Northland Regional Council

Scoping of Irrigation Scheme Options in Northland

Report

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Executive Summary

Targeted investment in irrigation infrastructure within Te Tai Tokerau has the ability to drive the development of more prosperous, stronger, resilient communities through enhancing and future-proofing local agrisector businesses for generations to come.

"Fresh water resources are essential for the growth of Northland. Droughts and flood events are becoming increasingly common and there is a need to be able to manage these extremes whilst supporting the development of industries to which water is essential including agriculture and horticulture." (Tai Tokerau Northland Economic Action Plan, 2016)

Northland's natural resources are precious. The fertile soils, abundant water and renewable energy all sit within an advantageous climate. Currently, there is a window of opportunity to capture community momentum, available funding and influence policy to support the prospect of achieving significant positive change in Northland's social resilience.

As the first step towards delivering on this challenge, a Strategic Irrigation Infrastructure Study was undertaken in 2015; its primary focus was to evaluate the opportunities presented by managing a reliable water supply to the farm gates of primary productive capable land. The study provided useful and relevant information to support strategic decision making in regards to water management across the entire Northland region. The analysis highlighted potential irrigable areas of interest within four definable districts; the Far-North, the Mid-North, Whangarei and its surrounds and Kaipara.

Six considerations were identified that would need to be addressed for Northland to enable positive economic growth and authentic social outcomes through the development of irrigation infrastructure:

- Engaging with the communities and stakeholders;
- Undertaking detailed scheme investigations;
- Identifying funding and development entity models;
- Undertaking farm level case studies;
- Refining the regulatory framework for water use; and
- Developing an employment ready workforce.

Kaipara and the Mid-North were prioritised and recommended to take forward to a more detailed level being the most likely to benefit from development of community scale irrigation supply infrastructure. The 'Stage 2' Scoping Study of irrigation schemes has focused on these areas with further detailed analysis of viable irrigation scheme supply, distribution and water storage options. The primary aim has been to create a prioritised list of options that could be taken forward into a pre-feasibility study.

To successfully move towards scheme implementation will require community commitment and significant investment. To reach this level of support needs practical information to support robust decisions. Any large scale water infrastructure development must work within but also help shape regional and national water planning instruments taking into account the community desire for acceptable water quality and allocation outcomes.

A key feature of this study has been the incredibly valuable interaction with the community stakeholders. These workshops have allowed a deep understanding of the values and challenges within the community objectives for the land, the water and the people. The consideration of existing initiatives, the years of local knowledge and drive for leadership have been taken into account. It was quickly evident that the development of irrigation schemes in Northland would require intergenerational, community focused thinking. This will help ensure the best overall outcomes are achieved and importantly that a social licence for the projects is obtained.

The analysis of land use capability revealed that in the Kaipara and Mid-North areas up to 40,000ha of land would be suited to agricultural and horticultural production. It is easy to see a continuation of the diverse land use that characterises Northland which already allows high value foods to be produced from a patch work of intensive artisan style enterprises.

The water these enterprises need to expand and succeed on the international market thereby driving community resilience and stability comes at a commercial cost not typical of other farming areas of New Zealand where more extensive pasture based systems have been adopted. The people of Northland have the opportunity to further evaluate the commercial cost of the water, appreciate the strength that reliable water brings to their futures and scrutinise how this sits within the environmental and cultural expectations placed on them Applying further decision criteria and looking at best available water sources allowed this to be focused down to four priority scheme areas totalling 11,600ha. These were shown to have the greatest opportunity for value add (GDP growth) and employment growth increases.

The four identifiable schemes and the potential benefits estimated in terms of value added and employment are summarised below that there are substantial social and economic opportunities to be realised through irrigation scheme development.

Table 1-1 Substantial social and economic opportunities identified.

	Kaipara	Mid-North A	Mid-North B	Mid-North C	Total
Command area	19,000	2,300	2,800	5,000	29,100
Irrigated area	6,300	1,600	1,700	2,000	11,600
Employment increase (Total direct and indirect)	950	500	650	600	2,700
GDP region increase ($ million per year)	$85	$70	$75	$96	$326

Northland offers a great opportunity for a strong agricultural and horticultural production led economy. It has good soils, great climate and we now know from this study good opportunity for providing reliable water to farmers though schemes. That water availability will allow long term decisions and choices to be made about production systems changes at a farm level.

An analysis of the increase in supply predicted from the primary production as a result of irrigation confirmed that demand for Northland's produce from consumer markets, both nationally and internationally, would not limit the development of irrigation schemes in Northland.

Hydrological modelling demonstrated how much water is needed for various land uses typical of Northland and provided insight into the availability from accessible local sources. A focus was given on reliability, the storage volume needed and the impact of climate change on both demand and supply.

When irrigation schemes are contemplated then it is common for other water users needs to be met alongside the development especially for underwriting municipal drinking water and industrial expansion supplies demands.

The following observations were made regarding the supply and demand models:

- The total demand for water on a per hectare basis in the Kaipara is significantly more than the Mid-North. The Kaipara storage is therefore relatively large.
- The seasonal variation for water in the Mid-North is significantly more than the Kaipara. The water in the Mid-North will be utilised over a longer period of each irrigation season.
- The proposed NRC water allocation plan needs to be considered in terms of the drafting of conditions of the water takes consents.
- The water allocation plan impacts the conditions for harvesting of high flows which in turn affects the potential extent of irrigable areas.
- Raising Lake Omapere to provide irrigation water storage and/or utilising existing Kerikeri Irrigation Scheme storage is likely to allow irrigation development options that don't rely on a high storage cost.

This information was then utilised to produce conceptual scheme pumping and distribution network designs to enable rough order capital and operational scheme costs. Table 1-2 summarises these costs.

Table 1-2 Estimated capital and operation scheme costs for the proposed scheme options.

	Kaipara	Mid-North A	Mid-North B	Mid-North C
Max irrigation demand (m^3/ha/year)	4,700	3,500	3,900	3,600
Average irrigation demand (m^3/ha/year)	3,400	1,800	1,900	1,500
Total capital cost ($m)	$108	$18	$30	$27
Capital cost ($/ha)	$17,300	$11,100	$15,900	$13,600
Operational cost ($/ha)	$390	$180	$210	$320

It is expected that optimisation of scheme layouts would potentially yield capital and operational savings on a per hectare basis.

The multi-criteria analysis used is not a screening process to determine feasibility; and it does not provide the final answer on what should be a commitment to build. It does however inform robust decision-making on the relative future viability of the schemes. It has allowed the relative strengths and weaknesses of the schemes to be further understood. Importantly, it has also highlighted factors that have not yet been well enough explored and therefore should be considered in future stages.

If the focus is only on farm gate cash return, the schemes are unlikely to proceed. The farmers alone can't afford to build these schemes without a good public sector support component. The social outcome is the significant story to tell; its winning hearts and minds and allowing community ownership that will keep the projects advancing.

The following key observations were made:

- The capital required is substantial and will likely need a special funding "vehicle" for implementation as no single entity, public or private is likely to be able to fund it.
- The staging of the funding may help the development process.
- The investment is not likely to be overly attractive if you only look at a simple cost recovery commercial analysis.
- The benefits will be long term and hence the need for a patient or "angel" investment system.
- The "real" benefits need to be considered as a whole of economy outcome and that makes it harder to measure.
- The returns may not accrue directly back to those who take the initial risk on the capital investment.
- The long term affordability for some land uses may be marginal but if you only pick the top returns then there is unlikely a critical mass achieved.
- In order to "turn the dial" economically for Northland, it is considered that all four scheme options need to be looked at collectively.
- These four community irrigation schemes, if developed together, will deliver regional scale benefits.

The following steps are recommended to successfully progress forward:

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5
Confirmation of NRC priorities	Update the community	Form a development entity	Undertake pre-feasibility studies	Develop an investment case

The development of a community irrigation scheme requires decisions to be made that have inter-generational benefits. The comparison of the four options has therefore, been undertaken using a balanced approach by looking at the scheme attributes identified by the project team as well as those issues highlighted as important by the communities. Rather than entirely focusing on farmer affordability and profitability, this approach will help ensure the best community and regional outcomes are achievable.

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1 Introduction

The objective of this scoping study is to identify manageable community irrigation schemes across the two cluster areas identified previously; Kaipara and Mid-North. These schemes will then be taken forward to inform more detailed technical pre-feasibility investigations with the ultimate objective of delivering investment ready proposals. This scoping study has been commissioned by Northland Regional Council (NRC) supported with co-funding from Crown Irrigation Investments Limited (CIIL) to develop findings from previous studies.

This study also aims to identify appropriate entities that could take the scheme options and advance the schemes further; and to recommend the pathway for development.

The scheme options have been developed, analysed and prioritised through a robust process which includes consideration of the following:

- Physical form of options so they can be positioned on maps within the two identified clusters;
- Technical feasibility and the ability to implement;
- Indicative capital and operational whole of life costs;
- Community, environmental and cultural aspects ;
- Affordability; and
- Potential development entities.

This included discussing findings and ideas with an initial group of representative stakeholders and drawing on local knowledge and insights (Opus, 2017).

The aim is not to fully undertake feasibility studies for the proposed schemes, but to determine a strong basis for taking the investigations forward, as well as eliminate those that are not likely to be viable.

1.1 Project team

The ‘project team’, comprises of Opus, BERL, Deloitte, and Aqualinc, with insight from Bob Cathcart.

The project team have seen projects from conceptual stages including addressing policy and planning issues, funding models and due diligence, procurement of physical works and seeing projects to the end point of authentic outcomes i.e. water flowing to those needing it most!

1.2 Background

1.2.1 Tai Tokerau Northland Growth Study

The government invested in a Regional Growth Study for Northland region in 2015 titled “Tai Tokerau Northland Growth Study” (MBIE, 2015). This study was initiated because of the pockets of high deprivation and the potential to create wealth through employment and investment.

This Tai Tokerau growth study stated:

> *“Northland has significant untapped economic potential. The region’s people and industries are currently not making the most of existing advantages, limiting economic growth. However, there is no silver bullet initiative or industry that will transform the Northland economy. Growing the Northland economy will require a coordinated effort across a range of industry and cross-cutting opportunities.”*

The study identified significant economic and investment opportunities to grow employment and incomes in Northland. Many of these opportunities need a reliable supply of water in particular to support growth in the farming, horticulture and processing industries (MBIE, 2015).

1.2.2 Stage 1 – Strategic Irrigation Infrastructure Study

In 2015 the Northland Regional Council (NRC) invested in a Strategic Water Management Study (Opus *et al*., 2015) for the region, jointly funded by the MPI irrigation Acceleration fund. This study, pending at the time, was also identified in the Tai Tokerau Northland Growth Study as an enabler for economic growth (MBIE, 2015).

Opus, with their consortium partners, BERL and Aqualinc, undertook this strategic water study to identify areas that could best benefit from water management infrastructure. Bob Cathcart also assisted the project team with local perspective and knowledge.

Analysis of the opportunities presented if a reliable water supply was available for primary productive capable land, enabled support for strategic decision-making regarding water management in Northland. The specific challenges faced, evaluation of the economy should productive agriculture in the area increase, and environmental and social impacts were included in this analysis.

A high-level assessment of the topography, meteorological and climate characteristics, and geographical features showed that there was potentially 91,000ha of irrigable area in Northland. A water balance looking at the demand, availability and spatial rainfall variation resulted in the aggradation of this 91,000ha into four areas; Far-North; Mid-North; Whangarei and surrounds; and Kaipara. If all of this area was irrigated, the study estimated that direct employment could be increased by approximately 3,400 people; and also increase the total GDP of Northland.

The information obtained in the study was analysed using a multi-criteria analysis (MCA). This led to the recommendation of a further, more focused study of potential in Kaipara and Mid-North 'cluster' areas (Figure 1-2 and Figure 1-1).

A number of recommendations were set out including that a wider stakeholder group be engaged and a more detailed study focussing on the chosen areas prioritised by the MCA. This report (Stage 2 - scoping study) explores some of these recommendations in more detail.

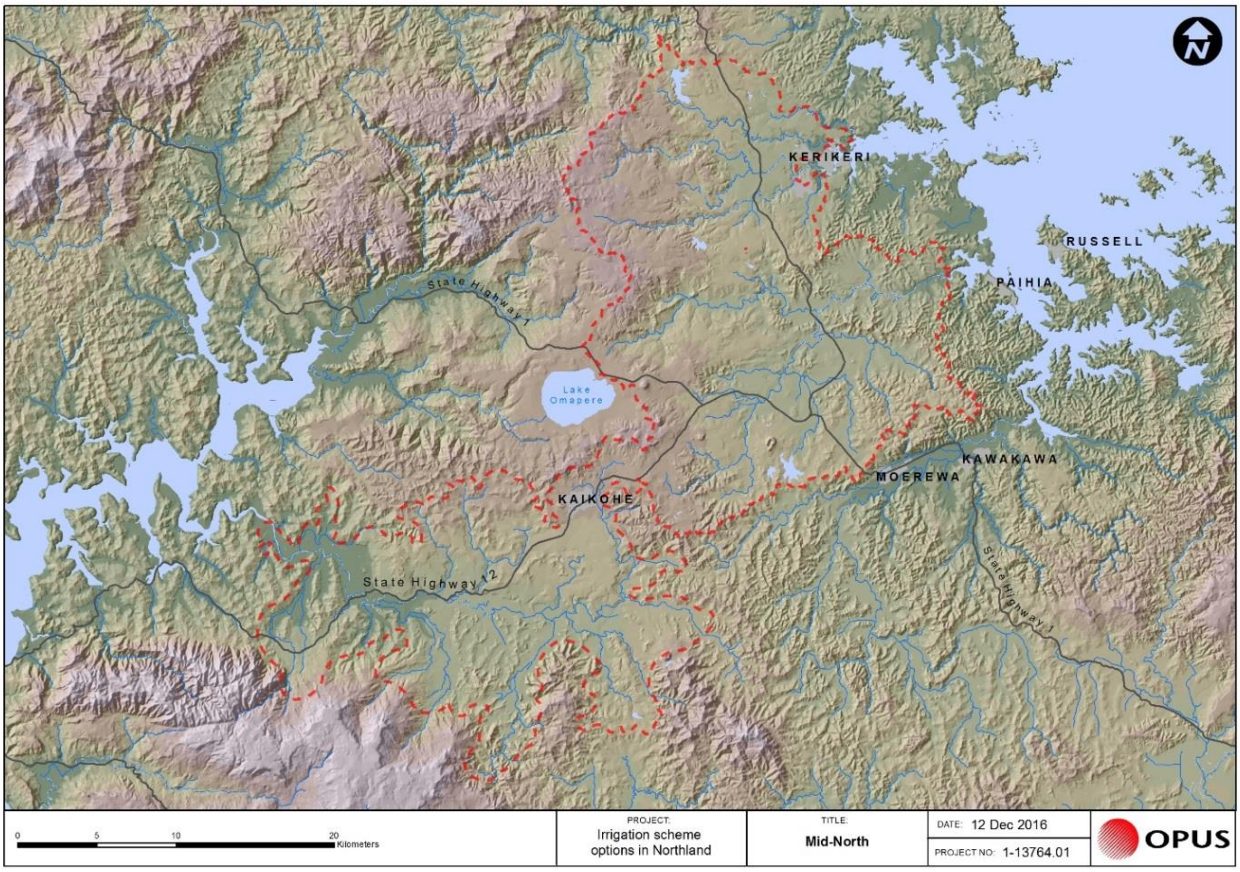


Figure 1-1 Mid-North 'cluster' area.

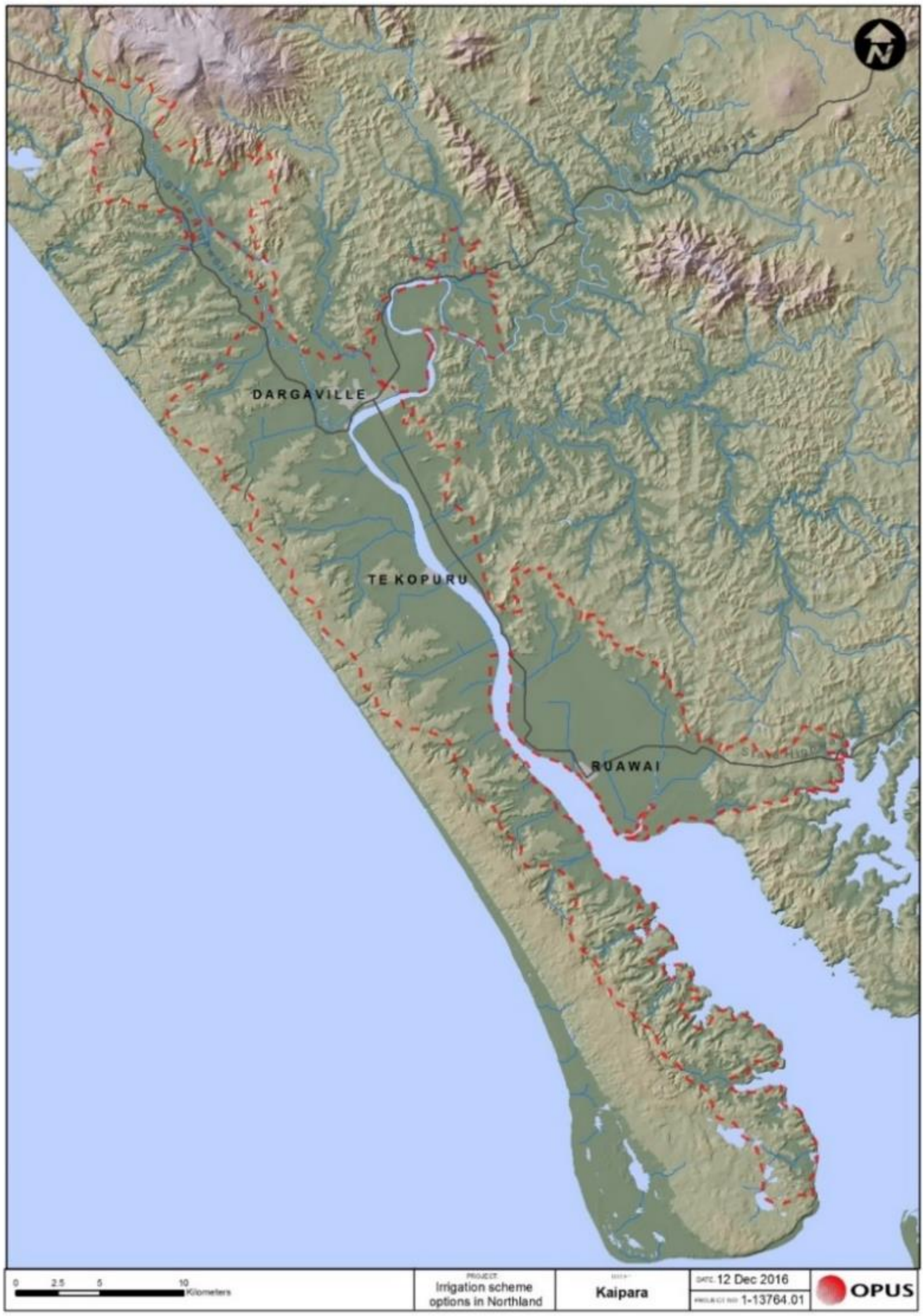


Figure 1-2 Kaipara 'cluster' area.

2 Environmental considerations

Environmental considerations need to be at the forefront of any decision making when considering water management. This stage of the study has not been commissioned to undertake an Assessment of Environmental Effects (AEE) for each of the schemes, however in the process of investigating the feasibility of the schemes the project team has identified a number of things to consider in this scoping study and future stages; including features of natural water resources in Northland, seasonal needs for irrigation, soil types, water sources, costs and impacts.

A thorough understanding of the environment and community interaction with it may also provide some opportunity for environmental benefits. Although this is not explored fully in this scoping study, an example of a potential benefit, specifically in the Mid-North area, is that even with best practice dam sealing, some loss or leakage can be expected which can complement stream flow, recharge groundwater and reduce the impact of existing water abstractions.

2.1 Features of natural water resources in Northland

The following local insights have been compiled by Bob Cathcart based upon many years of local knowledge and from stakeholder discussions.

Rainfall is highly variable, both within and between seasons. Relatively small rivers draining catchments with fine-textured rocks (sandstone, mudstone and shale/claystone) are not able to store large volumes of water. Even quite large streams in these catchments cease to flow in dry years.

While low flows may have historically been sustained by storage in wetlands, these wetlands have largely been drained for primary production.

There are no significant lakes associated with river systems and, because wetlands have been drained, floodwaters are not captured, rivers rise and fall quickly, particularly after high intensity, short-duration rainstorms which are a feature of the region.

Fissures and porous scoria and basalt in volcanic cones and lava flows feed water to springs around the fringes of the volcanic areas. Recharge of these aquifers is by way of soakage through the volcanic soils, particularly in basins and wetland areas on the lava flows. Land development for farming, horticulture and housing, and the channelling of water alongside roads means that water that would have ponded and soaked into the lava flows, now quickly runs off.

Sand deposits, interspersed with lignite and estuarine sediments, forming Pouto, Aupouri and Karikari Peninsulas store water and provide sufficient volumes for local needs, however apart from the Aupouri groundwater resource, there is insufficient water to support a community irrigation scheme.

Over a large part of the region, stream flows are insufficient to reliably supply the on farm water requirements of livestock farmers whether it be dairy or other pastoral based operations. Small (‘turkey-nest’) farm dams have been popular but are often too small or of poor water quality to supply the needs of more intensive but highly efficient and productive grazing systems.

2.2 Seasonal needs for irrigation

While the region has an average annual rainfall of between 1000 and 2000mm per annum, depending on altitude and proximity to the coast, the rainfall distribution and intensity is highly variable. Plant ecosystems, both indigenous and exotic, have adapted to relatively warm, moist conditions. Topsoil’s in this region are often shallow and subsoil conditions do not favour plant roots, thus the shallow root zone can dry and begin to limit plant growth within a few days.

During the spring months in Northland, dry conditions are known to occur thus impacting production. Once pasture and animal production has been impacted it is difficult to restore. For example, ryegrass goes to seed if placed under moisture stress during the spring and while rain during December and January will make it green, it will not grow as soil temperatures rise above levels which temperate grasses can tolerate.

This spring period is also critical to the establishment of summer crops; maize for both silage and grain, and fodder crops such as turnips and fodder beet. There is a short window between when the heavier soils are dry enough to cultivate and when the crop needs to be established. Unlike many crops grown in Northland, kumara generally only need watering for a few weeks after planting. Only small quantities are used, often from tanks towed behind tractors and filled from drains that have been purposely blocked to store water.

Summers, too, can be highly variable and rain, when it does come, is often in high intensity, short duration storms and water is ‘lost’ in runoff. Thunderstorms are common during December and these can drop large quantities of rain in a very short time over small areas while land nearby receives none.

Dry soils in summer have reduced infiltration rates due to a fine sand and peat surface ‘dust mulch’ which effectively sheds water. The structure of the friable clay topsoil’s of volcanic soils especially in the Mid-North can also be destroyed by heavy traffic, trampling and over-cultivation during summer, also creating a dust mulch. This causes them to shed water and makes them susceptible to surface (sheet and rill) erosion when cultivated or hard-grazed.

During the summer months soil temperatures are too high for temperate grasses and even some sub-tropical species, making it even more important that a dense pasture cover is maintained during this period. Irrigation could enable special-purposes subtropical pastures and crops to be grown.

Autumn rainfall is very similar to that of summer. In addition, it is the season of sub-tropical weather systems. These high intensity, short duration rainfall events cause extensive localised flooding, damage to property and infrastructure, and the potential water resource is ‘lost’ to the sea.

Drainage within Northland soils, all except peat and some sand soils, is totally dependent on the soil drying and cracking in autumn. Allowing the soil to ‘crack’ will tend to reduce or spread the water demand for pasture irrigation during this season.

As expected, the winter months are the wettest months of the year. Clay soils are often saturated right through the winter. Soils with expanding clays, particularly those formed on limestone and which have a high proportion of montmorillonite, tend to seal over in winter.

2.3 Soil types

In this section the major soil types are briefly discussed in regards to their heritage, limitations and the options in regards productive uses. The following local insights have been compiled by Bob Cathcart based upon many years of local knowledge and from stakeholder discussions.

