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The AgriBusiness Group™

Calculation of the Cost of Providing Additional Irrigation Capability through Damming in the Gisborne District

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Please Read

1 Executive Summary

The Gisborne District Council (GDC) is currently assessing options for improving water supply for irrigation on the Poverty Bay Flats. The key options are Managed Aquifer Recharge (MAR)and the use of surface storage in dams. As part of the assessment Gisborne District Council require a comparison of the cost of a range of surface water storage options with the potential cost of MAR to ensure that they make the best investment decision.

The GDC has provided a copy of a 1986 Ministry of Works – Water and Soil Division report titled “Poverty Bay Flats Irrigation Investigations – Progress Report” (WSD). The review and updating of this report was considered useful so that previous knowledge and investigations into surface water storage could be used to compare with the Managed aquifer recharge option. in order to be able to calculate the required measures which could be used to compare the costs of surface water storage with the costs of MAR. These measures would be the capital cost per additional hectare of irrigation capability (CCIC), the Net Present Value (NPV) and the Cost Benefit Ratio (CBR).

A review and update of the WSD report

The review of the WSD report found that the following limiting features need to be considered:

- It was not possible to calculate the volume of potential storage when considering the minimum flow regimes on the River. Minimum flows could restrict some of the dam sites by limiting the volume of water able to be stored or would increase the time taken to fill or maintain the capacity of the dam.

- The majority of the 22 investigation sites were relatively small and only have the capability to irrigate relatively small areas (< 200 ha’s) and therefore should only be considered as suitable for individual development. Four of them had the scale to offer sufficient scale to allow for communal irrigation development.

- The WSD report has a table (table 7) that includes details of Capital cost, Storage Capacity for the proposed dam and the possible area suited to be irrigated from that dam. Only one case study is detailed in the report and this detailed the costing relating to the potential for a single irrigation scenario. The report appears to have inconsistent methods of calculating the values and therefore it is difficult to evaluate which of the values in the report are accurate.

The Pouarua site is the one which is included in the table which details the cost and capacity of the dam. From that we deduce that the dam was estimated to cost $13.8 m and would provide sufficient irrigation water to irrigate 1,670 ha. It should be noted that there is no mention in the report as to how these two values were created.Caution should be taken as to the feasibility of any of the options mentioned in the SWD report in terms of their capacity to provide storage for irrigation at the current time because:

- No consideration of the requirements to allow for minimum flows in the rivers has been made.
- The data that was used to establish the water yield that is available from a catchment has been worked out from rainfall data from one catchment using a very basic yield ratio model.

- Average data has been used in the calculation of the yield ratio modelling and doesn't allow for the considerable variance which will occur between seasons.
- The calculations and costs are very much at the pre-feasibility stage and rely on the construction of soft rock dams which may be doubtful in their acceptability in the current environment.
- The report was written prior to the RMA (1991) and doesn't consider the difficulties of consenting such a scheme in the modern environment.

Calculation of the cost of the dam.

The two methods to calculate the cost of the dam,the Producer Price Index (PPI), and using Current Cost, using the midpoint, came up with very close estimates of the cost of the Dam. It was decided to use the Current Cost method because we know how that was compiled while we do not know how the old estimate was calculated. It also means that we can report a possible range rather than an absolute value. They are shown in the table below.

E S Table 1: Estimate of costs using current figures ($).

	$ 2 / m3	$2.5 / m3	$3 / m3
Land Purchase	6,000,000	6,000,000	6,000,000
Engineering and Design	1,843,348	2,304,185	2,765,022
Consenting	921,674	1,152,093	1,382,511
Construction	18,433,482	23,041,852	27,650,222
Total	27,198,504	32,498,130	37,797,756

The mid range cost of the Pouarua dam is estimated to be $32.498m at current cost

Calculation of the performance measures.

In order to calculate the Net Present Value it has been necessary to estimate the potential land use mix, work out the on farm capital costs necessary to make the land use change, calculate the Gross Margin returns before and after the transition and arrange the resultant costs and benefits out over a 30 year period.

The results of our analysis are shown in Table 8the table below.

E S Table 2 : Results of analysis.

