# Appendix 31: Economic Modelling

## 1. Introduction

In this paper, the assessment of the economy-wide effects resulting from the introduction of measures to clean up the Waikato River is undertaken through a modelling framework that is based primarily on economic input-output (IO) analysis. Today, IO analysis is one of the most widely applied methods in economics, with the approach being especially popular in the study of regional-level economics (Miller and Blair, 2009). One of the core strengths of IO analysis is that it captures the complex interactions and interdependencies occurring between different actors within an economy. This means that it is possible to consider a vast number of the indirect or flow-on effects that occur throughout an economy as a result of any type of economic change. IO analysis also enables economic impacts to be evaluated at the level of individual sectors or industries, thus providing a disaggregate picture of the nature of economic impacts.

## 2. Selection of an appropriate modelling framework

As stated above, this paper utilises IO analysis to assess the economic impacts on the Waikato and New Zealand economies associated with the proposed restoration actions under Scenarios 2 and 3 (refer Section 6 of the main report). The full details of this approach are contained in the remainder of this paper.

It is important to note that alternative methodologies do exist for assessing economic impact; with the key alternative being the use of Computable General Equilibrium (CGE) modelling. The authors of this paper are widely published in the application of both input-output (see, for example, McDonald and Patterson (2004), Patterson and McDonald (2004), McDonald et al., (2006), Patterson et al., (forthcoming) and Smith and McDonald (forthcoming) and computable general equilibrium (see, for example, Zhang et al., (2008) and Yeoman et al., (2009)) techniques. Key studies undertaken by the authors include the official 1999 and 2003 America's Cup EIAs (Economic Impact Analysis) for the Office of Tourism and Sport/Ministry of Tourism, the EIA of the 2011 Rugby World Cup for the NZRFU, EIAs for Auckland International Airport, Exercise Ruaumoko and numerous others.

Based on this experience the authors would like to note several key reasons for the adoption of IO rather than CGE in this study:

- *Paucity of regional/national data*. The development of a CGE model would require the creation of a multi-regional Social Accounting Matrices (SAMs), if both regional and national impacts were to be reported. No multi-regional SAMs have been generated in New Zealand to date[1]. The production functions used by CGE models require elasticities of demand for each factor component (i.e., K, L). While this data exists in unit statistical records held by SNZ, it is however not readily available. Similarly, no regional, and only limited *ad hoc* national, data exists for elasticities employed for household/government/etc. utility functions – a further requirement of CGE models.

- *Comparative statics and transitional dynamics*. The key advantage of CGE over IO is that dynamic behaviour can be simulated, including impacts associated with investment and employment and price change. A key limitation however is that most current CGE models utilize only a comparative static framework based on recursive dynamics i.e., the long run impact. Unfortunately, this tells us little about the transitional dynamics associated with the driving shocks.

- *Scenario analysis versus optimisation*. The key advantage of the IO over the CGE approach is that it is well suited to studying transitional dynamics through year-by-year comparisons.

- *Timeframe and budget*. Final key reasons for the selection of IO rather than CGE were the constraints of time and budget for this study.

# 3. Methodology

Prior to describing the specifics of the methodology, it is helpful to provide readers, particularly those not familiar with input-output analysis, with a brief introduction to the IO framework[2]. This introduction is provided in Section 3.1. The remaining sections of the methodology describe the way in which the three scenarios[3] are incorporated into an IO framework, including the major assumptions that are applied.

## 3.1 Input-Output Analysis

At the core of any IO analysis is a set of data that measures, for a given year, the flows of money or goods among various sectors or industrial groups within an economy. These flows are recorded in a matrix or 'IO table' by arrays that summarize the purchases made by each industry (its inputs) and the sales of each industry (its outputs) from and to all other industries. By using the information contained within such a matrix, IO practitioners are able to calculate mathematical relationships for the economy in

[1] Several attempts are however currently underway in academia (see, for example, xxxx (2009)).
[2] Those who wish to learn more about input-output analyses can refer to authors such as Miller and Blair (2009),
[3] Refer to Section 6 of the main report for a detailed description of the three scenarios which were analysed. Note that this appendix refers to Scenario 1 as BAU (business as usual), Scenario 2 as BMP (best management practice) and Scenario 3 as EBMP (extended best management practice). The BAU, BMP and EBMP terms were subsequently dropped in the final report but the nature of the scenarios and the actions they cover have not changed.

question. These relationships describe the interactions between industries, specifically, the way in which each industry's production requirements depend on the supply of goods and services from other industries. With this information it is then possible to calculate, given a proposed change to a selected industry, all of the necessary changes in production that are likely to occur throughout supporting industries within the wider economy. For example, if one of the changes anticipated for the Waikato region were to be an increase in the amount of dairy farming, the IO model would calculate all of the increase in outputs required from industries supporting dairy farming (e.g., fertilizer production, fencing contractors, farm machinery suppliers), as well as the industries that support these industries.

Typically the variables that drive an IO model - in other words, the variables that are used as inputs and which determine outcomes of all other variables - are the variables that are referred to as 'final demands'. Final demands constitute the value of each industry's output sold to final markets for production. These final markets are comprised primarily of consumption purchases by households, sales to government, private domestic investment and exports. The value of milk solids sold by dairy farmers to the dairy processing industry, for example, does not constitute a sale to final demands, whereas the value of cheese that is produced from these milk solids by the dairy processing industry and sold as exports is recorded under final demands.

As with all modelling approaches, IO analysis relies on certain assumptions in its operation. Among the most important is the assumption that the input structures of industries (i.e., technical relationships) are fixed. In the real world, however, technical relationships will of course change over time as a result of new technologies, relative price shifts causing substitutions, and the introduction of new industries. For this reason IO analysis is generally regarded as most suitable for short-run analysis, where economic systems are unlikely to change greatly from that which generated the initial data. It can however be noted that in this Study, some effort has been made to incorporate structural differences in the economy between the three scenarios assessed, through the generation of differing IOs for each scenario (this is discussed further below).

### 3.2 Incorporating the scenarios into the modelling framework

The following sections outline the way in which the scenarios are captured in the modelling framework, and the process used to calculate final economic impact results for each scenario. Essentially, the scenarios are incorporated into the model by using financial information produced in the accompanying appendices of this Study as inputs to the model, along with a series of assumptions regarding the funding arrangements for restoration actions. This is explained in more detail in the following sections of this appendix. As a summary, Figure 1 below (which uses Scenario 2 (BMP) as an example) shows the way in which information produced in the appendices (depicted in the blue boxes in the diagram) flows into the IO model. The primary components of the IO model are depicted in the grey boxes. The final results that are produced by the model (depicted in orange at the centre of the diagram) are the value added and employment effects associated with the scenario. Note that all results are reported in terms of the net change from the business as usual scenario – Scenario 1. For example, the value added impact reported for Scenario 2 (BMP) is not the total value added in the economy under the scenario, but rather the difference in value added between Scenario 1 (BAU) and Scenario 2 (BMP). Table 1 shows how the various types of capital and operating expenditures for bundle of restorative actions (e.g., to do with tuna or shallow lakes) were implemented into the IO framework.

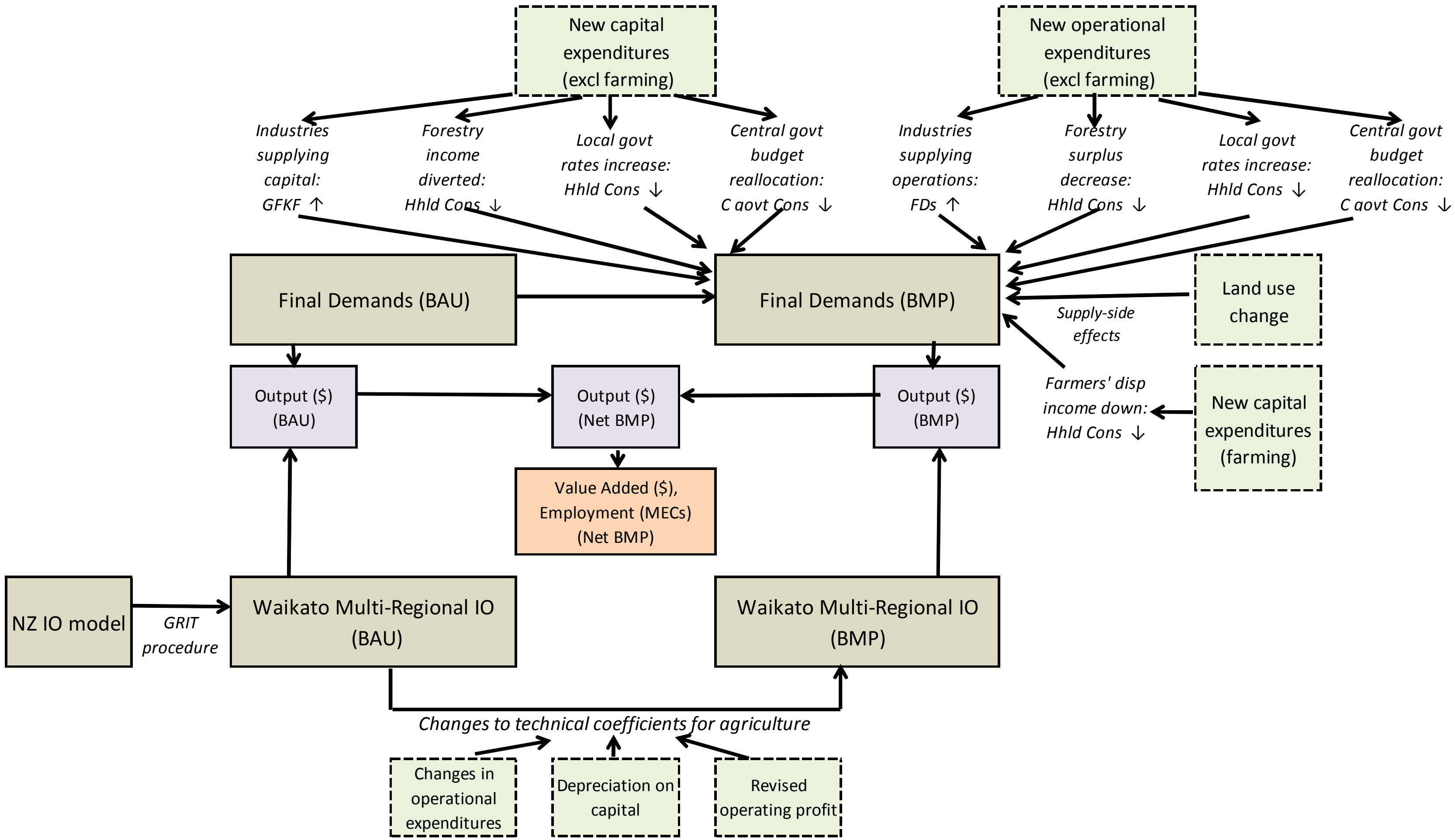



**Figure 1:** Summary of the modelling framework and input data used to estimate the economic impact of Scenario 2 (BMP).

**Table 1:** Figure 2 Implementation of capital and operating expenditures into the MRIO framework.

| | | Capital Expenditure | | | | | Operating Expenditure | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Land use change [1] | Is there a change in Gross Fixed Capital Formation? [2] | Is there an associated change in industry investment? [3,8] | Is there an associated Central Government budget reallocation? [4,7] | Is there an associated change in Local Government rates? [5,7] | Are adjustments for depreciation on the capital expenditure necessary? [6] | Are there significant structural changes in the input mixes of Waikato region industries? [8] | Are there significant changes in the operating surplus of industries per unit of output? [9] | Are there changes in industry output associated with operational activities? [10] | Is there an associated Central Government budget reallocation? [11] | Is there an associated change in Local Government rates? [5] |
| Farming | Yes | Yes | Yes | No | No | Yes | Yes | Yes | No | No | No |
| Forestry | Yes | Yes | Yes | No | No | No[12] | No | Yes | Yes | No | No |
| Shallow Lakes | Yes[13] | Yes | No | Yes | No | Yes[14] | No | No | Yes | Yes | No |
| Aesthetics | Yes[13] | Yes | No | Yes | No | No | No | No | Yes | Yes | No |
| Eels | No | Yes | No | Yes | Yes | Yes[15] | No | No | Yes | Yes | Yes |
| Whitebait | No | Yes | No | Yes | Yes | Yes[16] | No | No | Yes | Yes | Yes |
| Engineering | No | Yes | No | Yes | Yes | Yes | No | No | Yes | Yes | Yes |
| Social and Cultural | No | Yes | No | Yes | No | Yes[17] | No | No | Yes | Yes | No |

*Notes*

1 This refers mainly to agricultural/forestry land use conversion between the sheep and beef farming and forestry, but to a lesser degree land lost in meeting the mitigation actions. It is captured in direct terms by estimating the net change in gross output associated with the land use change. Downstream economic impacts are captured through the use of a Ghosh inverse matrix.

2 This refers to an increase in capital expenditure. This is implemented by an addition to the appropriate industry forming the capital in the GFKF final demand column.

3 This refers to a change in the funds available to households for investment due to loan servicing by farmers/foresters. This is implemented by a pro-rata change in capital purchases by households in the GFKF final demand column. This change effects not only household capital purchases in the Waikato region, but also purchases by Waikato residents from the rest of NZ.

4 This refers to a central government budget reallocation due to increased loan servicing as required to pay for the capital expenditure. The additional expenditure on loan payments is financed by equivalent reductions in central government investment elsewhere. This is implemented by substractions from the GFKF column of final demands. The impact is felt throughout all of NZ.

5 This refers to an increase in local government rates due to increased loan servicing as required to pay for the capital expenditure or increased payments for operational expenditure. This is implemented by a pro-rata subtraction from household consumption final demand of the increased rates value. This impact is greatest in the Waikato region.

6 In some cases it may be necessary to depreciation the capital expenditure through time. This is implemented by adding the depreciation value to the Consumption of Fixed Capital row. A real depreciation rate of 5.51% p.a. is assumed i.e., 8.50% p.a. nominal with an adjustment for inflation of 2.84% p.a. The inflation rate was determined using a six year average (2004 to 2010) of inflation as recorded by the RBNZ.

7 Loans include both principle and interest. A real interest rate of 5.51% p.a. is assumed i.e., 8.50% p.a. nominal with an adjustment for inflation of 2.84% p.a. The inflation rate was determined using a six year average (2004 to 2010) of inflation as recorded by the RBNZ. All loans are assumed to have a 20 year term.

8 Structural changes are accounted for by updating the technical coefficients in the MRIO based on information contained in the Farming building block.

9 This refers to change in the operating surplus of an industry due to changes in operating expenditure. The impacts associated with the gain/loss in income are implemented by adjusting up/down the household consumption component of final demands on a pro-rata basis.

10 This refers to changes in operational expenditures leading to associated increases/decreases in the demand for output of industries providing operational activities. This is implemented by additions/subtractions to the total final demands of each industry providing operational activities.

11 This refers to a central government budget reallocation due to increased funding of operational expenditure. This is implemented by pro-rata subtractions to the entries in the consumption of central government services final demand column. This impact is felt throughout NZ.

12 Capital costs associated with planted forest are not normally depreciated. IRD allows for land development costs to be spread over time as per depreciation. This is implemented through a decrease in operating surplus, but without the corresponding increase in consumption of fixed capital.

13 Land lost to riparian margins accounts for 1761ha in the shallow lakes building block, and a further 1450ha in the aesthetics building block.

14 Depreciation is calculated for the following items infiltration filters, weirs, netting, wave barriers, toilets, jetties etc.

15 Depreciation is calculated for retrofitted culverts, retrofitted flood pumps, and netting used for protection from hydro intakes.

16 Depreciation is calculated for fish friendly tide gates and culverts.

17 Depreciation is calculated for the following items foot/cycle paths, capital items associated with historic sites, education of wananga, and monitoring databases.

### 3.2.1 Development of a Waikato "Input-Output" table

As already stated, at the core of an IO modelling framework is a matrix recording transactions between different actors within an economy. Each column of the matrix reports the monetary value of an industry's inputs, while each row represents the value of an industry's outputs. Sales by each industry to final demand categories (i.e., households, local and central government, gross fixed capital formation, etc.) are also recorded, along with each industry's expenditure on primary inputs (wages and salaries, consumption of fixed capital, gross operating surplus etc.). Clearly the data requirements for constructing these IO matrices are enormous, and it is partly for this reason that IO tables are only produced in NZ on an infrequent basis. The latest available IO table for the NZ economy is based on data for the 1995-96 financial year (Statistics New Zealand, 2001). A subsequent supply-use table, which contains much of the information required to generate an IO table, is however also available for the 2002/03 financial year (Statistics New Zealand, 2007).

The first major step required for the assessment of economy-wide effects is to generate an appropriate IO table for use in the study. Essentially two major tasks were involved: (1) production of an updated IO table for NZ; and (2) regionalization of the national table so as to produce an IO table for the Waikato region. In terms of the first task, Market Economics Ltd (MEL) has produced an IO table for NZ for the year ending March 2007. This is the latest year for which all economic data required to produce an updated table is available. The NZ IO is essentially derived by converting the 2002/03 national supply-use table to an IO table, and then updating this table to 2006/07 using data contained within the National Accounts (i.e., gross output, value added and taxes by industry), as well as international merchandise (imports and exports of products classified according to the harmonized system) and Balance of Payments (imports and exports of services) data. Relationships between industries, or technical coefficients,4 are assumed to remain consistent with those in the 2002/03 table.

In terms of the second task, the Generating Regional Input-Output Tables (GRIT) procedure (Jansen et al., 1979; West et al., 1980) was relied on to produce a regional table from the 2006/07 national table. This method consists of a series of mechanical steps that reduce national input-output coefficients to sub-national (regional) equivalents with reference to available regional data. In this case reference was made particularly to employment by industry, population and household income data for the Waikato region.

[4] Refer to Section 3.2.2 for a description of technical coefficients.