2.3.1 Kaipara

2.3.1.1 Soils on estuarine and alluvial flats

The flats from Tangowahine to the southern edge of the Ruawai Flats are estuarine deposits that are sediment brought down by the river; which were sorted and distributed by tidal movement on the bed of the Kaipara Harbour. They tend to be clays and clay loams formed on finer sediments. The sands and silts were deposited on the floodplains of tributary rivers. However, there are areas of sand, fine sand and silt, reflecting the erosion processes occurring at different times within the catchment.

The most common soil type is Kaipara clay/clay loam, described as a gleyed soil. Just as there can be sand or mud banks within harbours, some Kaipara soils have a sandy layer in the profile known as a sand ridge. Apart from these sand ridges, Kaipara soils tend to be too wet for cultivation and sowing/planting of crops until late October and can be as late as early December. For example, kumara crops are usually planted in November but can vary for late October through to early January.

Soils that were previously swamp land, are still developing and improving under pastoral farming. Soil development and improvements in structure and internal drainage can be accelerated by subsoil drainage and liming to depth.

2.3.1.2 Alluvial soils

The immediate banks of the Northern Wairoa, Kaihu, Awakino and Tangowahine Rivers tend to be higher than land back towards the hills resulting from coarser sediments as well as sands and silts being deposited by overflowing floodwaters. Finer silts and clay are carried into the lower outer edges of the floodplain where they settle out over longer periods. The soils, Mangakahia and Whakapara silt loams, are therefore more free-draining nearer the river than in these ponding in outer basins (Mangakahia and Whakapara mottled clay loams).

2.3.1.3 Peat soils

The tributary rivers, streams and drains are all affected by the tide in their lower reaches. Swamps have developed in basins at the upper end of tidal effects and peats soils have formed in these swamps. They are deep peats with varying amounts of timber. Sand washed off the west coast sand terraces and dunes has mixed with or formed layers within the peat in valleys on the western side of the Kaihu and Northern Wairoa River.

These Parore peaty sandy loam soils are well suited to cropping but, like all peat soils, are ‘sinking’ as the peat dries and oxidises. Some upper valleys are sinking so quickly that drainage outfall to the river have already been lost with more currently being lost. They can, however, be cultivated over a much longer season than the clay soils.

2.3.1.4 Clay hill soils

The lower slopes of the hills east of the Ruawai Flats and Northern Wairoa River; as well as higher terraces on the Northern Wairoa, Kaihu, Awakino and Tangowahine Rivers are suited to occasional cropping which occurs as part of the farms’ pasture replacement programme. These soils can be too wet for cultivation until late October and sometimes even until early December. In droughts moisture stress at the other end of the growing season (March) has been observed and severely limits yields in crops such as maize. These factors make cropping on these soils highly risky.

2.3.1.5 Sand country

Sand has been deposited as marine terraces and dunes along the west coast, creating the barrier that forms Kaipara Harbour. The older and recent sands are formed largely from central North Island feldspathic sands, high in silica and are relatively low in iron. In comparison, Red Hill soils have formed on iron sand dunes. In many ways, the Red Hill soils have properties more akin to the soils of the Taranaki Ring Plain. With careful management to protect soil structure, Red Hill soils are well suited to cropping and tree crops such as avocados, subject to ripping to break iron and/or clay pans. However, extensive shelter is required to protect orchard crops from salt-laden westerly winds. Sheltered basins are well suited to winter or shoulder season vegetable crops if irrigation was available.

As you move down the peninsula the Red Hill soils become progressively finer textured. This is due to wind blowing finer sediments brought down by the Northern Wairoa River being deposited on the west coast beaches and then blown onto existing Red Hill soils.

The sand terraces and older dunes east of the Red Hill Soils, and east of the Kaihu and Northern Wairoa Rivers, have podzolised sand soils. These soils are generally unsuited to cropping due to their low fertility, poor structure and being extremely wet during the winter.

2.3.2 Mid-North

Two periods of basalt volcanic activity have spread lava flows across extensive areas around Pakaraka, Kaikohe, Okaihau, Waimate North and Kerikeri. Soils on the older remnant cones and lava flows are old, moderately to very strongly leached Red and Brown loams. The oldest of these soils (Okaihau gravelly friable clay) is described as an ‘ironstone soil’ and has a shallow, friable clay topsoil over an iron and aluminium gravelly subsoil. High levels of ‘free’ iron and aluminium in the low-pH subsoil are toxic to plant roots so plants tend to sit on the surface, making them very drought prone. Despite these limitations, with applications of lime to raise pH and careful nutrient management, this land supports very productive pastoral farming with maize, turnip and fodder beet summer crops. Humus from the topsoil is working its way down into and improving the structure of the subsoil, encouraging plant roots to penetrate to deeper levels. Other soils in this group include Ruatangata friable clay, Pungaere gravelly friable clay, Otaha clay and Taraire friable clay. Waiotu friable clay is a younger soil on these older lava flows and grows maize and pasture.

Tree crops have been grown on these soils however deeper-rooting crops such as avocados encounter micro-nutrient deficiencies as their roots penetrate the acidic iron and aluminium deposits. Shallow-rooted crops like citrus are being grown within the Kerikeri Irrigation Scheme area. Even Kerikeri friable clay, on which much of the Kerikeri horticultural area was established, is not suited to deeper rooted species like avocado.

There are extensive areas of younger Waimate North clay loam on the eroded cone of an old volcano and Whakapai clay loam on outwash slopes of younger volcanoes between Waimate North and Kaikohe. Both have accumulated clay in the subsoil, creating a pan which limits drainage and tree root penetration. While unsuited to deep-rooting tree crops, these soils are well suited to vegetable crops and shallow rooted crops such as citrus and kiwifruit.

More recent lava flows have either Kiripaka bouldery silt loam or Ohaeawai silt loam. The latter tends to be more stony and free-draining, suited to avocado where it is not too stony. There are two Kiripaka soils, one being shallow with a clay subsoil over basalt lava rock while the second is more free-draining and suited to a much wider range of tree and vegetable cropping than the dense subsoil variant. These soils have a longer cultivation season and some would be suited to winter production, particularly on frost-free slopes.

Pockets of alluvial and clay soils amongst the volcanic soils are suited to summer maize and fodder crops but some have a raised water table due to high groundwater.

2.3.3 Cropping and related soils

Few, if any, Northland soils are suited to continuous cropping and most need to be returned to pasture every few years to restore soil structure. Apart from tree crops and vegetable growing on some areas of sandy peat, most cropping (maize, kumara, squash, fodder beet and turnips) will be part of a pastoral farming rotation. Every 7-10 years, paddocks within a grassland farming system will be sprayed out, planted in a summer crop and then returned to pasture after harvest in the autumn. Some kumara crops may go through several years crop before being 'retired' to pasture. That is for an individual property 10-15% of the land will be in crop each year and the remaining 85 to 90% in pasture.

Rather than own the land for kumara, growers are more likely to contract or lease land from grassland farmers. Similarly, vegetable growers are more likely to lease land for two or three years. Only the peat, Red Hill soils and the most free-draining of the basalt soils are suited to winter cropping. Potato yields are most probably higher and spray requirements lower in Manawatu and Canterbury over summer than in humid Northland so potatoes will only be grown on winter country, again, the most free-draining and frost-free volcanic soils and frost-free Red Hill soils.

2.4 Water sources within the cluster areas

Apart from the Aupouri groundwater system, there is unlikely sufficient groundwater or low flow surface water in Northland to support community scale irrigation schemes.

For this reason groundwater is not considered to be a viable option for these 'cluster' areas and will not be considered further. Moving forward, the focus will therefore be upon schemes that require infrastructure i.e. water storage rather than bores.

Refer to Appendix A for maps of potential water sources within each of the areas.

2.4.1 Kaipara

The following water sources within the Kaipara have all been considered at a very high level due to work done as part of Stage 1.

2.4.1.1 Northern Wairoa River

The Northern Wairoa River (or Wairoa River) is approximately 80 km long from the confluence of the Mangakahia and Wairua Rivers down to the sea at the Kaipara Harbour, much of which is tidal with the levels and extent of salinity varying seasonally. The Kaihu, Tangowahine and Manganui Rivers all flow into the Northern Wairoa River (Figure 2-1).

The catchment of the Wairoa River, which drains one-third of Northland, approximately 365,000 ha, has tropical clay soils and there has always been a significant fine sediment load in the river. This river system, from the upper most extent of the catchment is approximately 150km long.

The concept of a barrage on the Northern Wairoa River has been looked at several times, however the costs of such schemes far outweighed the benefits so they went no further than 'discussion'. Unless a cost-effective way of flocculating and/or filtering this sediment can be found, this source would be unsuitable for irrigation.

Figure 2-1 Northern Wairoa River.

2.4.1.2 Kaihu River

The Kaihu River, and its tributaries, have a catchment area of approximately 35,000 ha. Rainfall in the upper catchment is on average more than 2,000mm and flooding in the lower flat part of this catchment is common.

Dargaville's municipal supply is supplied from within this catchment. Water restrictions have been in place in recent years due to low flows in the Kaihu River. There are already several irrigation takes from this river which are subject to the same restrictions on an annual basis. Any storage on this river and/or its upper tributaries is likely to be well into the upper catchment, due to topography.

Investigations undertaken into water storage in the upper Kaihu Valley in the 1970s were led by North Auckland Electric Power Board (now Northpower). They were focused upon electricity generation with little consideration given to other benefits. This was very much a "grand" scheme and would face many hurdles in the present day that would not have been considered major hurdles 40+ years ago.

2.4.1.3 Tangowahine River

The Tangowahine River is approximately 38 km long with a catchment area of approximately 9,000ha (including tributaries). In the upper catchment it flows through a gorge before opening out into a broad valley.

2.4.1.4 Manganui River

The Manganui River is approximately 53 km long with a catchment area of approximately 90,000ha (including tributaries). The river is slow flowing and subject to frequent flooding. Most of the catchment is less than 150 m above sea level apart from the Tangihua Ranges which forms the northern boundary of the catchment.

2.4.1.5 Foothills

The catchment areas from gullies and/or drains in the foothills on Pouto Peninsula, and edge of Mititai and Ruawai flats have relatively small catchment areas. Whilst able to potentially support storage for irrigation for a small area, it would be unlikely to be able to support the scale of a community irrigation scheme. However, storage in the foothills near an irrigable area could potentially be supplemented with water from a secondary source i.e. piped from a nearby river when flow allows, thus being a suitable storage option.

2.4.2 Mid-North

The following water sources within the Kaipara have all been considered at a very high level due to work done in the previous study.

2.4.2.1 Punakitere River

The Punakitere River, and its tributaries, have a catchment area of approximately 90,000ha which then flows into the Taheke River and out into the Hokianga Harbour.

There are many tributaries within this catchment such as the Te Tunaotemakau Stream and Wairoro Stream's that could be considered as sources/storage locations instead, or in addition to the Punakitere River. These streams may provide more preferable locations due to elevation or proximity to command areas.

2.4.2.2 Kerikeri River

The Kerikeri River, and its tributaries, have a catchment area of approximately 17,000ha.

NRC are currently investigating the preferred site for a flood detention dam slightly west of Waipapa. Sites further up in the catchment were also initially considered and are likely to be closer to future irrigable areas such as the Waipekakoura River. Whilst the Waipekakoura River is closer in proximity and elevation to potential demand areas the catchment size of this dam is only approximately 400ha so there is limited potential for irrigation and flood detention.

The catchment area of the preferred detention dam option is approximately 2,800ha with the concept design specifying approximately 12,000,000m^3 of available storage. NRC indicated the estimated cost of this project at $20 million.

There is the real opportunity for a multi-purpose water storage facility here however the preferred dam is in the lower catchment significantly below the potential irrigable areas which could present significant operational challenges and costs.

2.4.2.3 Puketotara River

The Puketotara River, and its tributaries, have a catchment area of approximately 4,300ha before the confluence with the Kerikeri River.

Dam sites were also considered for flood detention on this river before NRC settled upon the Kerikeri River site (Section 2.4.2.2) further down the catchment due to effective catchment size.

Of the three locations considered on this river during the flood mitigation studies, the mid-point located dam, had a catchment area of 1,450ha which could provide a sizeable source of water for storage.

2.4.2.4 Waitangi River

The Waitangi River, and its tributaries, have a catchment area of approximately 30,200ha before it enters the Bay of Islands.

The Waitangi River begins near Lake Omapere travelling east towards the Bay of Islands, soon travelling past Waimate North albeit at an elevation in the order of 100m lower.

The Pukekiwi sub-catchment was specifically raised within the stakeholder workshops. This catchment is approximately 200ha which is relatively small and unlikely large enough to capture the required water for a community irrigation scheme. However, this should not preclude this from being considered during pre-feasibility stages for 'buffer' storage should an adjacent area be progressed further. .

2.4.2.5 Lake Omapere

Lake Omapere is located approximately 240m above sea level and is between 2m and 3m deep. The lake is approximately 1,200ha in area with a catchment area of 3,400ha. It is a shallow water body that has been at times in its history a wetland and other times a lake, with half of its bed being the base/stumps of a forest and the other half basaltic rock.

It is believed that it was lowered to enable the construction of the North Auckland Railway to Okaihau in 1923. In the mid-1980s, due to a combination of events involving invasion by exotic aquatic plants and a large population of black swan, the nutrients, particularly phosphorus that had accumulated in lake bed sediments was released into the water column causing catastrophic algal blooms. Since then, the lake has gone through a series of bloom cycles, being restored each time with the assistance of indigenous freshwater mussels.

Landowners around the lake have, with community support, fenced the lake margin and tributary streams and established riparian vegetation to filter runoff from the land. The problem now is not so much runoff from the land but disturbance of lake-bed sediments and the release of nutrients, either directly or via plants, into the shallow water column. The lake catchment is too small to flush nutrients-rich water from the lake; instead; each bloom must run its course.

One of the mitigation measures that has been discussed in the past is the installation of control gates at the outlet enabling the lake to be quickly drained, flush the lake water, and be refilled with fresh water from runoff. Construction of a control gate on the Waihoanga Stream draining the lake on its western side would not only enable the lake to be opened and water release but could also provide storage to supply water for a variety of uses.

Lake Omapere Trustees are supportive of the potential complimentary use of water from the lake for productive purposes which is discussed further in Section 8.3.2.

A photograph of the lake is shown in Figure 2-2.

Figure 2-2 Lake Omapere.

2.4.2.6 Existing Kerikeri Irrigation Scheme dams

The Kerikeri Irrigation Scheme has two existing dams with a total storage volume of approximately 12Mm³. There is an unquantified portion of this not being utilised currently for various reasons. As this storage is already constructed, optimisation of this existing resource through expansion of the existing scheme on the fringes, or supply of water to a new area could more cost effective than constructing new storage. As this scheme is in private ownership (Kerikeri Irrigation Company) buy-in and/or support from the scheme would be critical to any possibilities being taken forward utilising existing infrastructure.

3 Preliminary command areas

A series of preliminary command areas were derived for discussions and analysis within the consortium and as part of the first series of stakeholder workshops (Opus, 2017).

Using Geographic Information Systems (GIS) analysis, a number of potential preliminary command areas were identified. The areas were determined taking into consideration the following attributes:

- Topography and features
- Soil type
- Legal boundaries
- Geographic location i.e. proximity to possible water sources and towns

Whilst this was largely a desktop exercise, visits to the sites were also undertaken by the project team. Refer to Appendix B for maps showing the possible preliminary command areas.

Table 3-1 shows key attributes for the 12 preliminary command areas in both cluster areas. It includes estimates of irrigated area which takes into account key factors such as risk of uptake, and suitability of land for irrigation i.e. possible change in land use. Although there are likely to be discrepancies with the actual irrigated areas, this is a suitable estimate based on current knowledge and reasonable assumptions at this scoping stage.

It also shows assumptions around irrigated land use which will be used within this study. It has been assumed that almost all of the irrigable area within the Kaipara preliminary command areas is likely to be pastoral dominated. All of the schemes in the Mid-North area are assumed to be predominantly horticulture.

Table 3-1 Assumed irrigated land use for Kaipara and Mid-North preliminary command areas.

Preliminary command area	Cluster area	Command Area	Estimated Uptake/ Irrigated Area	Irrigated Area	Irrigated Land Use (Proxy crops assuming dryland pasture currently)				
					Avocado, tamarillo	Kiwifruit, citrus	Veges, crops	Dairy	Beef / sheep, dairy support
		ha	%	ha	%	%	%	%	%
Awakino	Kaipara	1,300	50%	650	0%	5%	20%	70%	5%
Baylys/ Te Kopuru	Kaipara	16,000	30%	4,800	5%	10%	35%	40%	10%
Hoanga	Kaipara	1,900	50%	950	0%	5%	20%	70%	5%
Mititai	Kaipara	2,000	50%	1000	0%	5%	20%	70%	5%
Parore	Kaipara	500	50%	250	0%	5%	20%	70%	5%
Ruawai	Kaipara	8,500	30%	2,550	0%	5%	20%	70%	5%
Kerikeri	Mid-North	5,000	40%	2,000	5%	50%	0%	30%	15%
Ngawha	Mid-North	200	80%	150	20%	40%	40%	0%	0%
Ohaeawai	Mid-North	800	70%	550	40%	40%	20%	0%	0%
Rangihama	Mid-North	2,300	70%	1,600	10%	40%	20%	20%	10%
Te Ahu Ahu	Mid-North	400	70%	300	40%	20%	40%	0%	0%
Waimate Nth	Mid-North	1,500	50%	750	0%	40%	30%	20%	10%

3.1 Costs and impacts

To enable robust discussions in the first workshops, as well as building understanding on what a scheme could mean for the communities involved, some high-level estimates on costs were derived. These high-level estimates for each of the possible schemes considered potential irrigation land use, cost of storage, cost of distribution network and pumping, and cost of on farm irrigation.

These estimates were derived by proportioning the costs estimated as part of Stage 1 to the areas assumed in this scoping stage; and utilising best possible assumptions based upon experience.

Stage 1 also indicated estimates for the increase in employment, increase in value of output and increase in GDP as a direct result of water infrastructure for each of the cluster areas. These values were also calculated for each of the preliminary command areas based on area.

This allowed the working groups to understand the possible potential of these schemes i.e. positive impact within the community, and provided the basis for discussions.

Details of these assessments and estimates can be found in the Stakeholder Document (Opus 2017).

4 Water demand

This section outlines the methodology and presents a summary of estimates of the irrigation demands for the two selected cluster areas; Kaipara and Mid-North. Building on Stage 1, a more detailed analysis has been undertaken for the two cluster areas by identifying likely future irrigable crops within each area.

These preliminary command areas have several, sometimes conflicting, potential demands for the water; with the main demands being water for irrigation, municipal water supply, industrial demand and farm water for stock and processes.

Volumetrically, urban, industrial and stock water demands are only a small fraction of the total volume required for irrigation. In New Zealand, freshwater consumptive allocation (based on resource consents) is partitioned volumetrically where irrigation typically accounts for 77%, industrial is typically 10%, drinking water (urban and potable) is typically 10% and stock water is usually 3% of total consented volume.

Consideration should be given to these 'higher-value' (urban, industrial and stock water) uses of water. These uses could potentially require demand earlier than irrigators, which could help bridge a delay in the uptake for irrigation water.

There are also many other opportunities for water use in Northland that have the potential to occur from the storage and management of water. Firefighting, aquaculture, environmental flows (supplementing low flows), energy generation, flood mitigation and/or minimisation should be considered in parallel with water for irrigation.

4.1 Irrigation water demand

4.1.1 Soil-crop-water balance modelling

A farm-scale daily soil water balance model, Irricalc was used to calculate the irrigation water demands. As recommended by Food and Agriculture Organization (FAO) of the United Nations, daily soil moisture water balance modelling is the internationally accepted method for calculating irrigation requirements (Allen *et al*., 1998). This method has been field verified both internationally and in New Zealand, and has been shown to model well what occurs on-farm.

Model simulations were run from 1 July 1972 to 30 May 2016, covering 44 irrigation seasons. A description of the model is presented in Appendix C. Input data used (evapotranspiration, rainfall and soils information) for modelling is provided in the following sections.

4.1.2 Climate data

Daily virtual climate station (VCS) data was sourced from NIWA by Northland Regional Council (NRC) for this study. This data has been developed using recorded data from both NIWA and NRC climate stations. Therefore, this data is considered to be the most suitable climate data for local scale water studies within the region. The data retrieved from NIWA were rainfall and potential evapotranspiration (PET).

4.1.2.1 Sensitivity analysis for climate change

To assess the sensitivity of climate data on water resources and to future-proof the schemes, two climate change scenarios were developed using information from NIWA (NIWA, 2016). These represent the possible extreme changes of seasonal rainfall and PET projected for the two cluster areas. Crop irrigation demand for these two climate change scenarios was then modelled with Irricalc to give an idea of the effect of projected climate on the Kaipara and Mid-North areas.

The most relevant source for information is the report by NIWA "Climate change projections and implication for Northland" (NIWA, 2016). Following assessments by the Intergovernmental Panel on Climate Change (IPCC), Representative Concentration Pathways (RCPs) are used in the NIWA report to describe possible future climate change mitigation strategies. Two of these RCPs were selected for the present study (RCP 8.5 and RCP 2.6), in order to represent the two extreme possibilities. RCP 8.5 corresponds to a scenario leading to very high greenhouse gas concentrations (likely with greatest climate change), while RCP 2.6 leads to a very low level of greenhouse gas emissions and removal of greenhouse gases from the atmosphere (likely with least climate change).

For each RCP scenario, NIWA downscaled data from several different global climate models (41 models for RCP 8.5 and 23 models for RCP 2.6) to describe projected climate change for the Northland region in 2040 (average of 2031–2050 relative to 1986–2005) and 2090 (average of 2081–2100 relative to 1986–2005). For the present work, 2040 data was used in order to explore the effect of projected climate change on the near future irrigation demand of Northland. NIWA reports seasonal ensemble averages for each scenario taken over all climate models, with 5th and 95th percentiles.

Two extreme climate scenarios were devised for further Irricalc modelling in the present work:

- Climate Change Scenario 1 (CC1): lowest rainfall + highest PET (RCP 8.5)
- Climate Change Scenario 2 (CC2): highest rainfall + lowest PET (RCP 2.6)

Rainfall

NIWA (2016) sets out projected changes in seasonal rainfall for Kaitaia and Whangarei, and shows figures of these projected changes over maps of the entire Northland region. For the more extreme climate scenarios (RCP 8.5), there was a difference in projected changes in rainfall between the west and the east of Northland. The Kaipara area modelled in the present work, being on the west of Northland, matched best with the data described for Kaitaia, despite the geographical distance between Kaitaia and Kaipara. The Mid-North area similarly best matched the data for Whangarei.

The extremes of the reported model ranges for Kaitaia and Whangarei were used, based on the 5th and 95th percentiles for RCP 8.5 and 2.6 (2040, relative to 1986–2005). CC1 used the 5th percentile for RCP 8.5, while CC2 used the 95th percentile for RCP 2.6 (Table 4-1).

Table 4-1 Projected changes in rainfall used in the present study for climate change scenarios 1 (CC1) and 2 (CC2), for the Kaipara and Mid-North areas.

Modelled area	Scenario	Summer	Autumn	Winter	Spring
Kaipara	CC1	–6%	–6%	–12%	–12%
	CC2	+12%	+10%	+7%	+6%
Mid-North	CC1	–8%	–7%	–15%	–16%
	CC2	+13%	+10%	+11%	+8%

Time series of projected 2040 rainfall were calculated by applying the percentage changes for each season to daily rainfall time series of relevant virtual climate stations, covering the period 1 July 1972 to 30 June 2016.

Potential evapotranspiration

There are no climate change predictions for PET available for the study area. However, Aqualinc (2016) showed that change in PET can be estimated based on temperature. This study showed that if temperature increases by 0.8°C (relative to the period 1995 to 2015), and other factors remain constant (wind speed, humidity, radiation), PET will increase by about 3% in Lincoln, Canterbury. Aqualinc (2016) also states that NIWA also undertook a similar analysis in 2011, and came to the same conclusion that a 0.8°C increase in temperature by 2046 would result in about a 3% increase in mean annual PET. NIWA also assumed that wind speed, radiation and relative humidity remain constant.