	$ 2 / m3	$2.5 / m3	$3 / m3
Dam Capital $ cost / ha	16,287	19,460	22,633
NPV ($m)	106.78	99.71	92.64
Benefit Cost Ratio	2.28	2.13	1.99

The dam capital costs could range between $16,300 and $22,600 per ha with an average expected value of $19,500 per ha.

The NPV of the total operation is $99.71 m with relatively little variance occurring depending on the cost of the dam. This reflects the facts that the cost of the dam is relatively small in terms of the total capital spend. It should be noted that the result is for the gross margin return not the whole business return.

The benefit to cost ratio is 2.13 which is relatively low for a proposal like this. Again there is very little variance with the cost of the dam.

2 Introduction

2.1 Background

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The Gisborne District Council (GDC) is currently assessing options for improving water supply for irrigation on the Poverty Bay Flats. The key options are Managed Aquifer Recharge (MAR) and the use of surface storage in dams. As part of the assessment Gisborne District Council require a comparison of the cost of a range of surface water storage options with the potential cost of MAR to ensure that they make the best investment decision.

The GDC provided a copy of a 1986 Ministry of Works – Water and Soil Division report titled "Poverty Bay Flats Irrigation Investigations – Progress Report" (WSD). In that report there is a quite detailed assessment of the soil types, soil moisture deficits and irrigation requirements for areas of land suited to be irrigated on the poverty bay flats near Gisborne. The report also considers water supply, storage efficiency, types of storage and then a reasonably high level identification of 22 storage sites that could supply water for irrigation. Included in the WSD report is an estimate of the cost of some of the options divided by the area of irrigation to give a cost per hectare to provide water from each site.

GDC believed that this task could be completed with an updating of the report. A review of the report, however indicates the report needed
a review and update of the methodology andf how it calculates:

- The volume of water required to be applied to each irrigated hectare,
- The ability of each storage site to act as a complimentary source of water to the current existing methods of irrigation water provision,
- A recalculation of the total amount of additional irrigation water which was able to be supplied from each storage site.
- The current cost of construction of each storage site.

This review and update was necessary in order to be able to calculate the required measures which could be used to compare the costs of surface water storage with the costs of MAR. These measures would be the capital cost per additional hectare of irrigation capability (CCIC), the Net Present Value (NPV) and the Cost Benefit Ratio (CBR).

2.2 Methodology

2.1.1 A review of the WSD report.

There have been a lot of developments in terms of irrigation of crops that have occurred since the WSD was written. This review encompassed a review of the irrigation requirements of the current range of crops grown in the area, an estimate of the current capability to irrigate crops from both surface and groundwater and therefore how much additional irrigation is possible with the water storage options and how much could be stored in the sites.

This process entailed a visit to the Gisborne District to both view the sites and to collect information required for an updating of the data.

2.1.2 Update the costings of the water storage sites.

The costings of the sites were updated by two methods. The first method was by using the Producer Price Index (PPI) classification class Heavy and Civil Engineering Construction to upgrade the estimates from the 1986 estimates to current estimates. The second method was to incorporate modern technology into the building of the water storage devices. It entailed getting a list of the latest construction costs for water storage devices from AquaLinc (a Christchurch water design consultancy) which incorporated costings for existing dams using a range of construction techniques including earth and artificial lining of water storage devices.

The two methods of updating the data were compared and the best fit was chosen.

2.1.3 Calculate the comparative performance measures.

In order to calculate the economic measures it was necessary to estimate the additional irrigation possible from each storage site. A standard crop rotation was constructed which depicts the likely mix of crops that will be irrigated. Gross Margins were created for that rotation.

The following measures of economic costs were used:

- **capital cost per hectare** of irrigation capability created, the total capital cost was divided by the area estimated.

- **Net Present Value** (NPV) was calculated over a thirty year period using a discount rate of 8%.

- **Cost / Benefit ratio** in which the total costs have been divided by the total revenue to give the benefit over cost ratio.

The measures used and the method of calculation of these measures was governed by the methods advocated in the publication “Guide to Social Cost Benefit Analysis” which was published in march 2015 by the NZ Treasury and which is designed to govern how Cost / Benefit analysis is carried out in the Government sector to allow for comparison between different proposals.

3 A review and update of the WSD report

3.1 Review

In reviewing the WSD report a number of features of it meant that:

- It was not possible to calculate the volume of potential storage when considering the minimum flow regimes on the River.

