.18	2.0	11%

Table 11 shows the changes in labour that would occur. Again the jump from the 1300 litres/sec to the 1600 litres/sec is relatively minor at 10 Full Time Equivalents (FTE) whereas the change to 2000 litres/sec is much larger at 24 FTEs.

Table 11: Labour impacts of River flow regimes (Average) (Full Time Equivalents)

	1300 l/s	1600 l/s	Change	2000 l/s	Change From 1.3
Labour on farm	311	304	7	294	17
Labour post harvest.	118	115	3	111	7
Total Labour	429	419	10	405	24

However the situation changes considerably when we look at the impact of the maximum event in Table 12. The change in gross margin from the average event is quite significant as are the changes as the flow regime increases to the point where there is an almost complete loss of the gross margin return.

Table 12: Gross Margin analysis of River Flow Regimes (Maximum) ($ m per annum)

	1300 l/s	1600 l/s	Change	Change %	2000 l/s	Change From 1300	Change %
Gross Revenue	50.77	45.67	5.10	10%	31.73	19	38%
Total Costs	36.08	34.91	1.17	3%	30.87	5	14%
Gross Margin	14.69	10.76	3.93	27%	0.86	14	94%

This would normally be considered to be alright because of the probability of it happening being relatively low. Therefore the traditional thought would be that the odd bad year can be absorbed by all the good years. However some of the producers are in a position whereby there is no room for failure or even poor performance of their crops. They are locked into supply agreements which require them to produce the product. Failure to do so could mean the loss of the contract.

As can be seen from Table 13 the impact on employment would be quite catastrophic with 170 FTEs losing employment.

Table 13: Labour impacts of River flow regimes (Maximum) (Full Time Equivalents)

	1300 l/s	1600 l/s	Change	2000 l/s	Change From 1300
Labour on farm	272	242	30	145	127
Labour post harvest.	103	93	10	57	46
Total Labour	375	335	40	202	173

Overall analysis of the river flow regimes lead us to believe that although the average situation would indicate that 1600 litres/secs is not much inferior to 1300 litres/sec the maximum situation would suggest that it would be too extreme for the growers of some crops. Extending the limit up to 2000 litres/sec would be even more extreme and would most likely cause some growers to move their operations, and the post harvest employment that it supports to somewhere where those operations could access more reliable water.

2.4 Allocative Efficiency

Allocative efficiency is measured as dollars generated per cubic metre of water used ($ / m^3). As can be seen from Table 14 there is quite a wide range of results for the irrigated crops in the Poverty Bay flats. As would be expected the highest returns are earned for the crops for which it was felt that irrigation was essential. Sweet corn, kiwifruit and the four green crops grown by LeaderBrand all have very high measures of allocative efficiency. At the other end of the measures are the crops for which it is not felt that irrigation is essential. As a point of reference some of the pastoral systems measures are less than $1.0 / m^3.

Table 14: Allocative Efficiency measures.

Crop	$ / m^3
Sweet Corn Fresh	23.0
Kiwifruit Gold	15.1
Water melons	14.5
Cabbage	13.5
Broccoli	11.3
Lettuce	10.9
Mesclun	9.7
Maize Seed	9.2
Sweet Corn Produce	8.0
Persimmons	5.7
Tomatoes	5.3
Onions	5.0
Mandarins	5.0
Kiwifruit Green	4.8
Squash (plastic mulch)	3.3
Grapefruit	3.3
Oranges	2.6
Lemons	2.6
Tangelos	2.5
Squash (conventional)	2.4
Apples	1.9

It should be noted that the crops that score highly on the table of allocative efficiency have both a relatively high gross margin return and are very efficient in their use of water. The technical efficiency of water use is very high with these crops with water delivery systems such as drip or soak systems delivering just the right amount of water to the root zone where it is required.

For systems further down the table there are a number of factors including lower gross margin returns, inefficient water delivery systems such as spray systems and for some of them the fact that irrigation is a marginal operation.

2.5 Value of Water

The value of water used for irrigation on the Poverty Bay flats is approximately $11.3 million dollars per annum. This is the net gross margin of the land with irrigation minus the net gross margin of the land without irrigation.