The Aqualinc (2016) method was applied to Northland for this study. PET was calculated using the Penman-Monteith equation, which is the recommended method for estimating PET by the UN's Food and Agriculture Organization (FAO). Minimum and maximum temperature, wind speed, relative humidity and radiation were used to calculate PET for the period from 1972 to 2016. The climate data was primarily sourced from NIWA's Whangarei climate station (Network No. A54733).

Estimated percentage PET increases for a range of temperature increases were then calculated using the Aqualinc (2016) method and Whangarei data as described above. Projected temperature changes by 2040 were selected to be consistent with the rainfall projections, using the extremes of NIWA's reported model ranges (here CC1 uses the 95th percentile of RCP 8.5, and CC2 uses the 5th percentile of RCP 2.6; NIWA, 2016). The projected temperature increases for 2040 are shown in Table 4-2. Note that, unlike rainfall where data is available for Kaitaia and Whangarei, NIWA's projections for seasonal mean temperature changes are the mean estimates for the entire Northland region (NIWA, 2016).

Table 4-2 Projected temperature increases for 2040 used in the present work for climate change scenarios 1 (CC1) and 2 (CC2).

Scenario	Summer	Autumn	Winter	Spring
CC1	+1.6°C	+1.5°C	+1.4°C	+1.3°C
CC2	+0.3°C	+0.4°C	+0.4°C	+0.4°C

The estimated percent PET increases that match the projected temperature increases for 2040 are listed in Table 4-3. New time series of PET for each climate change scenario were generated by applying the projected percent PET increases for each season to daily historical time series from the relevant VCS in each modelled area, as described for rainfall above.

Table 4-3 Projected percent PET increases for 2040 used in the present work for climate change scenarios 1 (CC1) and 2 (CC2).

Scenario	Summer	Autumn	Winter	Spring
CC1	+5.8%	+5.5%	+5.1%	+4.7%
CC2	+1.1%	+1.5%	+1.5%	+1.5%

4.1.3 Soils

Soil data were obtained from Landcare Research's Fundamental Soils Layer (FSL) (Landcare, 2000). While the FSL is the most up-to-date digital version, there appears to be discrepancies between FSL data and what is likely be on the ground based upon local knowledge. This is also backed up by the NZMS 290 Series soil maps. This is not perceived to have a significant impact upon this high level study, however, specific soil analysis and mapping would help to inform future studies.

The key soil property for soil water balance modelling is the plant available water at field capacity (PAW). PAW is the amount of water that a soil can store, that is available for plants to use. The FSL database specifies PAW for 900mm depth of the soil profile. Given the same soil, PAW differs between crops, because different crops have different rooting depths. For temporary crops such as vegetables, PAW varies as rooting depth changes with crop development. Therefore, it is important to determine a representative time series of soil-water reservoir depth for each crop type and estimate the relevant PAW.

Using the soil PAW distribution for the command areas, Irricalc modelling has been undertaken for each crop. Crops were modelled using five PAW classes, except potato which has only been modelled using PAW classes (Northland's summer climate is considered to be too humid to allow potato growing due to high likelihood of blight. Soils that are practical can be used in winter for out-of-season production. Thus, potato growing is probably limited to where low PAW soils [e.g. sand, sandy peats and free draining volcanic] is available [per. comm., Bob Cathcart]). Table 4-4 lists the five PAW classes modelled for the 900mm soil-water reservoir depth. Figure 4-1 and Figure 4-2 show the PAW distribution over the Kaipara and Mid-North clusters, respectively.

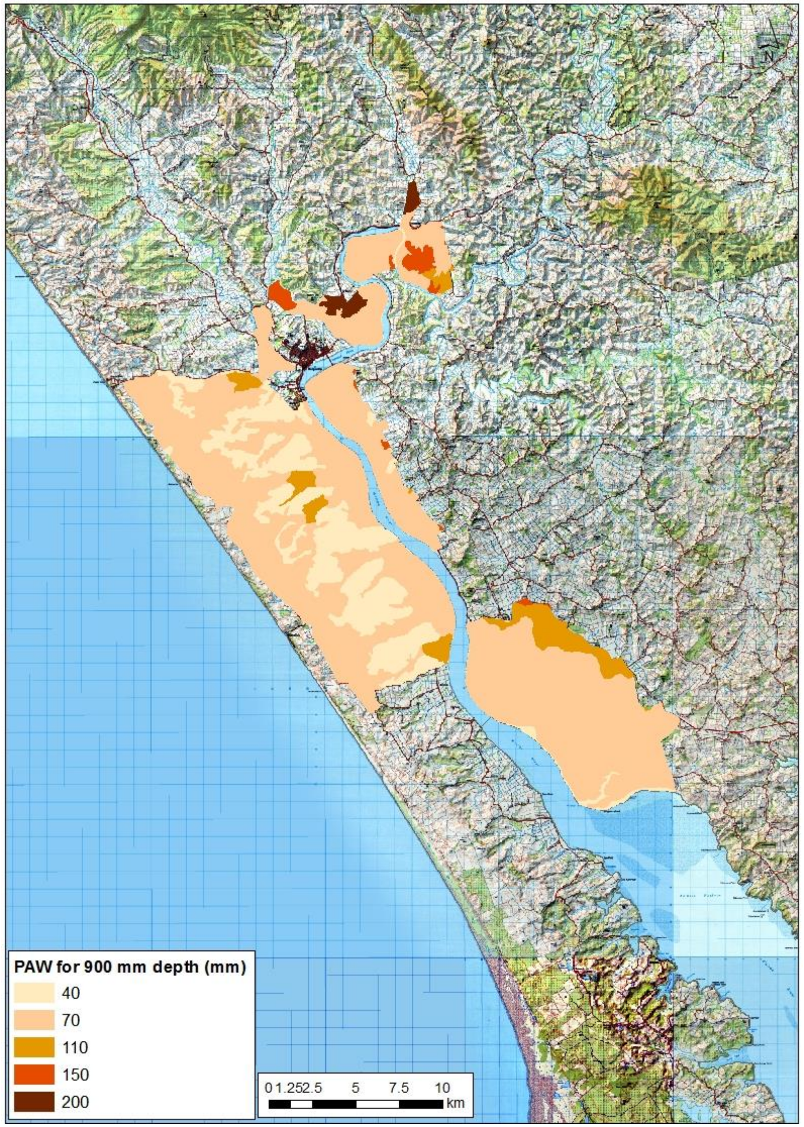


Figure 4-1 Soil PAW distribution within the Kaipara cluster.

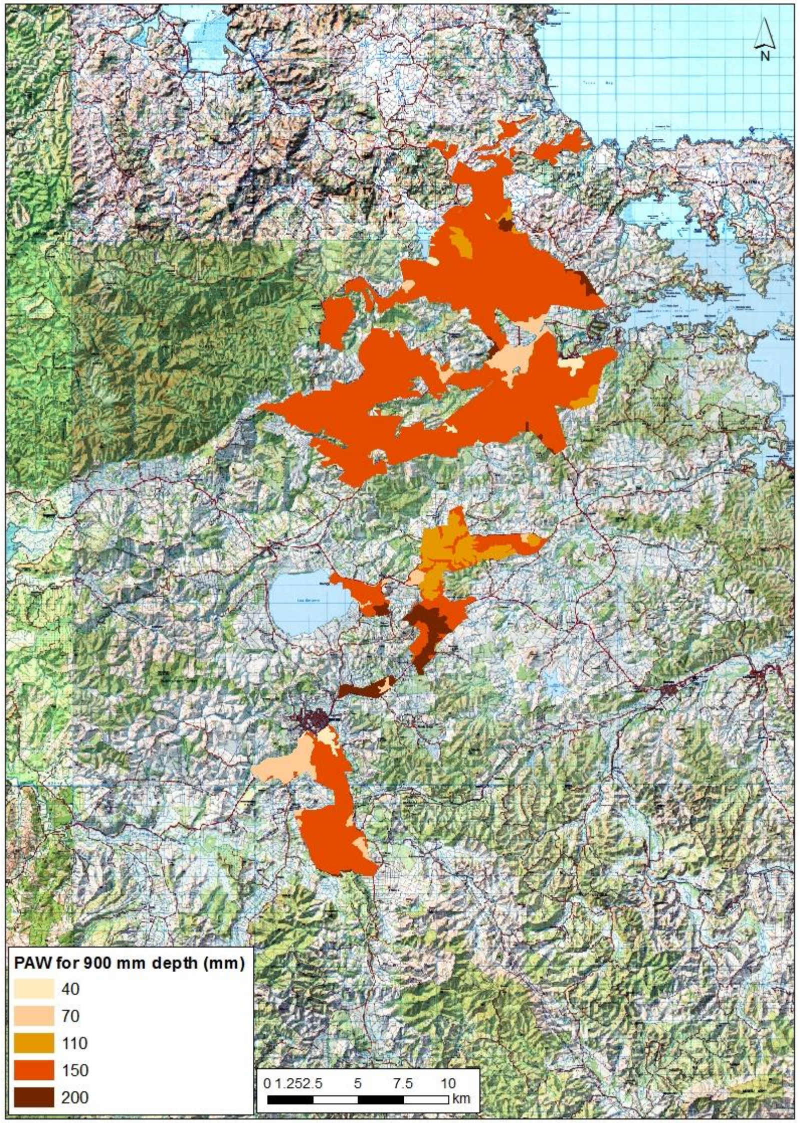


Figure 4-2 Soil PAW distribution within the Mid-North cluster

Table 4-4 PAW classes for a 900mm depth.

PAW range for 900 mm depth (mm)	PAW class (mm)
< 50	40
51 - 90	70
91 - 125	110
126 - 170	150
> 171	200

PAW values for the crops were adjusted based on relevant soil-water reservoir depths using the "rule of thumb" proposed by Trevor Webb of Landcare for North Otago:

> *"Assume the top 200mm of topsoil contributes 40mm of water, and the remainder of the soil profile down to a maximum of 900mm contributes a constant amount of water per unit depth. In stony soils, where the majority of the available water is within the top 500mm of soil, no adjustment of PAW should be made"* (Brown and McIndoe, 2003).

4.1.4 Crops

Potential crops that could be grown in each of the 12 preliminary command areas were identified in consultation with Bob Cathcart, local farmers, industry representatives and experts. However, as water is not currently available for irrigation in large parts of these areas, there is some uncertainty associated with the breakdown. Crops were used as 'proxy crops' for the Irricalc modelling and are reflective of the crop breakdown in Table 3-1. Further information can be found in Appendix D. Also used in the Irricalc modelling are the irrigation management parameters listed in Table 4-5.

Table 4-5 Modelled crop and irrigation management parameters.

Crop	k_c[1]	Maximum soil-water reservoir depth (mm)[2]	UCC[3]	Application depth (mm)[4]	Maximum return period (days)[5]
Pasture	0.8 – 1.0	600	70%	20 - 35	4 - 7
Citrus	0.7	1,200	80%	20 - 35	4 - 7
Kiwifruit	0.5 – 1.1	1,200	80%	20 - 35	4 - 7
Grapes	0.3 – 0.7	1,200	80%	2	1
Potato	0.5 – 1.15	500	70%	2 - 20	2 - 6
Kumara	0.4 – 1.1	800	70%	6 - 21	3 - 7
Avocado	0.6 – 0.85	1,000	80%	20 - 35	4 - 7
Vegetables	0.5 – 1.0	450	70%	3 - 21	2 - 7
Plant nurseries	0.3 – 1.1	800	70%	3 - 28	2 - 10

Notes:

[1] k_c is the crop coefficient (see Appendix D). The range indicates the k_c variation due to seasonal effect and/or level of the crop growth (e.g. vegetable).

[2] Based on rooting depth. This depth indicates the depth that the crop can utilise soil-water from.

[3] Christiansen's (1941) coefficient of uniformity.

[4,5] Application depth and return period vary for different soil PAW and months.

4.1.5 Irrigation demand

Initially daily irrigation demands for different crop-soil-climate combinations were modelled assuming an irrigable area of 80% of the command area. As the project progressed this percentage area was refined as per Table 3-1. It was also assumed that the net irrigable area of different crops is evenly distributed throughout the command area. A summary of model outputs of 90th percentile annual irrigation demands by command area, crop and soil PAW is given in Appendix D along with the modelling outlined above. Table 4-6 shows the demand for irrigation for each of these 12 preliminary command areas on a per hectare basis.

Table 4-6 Irrigation annual demand for the 12 preliminary command areas.

Command area	Annual demand per ha		Annual demand on scheme basis (as per table 3-1)	
	Average (m^3/ha)	Max (m^3/ha)	Average (m^3/yr)	Max (m^3/yr)
Awakino	3,140	4,440	2,041,000	2,886,000
Baylys/Te Kopuru	3,460	4,670	16,608,000	22,416,000
Hoanga	3,130	4,260	2,973,500	4,047,000
Mititai	3,380	4,600	3,380,000	4,600,000
Parore	3,340	4,740	835,000	1,185,000
Ruawai	3,960	5,390	10,098,000	13,744,500
Kerikeri expansion scheme	1,430	3,600	2,860,000	7,200,000
Ngawha	1,200	3,000	180,000	450,000
Ohaeawai	1,780	3,900	979,000	2,145,000
Rangihama	1,800	3,440	2,880,000	5,504,000
Te Ahu Ahu	1,710	3,520	513,000	1,056,000
Waimate North	2,130	4,080	1,597,500	3,060,000

The average demand above indicates the amount of water that would be required to meet on farm irrigation demands, as per previous sections of the report, on an average year i.e. 50% of the time. The maximum demand indicates the amount of water that would be required to meet on farm irrigation demands in the driest year i.e. 100% of the time.

4.2 Urban water demand

The main urban centres in the two cluster areas are Dargaville in the Kaipara District; and Kerikeri and Kaikohe in the Mid-North. This section considers the general question of water demand in these urban areas, and Section 4.3 considers the specific requirement for water for industry in the two areas.

4.2.1 Kaipara

Kaipara District has a population of about 19,000 usually resident people. The relatively static population of 17,400 up to 2001, has then increased by about 9% between 2001 and 2013 Censuses to 19,000 people. The main urban areas in Kaipara District and their 2013 populations are Dargaville (4,250); Mangawhai and Mangawhai Heads (2,415).

Dargaville is the main urban centre of the Kaipara District, and has a need for an adequate water supply for urban residential use and urban commercial and industrial use. The population of Dargaville has been static or slightly declining in the range 4,500 to 4,250 people from 1996 to 2013. The demand for urban water for residents is therefore unlikely to increase unless there is increase in industrial or commercial activity in Dargaville in future. However, there are reports of some historical opportunities being lost because of a lack of water for industries, in particular processing industries.

A key point raised by stakeholders in the Kaipara District is the need for a larger, more secure water supply for Dargaville.

If the estimate of supply to residents is approximately correct, this implies consumption per head of residents of 94m^3/yr, which is about 250L/person/day. This compares well with the Far North District Council estimate (213L/person/day) and other relatively small districts in New Zealand, like Stratford, South Waikato and Waimate.

Current understanding is that the current water supply in Dargaville supplies about 700,000m^3/yr for urban and industrial use. Approximately 400,000m^3 is supplied to the residents and 300,000m^3 to industrial and commercial users. The largest industrial user of water in Dargaville is Silver Fern Farms (SFFs) cattle slaughter and beef processing plant which, at estimate, uses approximately 200,000m^3/yr. This figure has been confirmed by Silver Fern Farms plant managers. The pattern of demand is discussed in more detail in Section 4.3.1.1.

4.2.2 Mid-North

The main urban water supplies are in Kerikeri and Kaikohe. Far North District (FNDC) has a population of about 56,000 usually resident people. The population grew by 5.5% in the ten years between 1996 and 2006 from 52,944 to 55,845. From 2006 to 2013, the population was static at about 55,800 residents. In recent Census periods, the population changes in the District have been as follows: 1991-96: 5,514 increase; 1996 -2001: 1,674 increase; 2001-06: 1,227 increase; and 2006-13: 105 decrease. This shows the importance to the District of generating more jobs to attract increased population in the District.

Within the District, the population of Kerikeri has grown quite strongly, from 4,197 (1996) to 6,507 residents (2013). If the past trends have held true, then the present population (2017) could be as many as 7,000 residents. The main driver of population increase in the District has been Kerikeri.

In contrast, the population of Kaikohe has been relatively static at a level of 4,107 people in 1996, about the same in 2006 of 4,113, and in 2013 a small decline to 3,915.

The FNDC data provided shows that average residential consumption is 213/L/person/day across the District. If this average is applied to the relevant populations the annual demand for water by the residents would be:

- Kerikeri: about 550,000m^3 per year
- Kaikohe: about 320,000m^3 per year

These numbers will increase as and if population increases with potential the expansion of irrigated horticulture production, packing, processing and transport in the Mid-North.

The residential connections (excluding lifestyle properties) in Kerikeri is about 1,900, and in Kaikohe is about 1,500. This implies an average population of over three residents per connection in Kerikeri and two and a half residents in Kaikohe.

The total water consumption by non-residential consumers in the whole of Far North District is at just under 333,000m^3/yr. If the average consumption per connection in Kerikeri and Kaikohe is the same as in the rest of Far North District, the non-residential consumption in Kerikeri and Kaikohe would total about 145,000m^3 per year.

4.3 Industrial water demand

Much of the industrial activities in the Kaipara and the Mid-North are expected to originate from the activity packing and processing the products from the primary industries. The nature and extent of the expanded production facilitated by reliable and relevant water supplies especially for irrigation of horticulture is likely to determine to a large extent the industrial demand for water in the Kaipara and the Mid-North.

4.3.1 Kaipara: Dargaville growth and survival

Dargaville has a static or slowly declining population. With just 4,250 people there is the prospect that the town will be unable to continue to provide the services which urban dwellers require in order to stay. With the prospect that services could decline, the town is faced with the prospect of whether or not it will survive as a vibrant place. This was a key point raised by stakeholders in the Kaipara District.

Specifically, then Dargaville, and Kaipara District must consider all constraints and all possible opportunities to grow activity and population in the town. Critical in consideration of these future pressures is the ability for Dargaville to provide the quantity of water of sufficient quality to retain and if possible attract additional packing and processing industries to provide a viable outlet for primary producers in the area, as well as providing employment for some of the people in the town and surrounding areas.

At present, Dargaville has some successful packing and processing industries including kumara packing and cattle slaughter and beef processing. However, these present industries together with the current residents, are consuming all of the current available potable water.

4.3.1.1 Current impacts of limited water supply on Silver Fern Farms

The current availability of potable water can cause the main processing plant, Silver Fern Farms (SFFs) to have to send stock elsewhere. The water demand by SFFs is to some extent seasonal. Data indicates that in most months (other than September and October) demand is greater than 15,000m^3, however, demand can peak at 25,000m^3 per month. The peak timing depends on the extent the climate has affected the pastoral industries' ability to fatten their stock, or alternatively, the need to clear stock in drought.

During drought conditions the Dargaville urban water supply is already under pressure, but the drought also forces farmers to send their stock to the processing plant due to lack of feed/water. SFFs cannot always handle the increased numbers due to insufficient water available for processing. The stock is sent to other regions for slaughter. Later in the season, when there is reduced stock coming through SFFs, the seasonal staff at the plant are laid off early causing a noticeable reduction in retail activity in the town as incomes are reduced.

This example shows three direct income effects of lack of reliable water sources in Dargaville and its hinterland:

- The drought with lack of stored water for selective irrigation means that farmers sell stock either as store stock or only partially-finished reducing the pastoral farmers' incomes;
- The increased early peak of sale cattle cannot all be handled by SFFs and so the season's tally and income is reduced;
- Consequently, the season is shorter and the SFFs seasonal employees' incomes are reduced; and
- Each of these three reduce the level of spending and activity in the town of Dargaville.

4.3.1.2 Potential future impacts of increased water supply for Silver Fern Farms

Silver Fern Farms (SFFs) plant currently handles about 100,000 cattle per year. This is comparable to the central North Island regions. SFFs also indicate that they are keen to increase the capacity, but are limited mainly to water availability.

While the StatisticsNZ database indicates that this meat processing industry employs about 240 people, this is an under-estimate and the direct employment in the plant could be just under 300 people. Assuming direct employment of about 300 people, comparison with the value chain 'multipliers' in New Zealand and other regions similar to Northland, it could be expected the total employment in the region generated by the plant to be about 750 people.

It is not appropriate to disclose potential plans which SFFs could implement to increase the quantity and value of cattle and beef handled though the plant. However, it can be assumed that certain parameters could estimate what the increase may generate in the region. For example, SFFs could increase their activity and employment by 50% by increasing the shifts, and thus, number of cattle slaughtered. They could also increase the level of processing into a higher-valued product form. This would increase the direct and indirect employment in the region generated by the plant to over 1,100 people. Most of these are likely to be residents of Dargaville or nearby.

Increasing the value generated in the meat coming from the plant could also increase the incomes of the District's farmers supplying cattle to SFFs. It can be assumed that expansion of SFFs detailed here, would increase their water demand by at from approximately 200,000m^3 to approximately 350,000m^3.

The indirect impact could also be to increase the Dargaville resident population to ~5,500 residents which implies resident's water demand of about 550,000m^3. Together with increases in demand for other commercial and industrial users, this would imply a need for a Dargaville water supply with an initial capacity of about 1.2Mm^3 per year.

Given that SFFs is currently paying full residential rates for the water it uses, it would appear probable that such a water supply should be viable without major financial dependence upon Kaipara District ratepayers. However, the potential for an improved water supply to halt the declining population in Dargaville and, in fact, initiate some growth would require some more detailed investigation in a Cost Benefit Analysis of the benefits or saved losses from investing in the Dargaville urban water supply.

4.3.2 Mid-North: Kerikeri and Kaikohe

Detailed information on the volumes of industrial water use in the Mid-North have not been obtained. As with residential/urban demand, the main centres of commercial and industrial demand are Kerikeri and Kaikohe.

There are 300 non-resident connections in Kerikeri and 230 in Kaikohe. Of these commercial connections, most are for retail and offices but there are also 68 industrial connections in Kerikeri and 50 in Kaikohe.

The total water consumption for all non-residential properties in the District is 332,907m^3 per year. This implies an average consumption per connection per year of 204m^3 or 560L/day (consumption of about 2.6 residents/day). This implies in turn an average consumption per connection of about 560 litres per day, which is the consumption of about 2.6 residents per day. However as retail and office connections are usually light water users, the 118 industrial users in the district are assumed to use somewhat more than 2.6 residents/day.

With expansion of the economy based mainly on irrigated horticulture, the non-residential water demand is likely to expand approximately at the same rate as the residential demand. The specific needs of the fresh fruit export industries for water in the packhouse and coolstore activities (based on the need to water blast wooden fruit bins, coolstores and general plant cleaning as well as for staff water) are not significant. Industry estimates indicate that for the volumes of the main fruits produced in the irrigation schemes, the annual requirement for potable water would be of the order of 20,000 cubic metres per year. This is very small compared with the current water consumption of about 333,000 m^3 per year for all non–residential properties in the Far North District as an example. Both of these contrast with the much larger volumes required for irrigation where for example 500,000 m^3 would only suffice to irrigation an area of 100-150ha.

The water demand generated by an industrial development at Ngawha could have a similar demand as packhouses. However if food or fibre processing is developed at Ngawha, the water demand could increase to the levels required by an expanded Silver Fern Farms in Dargaville, approximately 300,000m^3 per year. These levels again are low relative to irrigation volumes, however if food processing is developed the water will have to be potable. Also in all processing uses, there will be the need to accommodate increased waste water or grey water disposal.

A key cornerstone of the industrial park, which would have had a demand for water, was to have been the establishment of a pulp mill, making use of the power and heat from a new geothermal power station planned by lines company Top Energy. It potentially could lead to 200 - 400 new jobs for the area, and sales of approximately $300m.

4.4 Farm water (stock and process)

The value of quality, reliable water for stock and on farm processing is often left in the shadow of water for irrigation. However, work recently undertaken on the economics of stock water on hill country (Agfirst, 2016). reiterated the importance of providing a suitable and reliable water supply to animals to maximise production. Similarly, this was reiterated by some stakeholders in the engagement meetings from personal experience.