A final important point to note about the IO framework utilized in this study is that it is multi-regional. This means that the model considers not only the relationships between economic actors within the Waikato region, but also the relationships between economic actors within the Waikato and those in the rest of NZ. This multi-regional approach provides a means to evaluate the nation-wide implications of the possible clean-up options. The IO model utilized for each scenario contains 48 different economic industries by three different regions (Waikato region, rest of the North Island and rest of NZ).

### 3.2.2 Incorporating Economic Structural Changes into the Input-Output Table

The IO table developed for the Waikato region contains information on the production requirements of each industry in the Waikato economy. By selecting a column pertaining to a specific industry from the table, it is possible to view the total value of inputs purchased by that industry, from all other industries. For illustration, a simplified version of the dairy cattle farming column in the Waikato IO table is provided in Table 2 below. This table shows, for example, that Waikato dairy farmers purchased around $320 million of services from tertiary industries in the 2006/07 financial year.

**Table 2:** Inputs to Dairy Cattle Farming in the Waikato Region, 2006/07 ($mil)

| | | Dairy Cattle Farming |
|---|---|---|
| Industries | *Primary Industries* | 236 |
| | *Chemical manufacturing* | 26 |
| | *Other manufacturing* | 217 |
| | *Tertiary industries* | 319 |
| Primary inputs | | 1,042 |
| Total | | 1,840 |

**Table 3:** Technical Coefficients for Dairy Cattle Farming in the Waikato Region, 2006/07

| | | Dairy Cattle Farming |
|---|---|---|
| Industries | *Primary Industries* | 0.13 |
| | *Chemical manufacturing* | 0.01 |
| | *Other manufacturing* | 0.12 |
| | *Tertiary industries* | 0.17 |
| Primary inputs | | 0.57 |
| Total | | 1.00 |

As part of the process of constructing an IO model, it is necessary to take the information contained within an IO matrix and derive so-called 'technical coefficients'. These technical coefficients indicate how much input is required to produce one dollar's worth of output for any quantity of production, and are derived assuming continuous, linear relationships between the inputs and outputs of each industry. In order to calculate the technical coefficient for inputs of tertiary industries into dairy cattle farming in the example above, it is necessary to simply divide the total input of tertiary industries to the dairy cattle farming industry, by the total output (also equal to the total input) of dairy cattle farming (refer to Table 3). The technical coefficient of inputs from tertiary industries into dairy cattle farming is thus 0.17.

In this study, the technical coefficients derived from the Waikato IO table are assumed to apply to Scenario 1 (BAU). A core task undertaken for the assessment of the economy-wide effects associated with Scenario 2 (BMP) and Scenario 3 (EBMP) has then been to develop a modified table of technical coefficients for each of the two scenarios. Due to the nature of the scenarios, it has only been considered necessary to alter the technical coefficients for the farming industries, as it is these industries that primarily undergo structural change in the two scenarios. In summary, the process for modifying the technical coefficients for farming industries involves three steps:

**Step 1 Separate-out data for the Waikato River Reaches from the base IO table.**

In the base input-output table, the data pertaining to each industry is an aggregation of the data for all business activities across the region classified within that particular industry category. The first major step required for the modification of the IO table for agricultural industries is thus to disaggregate the data for each industry into two components: (1) data which relates to activities located within the Waikato River reaches (WWR); and (2) data which relates to activities located in the rest of the Waikato region (RWR). The result for dairy cattle farming, for example, is that instead of the IO table containing one column of data that specifies the value of each input to the industry, two columns of data are provided in the IO table– the first specifies the value of inputs into dairy cattle farming that is located within the WRR, while the second contains the value of inputs into dairy cattle that is located in the RWR.

Data on value added by industry type and by location is used for disaggregating the input column of each agricultural industry into two columns for the WRR and RWR respectively[5]. Very simply, for each agricultural industry the proportion of a total input value ($2007) in the base industry input column that is allocated to the WRR is equivalent to the proportion of that industry's total regional value added that is estimated to have been produced from within the WRR.

---

[5] Statistics New Zealand's Annual Enterprise Survey (AES; www.stats.govt.nz) contains data on employment counts (ECs) by meshblock at the very detailed 6-digit ANZSIC industry level. Market Economics Ltd has created modified employment counts (MECs) based on this data, which unlike standard ECs, include estimates of the numbers of working proprietors for each industry types. Total value added for horticulture and fruit growing and forestry and logging for each of the two areas WWR and RWR are estimated by first collating the total number of MECs for each 6-digit ANZSIC type across the two areas, and then multiplying by the average NZ value added per MEC for each 6-digit ANZSIC industry. An adjustment is also made to account for differences in productivity between regions by using agglomeration elasticity scalars (Mare and Graham, 2009). Finally the value added is aggregated across all 6-digit ANZSIC industries that make up horticulture and fruit growing and forestry and logging respectively.

**Step 2 Adjust input transactions to reflect new costs structures for agricultural industries**

Scenario 2 (BMP) and Scenario 3 (EBMP) entail some quite significant structural changes for farming in terms of the quantities of various inputs that are required per unit of farming output produced. The application of nitrification inhibitors to dairy farming pastures will, for example, require an increase in the input costs for agricultural chemicals. Similarly, increased costs are also proposed under Scenario 3 as a result of the additional labour required for the management of herd shelters during winter. By contrast, some reduction in operational costs are also presumed for dairy farming under both scenarios as a result of improved nutrient management, enabling a greater proportion of the nutrients contained within animal effluent to be captured and recycled, thus reducing fertilizer requirements. In Step 2, each of these new operational costs identified for Scenario 2 and 3 are either added to (where operational costs increase) or subtracted from (where operational costs decrease) the inputs column of the appropriate WRR agricultural industry in the scenario's IO table.

Scenarios 2 and 3 also imply changes in capital expenditures for farming. Additional capital costs are, for example, associated with fencing, construction of herd houses and so on. Importantly, an industry's purchases of capital are not included within the industry's inputs column in an IO table, although the depreciation on capital (called 'consumption of fixed capital') is included (i.e., under the primary inputs category). This approach is consistent with standard accounting practice in that depreciation on capital is viewed as an expense for industries (i.e., an input in the IO table). In order to capture the additional capital expenditures for farming in the IO tables of Scenarios 2 and 3, it is thus necessary to make appropriate adjustments to the depreciation inputs for each industry. A depreciation schedule listing all additional capital items purchased by each agricultural industry is used to calculate the additional depreciation on capital incurred by each agricultural industry for each year of the study under the two scenarios. A real depreciation rate of 5.51 percent is applied across all capital items for the purposes of these calculations. Having calculated the depreciation for each year, these values are then averaged across the whole of the study period so as to derive an average increase in depreciation for each agricultural industry for the two scenarios. These values are used to adjust the IO tables for Scenarios 2 and 3[6].

Operating profit is another important primary input category included in the inputs column for each industry. It should be noted that for every change in operational costs for farming, there will be an associated impact on operating profit. Say for example, if

[6] Note that we have not included expenditures on planting in the depreciation calculations. These costs are classified as land development expenditures and thus do not attract depreciation.

the fertilizer costs for Waikato dairy farmers were to decrease but we were to assume that the price received for milk solids were to remain constant, the net result for dairy farmers would be an increase in operating surplus. It is thus necessary to also make appropriate changes to the operating surplus entries in the IO tables to reflect the operational changes proposed for farming. Appendix 9: Farms provides estimates of the revised cash operating profit generated by each farming type, per hectare, according to the new agricultural practices proposed under each scenario. This information is used as a starting point for adjusting the operating surplus entries in the IO tables to reflect the new scenarios.[7] Appropriate additions and subtractions are also made to the new estimates of operating surplus to account for the changes in operational expenditures proposed under the two scenarios as well as the additional depreciation on new capital items.

**Step 3 Recalculate technical coefficients**

The above steps result in the production of a new column of input transactions for each agricultural industry in the WRR and for each scenario. In the final step, these input transaction columns are added back together with the appropriate parent industry input transaction column, thereby producing two new IO tables for Scenarios 2 and 3 respectively. Having completed these tasks, it is then possible to calculate coefficient matrices for the two scenarios.

### 3.2.3 Estimating Future Final Demands

As stated above, primary demand variables constitute a core input into the IO model. For each of the three scenarios investigated in this study it has therefore been necessary to generate a set of annual final demand projections by economic industry, covering the period 2011 to 2040. For Scenarios 2 and 3, the final demand projections for a particular year are developed by taking the final demand data from the base IO table, and then making appropriate additions and subtractions to capture the implications of each scenario occurring in that year. For Scenario 1 (BAU), the final demand projections are simply assumed to remain constant with those of the base year[8].

The additions and subtractions that are made to the final demand variables for Scenarios 2 and 3 are undertaken essentially to capture the capital and operational expenditures

---

[7] A series of steps are first required to convert cash operating profit to operating surplus. These include the removal of tax from the data, application of price deflators, and the apportionment of profit among the two primary input categories 'compensation of employees' and 'operating surplus'.

[8] Over the course of the study period it is likely that there will be a number of external factors causing final demands variables to grow and change over time, such as demands for commodity exports, oil prices, government policies and so on. Given that these factors will impact on each scenario equally, and that we are only interested here in calculating the net changes between scenarios, it has not been necessary to attempt to incorporate these influences in the future projections of final demands.

derived for the various restoration actions. Some changes in final demand variables are further necessary to capture changes modelled in the analysis of farming systems (see Appendix 9: Farms). The methods used to capture these changes in final demands are discussed in more detail below.

#### 3.2.3.1 Capital Expenditures

For all of the various restoration actions considered (see accompanying appendices) there are numerous capital items that are proposed to be introduced under Scenarios 2 and 3. Examples include the flood pumps and hydro screening necessary for tuna restoration (Appendix 5: Tuna), boat ramps (Appendix 25: Boat ramps), marae water treatment facilities (Appendix 17: Marae water supply), and the new education wananga (Appendix 27: Engagement). For the sake of consistency and convenience, all capital items from these appendices are treated in a similar manner. Two steps are required in order to incorporate the capital items into the IO model:

**Step 1 –Increase Gross Fixed Capital Formation**

When an industry sells output for the purposes of forming new fixed capital items, this sale is included in the final demands category called gross fixed capital formation (GFKF). The first step required for the inclusion of a capital item in the IO model is therefore to determine which industries are responsible for supplying the capital item. In terms of footpaths and cycle paths it is for example assumed that 100 percent of the costs of the capital are supplied by the construction industry. For those industries deemed to be responsible for supplying, sales to GFKF are then increased by a value equivalent to the costs of the capital items supplied. Note that for plant and machinery capital items it is assumed that 20 percent of the value of the capital is obtained from offshore.

**Step 2 – Allocate Funding for the Provision of Capital Items**

The next step is to derive and apply assumptions around the funding of capital items. For the majority of the capital expenditures specified in Scenarios 2 and 3, it is assumed that central government is responsible for providing an appropriate funding source. There are, however, a few capital items specified in the scenarios, such as the capital required for improved municipal wastewater treatment, where it is considered that funding is more likely to come from local government.[9] Overall, summing all capital expenditures identified, it is assumed that 24 percent is provided by local government

[9] If it is assumed instead that capital assumed are funded by the private sector, considerable additional work would be required to calculate the impacts due to the necessity to capture structural changes in the IO table. Not only would it be necessary to incorporate these changes in the IO table for each scenario, it would also be necessary to construct new IO tables for each year of the study.

and 76 percent by central government under Scenario 2, while under Scenario 3 the funding split is 7 percent local government and 93 percent central government.

Having determined who pays for capital, it is then necessary to determine the way in which capital is funded. In this study it is assumed that all new capital items are paid for over time through a loan system. The total loan payments incurred by central and local government for each year of the study are calculated by assuming that a loan payback period of 20 years and a real interest rate of 5.5 percent are applicable to all capital items.

In order to generate a budget that is sufficient to cover the additional loan payments associated with new capital items, it is assumed that local government undertakes an increase in household rates[10]. A corollary of the rates increase is that Waikato households will have reduced funds available for the consumption of other goods and services. This effect is captured in the IO model by decreasing all purchases by Waikato region households (i.e., household final demands) on a pro-rata basis by a total amount equivalent to each years' additional loan payment.

In terms of central government, it is assumed that the additional loan payments required to finance new capital are met by reductions in central government investment elsewhere. This is implemented by reducing GFKF for all regions in NZ, with the total reduction in capital for each year equivalent to that year's additional loan payments.

#### 3.2.3.2 Capital Expenditures (Farming)

The impact of new capital items on farm profitability, as well as the depreciation on new capital items for farming, have already been included in the IO model via the changes made to farming input structures (refer to Section 3.2.2). To complete the treatment of agricultural capital items, it is now necessary to make appropriate adjustments to final demands so as to capture the impacts of funding capital. In this study it is assumed that all additional capital items required by farms under the Scenarios 2 and 3 will be funded directly by farmers. As with the capital items discussed above, it is also assumed that farmers use a loan system to spread the costs of capital across time.

The first step involved in adjusting final demands for agricultural capital expenditures under Scenarios 2 and 3 is thus to calculate the loan payments incurred by farmers for each year of the study. A loan period of 20 years and a real interest rate of 5.51 percent are assumed. Next, it is reasoned that the additional investment required to finance the

[10] It is possible that local government would also increase rates for businesses in order to fund additional expenditures. Significant additional information would, however, be required to incorporate the effects of a rates increase on businesses within the model, including the distribution of rates payments among industry types and the ownership structures of Waikato businesses.

loan payments will divert farmers' expenditure away from other capital investments. This is affected in the model by adjusting down the GFKF column of final demands on a pro-rata basis, with the total reduction each year equivalent to farmers' additional loan payments.

#### 3.2.3.3 Capital Expenditures (Forestry)

Under Scenario 3 there is additional expenditure required for preparation and planting land for conversion from sheep and beef farming to forestry. In order to incorporate the impacts of these capital expenditures into final demands, it is first necessary to identify which industries that will provide the new capital[11]. It is determined that all planting and land preparation will be undertaken by the Forestry and Logging industry itself, and thus sales by this industry to GFKF are increased to account for the additional capital provision.

The funding for forestry capital items is treated in an analogous manner to farming: It is assumed that land owners are responsible for funding the land preparation and planting costs required for establishing new forest stands, and that this occurs through a loan system with a 20 year payback period and a real interest rate of 5.5 percent. It is also assumed that the funding of these items by land owners will cause a reduction in capital investment elsewhere.

#### 3.2.3.4 Operational Expenditures

A range of operational expenditures will be associated with the various restoration actions proposed for Scenarios 2 and 3, for example, costs for pruning required with increased forestry, Marae based training, ongoing work in restoring stream habitats, and septic tank maintenance. Two major steps are required to include these operational expenditures in the IO model for each scenario.

**Step 1 Identify industries responsible for providing operational activities.**

The first step requires selection of industries that are most likely to be responsible for undertaking each type of operational activity. Then, in order to incorporate the additional output required by industries undertaking these operational activities, appropriate additions are made to final demands[12]. It is, for example, assumed that

---

[11] Although these expenditures are actually classified as land development expenditures, rather than capital expenditures in accounting terms, for this component of the study the distinction is irrelevant.

[12] For the majority of cases, it is appropriate to make the additions within the final demands columns of central and local government sectors. Some operational expenditures (e.g., those associated with Marae water treatment) are, however, more appropriate to include in the final demand column for not-for- profit organizations. For the purposes of calculating the results of this study, it is actually irrelevant which column of final demands the operational expenditures are added to.

Marae based training is most likely to be undertaken by professional consultants included in the business services industry. The final demands by not-for-profit organizations for business services are thus increased by an amount equivalent to the operational expenditure.

**Step 2 Allocate funding for operational expenditures**

As with capital expenditures, it is assumed that the additional operational expenditures are funded either directly or indirectly by local or central government. Overall, summing the operational expenditures across all restoration actions, it is assumed that 35 percent and 65 percent of expenditures are funded by local and central government respectively under Scenario 2, and 35 percent and 65 percent under Scenario 3. The same assumptions are also applied in regards to the way in which government funds these expenses. In summary, for those operational expenditures funded by local government, it is assumed that there is a corresponding increase in household rates and a decrease in other household consumption. Operational expenditures funded by central government are assumed to cause a corresponding decrease in all other central government expenses (i.e., final demands).

In regards to forestry, it is assumed that all additional operational expenditures are funded by the Forestry and Logging industry itself. It is also assumed that the loss in forestry income resulting from these additional expenditures will impact directly on household consumption. Thus for each scenario, household consumption is adjusted downwards on a pro-rata basis. The total value of the decrease in household consumption is equivalent to the total increase in forestry operational expenditures.

#### 3.2.3.5 Operational Expenditures (Farming)

For the most part, changes in farming operational expenditures under Scenarios 2 and 3 have already been dealt with above in terms of changes to the IO matrices. There is, however, one additional effect resulting from changes in operational expenditures that needs to be implemented via changes to final demands. This effect is the change in consumption expenditures likely to occur as a result of changes in the profitability of farms.

As described in Section 2.2.2 above, changes to both farming practices and operational expenditures under the two scenarios results in revised estimates of operating surplus for each farming activity. In this study, it is assumed simply that any change in operational expenditures from Scenario 1 has an equal but opposite impact on household consumption. Thus for each scenario, household consumption is adjusted upwards on a pro-rata basis, with the total value of the increase in household consumption equivalent to the total reduction in operational expenditures across all farming types.

### 3.2.4 Depreciation on Capital Items

In order to complete the treatment of capital items from restoration actions it is necessary to deal with depreciation of capital. In economic terms, depreciation represents the decrease in value of a capital stock over a year. As already stated above, it is included in an IO table via the primary input category 'Consumption of Fixed Capital'.

As with the depreciation on capital for farming, the calculation of depreciation for capital items associated with other restoration actions, commences with the compilation of a depreciation schedule. This schedule identifies all capital items to be depreciated, the year in which each item is purchased and the industry that is responsible for the new capital. Using this information it is possible to calculate the additional depreciation expense incurred by each industry for each year of the study, under the two scenarios. Again, a depreciation rate of 5.51 percent per annum is applied in the calculations. Important to note is that many of the capital items included in the restoration actions do not constitute 'fixed capital' and thus are excluded from the depreciation calculations.