- The majority of the 22 investigation sites were relatively small and only have the capability to irrigate relatively small areas (< 200 ha's) and therefore should only be considered as suitable for individual development. Four of them had the scale to offer sufficient scale to allow for communal irrigation development. These areas are detailed in Table 1.

- The WSD report has a table (table 7) that includes details of Capital cost, Storage Capacity for the proposed dam and the possible area suited to be irrigated from that dam. Only one case study is detailed in the report and this detailed the costing relating to the potential for a single irrigation scenario. The report appears to have inconsistent methods of calculating the values and therefore it is difficult to evaluate which of the values in the report are accurate.

Table 1 : Potential Large Scale Dam Sites

	Catchment Area (ha)	Average Rainfall (mm / year)
Pouarua	2,010	1,000
Mangataikehu	3,910	1,325
Ngakaroa A	1,530	1,225
Ngakaroa B	655	1,250

The Pouarua site is the one which is included in the table which details the cost and capacity of the dam. From that we deduce that the dam was estimated to cost $13.8 m and would provide sufficient irrigation water to irrigate 1,670 ha. It should be noted that there is no mention in the report as to how these two values were created.

It should be noted that the Mangataikehu site appears to offer the potential to provide much more storage than the Pouarua site and therefore could offer much more irrigation capacity. We have chosen to use the Pouarua site data as the basis for our calculations solely because that is all that we have to work with.

Caution should be taken as to the feasibility of any of the options mentioned in the SWD report in terms of their capacity to provide storage for irrigation at the current time because:

- No consideration of the requirements to allow for minimum flows in the rivers has been made.

- The data that was used to establish the water yield that is available from a catchment has been worked out from rainfall data from one catchment using a very basic yield ratio model.
- Average data has been used in the calculation of the yield ratio modelling and doesn't allow for the considerable variance which will occur between seasons.
- The calculations and costs are very much at the pre-feasibility stage and rely on the construction of soft rock dams which may be doubtful in their acceptability in the current environment.
- The report was written pre the RMA (1991) and doesn't consider the difficulties of consenting such a scheme in the current environment.

3.2 Update

Because of the doubt that arises as a result of the inconsistency of the data presented in the WSD report it has been decided that the two pieces of data that were used to inform this calculation are the figures from the Pouarua Dam site that it would cost $3.9 million in 1986 and that it would theoretically irrigate 1,670 ha.

3.2.1 Calculating Water Demand

The calculations in the WSD report use a demand calculation based on 30 years of data to come up with an annual requirement of 590 mm in an average season and 840 mm in a 10 year drought season. It does not incorporate any allowance for the different seasonal plant demands for irrigation water in calculating how much would be required for irrigation.

In order to incorporate the different seasonal and plant demands for irrigation we have referred to AquaLincs report "Guidelines for Irrigation Water Requirements in the Poverty Bay Flats" which was written for the Gisborne District Council in 2012. The Aqualinc report calculates the annual irrigation requirement for a soil type with a maximum rooting depth of 700 mm for the crop types that are shown in Table 2. The annual storage requirement is included.

Table 2: Annual water requirement by crop and storage volume required.

	Annual Water Requirement (mm / year)	Volume of Storage Required (m3 / year)
Kiwifruit Green	307	3,070
Kiwifruit Gold	307	3,070
Apples - Galaxy	400	4,000
Apples - Envy	400	4,000
Persimmons	222	2,220
Oranges	222	2,220
Lemons	222	2,220
Mandarins	222	2,220
Squash	478	4,780
Tomatoes	521	5,210
Onions	516	5,160
Sweet Corn P	611	6,110
Maize Seed	611	6,110
Veg crops	630	6,300

The water requirement was calculated as an average figure of all of the crops which were represented in a report “The value of the horticulture sector to the Gisborne economy” which was written by The AgriBusiness Group for Horticulture NZ. As part of that exercise Trevor Lupton of Lewis Wright Valuation and Consultancy Ltd was able to compile a list of the crops that would be possible to grow if there was additional irrigation water available. The proportions of the crops to be grown were used to multiply their annual water requirement to come up with the annual water requirement.