Water for stock is of paramount importance and farmers are often required, particularly in the Kaipara, to sell stock during droughts due to a lack of stock water rather than lack of food. Increased reliability in stock water could alleviate the need for selling stock so early in the season.

Groundwater within the Kaipara and Mid-North regions can sometimes be low quality, and dependant on location, there are significant issues with high iron and saline levels. Systems to treat these issues, alongside those of surface water, can be costly to both install and operate. Increasingly stringent regulations around water use in dairy sheds will also put emphasis on water quality and reliability in the near future.

With predicted climate change for the region, the Kaipara area will need to monitor and adapt drainage schemes to continue to adequately manage flooding and sea level rise in the future. Water storage within the command areas could form part of a wider solution in the future as higher value land uses may be required to make farming this area viable.

5 Market assessment

The varied climate and soil conditions in Northland mean there are a range of opportunities for different applications of water across the region; in horticulture, field cropping, and pastoral use as well as urban and industrial use.

For instance, the technical expression that determines the availability of water in different soil and climate conditions is the 'Plant Available Water' or PAW. The variation in the PAW in different parts of the potential schemes means that the annual demand for water per hectare of a crop varies widely across the area. For example, the demand for water for kiwifruit across the Mid-North and Kaipara varies from 1,640m^3/ha/yr, up to 4,500m^3/ha/yr. Similarly for avocados, water demand in the Mid-North and Kaipara ranges from 1,300m^3, to 4,800m^3/ha/yr. The highest demand is about three times the lowest demand.

This is just one indication of the wide range in production conditions across the Mid-North and Kaipara areas.

This variability in climate and soil means that water application is/would be more tactical i.e. applied to specific areas of farms/orchards, in contrast to other parts of the country like Canterbury where water for irrigation is used for large areas of monoculture e.g. dairy and dairy support with fixed centre-pivot irrigation. Rather, the use of water, specifically irrigation, in Northland would be integrated as part of the production process, alongside farm/orchard management practices. While an important part of a farm/orchard it will not be the dominant production factor year-in and year-out.

This scoping study has investigated a range of horticultural and pastoral land uses with potential for development or expansion across Northland, selecting a few key ones based on market assessments. In view of the widely varied production conditions, estimates of productivity (yields), gross margins, and profitability are guides only, and a number of specific case studies will be required for specific water applications.

Strong and steady market growth is an indicator of the likelihood that the crops and land uses can be adopted with some confidence now and in future years when sections of irrigation schemes come on-stream.

Schemes which are planned on the basis of high product prices, and implemented when product prices are low suffer problems of uptake of water. Northland saw that in the past with the Kerikeri scheme where kiwifruit prices fell between planning and implementation.

The main horticultural and pastoral opportunities that have been investigated for different applications of water, demonstrate strong potential for future market growth. This was based on analysis of current, historical, and forecast trends and information. They are also relatively feasible to develop or expand, based on the project team's understanding of current and potential land use and irrigation uptake, and industry level production and gross margin estimations. Existing logistical arrangements either have the capacity to absorb an increase in production, or could potentially be expanded or be built new.

Overall, there are a range of profitable production possibilities available through potential different/expanded land uses, which can be aided by tactical water use. These could be investigated through development of some specific crop case studies.

5.1 Market for water for irrigation

There are needs for water for urban use and for industrial use, however the most important demand for water for this scoping study to consider is water for irrigation. This is for two reasons:

- The quantity of water required for irrigation is much larger than that required for urban or industrial use; and
- The production generated by irrigation is expected to expand the need for water for urban and industrial use.

Therefore it is useful to determine the likely potential production from irrigation alongside estimating the urban and industrial demands.

5.1.1 Demand for water is derived from market demands for products

The project team has determined the actual and potential demand for water in all its potential uses in the areas of prospective new or additional irrigation capacity.

In contrast to other main regions where irrigation provides high volumes of water to large areas of pastoral agriculture, especially dairy production, in Northland the most significant proportion of new irrigation uptake is likely to be for horticultural production. These uses may be consistent water application to the relatively smaller areas under horticulture, or for specific husbandry functions with different crops, be it for seed germination and initiating growth in kumara and maize, or for supporting bud break and shoot growth at the same time as flowering fruit set and fruit harvesting with avocado.

Other potential uses of irrigation include newer farm and orchard management practices and a wider range of fruit varieties becoming available. For example, there has been a recent increase in the production of blueberries grown under tunnels (i.e. covered), while new varieties of kiwifruit and blueberries are being trialled within the region. Some growers are also applying different farm management techniques, such as using fertigation through foliar spray for kiwifruit, or growing complementary crops together such as avocados and kiwifruit to remove the seasonal variation impact on revenue and seasonal labour demand.

The availability of water for irrigation would be provide the opportunity for supplementary production, not necessarily substitution of existing land uses. For example, more water available for irrigation is likely to result in a farmer/orchardist increasing the number of hectares of their existing land used for existing crops, rather than a significant change in land use.

Within the pastoral agriculture sector strategic application of water to maintain production during drought situations is likely to yield higher values than large-scale irrigation for example of dairy with centre pivots, in the Northland climate and soil situation. Other strategic or tactical application of water use is to provide supplementary pasture or feed crops to support production or finish livestock rather than feeds imported to the region such as Palm Kernel Expeller (PKE).

Another use for higher quality potable water which is not generally of importance in other regions in New Zealand is for stock water. This is necessary because of high mineral levels in local bore waters which suppress livestock production rates especially in the Kaipara District.

Finally for the potential demand for irrigation water to become an actual demand for water, the market prices for the irrigated product must be sufficient to allow Northland producers to invest in the infrastructure, and equipment to irrigate, to pay for the water, and to make the irrigated production profitably.

5.2 Markets in Northland

This Market Assessment section has considered markets for products from each of the main irrigation uses of the water and investigate the domestic and export markets for these products. It has assessed the ability to supply those markets with production from potential irrigation schemes in Northland now and into the future. For this potential demand to be filled, it will be necessary to have the labour required in production and the packing and processing, and the water required in production, packing and processing.

A summary of the attractiveness of key activities in Northland is presented in Table 5-1. There is supporting information in Appendix E.

Table 5-1 Summary of market assessment for different farm system types

Land uses	Avocados	Kiwifruit	Blueberries	Dairy production platforms	Sheep and cattle finishing, Dairy support	Vegetables, crops including kumara
Market state, capacity and logistics	World market is growing rapidly and NZ only 1.5% of market. There is market capacity and logistics to expand.	NZ export market will increase 31% in five years. NZ only 15% world market. There is market capacity and logistics to expand.	NZ produces about 2.7 tonnes or 1.5% of world production. The market is growing rapidly with new varieties being trialled.	Fonterra undertakes to process and market milk from share-owners. Shares cost $6 per kg MS supplied. The long-term inflation adjusted price is $6 per kg MS and projected $6.15 2016/17	AFFCO plant at Moerewa serves Mid-North; and Silver Fern Farms Dargaville serves Kaipara area. Both provide employment, and currently or soon will produce value added meat products.	The NZ market for vegetables is not growing strongly. Kumara from Kaipara has strong niche and vegetables
Production and margins per hectare	Sales per ha were $17,000 last two years $24,800. Gross margin $7,000 to $15,000 per ha. Top growers over $40,000 per ha.	Yields of 8 to 10,000 trays per ha give gross margins of $45,000 for green and $55,000 for gold. Top growers can get upwards of 20,000 trays/ha.	Yields 2,800 trays per ha. Gross margin of about $38,000 per ha. Top growers $60,000 per ha.	Farmers can use partial irrigation on their milking platform, can lift production to 1,000 kgsMS/ha. This implies a gross margin of about $1,500 plus per irrigated hectare.	Partial irrigation on sheep and beef farms vary according to systems. Finishing store stock or dairy support can give gross margin about $700-$1,000 on irrigated hectares.	Vegetable grower gross margins from irrigated production vary widely and depend on the specific functions of their tactical water use. Often spring certainty.
Attraction to invest	Capital orchard costs $60,000 plus per ha. Break-even payback period is five to eight years.	Capital costs to develop an orchard $85,000 per ha, paying clonal royalty over five years. The break-even payback period is six to seven years.	Capital costs to develop an orchard are $95,000 per ha. The break-even payback period is seven to nine years.	Capital costs to develop irrigation is about $13,500 per ha. .Break-even payback period is about eight years.	Capital costs to develop irrigation is about $6,500 per ha. Break-even payback period is about eight to ten years.	
Water requirements	Average water required is 3,500 to 4,500 m3/ha/yr. Range in Mid-North and Kaipara is 1,300 to 4,800 m3/ha/yr.	Average water required is 3,500 to 4,000 m3/ha/yr. Range across suitable soils in Mid-North is 1,650 to 4,500 m3/ha/yr.	Average water required is 2,500 - 3,500 m3/ha/yr. Range across suitable soils in the Mid-North is varied.	Average water required is 4,500 to 5,500 m^3/ha/yr. Range in Mid-North and Kaipara is 3,400 to 5,600 m^3/ha/yr. Case studies will verify economic water uses in the dairy system.	Average water required is 4,500 to 5,500 m^3/ha/yr. Range in Mid-North and Kaipara is 3,400 to 5,600 m^3/ha/yr. Case studies will verify economic water uses in grazing and finishing.	
Employment: hectares for an employee	2 to 5	2 to 5	0.04 or 400 square metres per employee	65	150	

5.2.1 Avocados

Northland is a main New Zealand region producing avocados. There is strong interest in expanding production in Northland and developments are already taking place.

The global market for avocados is very large and continues to increase strongly.

The relevant New Zealand comparison with the global market is that New Zealand production in the last three years has been about 0.8% of world production. New Zealand exports have averaged about 1.5% of world exports.

New Zealand production is increasing, but even if production doubled in the next few years, and the increase was all exported, it would be absorbed by under three months' growth in the world consumption. This general picture indicates that in a large and growing world market for avocados, New Zealand could make significant increases in production, and still remain a small player.

The production increase in New Zealand over the last ten years has been equivalent to an average of 330ha per year. On this basis, the known developments in Northland are equivalent to about four years at the past rate. It is therefore quite reasonable to assume that the ongoing expansion of demand in New Zealand and Australia, together with the successful marketing expansion into Asia could readily handle the marketing and logistics of an additional 300ha of orchards per year.

The existence of a considerable area of deep soils suitable to grow avocados, combined with availability of irrigation water means that over the coming five to seven years there can be expected to be the scope to expand the area of avocado as irrigated avocado to about 500ha in the Mid-North and 250ha in the Baylys-Te Kopuru area of Kaipara.

5.2.2 Kiwifruit

Kiwifruit is a small crop by global standards, accounting for approximately 0.22% of globally traded fruit. New Zealand is the third largest producer of kiwifruit globally, behind China and Italy. It is New Zealand's single largest horticultural export crop by volume.

Kiwifruit production has increased rapidly over the last several years, as new gold varieties have yielded healthy harvests.

The increase in supply has been accompanied by increased demand, both domestically but more especially in terms of export.

New Zealand kiwifruit have been marketed as a premium product overseas, as a nutrient dense fruit. This is to cover New Zealand's high cost of production (land, labour, freight), and due to the seasonal nature of the fruit with it having a limited shelf life and narrow selling window.

5.2.3 Citrus

Northland has about 295ha planted in citrus which is about one-sixth of the national total; recorded as 1,857ha.

The majority of citrus production is consumed domestically (~84%), worth around $59m. NZ's produces less than 1% of global production.

The industry suggests that yields of citrus in Gisborne region are significantly higher than in Northland, and that some Northland production is likely to be re-located to Gisborne. This is despite the relative advantage of citrus fruiting about two weeks earlier than elsewhere in the country.

Therefore, it is unlikely that there will be a need to market increased volumes of citrus from Northland.

5.2.4 Tamarillos

The NZ Tamarillo Co-operative Ltd (Tamco) is the country's only tamarillo co-operative. The size of the tamarillo industry is quite small, with Tamco buying about 90 percent of the national tamarillo crop. Production has been stifled since about 2006, due to the crop pest tomato potato psyllid.

Some areas of land in Northland have been identified by the project team and by a number of stakeholders as very suitable for production of tamarillos; however the project team is not aware of any major potential to expand demand for tamarillos, nor of any initiatives to expand production of tamarillos in Northland.

5.2.5 Berryfruit

While the berryfruit production and marketing industry has been relatively static for a long time, there have been new initiatives, including in Northland to grow berryfruit under cover and with new varieties to extend their season of production.

Whereas the current berryfruit industry probably offers a relatively limited opportunity for Northland, the more-specialised production under cover has a good potential to generate activity and employment and to have some demand for water. Berry fruit under cover can therefore be considered a prospective crop for irrigation schemes.

Across the Northland region, around 22ha are planted in berryfruit. It is a minor share of the national production of 2,600ha of berryfruit. The total area planted increased only marginally from 2007, when a total 2,500ha was planted. There is growth potential in Northland though, in terms of blueberry production.

5.2.6 Kumara

The area in production has increased only marginally over the last 15 years, and the value of that production has only grown at a similar rate as inflation. The number of growers has halved over that period, but with the area in production remaining relatively stable, this implies that some production areas may have been consolidated so that there are now fewer but larger growing areas.

Approximately 90% of kumara is grown in Northland, mainly in the alluvial plains of the Northern Wairoa River.

At present, all of the kumara production is consumed domestically within New Zealand, but trial shipments of fresh kumara have gone overseas to places such as Malaysia, to test the markets there. The main issue facing kumara growers at the moment is growing the demand for kumara, both fresh and processed, domestically as well as internationally.

5.2.7 Other vegetables

The other vegetables grown on significant areas in Northland in recent years have been sweetcorn (84ha.); Broccoli, cabbage and cauliflower (Brassica, 28ha.), and a few potatoes (22ha.).

The total area in vegetables has made up 3% to 3.5% of the total area in vegetables in New Zealand between 2000 and 2012. Auckland has produced on 11% to 13% of the total area.

In New Zealand as a whole vegetable production has not been a growth industry since 2000. The total area in 2000 was 55,514ha and in both 2007 and 2012 it was about 49,700ha.

There are intentions indicated in Auckland to develop 50,000 houses on the main national vegetable-growing area at Pukekohe. If that were done there would be a need to develop vegetable production elsewhere to supply the New Zealand domestic market, and possibly some export.

Main crops produced in Pukekohe are onions, potatoes, brassica, lettuce and carrots.

5.2.8 Pastoral irrigation

The most dramatic increase in production on irrigated pastures in the last twenty years has been of dairy production, on dairy production platforms. Much of the increase in pastoral production on land not particularly suitable for milking platforms for dairy production in recent period has been for dairy support, namely raising calves and yearlings for later entry into the herd, and wintering dry cows to allow pastures on the milking platforms to recover and regenerate.

In the sheep and beef side of the pastoral system, irrigated production can be economically profitable for finishing (or fattening) stock which has been bred on the harder country.

Compensatory weight gains are experienced in most New Zealand pastoral farming systems, where the slow growth over winter is compensated by higher growth in spring, early summer and the ‘finished’ stock are then sold before the nutrition is reduced by low rainfall conditions. The role of irrigation in this system is to be able to accept those stock that are not 'finished' when pasture growth ceases in unirrigated conditions, and bring their growth through to their potential.

In general in New Zealand it is assumed that any milk which can be produced economically on dairy farms with reasonable road access will be taken by the Fonterra co-operative, and processed into product, mainly for export.

The main potential benefits to dairy production of irrigation in Northland are:

- To reduce the fluctuations in production due to fluctuations in rainfall and water availability;
- To increase and managed the type and quantity of feed available to cows in all years and thus increase production per cow, and potentially in cow numbers;
- To maintain current cow numbers and production per cow, but reduce purchased feed; and
- In Kaipara in particular to increase per cow production by providing more palatable drinking water to the cows.

5.2.9 Sheep and cattle

While the actual area likely to be irrigated for beef, sheep and dairy support in these scheme areas is expected to be smaller than the areas of some other land uses, the impact of this irrigated production can significantly improve the outcomes on a much larger farming area. The outcomes improved include farm incomes, employment and environmental management of the more fragile pasture areas, such as the clays, and the harder country.

The irrigated feed production can be used tactically to increase the productivity of the pasture growth through techniques like techno-grazing and other systems.

It will be essential to research some farm system case studies to show the benefits of this irrigation in terms of drought mitigation, and other management functions across the range of soil, terrain and climate types in the scheme areas.

5.2.10 Prospective crops

There is an opportunity to investigate and promote/lobby for the establishment of production of 'new' crops within Northland to utilise the regions points of climatic difference. Development of scale could likely be key.

As an illustration it is interesting to note that in some of the Tasmanian Irrigation schemes there is substantial production of poppies for opiate pharmaceuticals. In fact the scale is such that there is a processing operation, Tasmanian Alkaloids located there. Tasmania has an average of 800 growers producing this annual crop each year. They grow approximately 60,000 tonnes of poppies on 25,000ha. This supplies about 45% of the world's opiate-based pharmaceuticals, such as codeine, morphine, used in painkilling drugs and cough mixtures.

Another crop noted is pyrethrum, which will also require local processing. There are possibilities of other similar crops, sometimes called 'chemurgic' crops. Presumably these could include medicinal marijuana were it to be legalised.

- Another opportunity which is developing in Northland, including the Mid-North is production of specialist berry crops under cover. These require water but generally not in large volumes.

Other prospects are specialist seed crops for the northern hemisphere market. In South Canterbury, irrigation is used by substantial businesses to produce and pack volumes of silver beet and carrot seeds, as very valuable field crops.

5.3 Other influencing factors

There are a range of other influencing factors to keep in consideration when assessing the relative merits of different land uses. Factors such as newer and more advanced management techniques, and new cultivars can lead to changes in yields, influence length and/or timing of harvest times, and subsequent gross margins.

For example, the application of foliar spray or fertigation could lead to higher kiwifruit yields, or the introduction of new cultivars which also produce higher yields. These types of factors can be directly influenced by growers themselves. External factors beyond growers' direct control include climate change, crop pests, and overseas production volumes.

From a pastoral sense there are also market drivers such as the recently introduced testing targeted at the use of palm kernel by Fonterra. This has the potential to influence the viability, uptake, and fit for irrigation with-in dairy farms in Northland as there become greater implications on the type, timing and quality of feed to avoid financial penalties.

Should Maori freehold land be optimised in terms of primary production this also has the ability to greatly influence outcomes due to a differing values and economics due to the land being freehold i.e. it possibly doesn't need to be as productive to be profitable.

6 Scheme refinement

Refinement of the 12 preliminary command areas into four possible scheme options was completed following feedback from the first stakeholder engagement workshop and using information gathered during the study as detailed in the previous sections.

6.1 Kaipara scheme refinement

The majority of the land being considered within the Kaipara is currently used for pastoral farming purposes with a small amount of land for cropping/market gardening. If water becomes available for irrigation it would be unlikely to see land use change substantially across the community.

Horticultural production is the key driver to the increase in Value of Output, GDP and jobs. This is due to pastoral farming typically requiring greater volumes of water than horticulture. The Baylys/Te Kopuru command area, due to soil types, is the most likely to be capable of horticultural production. The adjacent areas described as Parore and Mititai have been consolidated with Baylys/Te Kopuru to take forward as the scheme infrastructure can be combined.

The three preliminary command areas not located adjacent to Baylys/Te Kopuru (Ruawai, Hoanga and Awakino) will not be analysed further in this scoping study. Communities consulted indicated that there could be risk associated with uptake within these areas, and with benefits for job creation lower than others, the focus was placed on the other three; Baylys/Te Kopuru, Mititai and Parore.

The water resources readily available to this area are the Northern Wairoa River and Kaihu Rivers as discussed in Section 2.4.1 Utilising the Northern Wairoa River as a water source is considered unlikely to be feasible due to challenges around salinity, sediment loading and consentibility. Whilst technically feasible, capital and operational costs would likely be relatively large.

Therefore the Kaihu River is further analysed in this study as the water source for this scheme option.

6.2 Mid-North scheme refinement

The soil types in the Mid-North are typically suitable for a variety of uses, including horticulture. The six preliminary command areas initially identified have been consolidated into three possible schemes: Rangihama; Kerikeri; and the four smaller command areas namely, Waimate North, Ohaeawai, Te Ahu Ahu and Ngawha, being treated as one area as they would likely share plumbing and utilise the same water source(s).

There are multiple river water sources likely within this area due to the size of catchments and the altitude of the irrigable areas. These are discussed in Section 2.4.2.

In addition to river sources, there is also a strong community drive to investigate Lake Omapere as a possible source of water, where water could drain either east or westwards. There is little data available on the behaviour of Lake Omapere and as therefore, some assumptions have to be made about its ability to be considered a possible water source. These are discussed in Section 7.4.3.

Consideration has also been given to the existing Kerikeri irrigation scheme storage which is thought to be under-utilised currently.

6.3 Scheme options to progress

The 12 preliminary command areas have been refined into four potential scheme options to be the focus of the remainder of the analysis. These schemes, and the command areas they were derived from, can be described as follows:

- **Kaipara** (Baylys/Te Kopuru, Parore and Mitatai) with the Kaihu River as a potential water source shown in Figure 6-1.
- **Mid-North A** (Rangihama / Kaikohe) with the Punakitere River and/or Lake Omapere as a potential water source shown in Figure 6-2.
- **Mid-North B** (Waimate North, Ohaewai, Te Ahu Ahu and Ngawha) with the Waitangi River and/or Lake Omapere as a potential water source shown in Figure 6-3.
- **Mid-North C** (Kerikeri expansion) with the Puketotara River, Kerikeri River and/or existing Kerikeri irrigation Scheme dams as a potential water source shown in Figure 6-4.

It should be noted that this does not mean other potential water sources are not viable, and they may be considered in future pre-feasibility studies.

6.4 Scheme impacts

The estimated impacts on the economy of each of the potential scheme options are shown in Table 6-1. The information has been determined based on findings from Stage 1, scaled proportionally to the newly proposed command areas.

Table 6-1 Impacts of potential scheme options

Scheme Name	Scheme Command Area	Estimated Uptake/Irrigated Area	Total Sales at farm/orchard gate (Value of Output)	Value Added (GDP)	Permanent jobs created
	ha	ha	$m per year	$m per year	FTEs
Kaipara	19,000	6,300	22	16	230
Mid-North A	2,300	1,600	14	11	180
Mid-North B	2,800	1,700	16	12	210
Mid-North C	5,000	2,000	20	15	250

Please note that the areas shown in Table 6-1 for the Kaipara are slightly different to Table 3-1. This is a result of refinement and consolidation of the preliminary command areas from Table 3-1 and resultant inclusion of additional land into the command area.

Additionally, the potential demand for irrigation water has been combined from the information proposed for the initial preliminary areas. This information is shown in Table 6-2.