Once the additional depreciation for each industry for Scenarios 2 and 3 is calculated, the values are simply added to the primary inputs results for each year of the study[13].

### 3.2.5 Incorporating Land Use Changes

In most examples of regional economic impact analysis, the focus is on estimating demand-side effects.

In this type of analysis, the aim is to identify where there is a change in demand for the output of a selected industry, and then estimate the change in output of all up-stream industries from which the selected industry depends on for the supply of inputs. In this study we have endeavored to capture not only these demand-side (refer to section 3.3 below) effects, but also the most important supply-side effects associated with each scenario.

Clearly the most important supply-side effects that will occur under Scenarios 2 and 3 are those associated with changes in the amount of land devoted to different types of farming and forestry. In both these scenarios it is envisaged, for example, that there will

---

[13] In order to balance the IO table, any increase in primary inputs of an industry must be matched by a corresponding increase in the outputs of the same industry. It is assumed that the necessary increases in output occur in the final demands columns.

be quite substantial lengths of riparian margins that will be retired from farming and instead planted with vegetation. In terms of another example, Scenario 3 also envisages that there will be relatively significant conversions of land from agriculture to forestry. These types of land use changes are likely to impact particularly on industries down-stream from farming and forestry, such as dairy product, meat product and wood product manufacturing. The conversion of livestock farms to forestry under Scenario 3, for example, by creating a reduction in the supply of livestock, is also likely to create a reduction in the output of NZ's meat product manufacturing industry.

In order to capture the supply side effects resulting from land use change, reference is made to Ghosh multipliers (Ghosh, 1958, 1964; Miller and Blair, 2009) that are derived from the base IO table. Essentially these multipliers measure, for every unit of output change in a selected industry i, the corresponding changes in output of all sectors that depend on sector i's product as an input to their own production processes. Of course, the basic assumption in applying this supply-side approach is that the output distributions within the economic system are stable. This means that if the output of a sector is, say, doubled, sales from that industry to all other industries that purchase from that industry will also be doubled. Although this assumption is unlikely to hold for many economic situations (see, for example, Giarrantani 1980, 1981), it is considered to be a relatively reasonable assumption to apply in the assessment of changes to Waikato's agricultural and forestry industries. This is because the industries that will be primarily affected by the supply-side effects are those that use commodities produced by agriculture and forestry to produce manufactured products (i.e., dairy product manufacturing, wood product manufacturing, meat product manufacturing etc.). For these industries it is likely that there will be a relatively constant relationship between the availability of commodities for processing and the value of manufactured products produced.

In short, three steps are required for the incorporation of supply-side effects. The first is to estimate the loss or gain in agricultural output for each agricultural industry resulting from land use change. An assumed constant relationship between output and land use is used for this purpose. Second, the change in output for all down-stream industries is estimated through application of the Ghosh multipliers. Finally, reference is made to mathematical identities to determine the change in final demands necessary to affect the calculated change in output resulting from supply-side impacts (i.e., land use change). Note that the final step is to translate the supply-side impacts into changes in final demands, as it is final demands that are used as inputs into the IO model for the purposes of calculating the final results for each scenario.

### 3.3 Calculating Economic Impacts

Having derived an IO table and set of final demand projects for each scenario, it is now possible to calculate the economic output ($2007) for each economic industry, both within the Waikato region and the rest of New Zealand. Very simply, the vector of output by industry, X, is calculated according to the equation,

$$X = (I - A)^{-1} Y$$

Where A is the matrix of technical coefficients, I is the identify matrix and Y is the vector of final demands by industry. Note that economic output by industry is the core result produced by the IO model. The output series is then translated into the final reporting variables, i.e., value added ($2007) and employment (MECs), by assuming for each respective industry constant ratios between output and the three reporting variables.

It is interesting to note that in many IO applications, the quantities of goods and services that are consumed by households (i.e., the household components of final demands) are treated as exogenous variables. This means that household demands are determined at the outset by the modeler and there is limited ability to capture feedbacks occurring between changes in industrial output and consumer spending. In the real world, however, households (i.e., consumers) earn incomes in payment for their labour inputs to production processes, and thus it is likely that any impacts on industrial outputs which alter labour income will have flow-on implications to consumer spending. Such effects can be viewed as positive (i.e., reinforcing) feedbacks, since changes in consumer spending will further impact on industrial outputs.

Some of the most important induced impacts in this study arise as a result of additional infrastructure investment. Both Scenarios 2 and 3, when compared to Scenario 1, incorporate considerably larger investment in infrastructure required for the restoration of the Waikato River. Examples include investments in boat ramps, wastewater treatment technologies, riparian margin planting, and so on. For those industries that are responsible for supplying infrastructure, additional household income will be generated associated with the increase in demands for output. On the other hand, negative induced impacts are also associated with the proposed clean-up options. Scenarios 2 and 3 both involve, for example, a reduction in output from the dairy farming industry compared with Scenario 1. This will create associated reductions in consumption by dairy farmers.

In order to capture the feedbacks relating to consumer spending (often referred to as 'induced' impacts in economic impact assessments), this study utilizes an IO model that is 'closed' with respect to the household sector when calculating the impacts of changes in final demands. According to this approach, households are treated in a similar manner to industries in the IO matrix, with a column and row of the matrix recording inputs and outputs of the household 'sector'. Transactions presented along the household row of the matrix record the income generated for households by each industry within the economy in the form of payments for labour, while transactions recorded in the household column of the matrix record the structure of household purchases (i.e., consumption). Now, if it is assumed that the structure of household expenditure among different product types remains constant irrespective of the level of income, it is possible to calculate a vector of technical coefficients for households which can be included in the A matrix described above. When the change in final demands is multiplied by the Leontief inverse, the model will therefore calculate the value of outputs from each industry that will be purchased by households. Household incomes are, in turn, also determined by the level of output of each industry.

# 4. Results

## 4.1 Summary Results

The summary results generated from this study are described in Table 4. Based on the modelling approach and assumptions described above, it is calculated that the BMP scenario will generate a relatively neutral economic impact. Over the period 2011-2040, it is estimated that the scenario will result in a net gain in value added for the Waikato region of $20071.26 billion, but a net loss for the rest of NZ of $20071.01 billion. For the country as a whole the positive gain in value added is estimated at around $2007 251 million, equivalent to just 8.4 million or around 0.005 percent of current GDP on average for each year of the study. In terms of employment, the estimated increase for the Waikato region under Scenario 2 is 13,900 MEC job years[14], while for the rest of NZ the estimated loss is 15,850 MEC job years. Overall for NZ it is estimated that Scenario 2 will result in a net loss of employment of 1,950 MEC job years during the course of the study period, equivalent to 65 MECs per year or 0.003 percent of employment.

There are a number of reasons why Scenario 2 generates a relatively neutral economic impact when compared with Scenario 1:

- *High Multipliers for Capital Formation* – Scenario 2 entails increased expenditure on capital items above that of Scenario 1. In this study it has been assumed that all capital items are funded by a loan system, thus entailing relatively significant interest payments. The losses to the local economy associated with these payments are, however, to a large extent balanced by the gains to the economy created through the purchases of capital. This occurs especially because the

[14] A MEC job year is the employment of one person, measured as one Modified Employment Count (see footnote 4 above) for one year.

industries that are responsible for supplying capital (particularly the Construction industry) have relatively high backward linkages in the NZ economy.

- *Reductions in Purchases of Imports* – Related to the above point it is also worth noting that a number of capital expenditures (and operating expenditures) in this study are assumed to be funded by across-the-board reductions in household consumption. This is important because a proportion of total household consumption is directed towards purchases of commodities produced overseas. The displacement of expenditure on these items towards expenditure on commodities produced in NZ acts as net gain for the NZ economy.

- *Increases in Farming Profitability* – The alterations in farming practices (e.g., improved nutrient management) proposed under Scenario 2 result in improved profitability for farming. Although for dairy farmers there is still some reduction in disposable income despite the improved profitability, because of the need to invest greater amounts in capital, for the economy this is more than compensated for by dairy farmer's increased purchases of capital and operational expenditures. These additional expenditures create flow-on impacts through the entire economy and are relatively substantial when aggregated across all farmers within the Waikato river reaches. Overall, the positive economic gains generated from the Farming building block act to counterbalance the losses to the economy generated from the actions described in the other building blocks.

The results calculated for Scenario 3 are less favorable than Scenario 2 in terms of value added and employment impacts. Compared with Scenario 1, it is estimated that Scenario 3 will generate a gain in value added of around $2007602 million (an average of $2007`20.1 million for each year of the study) in the Waikato region, and a gain of 11,590 MEC job years (386.3 per year). For NZ as a whole, the value added loss is calculated as $20074,131 million (137.7 million per year or 0.082 percent of GDP), while the employment effect is calculated as a loss of 56,720 MEC job years (1,891 MEC jobs per year or 0.085 percent of employment).

A core reason for the reduction in value added and jobs under Scenario 3 relates to the effects of land use change. According to Scenario 3, there are significant tracks of land converted from sheep and beef farming to forestry. Under our model these conversions result in output loss for industries closely connected to sheep and beef farming (e.g., meat processing). Although these effects should, in theory, be compensated by an increase in output for industries closely connected to forestry (e.g., wood processing), these effects are generally outside of our study due to the large timeframes required for trees to mature to a state that can be harvested. It should also be noted that the loss of dairy farming land due to restoration actions is slightly higher under Scenario 3 compared with Scenario 2. This acts to further increase the impacts of land use change for Scenario 3.

Another observation that can be made from the summary results is that the economic impacts generated within the Waikato region are generally more favorable than those occurring in the rest of the New Zealand economy.  The reasons for this are obvious. On the one hand, it is assumed under both scenarios that operational and capital items will generally be provided by industries located within the Waikato, thus creating positive benefits for the regional economy.  On the other hand, it is assumed that a significant proportion of the capital and operational expenditures required for implementing the proposed restoration actions will be funded by central government, thus creating some loss in other central government expenditure throughout the NZ economy.

**Table 4:** Cumulative and Average Net Economic Impacts, 2011 – 2040. ("Best management practice" equates with Scenario 2 and "Extended best management practice" with Scenario 3).

| | Cumulative Net Economic Impacts | | Average Net Economic Impacts Per Year | |
|---|---|---|---|---|
| | Value Added | Jobs | Value Added | Jobs |
| | $\$_{2007}$m | MEC[1] Years | $\$_{2007}$m | MEC[1] Years |
| ***Best Management Practice*** | | | | |
| Waikato Region | 1,260 | 13,900 | 42.0 | 463.3 |
| Rest of New Zealand | -1,009 | -15,850 | -33.6 | -528.3 |
| **Total** | **251** | **-1,950** | **8.4** | **-65.0** |
| ***Extended Best Management Practice*** | | | | |
| Waikato Region | 602 | 11,590 | 20.1 | 386.3 |
| Rest of New Zealand | -4,733 | -68,310 | -157.8 | -2,277.0 |
| **Total** | **-4,131** | **-56,720** | **-137.7** | **-1,890.7** |

*Notes*

1. Modified Employment Count. This includes both employment counts and working proprietors.

## 4.2 Distribution of Economic Impacts across Time

Table 5 provides a summary of the way in which the value added and employment impacts under Scenarios 2 and 3 are distributed across time. Not surprisingly, the first year of the study entails substantial positive economic benefits in terms of value added and employment for both scenarios. It is, for example, estimated that there will be around $2007213 million of additional value added generated under Scenario 2 for the Waikato region during 2011, and $2007521 million under Scenario 3 for the same region and year. These results are a reflection of the significant amounts of capital expenditure that are assumed to occur predominantly during the first year of the study. This expenditure on capital not only creates value added and employment growth in industries responsible for supplying capital, it also produces flow-on impacts throughout the rest of the NZ economy.

As it is assumed that capital items are funded over a period through a loan system, the negative economic consequences of capital expenditure are spread out across time. These negative effects (resulting in reductions in expenditure elsewhere) are more noticeable under Scenario 3 as the scenario contains some very large capital items not included in Scenario 2 (particularly dairy herd shelters and hydro-dam intake nets). Note that after 2030 the loss in value added and employment under both scenarios starts to fall away. This occurs because it is assumed that all loans are taken out for a period of 20 years and thus by 2030 a number of the loans have been paid off.

**Table 5:** Net Economic Impacts 2011 – 2040. . ("Best management practice" equates with Scenario 2 and "Extended best management practice" with Scenario 3).

| | Value Added | Change in Value Added | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
| ***Value Added*** | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m |
| *Waikato Region* | | | | | | | | |
| Best Management Practice | 14,892 | 213 | 57 | 53 | 24 | 23 | 27 | 65 |
| Extended Best Management Practice | 14,892 | 521 | 153 | 89 | -50 | -51 | -37 | 96 |
| *New Zealand* | | | | | | | | |
| Best Management Practice | 168,365 | 310 | 22 | 3 | -31 | -31 | 4 | 57 |
| Extended Best Management Practice | 168,365 | 762 | 75 | -109 | -318 | -318 | -173 | 48 |

| | Employment | Change in Employment | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 2007 | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
| ***Employment*** | MECs[1] | MECs[1] | MECs[1] | MECs[1] | MECs[1] | MECs[1] | MECs[1] | MECs[1] |
| *Waikato Region* | | | | | | | | |
| Best Management Practice | 167,731 | 203 | 650 | 634 | 193 | 195 | 262 | 283 |
| Extended Best Management Practice | 167,731 | 502 | 2,218 | 1,420 | -862 | -861 | -654 | -564 |
| *New Zealand* | | | | | | | | |
| Best Management Practice | 2,221,400 | 4,362 | 78 | -163 | -618 | -594 | -84 | 145 |
| Extended Best Management Practice | 2,221,400 | 11,173 | 913 | -1,507 | -4,607 | -4,591 | -2,532 | -1,211 |

*Notes*
1. Modified Employment Count. This includes both employment counts and working proprietors.

## 4.3 Distribution of Economic Impacts across Industries

Table 6 below provides a summary of the value added impacts for each scenario distributed by time and by economic industry. Again the results are relatively predictable. As a general rule, the industries that benefit most across the study period are those that are primarily responsible for providing the additional capital items and operational activities required under the scenarios. The Construction and the Business Services (included under Industry Group 15) industries, for example, which are both significant providers of capital, show significant increases in value added under both scenarios, especially during the first year. Another interesting observation is that the quite significant gains for Industry Group 9 (Other Manufacturing) under both scenarios occurs partly because of the changes in operational costs for dairy farming, resulting in increased purchases of nitrification inhibitor chemicals.

The effects of land use change are also evident in the results for Scenario 3. In these regards it can be noted that the Livestock and Cropping industry, and to a lesser extent the Dairy Cattle Farming industry, exhibits declines in value added across the study period. These impacts clearly flow onto the Meat and Meat Product Manufacturing as well as the Dairy Product Manufacturing industries.

**Table 6:** Net Value Added Impacts for Selected Waikato Industries, 2011 – 2040.

| | 2011 | 2015 | 2020 | 2025 | 2030 | 2035 | 2040 |
|---|---|---|---|---|---|---|---|
| | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m | $\$_{2007}$m |
| *Best Management Practice* | | | | | | | |
| 1 Other farming and services to agriculture | 9 | 3 | 4 | 0 | 0 | 0 | 0 |
| 2 Livestock and cropping farming | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 Dairy cattle farming | 1 | 0 | -1 | -1 | -1 | -1 | -1 |
| 4 Forestry and logging | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 Other primary industries | 2 | 1 | 1 | 1 | 1 | 1 | 1 |
| 6 Meat and meat product manufacturing | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 Dairy product manufacturing | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 8 Other food and beverage manufacturing | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 9 Other manufacturing | 30 | 16 | 16 | 8 | 8 | 8 | 9 |
| 10 Wood and paper manufacturing | 6 | 2 | 2 | 2 | 2 | 2 | 2 |
| 11 Utilities | 4 | 2 | 1 | 1 | 1 | 1 | 1 |
| 12 Construction | 58 | 2 | 2 | 0 | 0 | 1 | 1 |
| 13 Wholesale and retail trade | 16 | 2 | 2 | 0 | 0 | 1 | 1 |
| 14 Transport | 4 | 1 | 1 | 1 | 1 | 1 | 1 |
| 15 Communication, finance, insurance, real estate and business services | 60 | 5 | 5 | 1 | 1 | 3 | 3 |
| 16 Government | 1 | 21 | 20 | 12 | 10 | 9 | 9 |
| 17 Other services | 6 | 1 | 1 | 1 | 1 | 2 | 2 |
| **Total** | **203** | **58** | **55** | **25** | **24** | **27** | **28** |
| *Extended Best Management Practice* | | | | | | | |
| 1 Other farming and services to agriculture | 31 | 21 | 18 | 0 | 0 | 0 | 0 |
| 2 Livestock and cropping farming | 0 | -11 | -22 | -25 | -25 | -25 | -25 |
| 3 Dairy cattle farming | 1 | -3 | -6 | -8 | -8 | -7 | -7 |
| 4 Forestry and logging | 7 | 48 | -6 | -13 | -11 | -10 | 0 |
| 5 Other primary industries | 6 | 2 | 2 | 1 | 1 | 1 | 1 |
| 6 Meat and meat product manufacturing | 0 | -7 | -13 | -15 | -15 | -15 | -15 |
| 7 Dairy product manufacturing | 0 | -1 | -2 | -3 | -3 | -3 | -3 |
| 8 Other food and beverage manufacturing | 1 | -1 | 0 | 0 | 0 | 0 | 0 |
| 9 Other manufacturing | 65 | 33 | 32 | 7 | 7 | 8 | 9 |
| 10 Wood and paper manufacturing | 16 | 8 | 7 | 3 | 3 | 3 | 3 |
| 11 Utilities | 10 | 2 | 3 | 0 | 0 | 1 | 1 |
| 12 Construction | 162 | 32 | 31 | 2 | 2 | 5 | 7 |
| 13 Wholesale and retail trade | 39 | -1 | 3 | -8 | -8 | -6 | -3 |
| 14 Transport | 10 | 9 | 4 | 1 | 1 | 1 | 1 |
| 15 Communication, finance, insurance, real estate and business services | 140 | 1 | 15 | -5 | -5 | 0 | 4 |
| 16 Government | 1 | 27 | 24 | 15 | 12 | 11 | 9 |
| 17 Other services | 13 | -4 | 1 | -1 | -1 | 0 | 1 |
| **Total** | **502** | **154** | **89** | **-49** | **-50** | **-37** | **-17** |

# 5. Discussion

This section outlines some of the important caveats and matters for further consideration relating to this study.