The result of this calculation is that there would be an average annual water demand of 490 mm / year. This figure was then multiplied by 1.15 to allow for the various losses that may occur between the storage device and the crop and so a figure of 551 mm / year is used as the amount that is required to be stored. This equates to 5,519 m3 of storage required in a dam. If this figure is then multiplied by 1,670 ha the total storage required to service that amount of horticultural activity it results in a dam size of 9.216 million m3.

4 Update the costings of the water storage sites.

Two methods of updating the costings were proposed the first was simply to update the original WSD cost through applying the Producers Price Index (PPI) and the second was to use current estimates of building costs.

4.1 Producers Price Index

Using the Producer Price Index classification class Heavy and Civil Engineering Construction resulted in identifying that costs had risen by 2.3 times so applying that ratio to the original estimate of $13.7 m results in a current figure of $31.74m.

4.2 Current Estimates of Costs

Discussions were held with AquaLinc[1] as to the current range of potential construction costs. They said that depending on the size of the dam, the difficulty of the site and the requirement to line it they estimated that it could cost between $2 and $3 / m3 of storage. Using that estimate the costs would be as depicted in Table 3.

Land purchase is taken as 400 ha at $15,000 per ha. Engineering is taken as 10% of the construction cost and consenting is taken as 5% of the construction costs. The percentage estimates are taken at levels which are well accepted in the current environment for per feasibility estimates.

Table 3 : Estimate of costs using current figures ($m).

	$ 2 / m3	$2.5 / m3	$3 / m3
Land Purchase	6.0	6.0	6.0
Engineering and Design	1.8	2.3	2.8
Consenting	0.9	1.1	1.4
Construction	18.4	23.0	27.6
Total	27.2	32.5	37.8

In order to calculate the annual running costs of the dam we have taken repairs and maintenance of the dam at 2.5% of the total cost and management and operation of the dam at 2% of the total cost. These are percentage costs which are well accepted in the current environment for pre feasibility estimates. The assumed annual running costs are shown in Table 4.

Table 4 : Annual running costs ($).

	$ 2 / m3	$2.5 / m3	$3 / m3
Repairs and Maintenance	460,837	576,046	691,256
Operation	368,670	460,837	553,004
Total	829,507	1,036,883	1,244,260

4.3 Costs used.

Surprisingly, the two methods of calculation (the PPI and using Current Cost, using the midpoint) came up with very close results ($31.74 for PPI and $32.5 for current costs). It was decided to use the Current Costs figure of $32.5 because we know how that was compiled

[1] Ian MacIndoe AquaLinc pers comm.

while we do not know how the WSD estimate was calculated. It also means that it is possible to report a possible range rather than an absolute value.

5 Calculate the comparative performance measures

In order to calculate the Net Present Value (NPV) figures it has been necessary to estimate:

- the potential land use mix,
- the on farm capital costs necessary to make the land use change,
- the Gross Margin returns before and after the transition and;
- arrange the resultant costs and benefits out over a 30 year period.

An example of the NPV calculation is shown in appendix 1.

5.2 Estimate the potential land use mix.

The land use mix used is the one provided by Trevor Lupton. In order to get it to fit the area available to be irrigated (1,670 ha) it was divided up to represent a proportional representation and then that figure was multiplied by 1,670. The results of this exercise are shown in Table 5.

Table 5: Estimation of the potential land use mix.

	Proportion	Area (ha)
Kiwifruit Green	0.03	53
Kiwifruit Gold	0.11	191
Apples - Galaxy	0.07	121
Apples - Envy	0.19	318
Persimmons	0.03	52
Oranges	0.00	8
Lemons	0.01	11
Mandarins	0.00	5
Squash	0.12	204
Tomatoes	0.03	57
Onions	0.01	10
Sweet Corn P	0.03	51
Maize Seed	0.02	32
Veg crops	0.33	557
Total	1.0	1,670

The area of each land use was multiplied by the appropriate capital cost and Gross Margin result to construct the cost / benefit streams for the NPV calculation.

5.3 On farm capital costs.

The capital costs that are required to convert across to the irrigated land use have been supplied by Trevor Lupton as shown in Table 6.

Table 6: On farm capital costs of conversion ($ / ha).