Table 6-2 Irrigation water demand for potential scheme options

	Max daily demand (m^3/d)	Max monthly demand (Mm^3/mth)	Average annual demand (Mm^3/yr)	Max annual demand (Mm^3/yr)
Kaipara	258,100	7.6	20.9	28.2
Mid-North A	77,300	1.7	2.9	5.5
Mid-North B	85,600	2.1	3.3	6.7
Mid-North C	97,000	2.4	2.9	7.2

Figure 6-1 ***Kaipara*** *(Baylys/Te Kopuru, Parore and Mititai) with the Kaihu river as a potential water source*

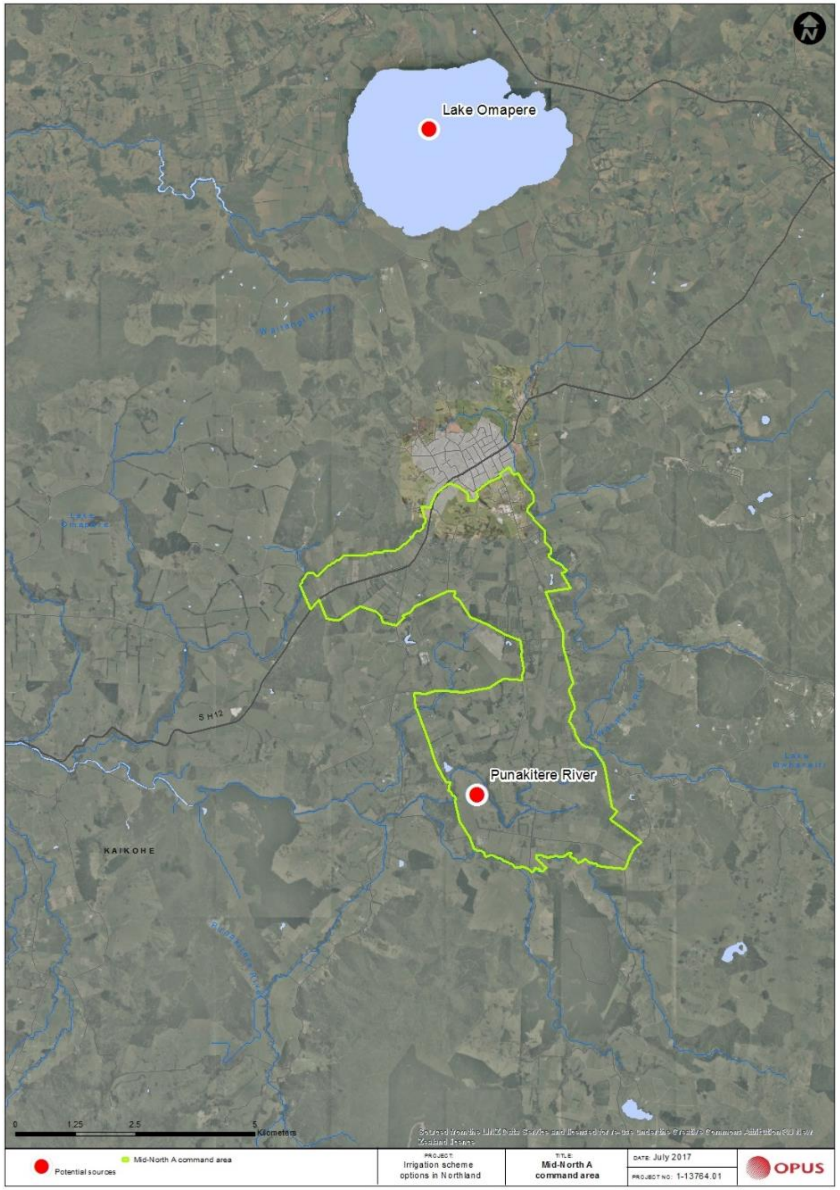


Figure 6-2 ***Mid-North A*** *(Rangihama / Kaikohe) with the Punakitere River and/or Lake Omapere as a potential water source*

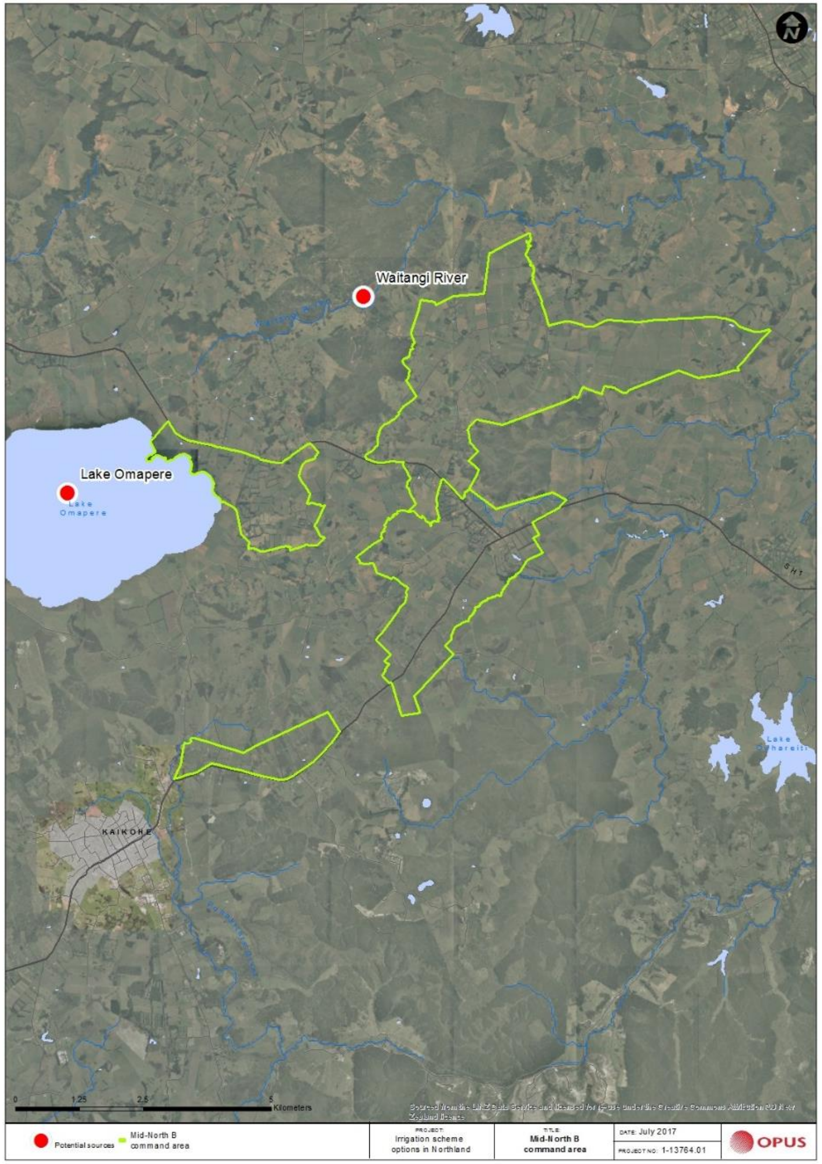


Figure 6-3 ***Mid-North B*** *(Waimate North, Ohaeawai, Te Ahu Ahu and Ngawha) with the Waitangi River and/or Lake Omapere as a potential water source*

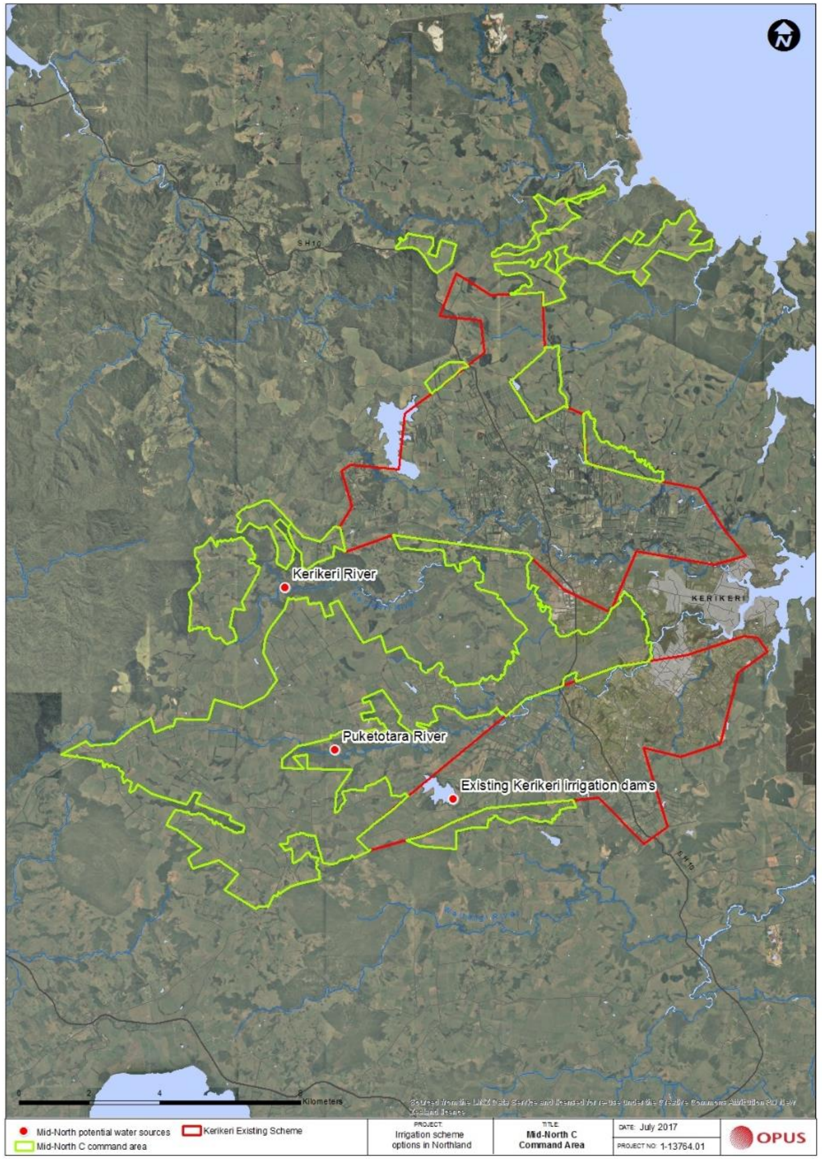


Figure 6-4 ***Mid-North C*** *(Kerikeri expansion) with the Puketotara River, Kerikeri River and/or existing Kerikeri irrigation Scheme dams as a potential water source*

7 Water availability

Time series of river flows developed in Stage 1 has been used to determine the daily resource availability (Opus *et al.*, 2015). Daily flow data is available from 1 July 1972 to 30 June 2015. As shown in Stage 1, most of the streams with high flows are considered to be highly allocated. Therefore, as with the previous stage, this study has also considered that no run-of-stream resources will be available for large scheme takes. This is a reasonable approach due to the fact that large schemes require high flow rates during the irrigation season, which incidentally coincides with low flow conditions. Thus, only harvested high flows, with water stored in reservoirs have been considered for schemes.

NRC is in the process developing policies for harvesting high stream flows, i.e. over and above the “primary allocations”. The Resource Management Act (RMA) requires that a consent authority shall *Manage the taking, use, damming and diversion of fresh water so that:*

1) *the life-supporting capacity, ecosystem processes and indigenous species including their associated ecosystems of fresh and coastal water are safeguarded, and*
2) *the natural hydrological variation of outstanding freshwater bodies and natural wetlands are not altered, and*
3) *rivers have sufficient flow variability to maintain habitat quality, including to flush rivers of deposited sediment and nuisance algae and macrophytes, and*
4) *flows and water levels support sustainable mahinga kai, and*
5) *saline intrusion in, and land subsidence above aquifers is avoided, and*
6) *recreational and amenity values associated with fresh water are maintained.*

As advised by NRC (per. comm., Osbaldiston, S. and Tait, B, NRC) the draft policy is as follows:

> *“The taking and use of fresh water from a river when its flow is above its median flow is a restricted discretionary activity, provided:*
>
> *1. the frequency of flushing flows that exceed three times the median flow of the river is not changed, and*
>
> *2. 50% of the river flow above the median flow remains in the river.”*

The matters of discretion are related to:

1. The timing, rate and volume of the take to avoid or mitigate adverse effects on existing authorised takes,
2. Preventing fish from entering the water intake, and
3. Measurement to ensure reasonable and efficient use.

Variation from the above would result in the activity becoming discretionary, rather than restricted discretionary. This should not be viewed as a restriction but more an indication of the consenting pathway required to access the necessary volume of water.

The available flows for harvesting have been assessed based on this draft policy to show how potential irrigation schemes would sit in respect to proposed policy and subsequent consent requirements should a scheme be progressed further. However, as it is a draft policy at this stage, sensitivity analysis has been undertaken to assess the potential effect on schemes, i.e. available resource and reliably irrigable area. This sensitivity analysis is presented in Section 8.4 to show the impact of the regional policy on the scheme options and the potential consenting pathway.

The location of intakes for each command area is shown in Appendix F. It should be emphasised that for the purpose of analysis the locations are intake locations for water harvesting and not storage locations as such. Storage locations will be determined during a subsequent stage using engineering assessments; therefore, water will not to be stored at these locations, unless stakeholders consider these locations for storages to also accommodate other requirements such as detention of flood flows.

7.1 Water supply reliability

The average annual and irrigation season reliability assessments that have been used for determining supply-demand reliability is shown in Table 7-1.

Table 7-1 Irrigation season reliability.

Reliability	
100%	Very good reliability
94-99%	Good reliability
87-94%	Marginal reliability
<87%	Poor or very poor reliability.

Two indicators used in Stage 1 to determine the irrigation water supply reliability have been adopted for this stage also. It is assumed that for the scheme water supply to be reliable, both of the following conditions are met:

- Mean annual and irrigation season average supply-demand ratio to be greater than 95%; and
- Periods of restrictions exceeding 10 consecutive days will occur in no more than 10% of the irrigation seasons modelled.

For storage-based irrigation systems, periods of restrictions tend to determine the overall reliability, as restrictions will occur when the storage volume is depleted. The reliability criteria can therefore, be loosely interpreted as the storage not being able to supply the demand (and emptying the reservoir) approximately once every 10 years. As the water demand has been assessed for 43 years (1972 – 2015) in this report, the number of restrictions exceeding 10 consecutive days have been limited to four events within this period

The series of assumptions will result in irrigation reliability towards the top end of the "good reliability" range in Table 7-1 above.

Simply, the 'supply-demand reliability' is dependent on water resource supply (availability) and demand for the water. Determination of the size of storage(s) has been undertaken to meet a specific level of irrigation supply-demand reliability. The size of the storage(s) is dependent on timing of the flow availability as well as timing of the scheme water demand. It is not industry standard to design storage that has the capacity to store water to meet the full annual demand. The storage(s) are continuously replenished through all available high flows, including some days during the irrigation season. Therefore, analysis of daily irrigation demand and mean daily flows (i.e. supply) were assessed to determine the optimum size of reservoirs.

As the supply-demand reliability is dependent on the storage capacity, a larger reservoir stores more water to increase the reliability of supply. However, the volumes that can be harvested is finite due to catchment area and stream flows together with regional policies. Further, it is often uneconomical to harvest/divert large volumes of water and convey to a distant reservoir via a large pipe/canal.

In general the approach is to develop a diversion rate/storage size relationship and price different scenarios to determine the optimised diversion rate. As the exact location of the reservoir for each command area is has not yet been determined, length of the diversion cannot be confirmed at this stage. Therefore the actual cost of the delivery system cannot be confidently assessed and it is assumed that the maximum daily volume that is harvested for each scheme is equivalent to 1.5 times of the scheme's maximum daily demand.

Storage sizing is primarily based on evaluating four aspects:

1 Scheme demand. The maximum demand for irrigating the total irrigable area (i.e. percentage of the command area) and other scheme demands, which are outlined in Sections 4.2 and 4.3. This storage sizing assessment determines whether water resource is available to meet the demand for the full area (i.e. irrigation), or what proportion of the area can reliably be supplied.

2 Water availability within the NRC policy to fill the reservoir. This will determine the potential available flow to replenish the reservoir (i.e. storage capacity).

3 Size of the intake pipe/canal (i.e. 1.5 times of the scheme's maximum daily demand).

4 Scheme supply-demand reliability.

The scheme supply-demand reliability, optimised storage size, irrigable area within each command area along with associated output from the assessment for each scheme is given in Sections 7.2 - 7.5.

Appendix H shows storage volume hydrographs and consecutive irrigation deficit days by scheme.

7.1.1 Sensitivity analysis for climate change

As shown in Section 4.1.2.1, it is projected that future climate will be different from the historical data due to climate change (NIWA, 2016). As a result of this change, future hydrological conditions will also be different from the past primarily due to a reduction in rainfall. It is possible that the inter-annual water resources are more variable and harder to predict due to unpredictable extreme weather patterns (NIWA, 2016). It is difficult to accurately assess the changes to stream flows due to overall climate change effects within this high level study. Based on rainfall and PET reduction projections (Section 4.1.2.1), it is estimated that seasonal surface water flows for the two clusters areas will change by the percentages listed in Table 7-2. It should be noted that these percentages are developed for the purpose of high level sensitivity analysis only, and therefore should not be used for any detailed analysis.

Table 7-2 Projected percentage change in seasonal surface water resource volumes for the Kaipara and Mid-North areas.

Modelled area	Scenario	Summer	Autumn	Winter	Spring
Kaipara	CC1	-4%	-4%	-8%	-8%
	CC2	9%	7%	5%	4%
Mid-North	CC1	-6%	-5%	-11%	-12%
	CC2	10%	7%	8%	5%

The impact of each of the climate change scenarios on each of the proposed irrigation scheme options is analysed and included in Appendix G. Generally the scenarios impact the proposed schemes by changing the requirements for storage volume, command areas or reliability of irrigation.

For example consideration of scenario CC1 in development of the schemes may result in increased storage volumes, reduced area for irrigation or reduced reliability of water. Conversely scenario CC2 results in a larger area of irrigation with the same storage or alternatively a lesser storage requirement.

What this clearly indicates is assumptions around differing climate change scenarios can have a significant impact.

7.1.2 Water losses

There are water losses within any scheme. While it is important to minimise these losses, some are unavoidable. The main type of losses include evaporation (primarily from storage), seepage/leakage (from storage and canal/pipe) and operational losses. Many factors interact to determine the level of water losses, typically leading to very site-specific analysis: subsoil, surface area and wetted area of the storage, and length of the diversion. As no site specific information has been established at this stage of the study, it is assumed that water losses equate to 5% of the total water use.

7.2 Kaipara

7.2.1 Water availability

The Kaipara scheme option consists of three preliminary command areas: Parore, Mititai and Baylys/Te Kopuru. The total area within the scheme is 19,054ha. The Kaihu River has been utilised as the water resource for this scheme. As shown in Appendix F, an intake location approximately 5km from the confluence of the Wairoa River has been used. The estimated mean and median flows at the intake locations are 9.9 and 5.9m^3/s, respectively.

7.2.2 Storage

Table 7-3 lists the optimised storage capacity, irrigable area, supply/demand reliability along with associate outputs for Kaipara scheme. This shows that 2,858ha would be able to be reliably irrigated under the proposed NRC flow harvesting policies.

Table 7-3 Potential storage capacity, irrigable area and supply/demand reliability for Kaipara.

Parameter	Value
Total command area (ha)	19,054
Storage capacity[1] (Mm^3)	15
Irrigable area with available resource[2] (ha)	2,858
Percent irrigable area[3]	15%
Irrigable area from a unit storage volume[4] (ha/Mm^3)	191
Maximum irrigation demand[5] (m^3/s)	1.41
Maximum total demand (incl. 10% other demands + 5% loss)[6] (m^3/s)	1.63
Maximum take rate from the source (river/stream/lake)[7] (m^3/s)	2.45
Average irrigation season supply/demand ratio[8]	99.0%
Average annual supply/demand ratio[9]	99.2%
No of periods of 10 days or more consecutive restrictions (1972-2015)[10]	4

Note:
[1] The optimised storage volume for the command area based on available flow, scheme supply-demand reliability, water demand for irrigation and other uses (e.g. drinking, stock water, industrial) [A]
[2] The optimised area that can be irrigated reliably with available harvesting flows and storage capacity [B]
[3] The optimised irrigable area as a percentage of the total command area
[4] [B] / [A]
[5] As a number of crops are irrigated within the command area, the daily irrigation demand varies due to factors such as different planting dates, stage of the crop growth and crop-water demand for different crops. This variable shows the estimated maximum irrigation demand [C]
[6] Optimisation of the water resource is based on estimated irrigation demand and allowance of 10% for other potential water uses (e.g. drinking, stock water, industrial) and 5% system losses. This variable shows the estimated maximum scheme demand from the storage.
[7] The maximum flow rate that is taken from the source. This flow rate is dependent on flow of the source, NRC allocation rules and maximum capacity of the diversion pipe/canal that delivers water from the source to the storage.
[8] Daily supply/demand ratio is the ratio of supply of available water and demand for irrigation on a day during the irrigation season. The daily ratios has been combined over an irrigation season to obtain the average seasonal supply/demand ratio. The variable shown here is the average value over the model period, 1972 – 2015 [D]
[9] Same as [D], however, the average ratio is for the full year.
[10] Number of water restrictions periods exceeding 10 consecutive days over period modelled.

7.3 Mid-North A

7.3.1 Water availability

It has been identified that there are two potential water sources available for Mid-North A: Punakitere River and Lake Omapere (Section 7.4.3). As shown in Appendix F, an intake location near Mangakahia Road has been considered for the Punakitere River assessment. The estimated mean and median flows at the intake locations are 2.88 and 1.58m^3/s, respectively.

Lake Omapere is discussed as a possible water source for the Mid-North B scheme (Section 7.4.3) as it is adjacent to the lake. However, Mid-North A could also use the water from Lake Omapere so it shouldn't be excluded in future studies for this area.

7.3.2 Storage

The optimised storage capacity, irrigable area and supply-demand reliability outputs for Mid-North A for sourcing water from the Punakitere River is listed in Table 7-4. This shows that 55% of the area, 1,278ha would be able to be serviced from the river with a reservoir of 6Mm^3.

Table 7-4 Potential storage capacity, irrigable area and supply/demand reliability for water sourced from the Punakitere River for Mid-North A.

Parameter	Value
Total command area (ha)	2,324
Storage capacity[1] (Mm^3)	6
Irrigable area with available resource[2] (ha)	1,278
Percent irrigable area[3]	55%
Irrigable area from a unit storage volume[4] (ha/Mm^3)	213
Maximum irrigation demand[5] (m^3/s)	0.71
Maximum total demand (incl. 10% other demands + 5% loss)[6] (m^3/s)	0.83
Maximum take rate from the source (river/stream/lake)[7] (m^3/s)	1.24
Average irrigation season supply/demand ratio[8]	99.4%
Average annual supply/demand ratio[9]	99.5%
No of periods of 10 days or more consecutive restrictions (1972-2015)[10]	4

* Refer to Table 7-3 for notes

7.4 Mid-North B

7.4.1 Water availability

Both the Waitangi River and Lake Omapere are being considered as a water source for Mid-North B. It should be noted that Lake Omapere could also be considered an option by Mid-North A area as discussed in Section 7.3.1.

7.4.2 Waitangi River

Based on the location of the command area, an intake location north-west of Te Ahu Ahu Road has been used. The estimated mean and median flows at the intake locations are 0.85 and 0.47m^3/s, respectively.

7.4.3 Lake Omapere

Background information on Lake Omapere can be found in Section 2.4.2.5. This section focuses on the water availability of Lake Omapere.

Continuous lake outflow data or lake levels are unavailable for the study modelled period (1972-2015) to accurately assess the potential for sustainable resource harvesting from the lake; only 20 flow data measurements and water level data between 1969 and 1976 is available. However, NRC has developed a water level-storage curve using available data (per. comm., T. Kay, NRC), which is shown in Figure 7-1.

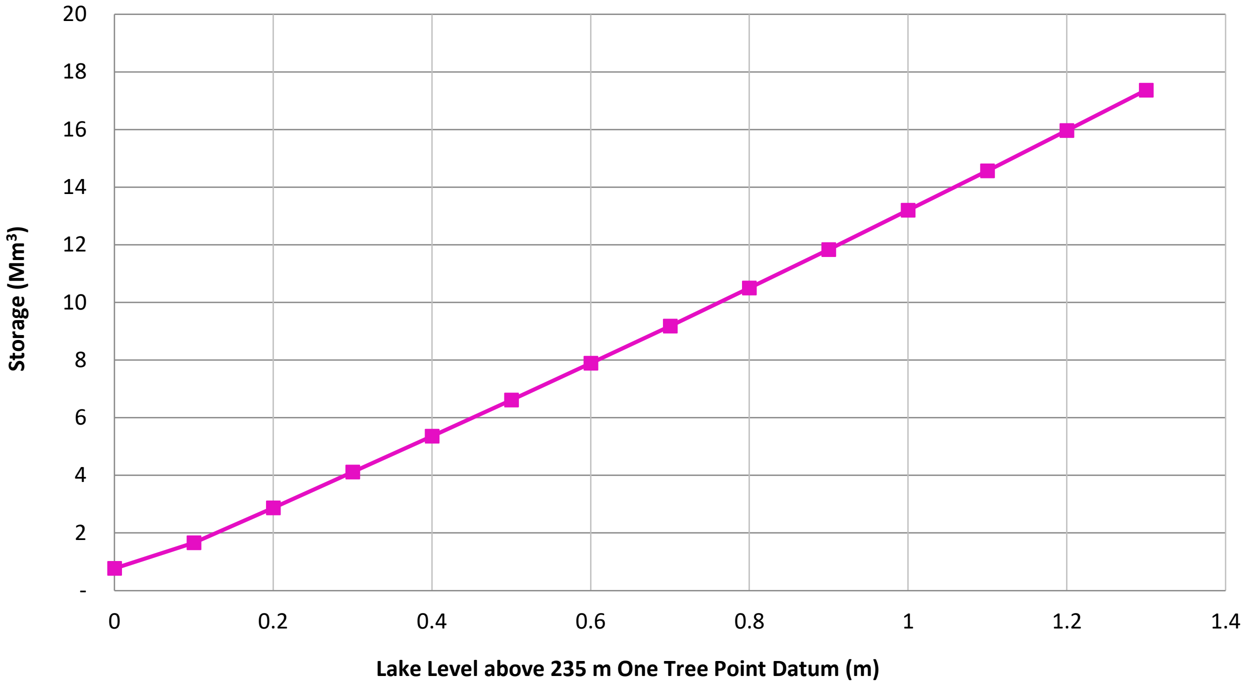


Figure 7-1 Water level-storage curve developed for Lake Omapere by NRC (Source: per. comm., T. Kay, NRC).