### (1) Funding Sources for new Operational and Capital Expenditures

When reviewing the results of this study, a matter that requires particular consideration is the issue of project funding. In these regards it should be noted that, in order to undertake a full assessment of the economic impacts associated with Scenarios 2 and 3, it is essential that each proposed restoration action is allocated to an appropriate funding source. It is further necessary to consider the flow-on implications of the additional funding requirements for each funding source, in terms of reduced expenditure elsewhere in the economy. For the purposes of this study it has been necessary to make a set of assumptions regarding which organizations/persons will be responsible for funding each restoration measure (both operational and capital expenditures) and the budget reallocations that will occur to provide this funding. It has, for example, been assumed that farmers will be responsible for funding all farming-related capital and operational expenditures, and that these additional expenditures will be financed through reductions in farmers' capital investments and consumption elsewhere. It has also been assumed that the majority of the new engineering infrastructure envisaged under the two scenarios, such as new wastewater treatment facilities, hydro-dam intake nets, culverts and so on, will be funded by either local or central government. Where central government is responsible for funding, it is assumed that the funds are made available by reductions in other central government consumption and investment.. Where local government is responsible for funding, it is assumed that the funds are made available by increases in rates for regional households. It is further assumed that all capital expenditures are financed by a 20 year loan with a real interest rate of 5.5 percent.

Importantly, the way in which the new expenditures are funded will impact on the distribution of effects across the NZ economy. In these regards, whereas the introduction of additional expenditure for capital and operational activities generally adds positively to the regional economy (by requiring additional output from local industries), the funding of such expenses is generally a negative effect on regional and/or the national economies (as it reduces available funds for consumption and investment elsewhere). Thus, if restoration actions are to be financed predominantly by local government and local residents, then the majority of the negative impacts associated with funding will occur within the Waikato region. Conversely, if central government is primarily responsible for the funding, then the impacts are more likely to be distributed across the entire country, although this will depend on the particular way in which government reallocates its budget to generate the required funds.

Related to the last point, it is worth noting that the results of this study are dependant not only on who it is assumed will be funding the restoration actions but also, and perhaps more importantly, the particular expenditures that it is assumed will be forgone in order to provide sufficient funding. Obviously different types of commodities have different production requirements. Some commodities are produced from production chains that are extensive within the NZ economy, and thus loss of expenditure on these items will generate quite substantial impacts to the NZ economy. Other commodities, however, are produced with relatively little input from NZ industries and therefore reallocation of expenditure away from these items will have relatively little impact. Overall, the particular assumptions employed in the study regarding the way in which funds are provided for restoration actions is an important determinant of the magnitude of the economic impacts.

In conclusion, it is, important to recognize that these assumptions that have been made in this study regarding funding of expenditures are only one set of many plausible funding arrangement options. It is therefore recommended that the study is undertaken again once there is more information available as to the likely funding structures, and for testing out the implications of alternative funding arrangements.

**(2) Loans**

Related to the above section on funding, it is important to note that all capital expenditures are assumed to be paid for using loans. There are several limitations to this approach:

- *Farming and forestry industries*. No attempt has been made to assess whether or not the farming sectors is able to absorb the loans necessary to pay for the capital-based restoration actions. It is indeed possible that many farmers will not have sufficient income or collateral to secure the loans necessary to undertake the proposed restoration actions; particularly under Scenario 3.

- *Land use conversion under Scenario 3*. It is highly unlikely that the sheep and beef farmers tasked with land use conversion under Scenario 3 will be able to raise sufficient capital to undertake the conversions. Under Scenario 3 it is noted, for example, that Class 3 Sheep and Beef farmers already have a negative cash operating profit. A further deterrent to securing loans is that fact that any conversion to forestry is unlikely, without a fully implemented ETS, to realise any revenues until at 18 to 26+ years after planting.

- *Local government loans*. It has been assumed that loan based borrowing by local government will be funded through rates increases. Other possibilities however include reallocation of the local government budget, central government subsidies, targeted rates, user charges, financial contributions and so on. It is important to note that with the exception of central government subsidies the burden associated with any local government mitigation initiative is likely to rest with Waikato residents.

- *Central government loans.* It is assumed that loans borrowing by central government will be paid for via a budget reallocation. Other alternatives however exist. It is important to note that under a central government funding scheme, the burden of the funding is likely to be shared by all New Zealanders.

**(3) Scheduling of capital expenditures**

The timing of capital expenditures can have a significant influence on the quantum of the economic impacts realised under each scenario over different years. It has, for example, been assumed in the Discounted Cash Flows (DCF) analysis (which is the primary source of information for this EIA study) that all capital expenditures associated with tuna and riparian aesthetics restoration, and engineering works occur in 2011; respectively these account for $203m and $434m under Scenarios 2 and 3. These capital expenditures will have greatest impact in the 2011 year, after which, without further capital expenditure or growth, the Waikato economy would return to near its pre-2011 state. It is further worth noting that placement of the capital expenditures in the near, rather than distant, future produces the largest impacts in Net Present Value (NPV) terms.

**(4) Forestry Harvest Costs and Revenues**

This assessment of economic impacts has not incorporated any costs or revenues associated with harvesting the new forest stands proposed for the EBMP scenario. One reason for the exclusion is that, because the study covers only the next 30 years, it is quite possible that the harvests will occur outside of the study period. A second reason is that the harvests are likely to involve substantial changes to the structure of the Waikato economy, but for just a relatively short period over which the harvests occur. Incorporating these structural changes into the IO modelling framework is simply beyond the project time and budget constraints.

In terms of interpreting the results of this study the important point to note is that, had the forests harvests been included, the impact on the results for Scenario 3 would be positive. Obviously the revenues generated from harvesting forests are significantly higher than harvest costs. The net increase in forestry revenues will generate not only higher value added for the Forestry and Logging industry, it will also result in flow on impacts to consumer spending thus generating increases in value added and employment for other industries.

## 6. References


Ghosh, A. (1958). Input-Output Approach to an Allocation System. *Economica 25*: 58–64.

Ghosh, A. (1964). *Experiments with Input-Output Models: An Application to the Economy of the United Kingdom, 1948-55,* London: Cambridge University Press.

Giarrantani, F. (1980). The Scientific Basis for Explanation in Regional Analysis. Papers of the Regional Science Association 45: 185–196.

Giarrantani, F. (1981). A Supply-Constrained Interindustry Model: Forecasting Performance and an Evaluation. *In:* Buhr, W. & Friedrich, P (eds). *Regional Development under Stagnation*. Baden-Baden: Nomos, pp. 281–291.

Jensen, R.C.; Mandeville, T.D. & Karunarantne, N.D. (1979). Regional Economic Planning. London: Croom Helm.

Maré, D.C.; Graham, D.J. (2009). Agglomeration elasticities in New Zealand. NZ Transport Agency Research Report 376. New Zealand Transport Agency, Wellington, New Zealand.

McDonald, G.W.; Patterson, M.G. (2004). Ecological Footprints and Interdependencies of New Zealand Regions. *Ecological Economics 50*: 49–67.

McDonald, G.W.; Forgie, V.E. & MacGregor, C. (2006). Treading Lightly: Ecofootprints of New Zealand's Ageing Population. *Ecological Economics 56*: 424–439.

Miller, R.E.; Blair, P.D. (2009). *Input-Output Analysis: Foundations and Extensions* (2nd ed.). New York: Cambridge University Press.

Patterson, M.G. & McDonald, G.W. (2004). How Clean and Green is New Zealand Tourism? Lifecycle and Future Environmental Impacts. Land Research Science Series No. 24. Lincoln: Manaaki Whenua Press.

Patterson, M.; McDonald, G. & Smith, N. (forthcoming). Ecosystem Service Appropriation in the Auckland Region Economy: An Input-Output Analysis. Regional Studies.

Smith, N.J.; McDonald, G.W. (forthcoming). Estimation of Symmetric Input-Output Tables: An extension to Bohlin and Widell. Economics Systems Research.

Statistics New Zealand (2001). Inter-Industry Study of the New Zealand Economy 1995–96. Wellington: Statistics New Zealand.

Statistics New Zealand (2007). 2002–03 National Supply-Use Table. Wellington: Statistics New Zealand.

West, G.R.; Wilkinson, J.T. & Jensen, R.C. (1980). Generation of Regional Input-Output Tables for the Northern Territory GRIT II. Report to the Northern Territory Department of the Chief Minister. St Lucia, Queensland: Department of Economics, University of Sydney.

Yeoman, R.; Kim, J. & McDonald, G.A. Computable General Equilibrium Model for Auckland. NZCEE Research Monographs. Palmerston North: New Zealand Centre for Ecological Economics.

Zhang, J.; McDonald, G.; Trinh, S. & Smith, N. Social Accounting Matrix Methodology. NZCEE Research Monograph. Palmerston North: New Zealand Centre for Ecological Economics.

# Appendix 32: Non-Market Values

## 1. Introduction

The objective of this paper is to identify the scope and size of non-market values (NMV) associated with restoring and protecting the health and wellbeing of the Waikato River. The Waikato River provides a range of benefits that are difficult to measure in monetary terms - in economics these are called non-market values. They include positive benefits such as recreation, ecosystem services[1], aesthetics, intrinsic/existence[2], legacy/bequest[3], historical, and cultural/spiritual values.[4] They also include negative benefits (e.g., intensive land use has significant non-market costs in terms of reduced water quality and quantity). The reason these costs and benefits are not currently included in the formal economy (e.g., in GDP) is that there are no markets where they are regularly bought and sold, and hence the price that people are prepared to pay for them cannot easily be determined.

This section complements the economic analysis of the direct costs and benefits undertaken in the economic modelling.

The practical use of economic valuation is assessing incremental change arising from a policy change and not at valuing an entire ecosystem (TEEB, 2009). The purpose of economic valuation in policy decisions is to provide information on the impact of the change and not to value the entire site or resource. For example, in this Study the aim is to value the change in the health and wellbeing of the Waikato River and not to attempt to value all the goods and services provided by the river.

This paper is structured as follows. Firstly, the concept of Total Economic Value is introduced to provide context and a structure to the range of values. This is followed by case study examples of the various types of values grouped under ecosystem services, farming impact on the environment and indigenous biodiversity values. Next, economic impacts are discussed including how NMVs can be incorporated into Gross Domestic Product (GDP) the aggregate measure of economic wellbeing using the concept of the Genuine Progress Indicator (GPI). There is a discussion of the implications of quantifying changes in NMVs for the Waikato River and also a brief overview of the impact of the Emissions Trading Scheme.

[1] Ecosystems provide a range of resources and processes such as drinking water, waste assimilation and treatment, nutrient and soil cycling, pollination, and many others. Collectively these are known as ecosystem services.
[2] Intrinsic/Existence values refer to values ascribed by people to something simply because it exists even if they never experience it directly.
[3] Legacy/Bequest values refer to the values people ascribe to maintaining something for future generations.
[4] This refers to values from all cultures.

## 2. Total Economic Value

Non-market values are important and need to be considered alongside market values in decision making. The Total Economic Value (TEV), which incorporates both market and non-market values of a natural resource is grounded on the utility of the resource. This utility derived ranges across a spectrum of values grouped as active use and passive use values (see Figure 1).

**Active use** values are classified as direct use, indirect use and option value.[5] Direct use values are consumptive and production related (e.g., agriculture, fisheries, water supply, engineering) and are mostly captured in market values. Direct use value changes have been quantified and are expressed in monetary terms as NPV where NPV is defined as the discounted sum of direct benefits minus direct costs.

Indirect use values are functional benefits that support or protect direct use activities (e.g., recreation, water retention, nutrient recycling).

Option value relates to the benefits of preserving the natural resource for a potential future direct and indirect use (e.g., native plant biodiversity as future source of medicines).

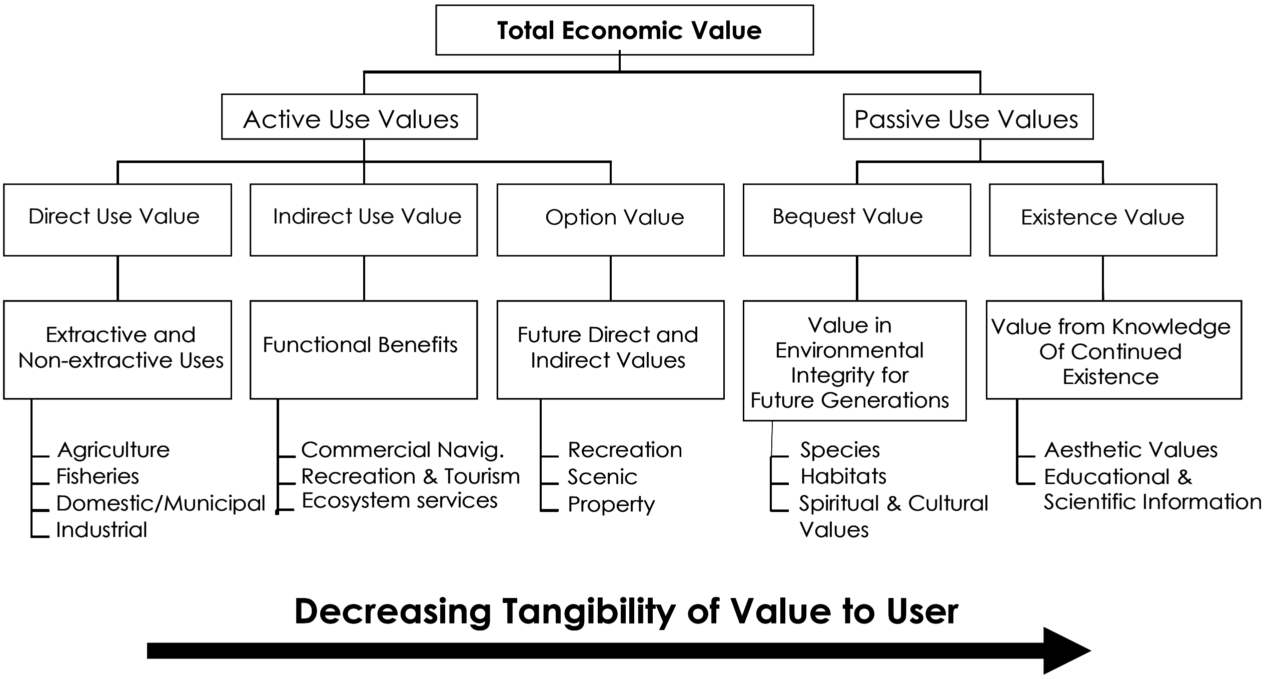



**Figure 1:** Total Economic Value (sourced from EVRI, 2009).

5 Studies cited later in the report have slightly different classification of value. One will classify option value under passive use. Another will classify recreation and cultural value as direct use value.

Passive use values are classified as bequest value (e.g., preservation for future generations, include spiritual and cultural values) and existence/intrinsic value (e.g., aesthetic, habitat, biodiversity).

It is important to note that the way in which economists categorise these values is to recognise the spectrum of total economic value. Traditionally, only the direct active use values are estimated in cost benefit analysis because there are market prices that can be applied to quantity changes to estimate changes in value.

Most of the values in Figure 1 must be valued indirectly through non-market valuation techniques. The Study team did not attempt to estimate dollar amounts for non-market values because the relevant data was not readily available and there was not enough time or budget to undertake the necessary survey and analysis work. However, the Study team did undertake a qualitative analysis of the main non-market values (costs and benefits) that may be relevant to the project and this analysis is set out below.

# 3. Case Studies

## 3.1 Ecosystem services

Natural capital encompasses ecosystems, biodiversity[6] and natural resources. Natural capital provides benefits that sustain societies through the provision of ecosystem services to society. The foundation of valuing these ecosystem services is scientific information that assesses the physical impact of changes to service provision and places a dollar value on the change. Studies that attempt to estimate the value of ecosystem services focus on active direct and indirect use values. Passive values such as cultural and spiritual values that help make up 'wellbeing' are not quantified and this means that estimating the value of ecosystem services in comparison with the direct costs of restoration underestimates the value of restoration.

The value of ecosystem services is context specific and not uniform universally. This means that economic values are not intrinsic to the ecosystem but linked to the utility and welfare it provides. This utility is influenced by the number of people who benefit and the socio-economic context including cultural and spiritual aspects. For example, the service 'water regulation' (regulation of hydrological flows such as provisioning of water for agricultural, industrial and transportation use) is an essential component for some locations but only an incidental service in others. Furthermore, the people who were surveyed in the study location may have markedly different incomes and cultural backgrounds that could result in significantly different willingness to pay for changes to environmental values. As a result, applying values estimated for one primary study site to another policy site (which is the

[6] Biological diversity (biodiversity) is the variety of all living things (plants, animals, fungi and microorganisms) and the ecosystems where they live (A strategy for New Zealand's biodiversity, www.biodiversity.govt.nz).

subject of a decision) using the benefit transfer technique can only be done if suitable adjustments are made that take into account both the differences in the sites and the populations affected (TEEB, 2009).

A policy change does not necessarily result in the loss of ecosystem service(s). Ecosystems have built-in resilience in the face of changing environmental conditions and disturbances. But, while there is uncertainty on threshold levels, the critical point at which the ecosystem is significantly changed, a precautionary approach is recommended (TEEB, 2009).

Ecosystem services can make up a significant component of Total Economic Value. The case studies set out below illustrate this significance.