	$ / ha
Kiwifruit Green	56,000
Kiwifruit Gold	157,000
Apples - Galaxy	43,500
Apples - Envy	68,900
Persimmons	60,000
Oranges	60,000

Lemons	60,000
Mandarins	60,000
Squash	8,000
Tomatoes	8,000
Onions	8,000
Sweet Corn P	8,000
Maize Seed	8,000
Veg crops	8,000

5.4 Gross margins used.

The gross margins used are those that were supplied by Trevor Lupton. They are show in Table 7.

Table 7: On farm capital costs of conversion ($ / ha).

	Gross Revenue	Direct Costs	Gross Margin
Kiwifruit Green	50,100	30,700	19,400
Kiwifruit Gold	102,000	42,400	59,600
Apples - Galaxy	43,750	30,850	12,900
Apples - Envy	124,724	82,500	42,224
Persimmons	73,400	52,300	21,100
Oranges	28,800	16,100	12,700
Lemons	54,600	26,100	28,500
Mandarins	42,500	30,500	12,000
Squash	7,800	4,800	3,000
Tomatoes	14,000	10,000	4,000
Onions	18,000	10,700	7,300
Sweet Corn P	3,900	1,900	2,000
Maize Seed	4,300	2,550	1,750
Veg crops	19,339	15,039	4,300

The gross margin that was used to represent the land use prior to conversion to irrigation was taken from the Ministry for Primary Industries in their Farm Monitoring database. The model used is the “Western Lower North Island Intensive Sheep and Beef” model. This model was chosen as it best represents the relatively intensive pastoral farming system which would be able to be carried out on the land which is suitable for horticulture. This model is one which purchases and finishes a high proportion of the sheep and cattle which it runs. The report has two years of financial and performance data in it so the data represented here is an average of that data.

The income figures that have been used represent a long term average for product prices. This was derived from the MPI’s Situation and Outlook for Primary Industries report. the product prices used are an average of the previous four years actual data and the MPI estimate of the likely returns over the next four years.

The gross margin figure used in the report for the prior land use is $1,958 / ha. This figure was deducted from each of the gross margin figures shown above in order to represent the financial returns for the new land use.

Please note that all of the data used and reported here is in the form of gross margin analysis. It represents the Gross Revenue – the direct production operating costs. It does not include all of the costs which are associated with owning the land and running the business. The results should be considered in this light and will be higher than if the total costs of running the business were included.

5.5 The results

The results of our analysis are shown in Table 8.

Table 8 : Results of analysis.

	$ 2 / m3	$2.5 / m3	$3 / m3
Dam Capital $ cost / ha	16,287	19,460	22,633
NPV ($m)	106.78	99.71	92.64
Benefit Cost Ratio	2.28	2.13	1.99

The dam capital costs could range between $16,300 and $22,600 per ha with an average expected value of $19,500 per ha.

The NPV of the total operation is $99.71 m with relatively little variance occurring depending on the cost of the dam. This reflects the facts that the cost of the dam is relatively small in terms of the total capital spend. It should be noted that the result is for the gross margin return not the whole business return.

The benefit to cost ratio is 2.13 which is relatively low for a proposal like this. Again there is very little variance with the cost of the dam.

Appendix 1 : NPV format.

			-	1	2	3	4	5	6	7	8
		Costs									
	Dam	Capital	- 32,498,130								
		Running Costs		- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883
	On Farm	Kiwifruit Green	- 2,167,640								
		Kiwifruit Gold	- 27,135,310								
		Apples - Galaxy	- 4,841,041								
		Apples - Envy	- 20,892,915								
		Persimmons	- 3,095,719								
		Oranges	- 477,734								
		Lemons	- 668,828								
		Mandarins	- 296,195								
		Squash	- 1,630,667								
		Tomatoes	- 458,625								
		Onions	- 76,437								
		Sweet Corn P	- 407,667								
		Maize Seed	- 254,792								
		Veg crops	- 4,458,854								
		Total	- 99,360,554	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883	- 1,036,883
		Benefits									
	On Farm			- 13,505,193	- 3,619,011	4,194,910	9,395,001	21,000,879	25,351,565	29,212,763	29,212,763
		Total	- 99,360,554	- 14,542,076	- 4,655,895	3,158,026	8,358,118	19,963,996	24,314,682	28,175,879	28,175,879
0.08	NPV	99,710,251									
	Costs	- 102,808,854									
	Benefits	218,720,633									
	B / C Rati	- 2.13									