It is possible that the volume of water stored in the lake can be altered by regulating the water release (at the outlet) and its timing. Further, the low point(s) of the lake may potentially be bridged with a stop bank to boost the storage volumes and reduce flooding of the neighbouring properties. Due to unavailability of robust data, there is significant uncertainty associated with available water from the lake for schemes. However, considering the storage potential presented through the water level-storage curve, a range of hypothetical storage volumes and the irrigable area from the resource has been assessed. It is recommended that detailed water resource and ecological studies are conducted in the next stage of the study to determine the sustainable level of water availability from the lake.

7.4.4 Storage

7.4.4.1 Waitangi River

The optimisation analysis of storage shows that the irrigable area of scheme is only 14% of the scheme area (Table 7-5) due to relatively smaller flows in the Waitangi River. It is estimated that flows are sufficient to fill 2.15Mm^3 only.

Table 7-5 Potential storage capacity, irrigable area and supply/demand reliability for water sourced from the Waitangi River for Mid-North B.

Parameter	Value
Total command area (ha)	2,813
Storage capacity[1] (Mm^3)	2.15
Irrigable area with available resource[2] (ha)	394
Percent irrigable area[3]	14%
Irrigable area from a unit storage volume[4] (ha/Mm^3)	183
Maximum irrigation demand[5] (m^3/s)	0.22
Maximum total demand (incl. 10% other demands + 5% loss)[6] (m^3/s)	0.25
Maximum take rate from the source (river/stream/lake)[7] (m^3/s)	0.38
Average irrigation season supply/demand ratio[8]	99.2%
Average annual supply/demand ratio[9]	99.4%
No of periods of 10 days or more consecutive restrictions (1972-2015)[10]	4

* Refer to Table 7-3 for notes

7.4.4.2 Lake Omapere

While Lake Omapere is a strong candidate for supplying relatively 'cheap' water (as the required investment is comparatively smaller than a new storage) to the proposed scheme, data is not available to quantify the potential. In the absence of available data, a range of potential service areas have been estimated with different storage volumes using nearby time series data from the Punakitere River. However, it is acknowledged that flow patterns of the Punakitere River would likely to be different to stored water capacity within the lake.

As shown in Table 7-4 it has been estimated that 1,278ha area can be reliably irrigated from a reservoir of 6Mm^3, which sources water from the Punakitere River. Assuming that similar hydrological conditions exist within both catchments, i.e. Punakitere River and Lake Omapere, the conservative irrigable area from 1Mm^3 storage would be approximately 200ha.

Figure 7-1 shows that storage potential of the lake is close to 14Mm^3 if raised 1m. However, inflow volumes into the lake and available volumes for the schemes will vary annually due to variability of inter-annual rainfall. Therefore, the volume available for sustainable development of an irrigation scheme may be likely to be significantly less than 14Mm^3 by the time this is taken account along with the raising of the lake for environmental reasons.

Table 7-6 lists a range of estimated irrigable areas using different storage volumes from Lake Omapere. As the water losses likely to increase with higher storage volumes (e.g. increased evaporation due to greater surface area and higher groundwater recharge due to elevated water level), the irrigable area has been reduced by 5% per 1Mm^3 with increased storage, which is considered to be a conservative estimate for this high level study.

Table 7-6 Potential irrigable areas with different storage capacities of Lake Omapere.

Lake Omapere useable storage volume (Mm^3)	Estimated irrigable area (ha)
1	200
2	380
3	540
4	680
5	800
6	900

It is important to note that the for mentioned numbers are based upon the proposed water harvesting regime 1.5 times (x1.5) the maximum irrigation demand so there is significant upside potential should different scenarios be considered.

As described in Section 7.3.1 the water from the lake could also be used to service the command area within Mid-North A, however, the total area, i.e. within Mid-North A and/or Mid-North B that could be serviced from the lake would remain the same, as shown in Table 7-6.

7.5 Mid-North C

7.5.1 Water availability

Two main water resources have been identified for Mid-North C; Puketotara River and Kerikeri River. The Puketotara River was used in Stage 1 and flow time series was available. The flow data for the Kerikeri River has been developed using a correlation with the Puketotara River. As shown in Appendix F, intake locations for Puketotara and Kerikeri rivers near Puketotara and east of Waiare Road, respectively, have been used. The estimated mean and median flows at the intake location for the Puketotara River are 0.51 and 0.23 m^3/s, respectively, while these statistics are for the Kerikeri River are 0.58 and 0.26 m^3/s, respectively.

There is a strong likelihood that the existing storages within the Kerikeri Irrigation Scheme (i.e. unutilised water) is able to provide water for irrigation of more/new areas, however to what extent is currently unable to be quantified.

7.5.2 Storage

Table 7-7 lists the optimised storage capacity, irrigable area along with reliability outputs of the assessment. This shows that potential for scheme development is limited with the available resources from Puketotara and Kerikeri Rivers. It is estimated that the resources from both rivers is sufficient to irrigate less than 600ha.

Table 7-7 Potential storage capacity, irrigable area and supply-demand reliability for Mid-North C.

Parameter	Puketotara River	Kerikeri River
Total command area (ha)	5,000	
Storage capacity[1] (Mm^3)	2.4	2.85
Irrigable area with available resource[2] (ha)	277	319
Percent irrigable area[3]	5.5%	6.4%
Irrigable area from a unit storage volume[4] (ha/Mm^3)	116	112
Maximum irrigation demand[5] (m^3/s)	0.16	0.18
Maximum total demand (incl. 10% other demands + 5% loss)[6] (m^3/s)	0.18	0.21
Maximum take rate from the source (river/stream/lake)[7] (m^3/s)	0.27	0.31
Average irrigation season supply/demand ratio[8]	98.0%	98.0%
Average annual supply/demand ratio[9]	98.5%	98.5%
No of periods of 10 days or more consecutive restrictions (1972-2015)[10]	4	4

* Refer to Table 7-3 for notes

7.6 Sensitivity of regional policy

Sensitivity analysis has also been carried out to assess the impact of the NRC draft policies for harvesting stream flows. The current draft policy allows for taking 50% of the flow above the median flow, but less than three times the median (i.e. flushing flows). The analysis has been undertaken to assess two aspects:

- Change in flushing flow level from three times the median flow to a higher level; and
- Storing higher flood flows, i.e. highest 5% flows, to mitigate flood risk, if in-stream storage is used.

Mid-North C scheme with water supply from the Puketotara River has been used for the sensitivity analysis.

7.6.1 Change in flushing flows

Table 7-8 shows the results of sensitivity analysis for changing the flushing flows from three times the median flow, to four and five times of the median flow. This shows that the irrigable area can be increased by 23% and 40% simply by changing the flushing flow level to four and five times the median flow, respectively, with the same size of storage. However, it is recommended that policy changes such as the level of flushing flows needs to be carried out with extreme caution using necessary ecological studies to prevent detrimental impacts to the river values.

It should be noted that the percentage increase in resource availability with change in flushing flow level is likely to be strongly river/catchment specific, i.e. depend on the flow regime/variability. Therefore, the findings shown in Table 7-8 are unlikely to be representative of other rivers.

Table 7-8 Sensitivity of changing flushing flow level for the Puketotara River in Mid-North C.

Parameter	Flushing flow level, times the median flow		
	Three	Four	Five
Total command area (ha)	5,000		
Storage capacity (Mm^3)	2.4	2.4	2.4
Irrigable area with available resource (ha)[1]	277	340 (23%)	388 (40%)
Percent irrigable area	5.5%	6.8%	7.8%

Note: [1] The values within brackets indicate the percentage area increase relative to the flushing flow level of three times the median flow.

7.6.2 Storing higher flood flows

The storage optimisations for the schemes discussed above have been undertaken under the assumption that storage will be located off-stream. However, there is potential for using in-stream storage, if that can also be utilised for flood mitigation.

Unlike using off-stream storages, which require expensive diversion pipes/canals, in-stream storage are able to store higher flows. This potential has been assessed for the Puketotara River and it is assumed that flows above the 95^{th} percentile flow (i.e. top 5% flows) are also stored in the storage (if capacity is available during the flood event), in addition to the flows that are available for harvesting under the NRC's draft policy. However, it should be noted that these high flows tend to be sediment carrying flows which can be an issue for any in-stream storage.

The sensitivity analysis shows that 1,734 ha, i.e. 35% of the scheme area, can be irrigated from a $15Mm^3$ reservoir in the Puketotara River, if the top 5% of flows are harvested. This is a significant increase in irrigable area from 277ha (i.e. 526% increase) under the draft policy. Therefore, further investigation is warranted for dual purpose storages (irrigation and flood detention) within some catchments.

8 Scheme infrastructure

This section is about determining the required capacity for any potential storage option within a reticulation network scenario, and about developing and presenting feasible irrigation and water storage scheme options. This builds on from the previous work around water availability and combines it with the revised and amalgamated irrigation, urban and industrial demand developed in the Stage 1 study.

The options for providing water to farms was generated in a desktop, scenario based assessment. Rough order costings were estimated for these schemes and based on Opus' extensive database for similar sized and configured schemes. This established some typical whole of life costs for the water which can feed forward into both economic calculations (regional GDP) and commercial viability (farm level affordability).

To determine the feasibility of the systems and the approximate cost of reticulation, a workable pragmatic model was developed. Certain key input information was needed such as command areas, total water i.e. annual volume and peak daily demand, abstraction rates and the amount of storage required for each 'cluster area'.

Although there are a number of options where storage might be best placed, at this stage, it has been assumed that storage is off-line i.e. harvested flows rather than in-stream or on farm storage. At the pre-feasibility stage, the nature of daily river flows compared with the irrigation demand will determine the best option for storage.

8.1 Scheme development

Infrastructure in the form of pipes and pumps has been determined for each of the four scheme options defined in Section 6. These configurations are shown in Appendix I with analysis in, Section 8.4.

8.1.1 Design parameters

Irricad software has been used to model the reticulation and pumping network. A number of key design parameters/assumptions were used:

- A maximum pipe velocity of 1.5m/s
- A roughness coefficient (C) of 130 was used in the Hazen-Williams equation (empirical relationship between flow, pipe properties and pressure drop from friction).
- Water was distributed to theoretical 400ha blocks within each cluster area. Generally, no 400ha block has less than 60ha of irrigated land.
- Pump stations were located to minimise pipe pressure and overall power requirements.
- The main pipes generally follow roads. Minor pipes generally take direct route to the centre of the theoretical 400ha irrigation blocks to allow for pipe quantities to be estimated.
- 10% of all water is assumed for uses other than irrigation i.e. stock water, industry, municipal supply.

8.1.2 Cost parameters

Base costs for pumping, pipes and storage have been developed from previous projects Opus has been involved with (Table 8-1).

Although this means there is reasonable confidence in the data, risk has been built into the cost estimates. The base costs do not include any on-farm irrigation requirements. The risk factors that have been considered are as follows:

- Friction factor changes.
- Pressure class changes.
- Pipe route uncertainty.
- Pipe size and volume uncertainty.
- Pipe supply cost escalations.

- Pipe install cost escalations.
- Pump supply and install costs.
- Storage construction methods.

8.1.3 Operational and maintenance requirements

The operational and maintenance parameters that were used to derive the base costs are also detailed in Table 8-1. The assumed net present value parameters are 30 years at a discount rate of 6% per annum.

Table 8-1 Capital cost, operation and maintenance parameters used in the model.

Description	Base	Average Risk	Maximum Risk
Capital Costs			
Pipe costs: The base cost has been developed from a pipe inventory schedule specific to each scheme and a pipe cost rates associated with large for off-farm irrigation schemes ranging from 2,000 to 20,000ha. The average and maximum risk take into account cost and quantity uncertainty around pipe and fitting, installation and route variations. It is assumed that the pipe will generally follow road corridors but outside road pavements. It includes all ancillaries i.e. valves, fittings and offtakes.	100%	115%	130%
Pump capital costs (per kW): The base rate has been developed from costs associated with large pump stations for off-farm irrigation schemes ranging in areas from 2,000 to 20,000ha. The average and maximum risk take into account that uncertainty around the costs revolving around the building, foundations, pipe, fittings and ancillary equipment.	\$1,000	\$3,000	\$5,000
Storage cost (per m^3): It has been assumed that there is no existing storage available for any of the schemes. The base rate has been developed from costs associated with large off farm irrigation schemes ranging from 2,000 to 20,000ha. It relies on finding a good location where significant portions of the dam wall are existing ground. The average and maximum risk is based on 'turkey nest' dams with simple to complex control structures. All the dams are assumed to use locally sourced material for the dam structure and lining.	\$2.0	\$4.5	\$9.0
Operation and maintenance			
Cost of electricity: (including network charges) per kWh	\$0.12	\$0.15	\$0.18
Real increase in the annual cost of electricity: The real cost of electricity relative to other costs depends on future supply and demand. The New Zealand Ministry of Business, Innovation and Employment published a document called "New Zealand's Energy Outlook Electricity Insight" in 2013. The prediction is for a long term increase in electricity of about 25% above current rates. Price increases caused by increased demand will be balanced by other generation technologies becoming economically feasible. The base, average and risk annual real increases have derived from this. • An annual increase of the base risk of 0.4% equates to approximately 12.5% over 30 years. • An annual increase of the average risk of 0.8% equates to approximately 25% over 30 years. • An annual increase of the maximum risk of 1.2% equates to approximately 32.5% over 30 years.	0.4%	0.8%	1.2%
Annual pipe costs (% of capital)	1.0%	1.0%	1.0%
Annual pump station and building costs (% of capital)	5.0%	5.0%	5.0%
Annual storage pond costs (% of capital)	0.2%	0.2%	0.2%
Present Value parameters (PV)			
Term (years)	30	30	30
Discount rate per annum	6.0%	6.0%	6.0%

8.2 Scheme analysis

Using the design and cost parameters outlined in Section 8.1, a summary of the costs associated with the proposed scheme configuration fitting within the constraints of the NRC proposed harvesting policy is shown in Table 8-2. It should be noted that the numbers within Table 8-2 assume the construction of new storage and do not take into account the possibilities associated with existing lakes or reservoirs.

Table 8-2 Summary of costs of the four proposed scheme options with storage volume assumed to equal the maximum allowed water take under proposed NRC proposed harvesting policy rules.

	Kaipara		Mid-North A		Mid-North B		Mid-North C	
	Base	Max Risk	Base	Max Risk	Base	Max Risk	Base	Max Risk
Total area (ha)	2,900	2,900	1,300	1,300	400	400	600	600
Storage volume (Mm³)	15	15	6	6	2	2	2	2
Total capital cost ($M)	$61.8	$185.0	$17.4	$64.8	$6.3	$23.6	$6.0	$23.6
Capital pipe costs (per ha)	$10,290	$13,370	$3,440	$4,460	$4,060	$5,330	$2,010	$2,680
Capital pump costs (per ha)	$840	$4,130	$780	$3,990	$760	$4,310	$670	$3,690
Capital storage costs (per ha)	$10,500	$47,240	$9,390	$42,250	$11,170	$50,250	$7,380	$33,220
Total capital cost ($/ha)	$21,620	$64,730	$13,620	$50,700	$15,990	$59,900	$10,070	$39,600
Operational energy costs (Year 1)/ha	$410	$610	$90	$130	$100	$130	$50	$80
Maintenance costs (Year 1)/ha	$160	$430	$90	$340	$130	$380	$70	$290
Total operational/maintenance costs (Year 1)/ha	$570	$1,050	$170	$460	$230	$510	$120	$370
Capital PV	$20,400	$61,100	$12,800	$47,800	$15,000	$56,600	$9,600	$37,400
Annual O&M Present Value	$8,200	$15,500	$2,400	$6,600	$3,300	$7,100	$1,700	$5,200
Total Present Value (PV) per ha	$28,100	$75,800	$15,100	$54,100	$18,000	$63,200	$11,100	$42,300

Table 8-3 compares each of the four proposed schemes assuming the storage is replenished fully over winter months (i.e. each irrigation season is entered with a full dam). This generally increases the amount of land able to be irrigated substantially, and in most cases decreases the capital cost per hectare to build.

Table 8-3 Summary of costs of the four proposed scheme options, with storage volume assumed to equal the annual demand.

	Kaipara		Mid-North A		Mid-North B		Mid-North C	
	Base	Max Risk	Base	Max Risk	Base	Max Risk	Base	Max Risk
Total area (ha)	6,300	6,300	1,600	1,600	1,700	1,700	2,000	2,000
Storage volume (Mm^3)	30	30	6	6	7	7	7	7
Total capital cost ($M)	$108.1	$342.6	$18.0	$64.0	$29.9	$81.5	$27.2	$91.1
Capital pipe costs (per ha)	$7,280	$9,470	$3,380	$4,430	$7,370	$9,620	$5,100	$6,650
Capital pump costs (per ha)	$540	$2,720	$800	$3,930	$710	$3,420	$1,300	$6,500
Capital storage costs (per ha)	$9,470	$42,600	$6,880	$30,980	$7,790	$35,040	$7,200	$32,400
Total capital cost ($/ha)	$17,280	$54,780	$11,060	$39,340	$15,870	$48,080	$13,600	$45,550
Operational energy costs (Year 1)/ha	$270	$400	$90	$130	$80	$110	$190	$290
Maintenance costs (Year 1)/ha	$120	$320	$100	$330	$130	$340	$130	$460
Total operational/maintenance costs (Year 1)/ha	$390	$730	$180	$450	$210	$450	$320	$740
Capital PV	$16,300	$51,700	$10,400	$37,100	$15,000	$45,400	$12,900	$43,000
Annual O&M Present Value	$5,500	$10,600	$2,500	$6,100	$2,900	$6,400	$4,500	$10,700
Total Present Value (PV)	$21,500	$61,700	$12,800	$42,900	$17,700	$51,400	$17,100	$53,100

Table 8-3 assumes that the storage volume is equal the demand i.e. high flows captured within the wet months, and zero replenishment during dry months.

This is considered extremely conservative as the nature of Northland weather would almost certainly enable replenishment at some level throughout the irrigation season. This would further decrease the cost per hectare to build, due to the need for less storage or a greater scheme area.

Further investigations could examine different scenarios such as reduced reliability or different harvesting regimes that would further reduce the cost per hectare to build. For example, the cost per hectare for Kaipara in Table 8-3 is $17,280/ha which was based on $29.2Mm^3$ of storage being required. Should the storage volume be reduce to $20Mm^3$, or 70% of annual demand (assuming some replenishment) this reduces the cost per hectare by almost $3,000/ha potentially making the scheme more affordable to previously economically marginal land use.

8.3 Cost impacts of utilising an existing lake/reservoir resource

The cost of constructing water storage for irrigation from scratch makes up approximately 75% of the capital cost of each of the schemes being considered in Northland. It is therefore appropriate to consider the opportunities associated with utilising an already existing water body to lower this cost component.

8.3.1 Kerikeri Irrigation Scheme dams

The water resource stored within the existing Kerikeri Irrigation Scheme dams are almost certainly not fully utilised. The volume of potentially unused water is currently unable to be quantified, however, it is understood to be a mix of un-allocated water and under-utilised (but allocated) water.

Potential capital cost benefits of using an existing lake/dam could be assumed to be a saving of $2M per 250ha of irrigation development (or greater, depending on risk profile adopted at this early stage). This is assuming that developing 1,000,000m^3 of storage at a base rate of $2/$m^3$ would equal $8,000/ha (assuming 4,000$m^3$/ha annual average allocation).

As the cost of storage is approximately 75% of the estimated capital costs of the Mid-North C scheme (scheme expanding the existing Kerikeri Irrigation Scheme), reducing the amount of new storage required through utilising existing storage will have a significant impact on the cost per hectare to bring further land under irrigation.

However, the majority of the proposed scheme command area is above the existing dams and subsequently, will have higher pumping requirements than much of the existing scheme. The existing scheme is also currently configured to supply water at the rate required for horticultural land use and currently operating in two distinct parts i.e. not all plumbed together. Whilst the cost of storage may be significantly reduced, there will be some hydraulic challenges to overcome should the existing storage and plumbing wish to be utilised in any form.

Based upon the previous comments, it is likely capital costs per hectare for expansion of the existing Kerikeri scheme could be considerably less than $10,000, inclusive of distribution and pumping, for some parts of the command area.

8.3.2 Lake Omapere

As outlined in Section 7.4.3, raising the level of Lake Omapere could provide storage for an irrigation scheme, either, the Mid-North A and/or Mid-North B Scheme areas. The construction costs are likely to be relatively cheap because the existing lake and surrounding area would only need to be altered slightly to provide enough volume for irrigation needs.

8.3.2.1 Raising the level

The lake would need to be raised slightly, inundating a small area of land around the perimeter and a piece of low lying area to the south-east corner of the lake. This area of marginal, flood-prone land could be either sacrificed (or part of) or protected by a constructed bund which could be ~1800m long. The lake also needs to be regulated at the outlet to control the lake level/storage and manage any environmental downstream requirements.

Conservatively, capital costs in in the order of $0.85–1.5M will be needed to raise the lake by 1m and 2m respectively. This is assuming fill had to be imported and placed to construct a bund to raise the lake by 1m (3m crest with 1:3 batters) at $30/$m^3$ and with an expected construction cost of $324,000. Similarly, raising the lake level by 2m would could expect a construction cost in the order of $972,000. An outlet control structure is expected to cost in the order of $500,000.

8.3.2.2 Residual lake levels

It is also assumed that a certain level is always maintained in the lake and not all the volume is used for irrigation purposes. Assuming that 0.5m depth of the raised lake (1200ha area) was available for irrigation, regardless of level raise, this could potentially provide reliable irrigation water for approximately 1500ha (based upon average demand of 4,000m^3/ha annually). The resultant capital cost per hectare for storage based upon a 1m lake raise can subsequently be calculated as $566 per ha ($0.14/m^3) or for a 2m lake raise, $1,000 per hectare ($0.25/m^3). This is rather ‘cheap’ storage compared to an average rate of $2 being considered in Table 8-1. Even if the available resource in Lake Omapere is significantly less than assumed, the cost per hectare is still going to be significantly less than the assumed base rate for other schemes.

8.3.2.3 Viability

The biggest influence on whether this resource is viable or not, will be the policy around harvesting the water, as the catchment area of the lake is small (even though the surface area of the lake is large).

However, if policy overly restricts the ability to take water from the lake, other considerations such as pumping water from the upper catchment of Waitangi River in high/flow, along with the viability of increasing the catchment of Lake Omapere through hill-water diversion canals should be considered.

Lake Omapere is located at a higher altitude than many of the other water sources being considered for the Mid-North A and Mid-North B schemes. This has a positive impact upon the operational costs of the scheme as there are less pumping costs to get water to the areas needed.

Based upon the above, it is highly likely that capital costs could be expected to be considerably less than $10,000, inclusive of distribution and pumping, for some parts of the command area if Lake Omapere can be utilised for water storage.

8.4 Costs of on-farm irrigation infrastructure

This high level scoping study does not review specific farm level irrigation infrastructure costs or requirements however Table 8-4 provides an indication of the type of capital costs that could be expected on-farm.