**Case Study 1**

The direct and indirect use value of ecosystem services for the Manawatu-Whanganui region has been estimated at $6 billion per annum (2006 dollars) using the rapid assessment method - benefit transfer (van den Belt et al., 2009). Market-based direct use values such as food and raw material production were based on regional GDP figures. Non-market direct (e.g., recreation, water regulation) and indirect use (e.g., erosion control, nutrient cycling) values were derived from a global meta analysis by Costanza et al., (1997).

The ecosystem service value for the Manawatu-Whanganui region is still considered conservative as it does not include some direct and indirect use values for some ecosystem types. More important, it does not account for passive values (e.g., cultural and spiritual aspects of water) due to lack of primary valuation studies (van den Belt et al., 2009). Such passive values can be significant as is shown in the next case study.

Table 1 shows the per hectare annual value of ecosystem services by type of ecosystem. These figures have been updated from 2006 prices using the all groups CPI index.

**Case Study 2**

A contingent valuation study of the Whangamarino Wetland in an unpublished Master's thesis quoted by Schuyt and Brander (2004) showed passive use values exceeded active use values. As an annual benefit, the passive use (preservation) value of the Whangamarino Wetland was assessed as 2.7 times greater than the active use value (recreation, flood control and fishing). The high passive value might have been influenced by the ecological significance of this wetland.

**Table 1:** Annual value per hectare of ecosystems services in the Manawatu-Whanganui Region (2010 prices).

| Ecosystem service | Direct | Indirect | Total |
|---|---|---|---|
| Wetlands | $5,900 | $42,400 | $48,300 |
| Estuarine | 2,000 | 24,000 | 26,100 |
| Horticultural | 21,100 | 100 | 21,200 |
| Lakes | 14,000 | 6,900 | 20,900 |
| Rivers | 14,000 | 6,900 | 20,900 |
| Coastal | 600 | 9,400 | 10,000 |
| Exotic forests | 500 | 2,000 | 2,500 |
| Native forests | 200 | 2,100 | 2,300 |
| Dairy | 1,600 | 500 | 2,100 |
| Scrub | 300 | 900 | 1,200 |
| Cropping | 900 | 100 | 1000 |
| Sheep and beef | 300 | 500 | 800 |

Source: updated from van den Belt et al., (2009).

The Whangamarino Wetland presents a case study of the ecosystem services provided by flood control on the Lower Waikato River (DOC, 2007). Its ability to store water during peak flows results in reduced public works on flood gates (estimated at millions of dollars) and less damage to surrounding farmland (avoided flooding of 7,300 hectares estimated at $5.2 million). Other ecosystem services provided by the wetland include:

- Raising water tables for irrigation during dry periods.
- Carbon sequestration (0.5 tonnes per hectare per year from peat bogs).
- Gamebird hunting (tens of thousands of gamebirds each year).
- Recreational and commercial fishing (tuna).
- Attraction for overseas tourism (bird watching).
- Habitat for diverse native wetland birds and other threatened/uncommon wetland birds (hosts 20 percent of New Zealand's breeding population of native wetland birds).
- Diverse freshwater fish fauna (threatened black mudfish).
- 239 wetland plant species (60 percent indigenous; a number are rare).

**Case Study 3**

This case study has shown that improving drinking water quality beyond mandated minimum standards can provide benefits that exceed the costs. Such benefits need to include non-market values such as health and quality of life (Silverman, 2007).

The survey conducted before and after a water treatment upgrade in a city in Ohio, United States, revealed:

- Enhanced public satisfaction with a high-profile public interest issue around improved water quality.
- Potential health benefits to the community through risk reduction in exposure to toxic substances.
- While water bills increased, this is more than offset by savings from lower use of bottled water and home water treatment systems.

**Case Study 4**

Patterson and Cole (1998) estimated the annual value of Waikato Region's ecosystem services at $9.4 billion (1997 dollars), which equates to $12.6 billion in 2010 dollars. Table 2 shows the per hectare values related to the river in 2010 dollars updated from 1997 prices using the all groups CPI index. These estimates include both direct and indirect use values (Environment Waikato, 2010) but not passive values.

This analysis used the same global meta analysis data (Costanza et al., 1997) as the Whanganui study and therefore the same caveats apply.

**Table 2:** Annual value per hectare of ecosystem services (direct and indirect) in the Waikato River system (2010 prices).

| Ecosystem service | Annual value per hectare ($/ha) |
|---|---|
| Estuarine | 62,000 |
| Freshwater wetlands | 53,200 |
| Lakes and rivers | 26,300 |
| Mangrove | 25,400 |
| Forests | 3,200 |
| Agricultural/Horticultural | 1,500 |
| Scrub/Shrub | 700 |

Source: updated from Patterson and Cole (1998).
Note: these values are comparable with the total column of the previous table.

In a more recent study McDonald and Trinh (2008) applied similar methodology to Patterson and Cole to the Upper Waikato catchment using 2004 prices. Direct values were based on the System of National Accounts (SNA) data and indirect values from Costanza et al., (1997) as refined by Balmford et al., (2002).

These four ecosystem service case studies all use average values based on international meta-analysis. They are useful when considering a change to land use such as converting dairy land to forestry, but unfortunately they are not very helpful in assessing changes to the quality of ecosystem services, which is a significant component of the river clean-up.

## 3.2 Impact of farming on the environment

Farming has both positive and negative impacts on total economic value. There are positive direct active use values from the income derived from farming and there are negative indirect costs from environmental degradation. In addition, passive use values, such as aesthetics, are also affected. These passive values are the most difficult to assess and can only be quantified using stated preference techniques such as choice modelling to determine willingness to pay (WTP). In the two case studies below a range of non-market values are quantified including indirect, indirect active use values and passive values.

**Case Study 5**

One such study has been carried out by the University of Waikato and Environment Waikato (Marsh et al., 2009). This survey attempted to estimate the willingness to pay for improvement in water quality in the Karaapiro (Upper) catchment of the Waikato River, focusing on lakes Arapuni and Karaapiro. The research was based on the Choice Modelling method of NMV and resulted in the following attributes being quantified without and with improved water quality:

- Suitability for swimming and recreation (probability of health warnings: 1 in 2 years improved to 1 in 50 years).
- Water clarity (visibility under water: 1 metre improved to 4 metres).
- Ecological health (percentage of excellent readings: <40 percent improved to >80 percent).
- Jobs in dairying (percentage of jobs lost: 0 percent to 20 percent).
- Cost to households ($per year for the next ten years).

In total 178 or 2.3 percent households (HHs) were surveyed in the catchment. The statistical analysis of the survey produced a model with a good fit to the data providing a high degree of confidence in the result. The average WTP for improvement in quality were:

| | |
|---|---|
| • Suitability for swimming | $161/HH p.a. for 10 years |
| • Water clarity | $65 |
| • Ecological health | $145 |
| • Jobs in dairying | -$190 |

Thus the combined WTP to improve water quality was $371 per household per annum for ten years. But if the quality improvements resulted in a 20 percent loss of jobs in dairying then overall WTP was reduced by $190 per household. Over the 7,802 households in the Karaapiro catchment this aggregates to $2.9 million per annum for quality improvements and $1.5 million for loss of jobs, with a Present value (PV) after discounting at 8 percent of $21.0 million and $10.9 million respectively.

It should be noted that the Karaapiro catchment covers the area from Lake Arapuni to the Karaapiro Dam including tributaries and that this is only a fraction of the 'Upper Catchment' used in the Economic Model. This means that the $21 million for Lake Arapuni to the Karaapiro Dam cannot be compared with the direct cost estimates in the Economic model.

Also, these WTP estimates are conservative as they do not include recreational values for the catchment streams, which are to be the subject of further research. Also it is likely that non-residents, such as tourists and recreational users of the lakes, will hold NMV for water quality in the lakes. These values have not been counted and will vary greatly.

When these NMV are put alongside the direct farm costs and benefits for the upper catchment estimated in Scenario 2 and 3 (see Section 6) there is still a considerable gap before benefits exceed total costs of cleaning up the farm nutrient, sediment and effluent issues (see Table 3).

**Table 3:** Direct Farm costs and benefits for the upper catchment (PV $m).

| | Scenario 2 | Scenario 3 |
|---|---|---|
| Capital costs | 61.0 | 385.3 |
| Operating costs | 127.1 | 391.8 |
| Total costs | 188.1 | 777.1 |
| Benefits | 12.1 | 296.0 |
| Net costs | 176.0 | 481.0 |

Source: Economic model Table x7.

It should be noted that while the direct costs and benefits are quantified over 30 years the indirect and passive values estimated in the choice modelling study were elicited by asking for willingness to pay over only 10 years, thus the two sets of figures are not directly comparable.

**Case Study 6**

In another study a choice modelling survey was used to explore New Zealanders' willingness to pay (WTP) for sustainable dairy and sheep and beef cattle farming (Takatsuka et al., 2007). This study surveyed randomly selected New Zealand residents to determine their WTP for:

- Improved water quality (0 to 30 percent reduction in nitrate leaching).
- Reduced methane emissions (0 to 30 percent reduction).
- Reduced demands by agriculture for surface water and groundwater (0 to 30 percent reduction in water for irrigation).
- More diverse rural landscapes (0 to 30 percent more trees).

In total 312 of 1,008 survey forms were returned providing a 31 percent response rate and a sample representing 0.02 percent of New Zealand households. The model coefficients were significant at the 10 percent level. However, the adjusted R-squared was low (0.03–0.05) implying that the model had a low level explanation of respondent utility.

The results showed that people were not WTP positive amounts when improvements were made on individual attributes. However they were WTP significant positive amounts when combined improvements (all at 30 percent change) were made in all four environmental areas. The combined WTP for respondents relating to the Waikato was $157 per household per year over five years. This translates to a regional WTP of $107 million in PV terms.

**Indigenous biodiversity values**

**Case Study 7**

Patterson and Cole (1999) have estimated that the value of land-based indigenous biodiversity in New Zealand as whole ecosystems was $46 billion per annum (in 1994 dollars). This was broken down into direct use, indirect use and passive use values. Direct uses, valued at $9 billion per annum, included food, raw materials and timber from land use. Indirect uses accounted for the largest value at $30 billion per annum and included ecosystem services such as climate regulation, erosion control, soil formation, nutrient retention, waste treatment, pollination and biological control. Passive use values, estimated at $7 billion per annum, included option value (option for future use), existence/intrinsic value (preserving biodiversity for its own sake) and bequest value (preserving for future generations).

This study indicates that indirect values significantly exceed direct use values, at 65 percent of total value compared with 20 percent, with passive values making up 15 percent.

**Case Study 8**

Kaval et al., (2007) estimated that households (HHs) in Greater Wellington are willing to pay additional rates per year for biodiversity enhancement (i.e., planting scheme) on private and public land. The survey conducted in 2007, showed the average amounts were $174 per HH per year for planting schemes on public lands and $166 per HH per year on planting schemes on private lands. Over 60 percent of respondents were willing to pay for these schemes.

The information provided in the survey showed that residents feel strongly about biodiversity in New Zealand and are willing to give up a proportion of their income to support it.

**Case Study 9**

Nimmo-Bell (Bell et al., 2009) has developed a database of non-market values covering four diverse ecosystems and 16 attributes including 13 biodiversity values. The ecosystems and attributes valued included:

| | |
|---|---|
| • South Island high country | Plants, insects and fish. |
| • Beech forest | Increased or decreased bird and insect abundance, wasp stings. |
| • Coastal marine | Shellfish, coastal vegetation, recreational fishing and children's ability to paddle. |
| • North Island urban lake[7] | Avoidance of hydrilla; loss of charophytes, birds, fish and mussels. |

The primary purpose of this database is for Biosecurity New Zealand to estimate the economic value of biosecurity response activities affecting indigenous biodiversity. The database will also be useful for other decision making involving changes to indigenous biodiversity by organisations such as DoC and regional councils.

This study showed the residents of the Waikato are willing to pay significant amounts to prevent exotic weed infestations in waterways and avoid the loss of native species (see Table 4).

**Table 4:** Willingness to pay by Waikato regional household to protect indigenous biodiversity.

| **Attribute** | **WTP per annum over 5 yrs** | **PV* of WTP/HH** | **Aggregate over 157,000 HHs** |
|---|---|---|---|
| Avoidance of hydrilla | $234 | $1,009 | $158m |
| Loss of charophytes | $146 | $630 | $99m |
| Loss of a native bird species | $138 | $595 | $93m |
| Loss of a fish or shellfish species | $120 | $517 | $81m |

* Discount rate 8 percent, 157,000 households in the region.
Source: Bell et al., (2009).

In another component of this study Kerr and Sharp (2008) showed that people in the South island are willing to pay significant sums for changes to bird and insect populations. An interesting observation from this study is that birds were valued higher than insects and that avoiding the loss of birds or insects was valued more highly than increases in the populations of birds or insects (see Table 5).

Transferring the results from such choice modelling studies is complex and open to many criticisms. However these results indicate that passive values for changes to environmental attributes such as aesthetics and biodiversity are significant and need to be taken into account when considering policy changes that will affect the environment.

---

[7] Lake Rotoroa (Hamilton lake).

**Table 5:** Willingness to pay by South Island households for changes in bird and insect populations.

| Species | Mean annual value per HH | PV @ 10 percent over 5 years | Aggregate over 300,000 HH |
|---|---|---|---|
| Few birds | -$300 | -$1250 | -$375m |
| Plentiful birds | $120 | $500 | $150m |
| Few insects | -$150 | -$625 | -$195 |
| Plentiful insects | $90 | $375 | $113m |

Source: Kerr and Sharp (2008).

## 4. Economic Impacts of Non-Market Values

A change to Gross Domestic Product (GDP) is a typical way to assess how a nation's well-being is changing. Gross Domestic Product, however, focuses on market values and does not distinguish between desirable welfare-enhancing activities against undesirable welfare-reducing activities (Costanza et al., 2004). For example, expenditure on prisons adds to GDP, while the benefits of reducing the jail population are not counted.

In order to better reflect over-all wellbeing, alternative, more holistic measures have been devised. For example, the Genuine Progress Indicator (GPI) measures net human welfare that covers both positive and negative contributors to human welfare. This includes both market and non-market values. For example, non-market services of parents (i.e., unpaid work) caring for children does not increase GDP but if the parent decides to work and pay for child care, GDP increases. GPI attempts to include unpaid services, such as child care. Genuine Progress Indicator also attempts to include the non-market values provided by the environment.

Genuine Progress Indicator is one approach to estimating changes in total well-being at the national level. Another measure is Gross National Happiness (GNH), which is a unique official statistic monitored in Bhutan (Adams, 2010). In New Zealand, as in other developed countries, there are no official well-being statistics estimated at the regional or national level. However, a GPI has recently been completed for Environment Waikato, but unfortunately the results are not yet available. The work was undertaken by the New Zealand Centre for Ecological Economics (NZCEE) and Market Economics Limited (MEL) as part of the SP1 FRST programme.

In the economic impacts section of this Study the direct benefits and costs associated with Scenarios 2 and 3 are taken two further steps, which are to assess the flow-on effects to the regional community through indirect and induced effects. In the first place, there are the indirect effects on industries supplying goods and services up-stream of the direct effects (e.g., firms supplying fencing materials for riparian planting on farms) and down-stream of the direct effects (e.g., dairy processing). Secondly, there are induced effects as households spend the income from wages from these industries creating another round of economic activity in consumption. Normally only market based costs and benefits are assessed in this way. The analysis could be extended to include non-market values, which would result in a GPI type approach as per the ANCEE and MEL study referred to above.

Restorative actions for improving the health and wellbeing of the Waikato River could be included in a GPI for the region. Such activities would include, for example:

- Reduced nutrient and effluent inflows from dairying.
- Reduced sediment loads from hill country farming.
- Improved drinking water quality on marae.
- Better access to the river for social and cultural activities.
- Improved aesthetics from riparian planting.
- Restoration of the ecological functions of wetlands and shallow lakes.
- Restored tuna and whitebait fisheries.

## 5. Implications for the Waikato River

The case studies presented indicate that the indirect and passive non-market values are likely to be highly significant and of comparable size to the direct market values. The latter have been quantified in dollar terms but at this stage the former cannot because of the time and budget constraints of this Study.

It is worth mentioning that there are non-market costs as well as non-market benefits. For example, the business as usual scenario could have significant non-market costs in terms of loss of opportunity for recreation, and adverse effects on the environment.

The case studies on indirect values and especially ecosystem services indicate that these indirect values can exceed direct values a number of times. For example, for Case Study 1, Wetlands are estimated to have an annual direct value of $5,900/ha and indirect value of $42,400/ha. On the other hand, Dairy has a direct value of $1,600/ha and an indirect value of $500/ha. On this basis society would be better off shifting dairy land into wetlands. This would involve the community making a trade-off by reducing regional income from dairying and increasing non-market values from wetland through increased ecological services.

At face value this analysis may seem counter-intuitive. If it were true then dairy farms would/should be converted into wetlands. It arises because wetlands are now so scarce that the marginal benefit/cost ratio of preservation/recreation is higher than the marginal benefit/cost of dairy pasture. A strong case may be made to convert some dairy land to wetland. But, at some point, the marginal value of lost dairy production will exceed the marginal value of the benefits from an additional hectare of wetland.

Riparian planting along streams improves ecosystem services. The direct costs under Scenario 2 amount to a PV of $16.1 million. Based on a shift from pasture to native plantings the indirect values change from $500/ha to $2,100/ha (Whanganui data), a net increase of $1,600/ha.  aken over the 412 ha converted to native under Scenario 2, this results in a PV of $3.3 million (assuming the benefits are received in years 11 to 30). Similarly, for Scenario 3 where 1,450 ha are converted from pasture to native the direct cost is $43.6 million and the indirect benefit $11.3 million. This comparison does not include the benefits from the improved water quality in the river. Consequently, the benefits of riparian planting ($3.3 million for Scenario 2) and ($11.3 million for Scenario 3) significantly under-estimate the full indirect benefits.

The two scenarios put forward in this report identify combinations of activities that will improve the quality of the river. Scenario 2 is less costly than Scenario 3 and will result in significantly less progress towards the goal of a river that is swimmable and the community are able to take food from it, over its entire length. The Cost Abatement Curves (CAC) provided highlights the trade-off between cost and benefit.