Table 8-4 Example on-farm irrigation infrastructure costs (Lincoln University, 2016).

System type	Price range (per ha)
Rotary boom	$3,200 - $3,800
Fixed boom	$3,500 - $4,100
Centre-pivot	$4,000 - $4,700
Lateral move	$4,000 - $4,800
K-Line	$2,200 - $2,700
Long lateral	$2,200 - $2,700
Guns	$3,500 - $3,800
Set sprinklers	$3,500 - $5,500

Most Northland dairy farmers have invested in land application systems for Farm Dairy Effluent (FDE). Opportunities to utilise this existing infrastructure is likely to be limited from an irrigation point of view. There are however, opportunities for infrastructure to be specifically designed for dual purpose in the future which can be beneficial. For instance, a centre pivot can apply FDE over a larger area at a lower rate. This has environmental benefits as well as being less labour intensive as moving pods or travelling irrigators.

8.5 Further refinement

To refine and improve this analysis, further work needs to be completed to better understand the following:

- Review the current models and assumptions.
- Better define the risk parameters.
- Storage locations. Requires site specific investigations and optimisation of river supply versus irrigation demand.
- Determined how river flow restriction rules be adjusted, i.e. explore the possibilities for water to be harvested during high flows and simultaneously act in a flood control capacity.
- More accurate determination of where the most suitable route for the pipes is required and where pipes cannot be installed.
- More accurate determination of where irrigation is required and where the farm offtakes would be.

9 Commercial analysis

There are fundamental questions that need to be asked about establishing irrigation scheme infrastructure in Northland that may help galvanise thinking on what the best pathway forward should be. Those questions are effectively about the ability to fund the necessary capital and the ability to make a commercial return on the investment.

To answer commercial affordability questions needs very detailed information on the investment objectives of the funders compared to the water users along with the wider community. That has been captured in the MCA process that, maybe surprisingly, didn't set affordability at the top of the priorities.

A full commercial analysis has not been conducted and the comments below do not represent a due diligence opinion that could be relied upon by an investor. It uses only the rough order costing generated around the critical elements such as the storage capital and energy operational costs estimates. These show considerable uncertainty and hence a range between the upper and lower bounds (Table 9-1) due to the limits of the information. The revenue earning capacity of the land use, whilst based on sound reasoning, assumes much about future land use change, crop mix, rate of development and the influence of many external factors such as international market price trends. The uncertainties in these assumptions are all cumulative and broad at best.

For the four proposed scheme options that are presented in this report, many of these funding options have been discussed at the community stakeholder meetings. The views are wide but generally have focused on the intergenerational community outcomes at whole of economy level rather than affordability, measured as a return on the capital.

9.1 Capital costs

Firstly, the relative total capital cost of each scheme need to be considered in the context of the whole as a development proposal. The approximate total capital is $183m. This would provide highly reliable water supply to approximately 11,600ha of land. Putting this in the New Zealand context this is not an overly large total irrigated area and yet would sit comfortably compared to other schemes developed in New Zealand, many of which are much larger in overall scale. As a comparison the total expected irrigable area in New Zealand is in the order of 1,000,000ha with more than 600,000ha of that already established. So a further 11,600ha proposed in Northland may be a substantial opportunity for Northland but is small in the context of demand on capital funding. Thought will need to be given in the next stages in the process to minimise transaction costs, particularly, if the development is completed in stages

The analysis from Stage 1 is still supported and an increase in irrigation would make a measurable difference in the Northland economy (as increase in GDP and employment numbers).

Table 9-1 Taken from Table 8.4 and assumes storage equals demand scenario.

	Area (ha)	Capital cost ($M)
Kaipara	6,300	108.1
Mid-North A	1,600	18.0
Mid-North B	1,700	29.9
Mid-North C	2,000	27.2
Total	**11,600**	**183.2**

The storage capital cost is the single most significant issue but at this stage, having no specific design or site investigation, the best that can be done is use rule of thumb costing based on previous schemes that have used a number of different construction methods. The ideal storage site would likely be an on-stream dam of a steep deep valley where a small wall will impound a large volume of water. The cost per m³ of water stored based on this style of construction could be in the order of $2/m³ putting it at the lower end of the cost envelope. If however the only available storage is within the scheme itself i.e. on the irrigated plains then adopting a "turkey nest" dam where you have to build four walls will push the costs toward $4.5/m³ or higher especially if there's no natural lining material to seal the dam. Synthetic liners on large scale dams would push the cost to over $10-15/m³ so these weren't contemplated this end of the scale.

The counter issue to the relatively simple steep deep dam wall is the construability within the overall scheme development timeline. If the total dam structure needs to be built and complete to allow the first flow of water to the first user then a large up front capital commitment needs to be made in one hit. The timing of revenue will be affected by the number of people ready to take water.

From the capital figures, the storage capital and the operating energy costs can be seen to produce the most sensitivity in the overall whole of life costings. The distribution network itself, the pumps and pipes and the R&M of these, are less significant and further design optimisation would likely reveal a tightening of those figures.

9.1.1 Uptake

It is likely logical that a detailed financial analysis will show it is critical to get water user commitment early and that early uptake of water commences so that a revenue stream can be established. If the community has taken "ownership" of the project then the risk could be lessened compared to if the water users are just customers of a scheme to pay as they use water. Under this scenario the level of upfront capital risk becomes significant.

Contemplation of making the storage construction in incremental phases has some merits if you only need to build what you need as the demand grows. Some water users may only want to commit to the additional land use change costs when they see their neighbours succeeding. Many will have different personal financial circumstances to support the level of commitment to change necessary.

To build only parts of the storage volume needed with an in-stream dam is complex. It's hard to come back later and raise a dam if that wasn't contemplated in the original design and likely poses supply disruption. The cost of a staged large dam likely climbs so may have limited advantage. Incremental storage construction would more likely be in smaller individual distributed turkey nest dams spread across the command area. As discussed above these are likely overall more expensive to build but may allow incremental funding to be raised and reduces the time that full capital level has to be financed. A simple analysis would suggest deferred construction would have some small financial advantage but probably a larger impact on reducing risk.

9.1.1.1 Kaipara example

Table 9-2 is a simple analysis of a deferred capital work programme to show the slight benefit in whole of life cost of building several smaller dams rather than one large storage. The complication is knowing what rate to adopt for the storage when you break it into smaller stages. The stages that have adopted for comparison are shown in this table.

Four scenarios for the Kaipara scheme are shown as an example in Table 9-2. These scenarios assume:

- Scenario 1 assumes building 100% of the storage now at the cost of $2.0/m³.
- Scenario 2 assumes building 50% of the storage now at the cost of $2.0/m³ and risk building the remainder of the storage at a later, higher price of $4.5/m³.
- Scenario 3 assumes building 100% of the storage now at the higher price of $4.5m³.
- Scenario 4 assumes building 50% of the storage now at the cost of $4.5/m³ and the remainder of the storage at a later time where the price remains $4.5/³.

If like in Scenario 1 or 2 the cost to build storage now is cheaper, the cost of the second stage being at a higher rate is more significant than the ability to defer the construction. If like in Scenarios 3 and 4, the storage is all going to cost the same regardless of the staging, it reveals a slight advantage in overall costing.

Table 9-2 Example of cost parameter scenarios for the Kaipara scheme assuming 6,300ha and 29.6Mm³.

		Kaipara No Restrictions			
Description		**Scenario 1**	**Scenario 2**	**Scenario 3**	**Scenario 4**
Storage cost / m^3: Ranges from ideally situated locations using local material to artificially lined "turkey nest" storages**.**	Now	$2.0	$2.0	$4.5	$4.5
	Later		$4.5		$4.5
Storage NPV ($million)		$55.8	$84.2	$125.7	$119.1

It must be remembered that these scheme capital costs are based on earlier assumptions around the volume of storage needed to achieve a high level of water supply reliability, close to 100%. Reliability comes at a cost. If a lower level of reliability was acceptable, say 80-90% then the overall scheme capital figure would be significantly lower with likely a small reduction in long term crop productivity. The effect would be more profitability at the farm gate but needs a higher acceptance of production failure risk in dry years. 80% reliable is the equivalent of having insufficient water available one year in five, while 90% reliable is one year of insufficient in ten.

9.2 Commercial return

Table 9-3 to shows examples of how various crop types may enable each scheme to cover its direct costs. It assumes that the cost side covers the capital for the storage and distribution, the operational costs for supply and the debt servicing on the capital. In addition each land use will have establishment costs and some of these are substantial, such as the licencing required for say gold kiwifruit. The ability to sell the produce assumes that market access has been established and that a reasonable price position is achieved, however there will be a range in returns which is shown.

This shows that some land uses (dairy and green kiwifruit) may be marginal in respect to their ability to generate the revenue to cover the whole of the capital costs of the scheme. This analysis assumes that the annual demand is the same size as the volume of storage and as such assumes no constraints on the water availability or consented takes. Further information is required to make a full assessment of some of the crop types.

Only the large scale land uses such as avocadoes and kiwifruit have been included in this analysis. A much smaller footprint but higher intensity greenhouse production base also requires water but at minimal volumes due to the virtual closed cycle systems able to be adopted. This also applies to the industrial use of water with a relatively small footprint and low overall volumes but needs reliability of supply to generate very high output from that water. The ability to pay for the water increases.

Table 9-3 Summary of land use types and estimates costs and returns for each scheme option.

	Mid-North A			Mid-North B				Mid-North C		Kaipara		
Scheme capital (per ha)	$11,060			$15,870				$13,600		$17,280		
Debt servicing, 30yrs, 6%	$803			$1,153				$988		$1,255		
Operating costs	$180			$210				$200		$390		
Annual water charges	$983			$1,363				$1,188		$1,645		
	Avocado	Dairy	Kiwifruit (gold)	Avocado	Dairy	Kiwifruit (gold)	Kiwifruit (green)	Dairy	Kiwifruit (gold)	Dairy	Avocado	Kumara
Enterprise establishment cost	$60,000	$10,000	$395,000	$60,000	$10,000	$395,000	$450,000	$10,000	$395,000	$10,000	$60,000	Not available
Debt servicing, 30yrs, 6%	$4,359	$726	$28,696	$4,359	$726	$28,696	$32,692	$726	$28,696	$726	$4,359	Not available
Total enterprise cost	$5,342	$1,710	$29,680	$5,722	$2,089	$30,059	$34,055	$1,915	$29,884	$2,372	$6,004	Not available
Farm gate returns - low	$16,000	$3,800	$76,000	$16,000	$3,800	Not available	$50,000	$3,800	$76,000	$3,800	$16,000	Not available
Farm gate returns - high	$48,000	$8,100	Not available	$48,000	$8,100	$76,000	Not available	$8,100	Not available	$8,100	$48,000	Not available
Production costs - low	$10,000	$2,375	$40,000	$10,000	$2,375	Not available	$35,000	$2,375	$40,000	$2,375	$10,000	Not available
Production costs - high	$30,000	$4,050	Not available	$30,000	$4,050	$40,000	Not available	$4,050	Not available	$4,050	$30,000	Not available
Gross profit - low	$658	-$285	$6,320	$278	-$664	Not available	-$19,055	-$490	$6,116	-$947	-$4	Not available
Gross profit - high	$12,658	$2,340	Not available	$12,278	$1,961	$5,941	Not available	$2,135	Not available	$1,678	$11,996	Not available

9.3 Investment

The commercial analysis needs to take into account the investors risk appetite. Successful schemes to date have often had an “angel” foundation investor who sees the long term intergenerational goal but had the financial substance not to see a return on the investment for some time, if ever.

There needs to be a point at which a scheme can be started and there is normally an acceptable trigger point for a go now decision. In some cases there may only be 30-40% uptake at the commencement of the discussions, and some schemes have been immediately at 90% uptake or even oversubscribed.

The long term benefits may lag the investment by a considerable period due to time it takes to bring crops into production, shift from remote to local processing and gain market dominance as a reliable supplier i.e. shift away from being small price takers to being price leaders. This is very dependent on how the stages for investment is set up. If you have to commit to the whole investment up front you are exposed for longer compared to incrementally development and maximising the benefits from the existing supply chain.

The wider benefits for additional community infrastructure such as ports as well as roads and the essential supply routes to ports for export and from ports for inputs (fertilizer, packaging) may open up an interest from Auckland and Tauranga bulk handling locations and their respective well-funded Councils.

This suggests that a development strategy needs to take a long view, way beyond short term [election] cycles that often drive the sort of community outcome that is suggested. How can a period of intense public sector investment that will be needed to break the socio-economic situation be shown as beneficial if the time taken to realise the change in the community takes 10-20 years. The benefits may be substantial in the cycle over a period as long as twice the length of a resource chosen i.e. 2 x 35 years. The stability of the base investment that is needed and the removal of the need to pay down debt capital needs longer term expenditure decisions outside the scheme itself.

There is a clear message from the community engagement workshops that the whole of the capital costs of developing a scheme should not be solely covered by the water user as there are flow-on benefits within the community and would suggest a cost distribution is needed.

All the external expenditure happens in the local community and wider economy so is measurable as improvement in GDP. And there is a perception of buoyancy in the community with things happening.

As part of spreading the cost burden for a whole of economy outcome there may be some argument for a differential charging system where by those who can afford a higher charge pay more compared to the marginal users. The argument for this apparent inequality is that without a range of land uses that create overall demand for water the scale of any one scheme may drop below a feasible level and therefore not proceed at all. Taking a wider view leads to a wider set of benefit.

If driving the community forward through the opportunities that agri-sector activity may allow is accepted then it needs to start soon and needs to have the patience for intergenerational outcomes. That sits nicely into iwi thinking patterns, where as long as the capital is not eroded then the benefits are likely to be worth the wait.

There may be private investors who take a whole-of-community approach through philanthropic contributions to kick start the activity and have very long terms expectation on returns and favour the community outcome above all else.

The issue to consider with the prioritisation exercise is it is looking at the schemes individually. Would doing just one of them make enough of difference to the Northland economy as a stand-alone project? The issue of scale comes into play here that would challenge if a small development would trigger the secondary and tertiary activities to be justified. Establishing just say a single 1,600ha scheme may not drive much change at all, albeit would benefit a small number of farmers.

Although commercial analysis at this stage is likely to raise more questions than it answers, it provides a useful starting point for further analysis and focuses the need for additional detail into particular areas.

9.3.1 Staged development

Other schemes that uptake to the full scheme capacity doesn’t happen early. In fact, some schemes have only reached 30-40% of uptake potential by the 5th year after construction. It is easy to contemplate not achieving full design capacity until year 10 or even 15 for a scheme that essentially has an operational design life of up to 80 years.

If the scheme is developed incrementally and only the cost of supply is covered (i.e. the O&M costs) and not a return on the capital investment then having a community who make returns on their own irrigated farms many be the strongest case for advancing. This needs a very well structured long term masterplan covering land allocation, water allocation plans and funding models that are not undermined by subsequent loss of focus or inadvertent outcomes. Ensuring the masterplan is adhered to needs an overarching agency that is tasked and mandated with ensuring the long game is adhered to.

This masterplan needs to ensure that staged development is anticipated in long term policy around water allocation so that the water is not allocated in a way that detracts from the long objective, but also allows those who ae ready now with smaller individual development to advance as and when needed. The establishment of distribution albeit less of a cost component may also allow staged development, build only the part of the network needed according to the demand. Land use designations may need to take a long term view on dam and inundation footprint, network corridors, and ensuring the best land is keep for the rural productivity and not inadvertently lost to other developments.

It needs to be considered whether the total capital across all four scheme options (estimated at $183) can be funded from a single source, or, whether funding from the water users or if more complex models for wider community and government investment is needed. The Regional Council and Central Government have an interest in what funding requirements might be, as an investment (assumes a return on that investment is possible) or as an enabler for others to participate in a wider community outcome. From discussions within the sector and specifically with stakeholders the availability of funding if the deal is right is not a limiting factor. It is the nature of the deal that is the issue.

The Tasmanian Irrigation Ltd funding model looked at the long term net cashflow in an irrigation scheme investment to see if the sales of water would cover the operating costs of a scheme development including servicing the finance charges. They also looked at what could reasonably be afforded by the farmers based on assumed crop mix and farm gate returns. The difference between what could be afforded and what the investment needed to return helped set the market rate for the water and what might be attractive to external investors into the schemes. The Australian government played a large role as the foundation investor (up to 70% of capital requirements) with the intention that once established the schemes were returned to the community to operate.

Only the four proposed scheme options have been considered in in this commercial analysis. However a development entity may also revisit some of the priorities outside these districts and provide the necessary capital funding for say the Far North and areas around Whangarei where smaller schemes may become attractive especially as water allocation plans are modified.

10 Community analysis

The commercial aspects of the scheme discussed in Section 9, is only one of the many considerations that should be taken into account when considering the potential viability of the scheme options. The Tai Tokerau Northland Economic action plan (MBIE, 2015) states:

> *If the region is to achieve its growth potential, it will require persistent, long term commitment to the goals and outcomes that are articulated in this document. As we move along the journey we will need to refine, refocus and redirect our efforts. This is a living document that will be updated as a result of ongoing conversations and collaboration. Success will benefit us all but requires us to collaborate and play to our strengths; business, Iwi/Maori, community, local government and central government (MBIE, 2015).*

10.1 Stakeholder engagement

The development of an irrigation scheme in Northland requires inter-generational, community focused thinking to ensure the best overall outcomes are achieved. Therefore the project team has engaged with the local potentially affected communities throughout this study.

Some of the key challenges and opportunities identified have been discussed in Sections 10.2 to 10.8; and the details of the engagement process have been documented in a report compiled separately (Opus, 2017).

10.2 Social impacts

The Northland region is the most highly deprived region in New Zealand. While one-fifth of the country fall within the lowest quintile (i.e. highest level of deprivation) of the Deprivation Index 2013, within the Northland region alone over a third of the population fall within this category. The Deprivation Index measures the relative socioeconomic deprivation of an area, and does not relate to individuals. It encompasses the dimensions of communication, income, employment, home ownership, living space, support, and transport. The 'Mixed Fortunes Report' also found that Northland had the lowest outcomes in terms of educational success, youth unemployment, youth offending, while it also ranked poorly in terms of social hazards. It also consistently performs poorly in terms of work and incomes, and children and youth (Salvation Army, 2015).

The potential to significantly increase employment in the region as a result of the irrigation schemes, would have flow-on effects on society. The increased in demand for employment would include an increase in demand for a skilled workforce. This would have subsequent requirements for (further) training for employees, increase the permanency of employment available, and increase the potential for seasonal worker employment. It would have impacts on an individual and community level locally and regionally.

The associated social multipliers resulting from (more) employment, are benefits to individuals, families, neighbourhoods, and communities of. These include, but are not limited to: reduction in crime, drugs, and family disruption; increased and strengthened security; improved education, healthcare for the infirm and the elderly; and even environmental protection. Increased employment improves income distribution and reduced inequality, and can result in increased productivity. It can also stabilise business expectations and promote investment in the poorest communities.

There are mutually reinforcing dynamics, in that an increase in opportunities in one area increase the opportunities in others, i.e. the principle of cumulative causation may apply. For example, increased employment in the region can lead to improved health and education outcomes, as well as a reduction in the social costs of unemployment such as those related to drug abuse and family disruption. These reinforcing dynamics comprise a virtuous cycle of socioeconomic benefits.

10.3 Cultural Considerations

It is acknowledged that Northland is one of the most culturally diverse regions in New Zealand. As such, cultural considerations are going to be of paramount importance in the development of water storage, and irrigation, within the region.

The importance of these cultural considerations is reinforced during the engagement with the community. The ability for developers of the potential irrigation scheme options will need to fully consider this to gain a social licence to proceed within these communities.

The schemes located within the Mid-North are within the role of Ngapuhi. Approximately 30% of the Northland population identifies as Maori with the majority affiliating with Ngapuhi. Ngapuhi has not yet reached a deed of settlement with the crown which is often viewed as a risk due to the uncertain future. However, it could equally be seen as opportunity for similar reasons. Iwi in the Kaipara region are Te Uri o Hau, Te Roroa and Ngāti Whatua and have reached settlement.

In the future, targeted discussions, and investigations aimed at specific scheme configurations once they are determined, will be required to understand important cultural consideration and determine appropriate avoidance, remedial or mitigating measures in progressing any scheme.

Open communication with the right people, supported by appropriate studies such as cultural impact assessments and AEE, are critical to achieving the best outcome for all.

10.4 Employment

Irrigation schemes in Northland have a potential to significantly increase employment in the region. The more-detailed investigation of the refined potential scheme options confirm that even if the total area irrigated in these schemes totalled only 11,400 hectares, the direct employment on the growers' properties, namely the orchards and farms would total between 900 and 2,000 Fulltime Equivalent jobs (FTEs) (Opus *et al.*, 2015).

The land use types with the potential to create a large number of jobs per hectare are the horticultural ones; particularly the permanent tree crops with their orchard husbandry, and the large volume of fruit harvested. The large areas expected to be developed under irrigation for kiwifruit and avocados, and to a lesser extent citrus and tamarillo are expected to generate 80% to 90% of the additional jobs. The actual level depends upon the technology adopted and in particular the yield of fruit per hectare achieved.

Together with the employment in the packing, processing, logistics and transport, the total employment generated within the region is estimated to be in the range 2,500 to 3,500 FTEs.

10.4.1 Regional distribution of employment

The large increases in employment are predicted the areas suitable for horticulture. However the employment generated on-farm by beef, sheep and dairy support, and by dairy production will be spread around the Kaipara and Mid-North areas contributing to the ongoing viability of communities in the region.

Later schemes developed within the long-term water management and irrigation programme are likely to extend this strengthening of the rural communities further, with the associated improved social fabric.

10.4.2 Labour for horticultural enterprises

It is a significant concern in the Northland communities that one of the key requirements to expanding horticultural production in Northland is an increase in the availability of suitable labour for the work. This is likely to be borne out by the extent of the employment of Pasifika people in Northland through the Registered Employer Scheme. This was raised this matter in Stage 1.

There is a successful labour force scheme run through the Aupouri Maori Trust Board by the business and skills development group Kiwi Dot Com, Christine Snelling of Kaitaia. Unfortunately funding for this scheme was terminated when the Trust Board was disestablished.

The website of one labour service business that is run locally shows that this business owns a 24ha orchard and runs a contracting labour service for local orchards. This business has found that growing complementary crops including for example avocados, kiwifruit and berries under cover, enables horticulturalists to provide employment virtually year-round. This is potentially a major benefit to expanding employment in horticulture in the Northland region.

10.5 Farmer and community well-being

The impact that the security of being able grow produce, feed animals, and meet financial obligations, has on a farmers mental state should not be under-estimated. Droughts do not only affect farmers but also associated enterprises such as contractors, suppliers and retailers right through to the consumers of produce; and can lead to increased stress levels for all concerned.

With pressure mounting to increase primary industry exports, growing health and safety requirements and farming with tighter environmental limits, reducing the reliance on natural rainfall may provide a significant benefit by removing one of the major stressors. Suicide is a real issue associated to stress however it is often not directly addressed.

10.6 Transportation and Logistics

The expansion of the areas and production of horticultural crops in Northland, in particular of avocadoes and kiwifruit imply very significant increases in volumes of fresh product exported from Northland. As outlined, there are well-established post-harvest operators, and exporters involved with these products and others.

It can be expected that in future exports will reach the volumes which justify the international vessels calling at a Northland port; Marsden Point.

These decisions will be made for commercial reasons by the exporters and the international shipping lines, however policies and decisions are being made at national and regional government levels which may limit the opportunities for these more efficient transport options to be utilised in future (Ministry of Transport, 2014).

It would therefore be a relevant that the developers of irrigation schemes participate in the decisions related to ports, major road links and the like.