The willingness to pay survey in Case Study 5 indicated that upper catchment respondents were willing to pay in PV term $21 million for improvements in water quality, clarity and ecological health of Lakes Arapuni and Karaapiro.

Case Study 6 indicates that the willingness to pay for improvement in water quality, reduced GHG emissions, reduced demand for irrigation water and more diverse landscapes (all at 30 percent change), when extrapolated over the Waikato region could be in the order of $107 million in PV terms.

Case Study 9 indicates that the willingness to pay for the passive values of waterways (protecting indigenous plant and animal species) in the Waikato region could be in the range of $80 to $160 million in PV terms. Also, actions taken that would increase the number of native birds and insects in the region (e.g., riparian planting and lake restoration) would have benefits of a similar magnitude.

Unfortunately, it is not possible to add these indirect and passive values together in the same way that the direct costs can be added together. This is because of the overlap in types of benefit and the different methodologies used to derive them. Extrapolating from specific case studies derived in different regions and countries assumes that the sites and attributes are similar and the populations are similar. In many instances the validity of such assumptions may not stand up to close scrutiny. Never-the-less the quantum of these indirect and passive values is significant when compared with the direct costs.

Another important qualification with the studies on ecosystem services is that average values are used that have been derived from international meta-analysis, and thus these figures do not take into account the degraded nature of the Waikato catchment's ecosystem services. This suggests that the marginal benefit/cost ratio for restoration activities in the Waikato is likely to be higher than the figures used because of the degraded nature of the Waikato catchment's ecosystem services. However, to confirm this it is necessary to undertake a study to benchmark the actual value of ecosystem services in the catchment and then assess how these values change due to the mitigation activities.

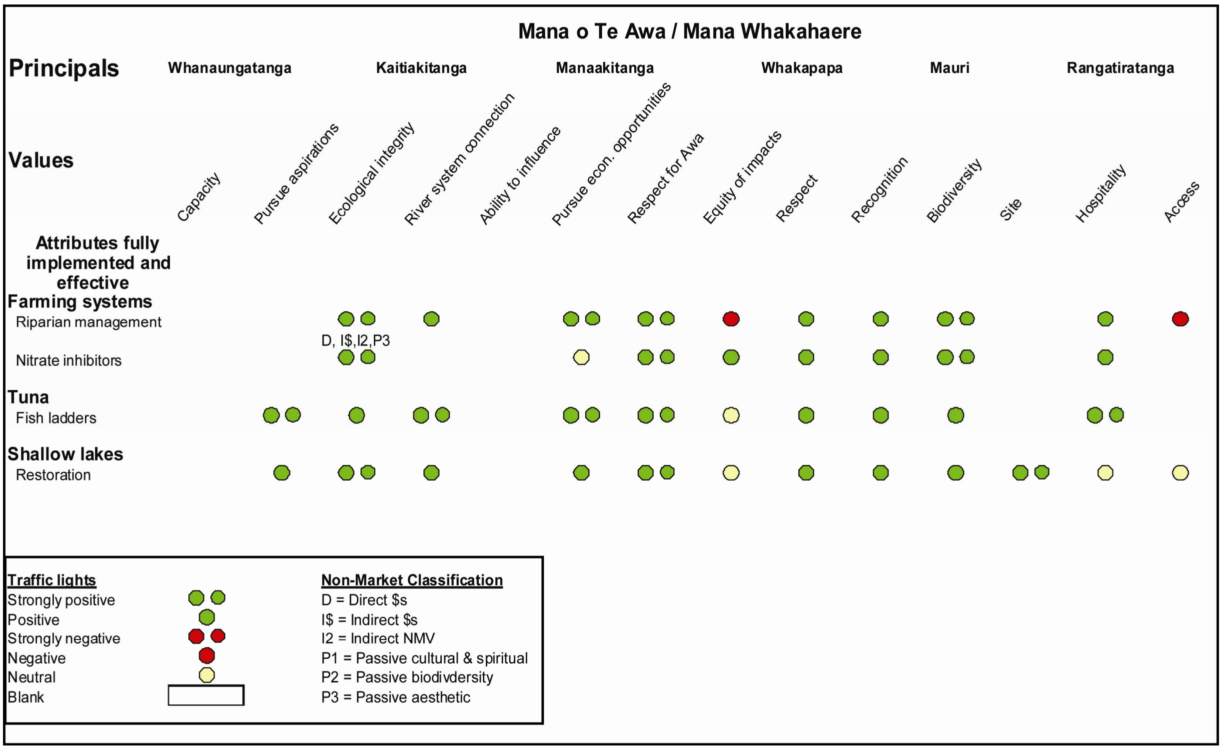
Because non-market valuation studies are expensive and time consuming, very few are undertaken in New Zealand. This means that secondary sources of information are utilised as above, with estimates that do not provide similar degrees of robustness compared with direct cost estimates. One of the key issues is whether stakeholders in the Waikato region share the same views of the environment as the respondents in the case studies (such as the averages sourced from a global meta-analysis). This question would normally be answered by conducting surveys. However, this Study was not in a position to conduct such surveys although it may be possible for surveys to be conducted as part of the 'clean-up' of the Waikato River.

While all peoples place an intrinsic value on indigenous biodiversity, attempting to estimate dollar values for these can be highly sensitive. For Maaori, such intrinsic values are an integral part of their belief system being based on principles such as kaitiakitanga (guardianship). Some things many people regard as being beyond dollar values. For these the political process is the way that society ultimately resolves the trade-offs between conflicting values. However, in order to make sustainable progress political decisions need to be well informed.

One way to compare non-market and market costs and benefits is through the report card. This requires that targets be set for non-market and market indicators, and the current state reported in relation to the target. For example, an important non-market value is safety for swimming for which an indicator is the *E. coli* concentration for which the safe guideline value is a median of 125 CFU per 100 mL. Measurements of 125, 500, 1000, 5000 and 10000 CFU per 100 mL might be assigned scores of A, B, C, D and E. A market indicator might be household income for which values of $60K, $50K, $40K, $30K and $20K might be assigned scores of A, B, C, D and E. In this way different types of indicator can be compared. The validity of this approach depends on being able to select targets and scale indicators in a sensible manner. It does not solve the problem of estimating the value of safe swimming.

Another way to display and compare costs and benefits is to use the 'traffic light' approach. This uses green, amber or red symbols to show how a group of restoration actions affect values or high level principles. An example is provided in Table 6. Here four actions are scored: riparian management, nitrate inhibitors, fish ladders and shallow lake restoration. The classification of non-market values are added for one cell – the impact of riparian management on ecological integrity. Tables can be replicated and used to compare Scenarios 1 to 2 to 3.

**Table 6:** Example of a 'traffic light' approach - linking actions to values.




The following issues have been identified from the case studies:

- What are the relative orders of magnitude between non-market values – similar order of magnitude?
- Are the potential non-market benefits likely to exceed the net direct quantified costs and benefits estimated in the previous section? – Possibly.
- What further work needs to be done to quantify the non-market values associated with the project – surveys of willingness to pay for changes to river quality?

## 6. Conclusions

Non-market costs and benefits need to be anchored on the ecological assessment of the changes to the environment and stakeholder perceptions of these changes. This is because the economic assessment of non-market values is essentially grounded on human welfare change.

All restoration activities considered in Scenarios 2 and 3 clearly have positive impacts on non-market values in the catchment.

Based on a review of nine case studies (three in the Waikato) the value of these benefits is likely to be of a similar magnitude to the direct market costs of the restoration actions assessed in the Economic Model. However, the results of the nine studies cannot be compared directly with the costs of restoration because different methods were used and some of the measures overlap.

The benefits estimated by the nine studies reviewed almost certainly under-estimate the true non-market benefits of restoration for two reasons. First, they omit some the values that are important in the Waikato (e.g., fisheries). Second, they include 'ecosystem services' that help support communities but they do not consider cultural and spiritual values that are an important part of community wellbeing.

Consequently, the total benefits including 'ecosystem services' and the benefits to community wellbeing are likely to be higher than the direct costs of restoration for some of the restoration actions. Those actions where the Study team considers this to be the case are the 'Priority Actions' identified in Section 7.

# 7. Climate Change, the ETS and Forestry and Agriculture - Implications for the Waikato River

Material for this Section has been drawn from MAF's website.[8]

## 7.1 Climate Change

'Climate change' is the phrase used to describe changing climate patterns that can be attributed to human activity that alter the earth's atmosphere and are beyond natural climate variations observed over comparable time periods. While New Zealand's greenhouse gas (GHG) emissions in a global context are small, at 0.2 percent of the world's total, on a per-person basis the level of emissions ranks New Zealand 12th in the world. Also, the pattern of GHG emissions in New Zealand is quite unlike any other developed country in that methane and nitrous oxide from agricultural activity account for 48 percent of total emissions (MAF, 2010a).

## 7.2 The Emissions Trading Scheme

In September 2007, the government released a comprehensive statement on climate change which set targets for reducing New Zealand's greenhouse gas emissions. The announcements included details of a range of initiatives across all sectors, including a proposed New Zealand Emissions Trading Scheme (ETS) and a Plan of Action for Sustainable Land Management and Climate Change (MAF, 2010b). The ETS is a price based mechanism for greenhouse gases and is a key part of overall climate change policy. Forestry is the first sector to be involved in the ETS.

## 7.3 Forestry in the ETS

The forest estate is already a significant store of carbon and there is potential for this to grow further with farm and larger-scale plantings of both exotic and indigenous

[8] http://maf.govt.nz/climatechange/agriculture/agriculture-in-nzets-guide/page-03.htm#P111_12341 and http://www.maf.govt.nz/sustainable-forestry/ets/

forest species. For this reason, it was the first sector to enter the ETS - effective 1 January 2008 (MAF, 2010c).

Forest owners either automatically (pre-1990) or voluntarily (post-1989) become participants in the ETS depending on the date the forest was established; the type of forest owned (or leased, or held under a forestry right); and whether any deforestation has occurred. Forest land is defined as being at least 1 hectare (ha) with forest species that have (or are likely to have at maturity): a crown cover of more than 30 percent on each hectare; a crown cover with an average width of at least 30 m; and be capable of reaching five metres in height at maturity.

Post-1989 forest owners can register their forest and receive Carbon Accounting Unit (CCU) credits on an annual basis as carbon is accumulated by the forest. These can be sold as Kyoto compliant units. The current price of a CCU is $25 per tonne. The amount of carbon accumulated each year reaches a maximum of around 37 tonnes per hectare a little after mid-way through the 26 year rotation of a typical pruned Pinus radiata regime. These units can be sold as they are earned or banked to meet the liability at harvest when around two thirds of the credits must be paid back. The remaining one third related to the part of the tree remaining in the ground are required to be paid back over time in line with decay and return to carbon dioxide. The delay between selling units and repaying them offers forest owners a cash flow stream that could significantly improve the economics of forestry.

## 7.4 Agriculture in the ETS

The ETS for agriculture includes greenhouse gases from pastoral agriculture, horticulture and arable production. Methane from livestock emissions and nitrous oxide from animal urine and dung and synthetic fertiliser are the primary sources. Although the agricultural sector as a whole also produces carbon dioxide emissions through energy and fossil fuel use, for the purposes of the NZ ETS, the term 'agricultural emissions' refers to methane and nitrous oxide only.

The ability to trap heat from the sun is measured over a one hundred year period and is called Global Warming Potential (GWP). Carbon dioxide has a GWP of 1. Methane captures the heat from infrared radiation more effectively than carbon dioxide with a GWP of 21. Nitrogen in the form of nitrous oxide is even more effective with a GWP of 310. In New Zealand agriculture, methane is twice as important as nitrous oxide on a total output basis.

Participants can voluntarily report their emissions in 2011 and are required to report their emissions from 2012 though to 2014, but they are not required to pay for their emissions in these years. Agriculture fully enters the scheme in 2015.

Agriculture sector participants will be eligible to receive a free allocation of Kyoto compliant units called New Zealand Units (NZUs) from the Government to help significantly reduce the cost of participation in the NZ ETS. Allocation will be on an 'intensity' basis, meaning participants receive an allocation that is linked to their output. The assistance level will start at 90 percent of the sector's baseline and will phase out at 1.3 percent per annum from 2016. The baseline and other details are yet to be established.

### 7.5 Implications for the Waikato River

The link between GHG abatement policies and improvement in the quality of the river is that for the most part actions taken to reduce GHG emissions also reduce inputs of N, P, sediment and faecal organisms to waterways, with benefits for water quality (Wilcock et al., 2008).

#### 7.5.1 Forestry

For forest land owners, the ETS is said by the Government to offer significant opportunities for land development and economic growth. However, even after the start of the scheme there is considerable uncertainty surrounding the economics. This is primarily because of the considerable time lag between when CCUs may be sold as the forest grows and when they must be paid back at harvest. If the price of carbon rises in real terms then forest owners could face potentially crippling liabilities. Alternatively if the price of carbon falls over time then forest owners could receive very high returns over the length of the rotation.

Forestry is economically marginal on hill country at present without the ETS. With the ETS the uncertainties around pricing of CCUs could make or break forestry. For example, if Carbon Credits were sold at $25/tonne (each year the credits were generated) and then had to be purchased back at $50/tonne (at the end of the rotation) this could result in forest owners owing large sums. Alternatively if the price went down at harvest forest owners could make large profits.

The table below for a pruned regime over 26 years highlights the range in returns under four price scenarios.

**Table 7:** The impact of CCU price changes on forestry NPV.

| Carbon Credits \$/tonne $CO_2$ (2010 prices) | | NPV/ha @ 8 percent |
|---|---|---|
| **Sell price** | **Purchase price** | |
| 25 | 25 | 812 |
| 50 | 50 | 4,300 |
| 25 | 50 | -1,405 |
| 50 | 25 | 6,518 |

#### 7.5.2 Agriculture

While the forestry sector is seen to be a beneficiary of the ETS, the agriculture sector sees it as a significant threat to international competitiveness. New Zealand is the only country to have committed to an ‘all gases all sectors’ ETS scheme. Potentially, this places New Zealand agriculture at a disadvantage in international markets as other countries will be, in Global Warming terms, subsidising their agriculture while New Zealand continues its policy of fully exposing agriculture to market forces without subsidies. In the early years of the scheme, during the phase in, the direct impact may be low in financial terms because farmers will not have to pay the full cost. However, the bureaucracy around the ETS is likely to be a significant burden even if the recording is done at the processor level. For the policy to be effective, the costs must be passed back to farmers so that behaviour changes and emissions are reduced.

A major concern of farmers is that the technologies do not exist for them to reduce emissions and that the scheme should not be initiated until these are available.

Considerable research has been conducted on actions that might improve farming emissions and results are starting to become available. De Klein and Eckard (2008) report that of the currently available technologies, nitrification inhibitors, managing animal diets and fertiliser management show the best potential for reducing emissions in the short term. They also note that abatement technologies that increase the efficiency of N within the soil-plant system are likely to increase pasture and/or animal productivity, which in turn, is likely to increase methane emissions. Thus a whole farm systems approach is necessary to ensure that total emissions abatement is achieved.

Monaghan et al., (2007) indicated that under current pricing structures, nitrification inhibitors are likely to be a cost effective option for grazing systems in some parts of New Zealand, while wintering pads generally reduce farm profitability. Given that current technologies may deliver up to 15 percent reduction in $N_2O$, which translates to only a 2–4 percent decrease in overall emissions, further research is needed before farmers will be convinced to change their management systems.

While nitrate inhibitors are practical on flat land, this is not the case on hill country that is too steep for tractors. This poses an additional challenge for sheep and beef farmers on hill country to reduce emissions. It also improves the relative profitability of forestry on hill country.

Changing land use from intensive pasture based systems to forestry has the potential to have the greatest impact on GHGs, but at a major cost in lost income. Converting dairy systems to forestry can have up to a 90 percent decrease in N while converting sheep and beef to forestry reduces N by around 65 percent. In addition, converting Class 3 sheep and beef can have a beneficial effect on waterways by halving sediment loads (Monaghan, pers. comm., 2010).

Given the significant uncertainty that surrounds the ETS it was decided to exclude it as a consideration in the quantitative analysis of the report. Firstly, while forestry is currently in the ETS agriculture is not and there is no surety over if/when it will be. Secondly, the price likely to be paid for carbon credits over the 30 years of the study is extremely uncertain. Thirdly, the current economic impact (input/output) model is not able to accommodate GHG. And fourthly, New Zealand's approach to GHG may change, for example, to align more closely with the policies of the country's major trading partners.

The consequences of including GHGs in the quantitative analysis would likely be as follows. Firstly, forestry would be more attractive financially (assuming that the price of carbon does not rise significantly between the sale and purchase back of credits at harvest). Secondly, given forestry becomes more attractive there would likely be more sheep/beef to forest conversions on hill country and greater benefits in terms of reduced erosion and nitrogen input. Lastly, it is likely to make pastoral farming less attractive financially than has been estimated in which case there may be less intensive pastoral farming as farmers seek alternative enterprises with lower GHG emissions. This will have benefits in terms of reduced stock numbers, lower nitrogen leaching and lower faecal microbe runoff into waterways.

# 8. References


Adams, C. (2010). Happiness beats GDP gauge, New Zealand Herald, 17 May 2010.

Balmford, A.; Bruner, A.; Cooper, P.; Costanza, R.; Farber, S.; Green, R.; Jenkins, M.; Jefferiss, P.; Jessamy, V.; Madden, J.; Munro, K.; Myers, N.; Naeem, S.; Paavola, J. Rayment, M.; Rosendo, S.; Roughgarden, J.; Trumper, K.; Turner, R. (2002). Economic reasons for conserving wild nature. *Science 297*: 950–953.

Bell, B.A.; Cudby, C.; Yap, M. (2009). Biodiversity valuation manual: a technical manual for MAFBNZ (Working Paper No. 11). Wellington: Nimmo-Bell & Company Ltd.

Costanza, R. et al., (2004). Estimates of the Genuine Progress Indicator (GPI) for Vermont, Chittenden County and Burlington, from 1950 to 2000. *Ecological Economics* 139–155.

De Klein, C.A.M.; Eckard, R.J. (2008). *Targeted technologies for nitrous oxide abatement from animal agriculture 48*: 14–20.

Department of Conservation (2007). The economic values of Whangamarino Wetland, Department of Conservation, May 2007.

Environment Waikato (2010). The hidden economy. Downloaded on 13 June 2010 from http://www.ew.govt.nz/Environmental-information/About-the-Waikato-region/Our-economy/The-hidden-economy/

EVRI (2009). Environmental Valuation Reference Inventory. Environment Canada http://www.evri.ca/

Kaval, P.; Yao, R.; Parminter, T. (2007). The value of native biodiversity enhancement in New Zealand: A case study for the Greater Wellington Area, University of Waikato, November 2007.

Kerr, G.; Sharp, B. (2008). Biodiversity management: Lake Rotoiti choice modelling study. AERU Research Report No. 310, Lincoln University, September 2008.

MAF (2010a). Agriculture in the ETS. http://www.maf.govt.nz/climatechange/agriculture/agriculture-in-nzets-guide/page-03.htm#P111_12341

MAF (2010b). Sustainable Land Management and Climate Change: Plan of Action. http://www.maf.govt.nz/climatechange/slm/

MAF (2010c). Sustainable forestry. http://www.maf.govt.nz/sustainable-forestry/ets/

Marsh, D.; Davies, A.; Petch, A. (2009). Willingness to pay for water quality in the Karaapiro catchment – a case study of residents. Report to the Environment Committee, Environment Waikato, 31 July 2009, 10 p.

McDonald, G.; Trinh, S. (2008). Upper Waikato region's hidden economy: assessing the value of the region's ecosystem services. Prepared for Environment Waikato, August 2008, 37 p.

Monaghan, R.M.; de Klein, C.A.M.; Muirhead, R.W. (2007). Prioritisation of farm scale remediation efforts for reducing losses of nutrients and faecal indicator organisms to waterways: a case study of New Zealand dairy farming. *Journal of Environment Management 87*: 609–622.

Patterson, M.; Cole, A. (1998). The Economic Value of Ecosystem Services in the Waikato Region. Report prepared for Environment Waikato. Massey University, Palmerston North.

Patterson, M.; Cole, A. (1999). Assessing the value of New Zealand's biodiversity. Occasional Paper Number 1, School of Resource and Environmental Planning, Massey University, February 1999.

Takatsuka, Y.; Cullen, R.; Wilson, M.; Wratten, S. (2007). Values of ecosystem services associated with intensive dairy farming in New Zealand. Contributed paper Australian Agricultural and Resource Economics Society 51st Annual Conference, 13-16 February, 2007, Queenstown, New Zealand.

The economics of ecosystems and biodiversity (TEEB) (2009). The economics of ecosystems and biodiversity for national and international policy makers – Summary: Responding to the value of nature, United Nations Environment Programme, www.teebweb.org.

Schuyt, K.; Brander, L. (2004). The economic values of the world's wetlands, World Wildlife Fund, Gland, Amsterdam, January 2004 quoting.

Kirkland, W.T. (1988). Preserving the Whangamarino Wetland – an application of the contingent valuation method, Masters Thesis, Massey University.

Silverman, G.S. (2007). Community benefits and costs of surpassing drinking water quality standards. *Journal of the American Water Works Association*.

van den Belt, M.; Chrystall, C.; Patterson, M. (2009). Rapid ecosystem service assessment for the Manawatu-Wanganui Region, New Zealand Centre for Ecological Economics.

Wilcock, R.; Elliot, S.; Hudson, N.; Parkyn, S.; Quinn, J. (2008). Climate change mitigation for agriculture: water quality benefits and costs. *Water Science & Technology 58*: 11.

# Appendix 33: Restoration Case Studies

## 1. Introduction

Over the past 30 years there has been a substantial increase in river restoration efforts worldwide (Alexander and Allan, 2007; Giller, 2005) and this has been accompanied by advances in the science of river restoration (Ormerod, 2004; Roni et al., 2002). There are now a number of useful reviews of restoration which help to identify what makes for successful restoration outcomes and commonly occurring problems. However, despite the amount of restoration activity occurring there are few clear success stories and the scientific basis for restoration is incomplete (Brooks and Lake, 2007).

**Restoration in the United States**

In the United States there has been an exponential increase in river restoration projects since the 1990s and restoration now plays an important part in environmental management. The River Restoration Science Synthesis (NRRSS) project has compiled a database of over 37,000 restoration projects being carried out mainly in the United States (Bernhardt et al., 2005a; Bernhardt et al., 2005b). These range in size from small community-based activities reliant on voluntary and 'in-kind' support through to large restoration projects which have been running for decades and involve expenditure of billions of dollars. The picture that emerges is that a comprehensive analysis of restoration progress in the US is not possible because of lack of records and piecemeal information. Of the 37,000 projects reviewed only 10 percent indicated that monitoring of progress or effectiveness was being carried out, although more expensive projects of the order of about US$1 million were likely to be monitored. This lack of monitoring or sufficient recording of project objectives, budgets, or efficacy means that opportunities to learn from project successes and failures are being lost.

**Restoration in the Europe**

In Europe waterways and lakes have suffered from various forms of control, manipulation and pollution for the past 6000 years so that there are now few rivers with natural flows and that are in a pristine condition (Nienhuis and Leuven, 2001). In Western Europe eutrophication from intensive agriculture and farming is a particular problem (Gulati and van Donk, 2002). The River Thames in the Britain is one of the first well documented cases of successful restoration. The Thames had become seriously polluted by the early 1800s. Restoration started in the 1960s and largely through the building of sewage treatment plants the fish fauna of the river underwent a remarkable recovery (Gameson and Wheeler, 1977). There are now numerous cases of restoration being undertaken throughout Europe (e.g., see reviews in van Andel and Aronson, 2006; Nienhuis and Gulati, 2002). However, river restoration efforts in Europe are often complicated and compromised, especially for the large rivers because they flow through several countries (e.g., Weiring et al., 2010), and where flood protection and transport are of over-riding priority to restoration (e.g., Buijse et al., 2002).

**Restoration in Australia**

In Australia the construction of weirs, floodplain levees, dams and inter- and intra-catchment water transfer schemes have had a major impact on natural river systems. Flow regulation affects all the major Australian rivers and such regulation is acknowledged as a major cause of deterioration in many Australian river and floodplain ecosystems (Arthington and Pusey, 2003). There is now a national commitment to ecologically sustainable development and water reform, including restoration.

Brooks and Lake (2007) have collated and synthesized data on restoration projects in Victoria, Australia. Most of the 2,247 projects reviewed focused on riparian management including fencing, off-river watering points (to keep stock out of the riparian zone), native plant revegetation, weed management and willow removal. The rest mainly included bank stabilisation, habitat improvement and channel reconfiguration. Although financial information is often missing, it appears that a conservative estimate of total expenditure (not accounting for 'in-kind' and volunteer support) is that AU$131 million has been spent in Victoria on river restoration over the 1999-2001 period, or AU$44 million per year. Riparian management was the least expensive activity whereas projects involving stormwater management were the most expensive. In rural areas riparian restoration is seen as an effective way to improve water quality by reducing sediment and nutrient inputs, stabilising river banks and limiting channel incision. As found in the US, records of monitoring are often scarce or incomplete. Of the 2,247 Victorian cases examined only 14 percent appeared to include monitoring or evaluation, but information was inadequate for determining whether monitoring was being carried out to check that construction projects remained intact and that planted vegetation had survived. It was also not clear from the information recorded if monitoring data was used to evaluate the success of the project in achieving the restoration goals. Opportunities to use experience gained from past river restoration is limited. Another problem that has occurred is that organisational restructuring and poor data management have resulted in data and historical information relating to restoration projects being lost.

**Restoration in New Zealand**

Over the last 20 years there have been increasing attempts at restoration of New Zealand freshwater ecosystems (Quinn, 2009) and guidelines for restoration of aquatic habitats have been published (e.g., Collier, 1994; Rowe, 2004; Sorrell et al., 2004; Suren et al., 2004). Quinn (2009) summarised the range of restoration activities occurring in New Zealand, from individual landowners fencing and replanting along riparian zones through to nationally significant projects involving Fonterra and the government (Dairying and Clean Streams Accord) and regional coalitions between Maaori and regional and central government and multi-million dollar budgets (e.g., Lake Taupoo $81.5 million and Rotorua/Te Arawa lakes $144 million). Stream and lake restoration case studies are being documented, and show progress towards many aspirations, on dairy (e.g., Wilcock et al., 2007; 2009) and drystock farms (Dodd et al., 2008 a,b,c; Quinn et al., 2007; 2009). Monitoring of intensive action to restore Lake Okaro has also shown significant benefits since 2003 (e.g., Paul et al., 2008; Özkundakci et al., 2009; Gibbs and Özkundakci, 2010). There are active research programmes on aquatic restoration within New Zealand CRIs, universities[1] and NGOs[2] and there is considerable collaboration between these organisations and with stakeholders.

**Restoration and Indigenous Communities**

Worldwide there are now many river restoration initiatives focused on the values of indigenous communities and also benefiting from the input of Traditional Ecological Knowledge (TEK). There are numerous websites and on-line resources available which focus on restoration from the perspective of indigenous peoples.

The **Indigenous Peoples' Restoration Network (IPRN)**[3] operates under the auspices of the Society for Ecological Restoration International[4]. The network's mission is:

- "to support native and tribal communities in need of technical assistance for environmental restoration and cultural rehabilitation; and
- to assist leaders and practitioners in their efforts to apply traditional ecological knowledge within their own vision of political, economic, and cultural sovereignty."

Their website provides many useful links to databases, resources, references and indigenous groups and organisations worldwide, including New Zealand, Australia and the Pacific Rim.

In the United States, the **American Indian Environmental Office (AIEO)**[5] coordinates the US Environmental Protection Agency (USEPA) environmental protection efforts in Indian Country, with a special emphasis on building tribal capacity to administer their own

[1] http://www.niwa.co.nz/our-science/freshwater/research-projects/all/restoration-of-aquatic-ecosystems and http://www.lernz.co.nz/index.html
[2] http://www.landcare.org.nz/regional-focus/central-north-island/waikato-lakes-catchments/
[3] Contact with IPRN has been established by Dr Gail Tipa, g.tipa@xtra.co.nz, ph 64 3 4894534
[4] http://www.ser.org/iprn/default.asp
[5] Contact with AIEO has been established by Dr Gail Tipa, g.tipa@xtra.co.nz, ph 64 3 4894534

environmental programs.[6] The American Indian Tribal Environmental Portal provides specific details relating to environmental policies, practices and laws.[7]

**Restoration resources and support**

In addition to the resources and networks being developed by indigenous groups there are now worldwide initiatives to support and encourage river restoration. The following international centres aim to share technical knowledge and resources on river restoration:

**Pacific**
Australian River Restoration Centre (ARRC)

**Asia**
Asian River Restoration Network (ARRN)
Japan River Restoration Network (JRRN)

**Europe**
European Centre for River Restoration (ECRR)
The River Restoration Centre (UK) (RRC)
Danish Centre for River Restoration (Dansk Center for Vandløbsrestaurering – DCVR)
Netherlands Centre for River Studies (NCR)
Italian Centre for River Restoration (Centro Italiano per la Riqualificazione Fluviale – CIRF)

**North America**
River Restoration Northwest

**Project WET**[8] is a nonprofit organisation which aims to support and educate children, parents, teachers and the wider community on water education.[9] Project WET operates worldwide and achieves its aims through training workshops, organizing community events and festivals and building international networks.

The Queensland-based **International WaterForum** is a joint venture between the International WaterCentre, the International Riverfoundation, the University of Queensland, Griffith University, Queensland Government and Brisbane City Council.[10] Their aim is to improve the business of water and river management by facilitating opportunities for education, professional development, knowledge sharing, networking

---

[6] http://www.healthfinder.gov/orgs/HR3413.htm
[7] http://www.epa.gov/tribalportal/trprograms/env-programs.htm
[8] Contact with Project WET has been established by Dr Gail Tipa, g.tipa@xtra.co.nz, ph 64 3 4894534
[9] http://www.projectwet.org
[10] http://www.watercentre.org/news/international-waterforum

and recognition of excellence within water and river management. The International WaterForum is also responsible for organising the **International Riversymposium**, a conference that focuses on water and river management. The 13th International Riversymposium is scheduled for 11-14th October 2010, in Perth.[11]

**Case Studies**

There are numerous documented cases of river restoration worldwide. Many of these are of little direct relevance to the Waikato River because of differences in climate, hydrology, and ecology. The following selection of case studies has been chosen because they provide lessons that could benefit restoration of the Waikato River. They have been chosen because they are good examples of:

- Approaches that can be taken (e.g., Glen Canyon, Columbia River Basin, Willamette Basin, South East Queensland).
- The complexity and expense of restoration projects (e.g., Colombia River Basin, Willamette Basin, Murray River, South East Queensland).
- Restoration of traditional fisheries, important to indigenous communities (e.g., Colombia River Basin).
- Engagement with indigenous communities as part of the restoration process (e.g., Colombia River Basin, Willamette Basin, Murray River).
- Community involvement (e.g., South East Queensland).
- Mitigating the impact of hydro dam operation (e.g., Glen Canyon).
- Regional significance (e.g., Murray River, South East Queensland).

**Glen Canyon**

The Glen Canyon dam case is an example of where it is recognised that science cannot provide certainty of a desired outcome and with collaborative input from the community and stakeholders a Collaborative Adaptive Management (CAM) approach was taken (NRC, 1999). The Glen Canyon dam is located on the Colorado River just south of the Arizona-Utah border. The Colorado River then passes through Marble Canyon before entering the Grand Canyon National Park and flowing into Lake Mead, formed by the Hoover dam. The area is home to several American Indian tribes and as well as its cultural importance it has exceptional ecosystem values and is a World Heritage Site. The Glen Canyon dam and its operations have profoundly altered the hydrology and temperature regime of the river with significant effects on the Colorado River ecosystem and the surrounding desert country.

[11] http://www.riversymposium.com/

The Glen Canyon dam Adaptive Management Program (AMP) was established in 1997 with the aim of co-ordinating research and monitoring of the downstream ecosystem and resources. A Federal Advisory Committee which includes input from stakeholders has responsibility for facilitating the program and making recommendations on actions to improve the downstream ecosystem and resources. Scientific experimentation is integrated into the management actions.

While the Glen Canyon case had been promoted as an example of the successful application of CAM it has also been severely criticised by Susskind et al., (2010). They maintain that the programme has failed to increase the understanding of stakeholders and has not resulted in them making informed management recommendations. The result is that it has not stabilised or improved the river ecosystem, despite the expenditure of several millions of dollars over the past 13 years. Susskind et al., (2010) maintain that this failure has arisen because of fundamental flaws in the set-up of the Adaptive Management Program, with only partial stakeholder representation, confused and uncertain decision making authority and lack of responsibility, and an ineffective dispute resolution process.

**Columbia River Basin**

The 2000 km long Columbia River is the largest river in the Pacific Northwest. Its catchment lies within seven US States and British Columbia, Canada. The river's ecology and resources make a significant contribution to the economy of the Pacific Northwest region. About eight million people live within the catchment basin and the river has 14 hydropower dams. Traditionally, the Columbia River and its tributaries supported the largest salmon fishery in the world. With the extensive development of the river catchment there has been substantial habitat loss and degradation and contamination by chemical pollutants now pose a risk to fish, wildlife and humans[12].

Some of the local Indian tribes regard salmon to be part of their spiritual and cultural identity, and fishing is still the preferred livelihood of many tribal members. Treaties between individual tribes and the federal government acknowledge the importance of salmon and steelhead and guarantee fishing rights. To mitigate the effects that hydro dams have on fish migration, hatcheries now operated along the river. In 1977 four Indian tribes with treaty fishing rights on the river formed the Columbia River Inter-Tribal Fish Commission (CRITFC)[13] to coordinate their activities in fisheries management and restoration. They have also developed a holistic salmon management plan that aims to increase survival at each stage of the fish's anadromous[14] life cycle.

[12] http://www.cleanwaternetwork.org/sites/default/files/Columbia%20River%20One-Pager%20final.pdf
[13] http://www.critfc.org/
[14] Fish that migrate from the sea up rivers to spawn.

Restoration in the lower river is co-ordinated by the Lower Columbia River Estuary Partnership (LCREP)[15]. This Partnership integrates the restoration activities of multiple stakeholders from 28 cities, 9 counties, and the states of Oregon and Washington. They also have responsibility for implementing the Comprehensive Conservation and Management Plan for the Lower Columbia River.

The US Senate is currently considering legislation that would authorise the US Environmental Protection Agency to provide 'clean-up' technical assistance and help to river stakeholders (including state and local agencies, tribal governments, industry, landowners and environmental groups). The legislation would also authorise a budget of US$40 million annually.

**Willamette Basin**

The Willamette Basin restoration programme has many parallels with the Waikato River restoration proposal. The Willamette River is 301 km long and is a major tributary of the Columbia River, draining a densely populated region of the Pacific Northwest of the United States. The river and its tributaries form a basin called the Willamette Valley.

The area has been home to several American Indian tribes for at least 10,000 years, many having a close association with the river and depending on it for food, clothing, tools, transportation, and spiritual sustenance. Widespread development and increases in population over the past few hundred years had resulted in the river becoming seriously polluted. Fisheries had declined and the water was unsafe for drinking or swimming.

Faced with continuing catchment basin development and a growing population the Willamette Restoration Initiative (WRI) was charged with developing the Willamette Restoration Strategy (WRI, 2001). The strategy sets out to:

- protect and restore fish and wildlife habitat;
- enhance populations of other declining native species;
- improve water quality; and
- improve management of floodplains.

The WRI's activities are controlled by a board of directors, selected to represent the various interests and perspectives of the wider community, including those of local Indian tribes. The board has representatives of local government, utilities, tribes, academia, watershed groups, soil and water conservation districts, agriculture, forestry, environmental groups, and state and federal government.

[15] http://www.lcrep.org/about-us

The strategy was developed through a collaborative process and represents a holistic, integrated action plan. It incorporates existing restoration initiatives and builds on the existing knowledge of the system. It incorporates a variety of restoration approaches and by recognising the multiple and diverse values held by stakeholders, attempts to balance the goals of a healthy environment, a high quality of life, and a strong economy.

The strategy has identified 27 critical actions which fall into four restoration focus areas of:

- clean water;
- water quantity;
- habitats and hydrologic processes; and
- institutions and policies.

The strategy provides ways to measure restoration progress and to determine if the critical actions are achieving the restoration outcomes intended. Importantly, while the strategy provides a foundation for action it is recognised that a flexible approach is needed and that there needs to be continuous assessment and revision to incorporate improved understanding and possibly changing restoration needs.

An interesting approach taken as part of the Willamette Basin restoration has been the use of alternative futures analysis (Baker et al., 2004). This involved modelling three alternative scenarios which captured future landscapes for the year 2050, based on different development options. The Plan Trend 2050 scenario assumed that current policies and trends continue. The Development 2050 scenario represented a loosening of current policies and a market-driven approach. The Conservation 2050 scenario assumed that ecosystem protection and restoration were accorded higher priority, although still within the bounds of what stakeholders considered realistic. The modeling results have been used to guide the basin-wide restoration strategy.

Restoration of the Willamette basin is recognised as being extremely complicated and requiring long-term commitment. Recent estimates just for restoration of streamside vegetation and streamside habitat throughout the Willamette basin ranged from US$593 million to US$1.2 billion (Michie, 2010).

**Murray River**

Restoration of the Murray River is Australia’s largest river restoration project and is one of the largest restoration projects in the world. The Murray River is 2,756 kilometres long and runs through the three states of Victoria, New South Wales and South Australia. It is navigable for 1,986 kilometres, has four dams, 16 weirs and 15 navigable locks and provides domestic water supply for over 1.5 million households. Aboriginal occupation along the river goes back 40,000 years.

Flow regulation of the river was introduced to make the supply of water more reliable but it has significantly changed the river ecosystem and water quality has deteriorated. Native fish have declined in numbers and in range, vegetation has been affected and some areas of land have become affected by salt. In 2002, in response to this deterioration the Murray-Darling Basin Ministerial Council established the Living Murray program.[16]

The Australian, New South Wales, Victorian, South Australian and the Australian Capital Territory governments together made an initial commitment to the Living Murray Project of A$500 million over a five year period from 2004–05 and a further A$150 million over eight years. The Living Murray has established five programmes through which to direct restoration activities:

- **Water Recovery** which addresses over-allocation of water resources in certain parts of the River Murray system and reclaims water for delivery to icon sites.
- **Water Application** which ensures that water is delivered to achieve ecological benefits at the icon sites.
- **Environmental Works and Measures** which aims at developing infrastructure which will help make the best use of water in the River Murray system.
- **Communication and Community Consultation** which will ensure that local communities, key stakeholders, and the public are able to receive information and offer their input.
- **Indigenous Partnerships** which establishes a partnership programme so that the social, spiritual, cultural, environmental and economic interests of indigenous communities are considered.

**South East Queensland**[17]

The South East Queensland Healthy Waterways project has several useful parallels with the Waikato proposal especially in the terms of partnerships and collaboration, capacity building, monitoring and reporting. The project was initiated to address concerns about degrading water quality in the waters of Moreton Bay and inland waterways. Deteriorating water quality was linked to sewage discharges and runoff and deposition of fine-grained sediments into Moreton Bay.[18]

---

[16] http://www.thelivingmurray.mdbc.gov.au/index.html

[17] Contact with the SEQ Healthy Waterways project has been established by Dr Bruce Williamson, Diffuse Sources, bruce.williamson@diffusesources.com, ph 64 3 5484342

[18] http://www.healthywaterways.org/HealthyWaterways/Home.aspx

Fundamental to the project is the SEQ Healthy Waterways Partnership, a collaboration between government, industry, researchers and the community. In many ways the approaches that are being taken are unique. The partnership includes representatives of 7 state agencies, 3 national agencies, 4 state corporations, 11 local governments, 37 industries, 9 research institutes and 40 community and environmental groups. Together they developed a restoration strategy which includes 12 action plans based on a combination of issue-based, enabling and area-based plans:

**Issue Based Action Plans**

- Point Source Pollution.
- Non-Urban Diffuse Source Pollution.
- Water Sensitive Urban Design.
- Protection and Conservation.
- Coastal Algal Blooms.

**Enabling Action Plans**

- Ecosystem Health Monitoring Program.
- Communication, Education and Motivation.
- Management Strategy Evaluation.

**Area Based Action Plans**

Which focus on Moreton Bay and three separate catchments.

In total there are over 500 actions in the strategy that the partners have committed to implementing.

Another important aspect of this project is the Ecosystem Health Monitoring Program (EHMP). It is one of the most comprehensive marine, estuarine and freshwater monitoring programs in Australia and delivers a regional assessment, or 'Report Card', of the ambient ecosystem health for each of 19 catchments, 18 river estuaries, and Moreton Bay.

**Dam decommissioning and removal**

With the large number of dams affecting river ecosystems in the US, attention has turned to the option of their removal or ways of mitigating their impacts (e.g., Donnelly et al., 2005; O'Connor et al., 2008). The Federal Energy Regulatory Commission (FERC) has mandated changes in hydro dam operation to address environmental conditions including increased minimum flows, improved fish passage (both upstream and downstream), periodic high flows and riparian protection measures. Where mitigation cannot be achieve dam removal is now seen as a legitimate option for consideration, especially where fish passage needs to be improved. Examples of successful dam removal have occurred in the US, Canada, and Europe.

While there are more than 75,000 listed dams in the US (greater than 1.8 m high) there are also an estimated two million smaller dams (Shuman, 1995). As such, the majority of dams that have been removed and are currently being considered for removal are relatively small, non-hydroelectric dams, particularly run-of-river structures. It is estimated that since 1912 750 dams have been decommissioned with the rate increasing in recent years (O'Connor et al., 2008). It is important to note however that in the US many of the structures being removed have reached the end of safe operational life or are obsolete. For example there are many dams built in the 1800s to power textile mills which have now ceased to operate. The dams no longer serve any useful purpose and their removal is essential if the rivers they dam are to be restored to a natural state.

**Lessons from past restoration attempts**

Based on the many documented examples of restoration activities there are some general observations and conclusions that can be made about river restoration, what needs to be considered, what makes for a successful outcome, and what needs to be avoided:

1. Restoration is expensive – Restoration projects on a catchment scale can typically require budgets of many millions of dollars.
2. Restoration is long-term – It may be several decades before significant restoration is achieved.
3. Collaboration is needed – Restoration often requires participation, co-operation and collaboration from many parties including state and local government agencies, industry, universities, and representatives of indigenous groups, environmental care groups, sports groups and the wider community.
4. Build on existing initiatives – Attempts should be made to build on existing restoration and environmental management and monitoring activities.
5. Define outcome – The overall outcome that is desired from restoration needs to be defined.
6. Set agreed objectives – It is important to have clearly defined and agreed restoration objectives that will meet the desired outcome, and all partners need to be committed to achieving these.
7. Use traditional knowledge and science – Successful restoration relies on incorporating traditional knowledge (in this case maatauranga Maaori) and science. Also, scientific input must incorporate multi- and interdisciplinary approaches (e.g., drawing on physical, chemical, geomorphological and ecological expertise).
8. Use science – Use the extensive and growing body of restoration science to inform actions, monitoring and analysis.

9. Track expenditure and progress – Records of expenditure and completion of specific restoration activities need to be recorded and audited.
10. Monitor – Progress towards completing restoration activities, achievement of objectives and progress towards the overall outcome need to be monitored and the results publicised.
11. Learn from monitoring – Monitoring results need to be analysed to determine the effectiveness of the actions undertaken.
12. Use adaptive management – Because the outcome of specific restoration actions will not be reliably predictable there needs to be ongoing review of progress and if necessary modification and resetting of objectives and actions.
13. Outreach – There needs to be easy access to project information, objectives, planned actions, resources and monitoring results to all stakeholders and the community.
14. Plan for the future – Restoration projects are typically of a long duration and this needs to be considered when setting up administrative and management systems. Staff turnover and operational restructuring need to be allowed for with robust systems able to survive in the long-term. Planning has to include information security and backup and archiving. Standardised data systems and mandatory reporting are needed and changes in computing systems need to be considered so that information is not lost.

## 2. References


Alexander, G.G.; Allan, J.D. (2007). Ecological success in stream restoration: Case studies from the Midwestern United States. *Environmental Management 40*: 245–255.

Arthington, H.; Pusey, B.J. (2003). Flow restoration and protection in Australian rivers. *River Research and Applications 19*: 377–395.

Baker, J.P.; Hulse, D.W.; Gregory, S.V.; White, D.; Van Sickle, J.; Berger, P.A.; Dole, D. & Schumaker, N.H. (2004). Alternative futures for the Willamette River Basin, Oregon. *Ecological Applications 14(2):* 313–324.

Bernhardt, E.S.; Palmer, M.A.; Allan, J.D.; Alexander, G.; Barnas, K.; Brooks, S.; Carr, J.; Clayton, S.; Dahm, C.; Follstad-Shah, J.; Galat, D.; Gloss, S.; Goodwin, P.; Hart, D.; Hassett, B.; Jenkinson, R.; Katz, S.; Kondolf, G.M.; Lake, P.S.; Lave, R.; Meyer, J.L.; O'Donnell, T.K.; Pagano, L.; Powell, B. & Sudduth, E. (2005a). Synthesising U.S. river restoration efforts. *Science 308*: 636–637.

Bernhardt, E.S.; Palmer, M.A.; Allan, J.D.; Alexander, J.; Barnas, K.; Brooks, S.; Carr, J.; Clayton, S.; Dahm, C.; Follstad-Shah, J.; Galat, D.; Gloss, S.; Goodwin, P.; Hart, D.; Hassett, B.; Jenkinson, R.; Katz, S.; Kondolf, G.M.; Lake, P.S.; Lave, R.; Meyer, J.L.;

O'Donnell, T.K.; Pagano, L.; Powell. B. & Sudduth, E. (2005b). Synthesizing U.S. river restoration efforts. *Science* supporting online material. http://www.sciencemag.org/cgi/content/full/sci;308/5722/636/DC1

Brooks, S.S.; Lake, P.S. (2007). River restoration in Victoria, Australia: Change is in the wind, and none too soon. *Restoration Ecology 15(3)*: 584–591.

Buijse, A.D.; Coops, H.; Staras, M.; Jans, L.H.; van Geest, G.J.; Grifts, R.E.; Ibelings, B.W.; Oosterberg, W. & Roozen, C.J.M. (2002). Restoration strategies for river floodplains along large lowland rivers in Europe. *Freshwater Biology 47*: 889–907.

Collier, K.J. (ed). (1994). The restoration of aquatic habitats. Wellington, Department of Conservation. 171 p.

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G. & Wedderburn, M.E. (2008a). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 1. Goal development and assessment of current performance. *New Zealand Journal of Agricultural Research 51(1)*: 127–141.

Dodd, M.B.; Thorrold, B.S.; Quinn, J.M.; Parminter, T.G. & Wedderburn, M.E. (2008b). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 2. Forecasting and planning land use change. *New Zealand Journal of Agricultural Research 53(1)*: 143–153.

Dodd, M.B.; Quinn, J.M.; Thorrold, B.S.; Parminter, T.G. & Wedderburn, M.E. (2008c). Improving the economic and environmental performance of a New Zealand hill country farm catchment: 3. Short term outcomes of land use change. *New Zealand Journal of Agricultural Research 53*: 155–169.

Donnelly, C.R.; King, L. & Phillips, M. (2005). Once removed – decommissioning Finlayson Dam. International Water Power and Dam construction. http://www.waterpowermagazine.com/story.asp?storyCode=2028607

Gameson, A.L.H.; Wheeler, A. (1977). Restoration and recovery of the Thames Estuary. *In:* Cairns, J.; Dickson, K.L.; Herricks, E.E. (eds). *Recovery and Restoration of Damaged Ecosystems.* The University Press of Virginia, Charlottesville (VA): 72–101.

Gibbs, M.; Özkundakci, D. (2010). Effects of a modified zeolite on P and N processes and fluxes across the lake sediment–water interface using core incubations. *Hydrobiologia*: 1–14, DOI 10.1007/s10750-009-0071-8.

Giller, P.S. (2005). River restoration: seeking ecological standards. *Journal of Applied Ecology 42*: 201–207.

Gulati, R.D.; van Donk, E. (2002). Lakes in the Netherlands, their origin, eutrophication and restoration: state-of-the-art review. *Hydrobiologia 478*: 73–106.

Michie, R. (2010). Cost estimate to restore riparian forest buffers and Improve stream habitat in the Willamette Basin, Oregon. State of Oregon Environmental Quality, Water Quality Division, Water Management Section. DEQ 10-WQ-007. http://www.deq.state.or.us/wq/tmdls/docs/WillametteRipCost030310.pdf

Nienhuis, P.H.; Gulati, R.D. (eds) (2002). Developments in Hydrobiology. Ecological restoration of aquatic and semi-aquatic ecosystems in the Netherlands (NW Europe). Kluwer Academic Publishers, The Netherlands. 233 p.

Nienhuis, P.H.; Leuven, R.S.E.W. (2001). River restoration and flood protection: controversy or synergism? *Hydrobiologia 444*: 85–99.

NRC (1999). Downstream: Adaptive management of Glen Canyon Dam and the Colorado River ecosystem. National Academy Press, Washington, DC.

O'Connor, J.; Major, J. & Grant, G. (2005). Down with the dams: Unchaining U.S. rivers. *Geotimes*. March 2008. http://www.geotimes.org/mar08/article.html?id=feature_dams.html

Ormerod, S.J. (2004). A golden age of river restoration science*. Aquatic Conservation: Marine and Freshwater Ecosystems 14*: 543–549.

Özkundakci, D.; Hamilton, D.P. & Scholes, P. (2009). Effect of intensive catchment and in-lake restoration procedures on phosphorus concentrations in a eutrophic lake. *Ecological Engineering*. http://dx.doi.org/DOI:10.1016/j.ecoleng.2009.11.006

Paul, W.J.; Hamilton, D.P. & Gibbs, M. (2008). Low-dose alum application trialed as a management tool for internal nutrient loads in Lake Okaro, New Zealand. *New Zealand Journal of Marine and Freshwater Research 42:* 207–217.

Quinn, J.M. (2009). Special issue on restoration of aquatic ecosystems*. New Zealand Journal of Marine and Freshwater Research (43)*: 653–657.

Quinn, J.M.; Croker, G.F.; Smith, B.J. & Bellingham, M.A. (2009). Integrated catchment management effects on runoff, habitat, instream vegetation and macroinvertebrates in Waikato, New Zealand, hill-country streams. *New Zealand Journal of Marine and Freshwater Research 43(3)*: 775–802.

Quinn, J.M.; Dodd, M.B. & Thorrold, B.S. (2007). Whatawhata catchment management project: the story so far. Proceedings of the New Zealand Grassland Association 69: 229–233.

Roni, P.; Beechie, T.J.; Bilby, R.E.; Leonetti, F.E.; Pollock, M.M. & Pess, G.R. (2002). A review of stream restoration techniques and a hierarchical strategy for prioritizing restoration in Pacific Northwest watersheds. *North American Journal of Fisheries Management 22*: 1–20.

Rowe, D. (2004). Lake restoration. *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (eds). *Freshwaters of New Zealand*. Christchurch, New Zealand Hydrological Society and New Zealand Limnological Society: 39.1–39.16.

Shuman, J.R. (1995). Environmental considerations for assessing dam removal alternatives for river restoration. *Regulated Rivers: Research & Management 11(3-4)*: 249–261.

Sorrell, B.; Reeves, P. & Clarkson, B. (2004). Wetland management and restoration *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (Eds). *Freshwaters of New Zealand*. Christchurch, New Zealand Hydrological Society and New Zealand Limnological Society: 40.1–40.12.

Suren A.; McMurtrie, S. & O'Brien, L.M. (2004). River restoration. *In*: Harding, J.S.; Mosley, M.P.; Pearson, C.P.; Sorrell, B.K. (eds). *Freshwaters of New Zealand*. Christchurch, New Zealand Hydrological Society and New Zealand Limnological Society: 38.1–38.20.

Susskind, L.; Camacho, A.E. & Schenk, T. (2010). Collaborative planning and adaptive management in Glen Canyon: A cautionary tale. *Columbia Journal of Environmental Law 35(1)*: 53 p.

Van Andel, J.; Aronson, J. (eds). (2006). *Restoration ecology: the new frontier*. Blackwell Publishing, USA. 341 p.

Wiering, M.; Verwijmeren, J.; Lulofs, K. & Field, C. (2010). Experiences in regional cross border co-operation in river management. Comparing three cases at the Dutch-German border. *Water Resources Management.* January 2010.

Wilcock, R.J.; Betteridge, K.; Shearman, D.; Fowles, C.; Scarsbrook, M.R.; Thorrold, B.S. & Costall, D. (2009). Riparian protection and farm best management practices for restoration of a lowland stream in an intensive dairy farming catchment: a case study. *New Zealand Journal of Marine and Freshwater Research 34(3)*: 803–818.

Wilcock, R.J.; Monaghan, R.M.; Thorrold, B.S.; Meredith, A.S.; Betteridge, K. & Duncan, M.J. (2007). Land-water interactions in five contrasting dairying catchments: issues and solutions. *Land Use and Water Resources Research 7*: 2.1–2.10.

WRI (2001). Restoring a river of life: The Willamette Restoration Strategy Overview. http://ir.library.oregonstate.edu/jspui/bitstream/1957/58/1/WRS_OVER.pdf