10.7 Environmental impacts through change in land use

This study was not commissioned to directly consider the environmental impact of irrigation and change in land use, however it is too important to note the following key observations:

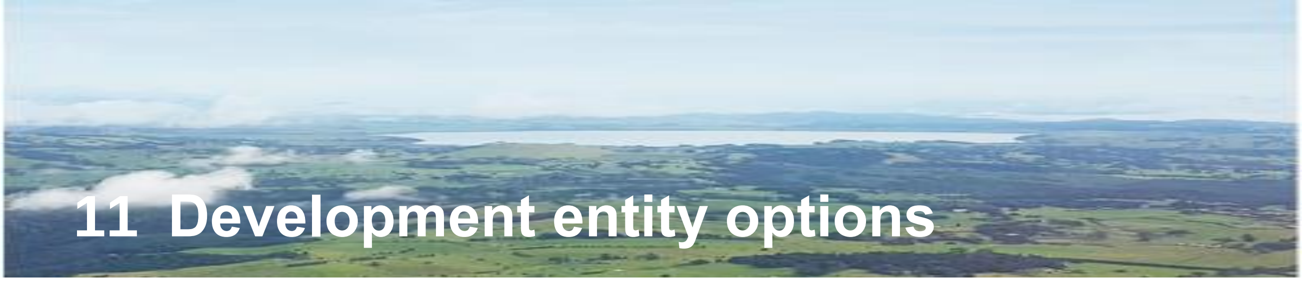
- Change in land use through availability of water will likely result in less Dairy Farms in Northland.
- Change in land use will likely tend towards horticultural uses where a greater level of precision and technology is typical utilised around nutrient management
- There is possibly quite a bit of land that could, through being under-utilised historically, could have organic status enabling focus upon this market.

10.8 Alignment with other community projects, initiatives or drivers

There are already many initiatives underway within the Mid-North and Kaipara communities. These include, but are not limited to:

- Tai Tokerau Northland Economic Action Plan
- Ngawha Geothermal Expansion and Industrial Park
- Mid-North Multiple Maori Land Blocks
- Integrated Kaipara Harbour Management Group
- Kauri Coast Water
- NRC Priority Rivers and Catchment Programmes
- Restoration of Lake Omapere
- Council long term plans (LTPs)
- Various Agricultural Initiatives such as Project 350;Northland Diversified Forages; and Feed system trials at Northland Agricultural Research Farm (NARF).

It is essential to ensure that any irrigation scheme aligns with, or at a minimum, does not disrupt development of, any of the other initiatives in the community. It is important for such opportunities listed above to be investigated and determined together to ensure the best outcome for the communities.



11 Development entity options

The objective of this section is to provide initial options as to the form of an appropriate development entity that will be able to carry any particular irrigation scheme or portfolio of schemes forward to an investment ready proposition.

Our experience in establishing and working with development entities in the primary and infrastructure sectors and examples of development entities that have been used to implement irrigation schemes in New Zealand and internationally provide useful insights into a range of possible options for this project to consider. This experience allows reflection of the strategic objectives for the project and design a range of pragmatic options for further consideration.

Therefore, the proposed approach to developing a range of options has focussed on designing options that are exclusive from each other to foster a rigorous debate on the merits of each so an informed decision can be made on the range of options to take forward for further consideration.

11.1 Methodology

STEP 1: BASE ANALYSIS

The purpose of this is to ensure that this analysis integrates and builds on all the findings of the previous sections of work so each development entity option considered is relevant to the key project considerations and the challenges and opportunities identified for each of the catchment areas. This has been achieved through discussions with the project team members to better understand the expectations of the irrigation schemes and the opportunities to grow value chains that provide benefits to the users of water – bearing in mind that the Northland region is not established in its use of water from irrigation schemes.

This study has also reviewed existing water storage entities (which are in a range of development stages from pre-construction to operations) and briefly present them as case studies with the view of learning from their experiences.

STEP 2: OPTION DEVELOPMENT

The objective of this phase is to design a broad range of Development Entity options for initial consideration by the project team. A description and scope of services for each Entity makeup will be developed along with the strengths and weaknesses of each against the high level requirements prepared in Phase 1.

11.2 Case studies

Various selected case studies from both within New Zealand and in Australia have been reviewed and are included in Appendix J. Analysing these case studies provides insight into the various approaches taken to developing an irrigation scheme (or portfolio of schemes) and allows an understanding of the factors which contributed to their individual success.

It is important to note that there are numerous irrigation schemes and development/governance models which exist across New Zealand and Australia. Several of these have been selected which demonstrate some of the different considerations which will likely be relevant for any irrigation development in Northland. Development of irrigation in Northland will have its own unique requirements and therefore no single model currently in existence is likely to deliver on the requirements of the region and therefore considerations of attributes of existing schemes is relevant.

11.2.1 General observations

Many of the larger schemes which are in operation such as the Rangitata Diversion Race were built some time ago and under different circumstances. Many of the more recent schemes have been developed and funded with a mix of farmer equity, local government funding and debt funding and with limited assistance from Central Government. The assistance which has been provided from Central Government has been from the likes of the then Sustainable Farming Fund (SFF), Community Irrigation Fund (CIF), Irrigation Acceleration Fund (IAF) where the funding provided has focused on supporting the development of the scheme and is not been directly linked to capital expenditure.

Many of the schemes across New Zealand which are currently under development use storage as a mechanism to increase the reliability of the scheme. There are a range of others which are also in the development pipeline which are run-of-river and are more subject to variances in seasonal water availability. Within all of these schemes there are two distinct types of development; Regional or Community.

- Community schemes currently under development are likely to be funded under the traditional co-operative approach using a mix of debt and farmer equity.
- The larger 'regional' size schemes are complex and involve multiple stakeholders and generate multiple benefit streams. There have been limited examples of these schemes being constructed and there remain a number of challenges going forward regarding the size, complexity and funding of the schemes. Notwithstanding the challenges there have been some major co-operative funded schemes such as Central Plains Water which has limited funding sources other than farmer equity.

Developing irrigation schemes are complex and take time. A range of smaller scale community and co-operative schemes have progressed and in some cases reached construction however progress on the larger regional scale schemes has been slow.

Often the case is that regional schemes have multiple benefit streams (environment, social, cultural, economic and financial) and therefore part of the capital cost contributes to other benefits than direct irrigation benefits. In addition there is subjectivity around the quantification of these other benefits and who should pay for them.

There are a number of large scale schemes that have been in the planning stages for extended periods, in some cases up to 10 years. Whilst extended development programmes are normal for large scale infrastructure projects, particularly those with a high public profile, progress towards bringing the projects to construction can be time consuming and costly.

11.2.2 Summary

Based on consideration and review of the case studies in Appendix J, the following are the key high level learnings:

- There is no "one size fits all" scheme design. The schemes that were studied are all unique and have their own idiosyncrasies which required suitable legal structures, ownership and governance arrangements etc. to ensure that the projects were developed and resulting benefits realised.
- Early and on-going sector engagement and communication is a relatively low-cost but highly beneficial activity to undertake. The schemes that were studied had varying levels of sector engagement and communication throughout the development and operations phases. In some instances this likely reduced the opposition to scheme development while in others it likely encouraged scheme uptake and / or capital raising. There is no question the development of irrigation schemes in New Zealand is contentious and bringing community and environmental groups on the journey of the development process is likely to yield more collaborative outcomes when projects near the construction stage.
- There is no guarantee that the market would develop as many schemes as wider society would like without some degree of local or central government intervention. There are examples of schemes that which have complex revenue and benefit streams which are sometimes hard to capture but nevertheless provide benefits to wider society in the form of jobs, culture, the environment etc. Possible interventions include mandates (e.g. schemes must be developed) and provision of capital (e.g. to fund entire schemes; to overcome the initial uptake risk but repaid over time).
- In the absence of sufficient in-house capability, it is important that experienced, adequately skilled, independent advisers whose incentives are aligned with the success of the scheme are used. Scheme development is a complex undertaking and without suitably experienced and capable individuals, schemes may not be developed.

11.3 Design principles for a suitable Development Entity

This section discusses the seven principles and or organisational characteristics that should be considered in designing a development entity for irrigation scheme development in the Northland region. The table in Appendix I discusses each of these characteristics in the context of the Case Studies.

Before discussing each of the organisational characteristics in more detail, it is worth noting that the presence of a particular characteristic may lead to the presence of another characteristic. For example, a limited liability company necessarily entails equity capital but does not preclude other forms of capital. However, such an ownership structure need not remain forever and there are several examples where it has changed over time.

It is also worthwhile noting that each of these characteristics should be viewed as a continuum, with bookends which differ markedly. Again however, where an entity falls on each of these spectrums can, and often does, change with time.

Lastly, the actual nature of the development options will ultimately dictate somewhat the final entity design insofar as a single scheme development would not require some of the characteristics that a portfolio of schemes would require.

11.3.1 Legal Structure

In this context "legal structure" refers to the recognition that an entity's organisational arrangements have under the law.

There is a broad spectrum of legal structuring options. At one end of this continuum is central or local government controlled entities (e.g. government departments and agencies, council-controlled entities) while at the other end is legally independent entities such as limited liability companies and limited partnerships. In between these book-ends, however, are a number of mixed-ownership models including cooperatives and publically-owned corporations.

The following section discusses advantages and disadvantages of a number of alternative legal structures.

In addition to legal structure, an entity must also decide upon its profit motivation, i.e. whether it is "for-profit" or for "public benefit." While for-profit entities seek to make maximize profits as the name suggests, public benefit entities may also seek to maximise profits but also consider wider societal factors which may at times run counter to this objective.

The Case Studies that were considered include both for-profit and public benefit entities as well as a range of legal structures as summarised in the table in Appendix J. The legal structures used are:

1 **Limited Liability Company** – privately held, publically held and a combination of both. Commonly used in many forms of business in NZ.

2 **Cooperative** – primarily owned by the direct beneficiaries of a particular scheme and are often managed as a cost centre and the value is passed back to the cooperative members as participants in a value chain;

3 **Limited Liability Partnership** – is an entity that has limited liability status but where the profits and or losses are accounted for at the ownership level;

4 **Not for Profit Entity** – this is used in NZ whereby the entity has community based principles and therefore does not have a profit motive and therefore is exempt from company tax.

11.3.2 Ownership

In this context "ownership" refers to who owns the development entity which may in turn own other development entities.

While ownership is often closely related to legal structure, this is not always the case. For example limited liability companies must always have at least one shareholder whereas cooperatives do not in and of themselves have any specific ownership requirements. In fact, co-operatives can be structured in a number of different ways all depending of the specifics of the scheme.

An entity's ownership can also influence the type of governance that is required. For example, a limited liability company with a number of shareholders is likely to have very different governance to that of a government department.

Similarly, ownership can also be closely related to capital and the financing structure. For example, if a large amount of capital is to be raised from the public, then a limited liability company may be the preferred option. However, to take advantage of taxes losses during the development phase, a limited partnership may be used.

However, ownership does not need to be related to the contribution of capital. Ownership could be created by law (e.g. an Act of Parliament), by mandate (e.g. transferal of schemes to another entity) or participation in the scheme (e.g. water entitlements). It follows that ownership can be conveyed in many forms (statutory ownership, shares, water entitlements), may provide different rights (e.g. voting, right to receive distributions) but could also entail certain obligations (e.g. conforming with the Companies Act). The following section discusses advantages and disadvantages of a number of alternative ownership structures.

For infrastructure investments such as irrigation projects one of the key considerations should be the ability to retain flexibility in the ownership structure so that different forms of capital can be introduced to the structure, as the structures matures

As with all of these characteristics, they can all change over time. The ease with which ownership can change depends at least in part upon the particular ownership model that is adopted at the outset. For example, in an extreme example it may be more difficult for a limited liability company with a number of shareholders to become a government entity than for a government entity to become a limited liability company.

There could also be a number of reasons why ownership does change, such as a scheme becoming operational or self-funding, it is decided that water users can best manage the scheme for themselves or capital is to be recycled.

The Case Studies that were considered include limited partnerships, a range of legal structures as summarised in the table in Appendix J.

11.3.3 Governance

In this context "governance" refers to the arrangements for governing the development entity.

From the Case Studies, a wide-variety of governance arrangements in place, from self-governing co-operatives to autonomously run companies which are ultimately accountable to government ministers. Also, there are examples of governance boards which work closely with local communities and stakeholders throughout the development and operational phases.

As discussed previously, the governance arrangements can be closely related to other organisational characteristics, particularly legal structure and ownership. For example, if there is a large degree of separation or autonomy from the owners (in an irrigation sense this should be also thought of as the water users), it is likely that the entity will need stronger governance arrangements than a situation where owners are more actively involved.

Governance arrangements may not only cover the day-to-day operations of the entity may also extend to general conduct of the entity in pursuing its objectives.

Given that existing ground and surface water takes are now generally limited across the country, future irrigation development will, for the most part, draw on more complex water resources and potentially involve civil engineering structures and distribution networks that are larger in scale than existing local scheme developments . This increase in scale and complexity has resulted in a recent change in development practice. There has been a shift away from local scale proposals led by farmer groups to larger propositions nested within regional, strategic water management initiatives.

11.3.4 Capability

In this context "capability" refers to the skills and talents of individuals and groups inside the development entity.

A wide variety of skills are required to successfully develop and operate an irrigation scheme, including:

- **Technical:** hydrological and civil engineering;
- **Financial:** accounting, financial modelling, financing, structuring;
- **Commercial:** procurement, project management, legal; and
- **Other:** public relations, communications, health and safety, environmental, cultural.

These skills are required at various stages of the development process including pre-feasibility, feasibility development and operation.

An entity may or not possess all of these skills in-house and may therefore opt to engage external advisers to assist, although not all entities will do so. Whether or not an entity possesses these skills in-house or is willing to engage an external adviser likely depends upon the size of the development pipeline (i.e. single vs. multiple projects), the size and scale of the investment, the complexity of the scheme, likely opposition to the scheme and, slightly cynically, the naivety of the developer. When external advisers are engaged, it is important that they are independent and that their incentives aligned with those of the development entity.

It is likely that an entity's capability increases as it becomes more experienced and progresses through the development process. If multiple projects are to be developed, it is possible that the level of reliance on external advisers may be able to be reduced as there is likely to be an enduring benefit to build capability and intellectual property in-house.

On the other hand, the use of the use of external advisers reduces the need to carry specialist capability in-house and also enables the transfer of risk. The following section discusses advantages and disadvantages of having capability in-house and use of external advisers.

Again, capability is likely influenced by the other organisational factors considered here, such as the organisational structure and the availability of capital – including the requirements of potential investors and the level of scrutiny/due diligence they expect from an investment opportunity. For example where direct benefits of an irrigation scheme are able to be linked to an individual water user, their threshold for due diligence may be different from an institutional investor for which the financial return is solely linked to the ability of water user to pay

The Case Studies that were considered include entities where there is considerable in-house capability and others where this is not the case as summarised in the table in Appendix J.

11.3.5 Capital

In this context "capital" refers to monetary amounts required to fund any aspect of a development, including pre-feasibility, feasibility, development and operations.

Capital is required to fund any initial feasibility and pre-feasibility work undertaken on an irrigation scheme. It is also required to fund any resulting development activities, such as the detailed scheme design and construction. Depending upon the commerciality of the scheme, on-going capital may be required to fund the operations, particularly in the earlier years as revenue from water users grows.

Upfront capital can come in a variety of forms including one-off, non-refundable government grants, equity investment in a variety of structures, debt funding or any number of hybrids. Similarly, on-going capital requirements may take the form of retained profits, operating grants, levies on water users or additional debt and equity funding.

In addition to the capital required to develop and operate irrigation schemes, capital is also to operate the development entity including funding any in-house capability and funding any governance requirements. Capital may also be required by irrigators to invest in on-farm improvements necessary to allow them to make use of the irrigation water.

The form that the capital comes in depends on a number of factors including the legal structure and organisational form, market conditions, and the commercial viability of the scheme and importantly the risk of the project. For example early stage capital used to investigate the commercial viability of projects may come from different sources to that which funds the construction of a project. That said projects which may use a cooperative funding structure (where benefits flow directly to water users) may provide capital throughout the development process (e.g. Central Plains Water).

The following section discusses advantages and disadvantages of a number of alternative sources of capital and capital structures. The Case Studies that were considered illustrate a number of these as shown in the table in Appendix J.

Like many of the other organisational characteristics, the capital structure may also change over time, as for example, initial uptake risk is overcome.

11.3.6 Value-Chain Proposition

In this context the "value-chain proposition" refers to any wider economic benefits that are available to the value chain as a result of the development of an irrigation scheme.

The primary motivation behind a number of the irrigation schemes that were considered was to enhance the local primary industry by increasing access to a reliable water supply. Several of these schemes also had wider environmental or cultural motivations.

In its broadest sense investment in irrigation infrastructure can support economic growth through:

- Increased production and better utilisation of existing resources;
- Diversified land use and a wider range of high value crops;
- Certainty of production and access to high value markets;
- Improved farm business risk management;
- Providing a buffer for regional and national economic risks from droughts and climate change; and
- More economic and competitive use of value-added processing facilities.

As noted the development of irrigation schemes is typically predicated upon increasing productivity by having a more reliable water supply, producing new, higher value products as well as enabling a degree of diversification. However, the benefits of successful irrigation schemes extend beyond the immediate water users right through the value-chain and may even get transmitted through the wider economy with a multiplier effect via through secondary industries, the purchase of local goods and services etc. This could be for multi dams.

Some of the schemes suggest the wider value-chain infrastructure should support well-functioning irrigation schemes. This includes locating processing plants, pack houses and transport and distribution hubs in close proximity to the irrigation schemes. This appears to have been more of a consideration in recent large scale schemes.

11.3.7 Organisational Flexibility

In this context "organisational flexibility" refers to the amount of freedom that an entity has at any point in time – e.g. multiple dams.

Each of the six organisational characteristics discussed above should not be considered to remain static over time. However, it is of note that they may, and typically do, change over time and the degree with which they can do requires any specified development entity to retain a level of organisational flexibility.

In the Case Studies that were examined, varying degrees of organisational flexibility have been seen. In one instance, a development entity had its objectives specified in an Act but was able to try and meet them as it saw fit. In another case, a development entity had clearly defined actions and activities but had limited flexibility in how it was funded.

Organisational flexibility too, can change over time and for a number of different reasons; from an irrigation scheme becoming commercially viable or / self-funding, to a government entity wanting to exit its investment and recycle capital to an entity transitioning to operations.

In the Case Studies that were considered, there were numerous examples of capital and ownership changing over time, capability changing over time as a track record of successful irrigation schemes was established and governance arrangements changing as ownership moved into a co-operative structure.

11.4 Option development and analysis

The purpose of this section is to identify a possible range of options owners, stakeholders and beneficiaries have to develop, deliver and manage potential irrigation schemes in the Northland Region (Table 11-1).

For each option, the list below was completed:

- Identified a range of development entities that are distinguishable from each other;
- Provided a high level description and structure for each;
- Document the strengths and weakness and key considerations to implement;
- Developing a set of criteria to apply when evaluating options;
- Undertake evaluation; and
- Document findings.

To differentiate the range of options with the objective of getting engagement and creative thinking around what might be a portfolio of Development Entities for consideration. Of the design principles above, the following were selected to develop the options:

- **Scope** – single or multi dam ownership
- **Integrated** – professional/retail investor or farmers or an integrated value chain approach
- **Shared Resources** – the entities are completely autonomous or the share collaboratively, back offices systems and process and collectively raise funds from government and third parties etc.

There is always variations on a theme and the following could be second order considerations to give greater variety as they could be a common and /or different response to:

- Funding from capital and debt
- Selecting governors
- Legal structures
- Capability

Table 11-1 Summary of advantage and disadvantages of ownership models.

Single autonomous dam ownership by a commercial / infrastructure investor	
Description	One dam, and a self-contained entity that supplies water to users. So a third party builds it for the community, and some public money may be used. The users may have a limited investment, but by and large they are customers of the scheme and it is there water rates that will effectively pay for the scheme overtime.
Advantages	Commercial focus, Capability, Access to funding sources
Issues	Affordability, Likelihood of getting underway, Buy in from water users, Potentially less focused on the environmental outcomes, Not all benefits of the scheme remain in the community, Ability to involve public funds
Single autonomous dam ownership by the farmers and or users of the water	
Description	They are building it for themselves. Farmers have 100% ownership of the scheme and are responsible for the funding and cost of running. Some public money may be used.
Advantages	Greater buy in, Farmers receive benefits, Focused on delivering cost effective and reliable water
Issues	Capability, Ability to raise funds, Ability to get all the farmers who need to be involved, committed, Council wanting to be involved
Integrated Value Chain	
Description	Farmers and other participants in the value chain have 100% ownership of the scheme and are responsible for the funding and cost of running.
Advantages	Greatest buy in, Wider sources of capital, Value chain receive benefits, Provides wider benefits than just increased agricultural production
Issues	Getting the value chain together, Complexity, Who funds external benefits
A portfolio approach	
Description	Whereby a number of water schemes collaborate and share capability, back offices systems and process and collectively raise funds from government and third parties. A holding company maybe formed to take on these collective activities and operating "subsidiaries" (wholly owned or not) would be formed underneath on a case by case basis – would focus on the water scheme itself with the beneficiaries of that scheme.
Advantages	Efficient use of resources, Greater participation from community, Lower risk /greater diversification across a number of schemes, Learnings could be shared
Issues	Ability of shared entity to meet all the demands – would have to prioritize, Complexity

11.4.1 Development entity options

In evaluating these options a set of criteria were developed. The weighting would have to be determined but at this stage it is assumed they are equally weighted.

In considering the options, the following criteria were considered as shown in Table 11-2.

Table 11-2 Criteria for assessing the options

Name	Short Description
Participation	To remain flexibility and provide opportunities for Iwi and community to participate in ownership and the solution
Best use of Capability	Best utilisation of a capability in the region as it is in short supply
Efficiency and Effectiveness	Efficient and effective use of resources especially in the earlier years
Likelihood of success	Will the model provide the resources when and where required to especially in the earlier years

11.4.2 Summary of the evaluation

Table 11-3 is a summary of the options analysis. This evaluation was undertaken by the project team and the results reflect the analysis that has been undertaken to date and where the decision making process is currently.

Table 11-3 Comparison of options

Option/Criterion	Participation	Best use of Capability	Efficiency and Effectiveness	Likelihood of success
Single autonomous dam ownership by a commercial / infrastructure investor	🟡	🟡	🟡	🟡
Single autonomous dam ownership by the farmers and or users of the water.	🟢	🟢	🟡	🟡
Integrated Value Chain	🟢	🟢	🟡	🟡
A portfolio approach	🟢	🟢	🟢	🟢

Where:

🔴 Does not meet this criterion

🟡 Partially meets this criterion

🟢 Substantially meets this criterion

The analysis is favouring a portfolio approach at this stage which assumes a multi-dam approach, and that investment will be required up the value chain by industry participants. This will allow value to be extracted from the investment in water storage and the potential role various the community groups could have in the overall project.

These assumptions may not hold true as the feasibility and business case continues to further investigate at a more detailed level the viability of the scheme, however, the evaluation to date is favouring a portfolio approach.

11.5 Summary of findings

The above evaluation provides insights onto the preferred and less preferred Development Entity options at this stage, however, as it has been regularly mentioned throughout this report, circumstance can change during both the prefeasibility, feasibility, funding and development stages and therefore the above evaluation are the results at this point in the process. All Development Entity Options have their strengths and weaknesses therefore, it is recommend that the range of Development Entities are continued to be explored as further investigation is undertaken and the evaluation revisited. For example, if it is finally agreed that the irrigation scheme is multi-dam then the ultimate Development Entity will be different if the scheme is only a single dam.

12 Prioritisation

This study has presented four consolidated schemes across Kaipara and the Mid-North ‘cluster areas’ (Section 6). The project team have considered the scheme attributes such as availability of water for irrigation (hydrology and policy analysis); the storage requirements; the soils, topography and suitable crop types; the market demand for these crops; the conveyance and pumping engineering solutions and associated costs; the affordability of each option; and potential development entities. The study has not determined any reason to exclude any of the schemes proposed.

Alongside this analysis the project team has begun to engage with the communities that will potentially be positively or negatively impacted by these schemes (Opus 2017). This ongoing engagement has identified attributes that the schemes must possess if they are to be accepted by those communities.

The development of a community irrigation scheme requires inter-generational decisions to be made. The comparison of these options has therefore undertaken a balanced approach by combining the scheme attributes analysed by the project team as well as those highlighted as important by the communities; rather than entirely focusing on farmer affordability and profitability. Such an approach will help ensure the best community and regional outcomes are achievable.

Multi-criteria analysis (MCA) was used in Stage 1 by the Northland Regional Council as an effective tool to prioritise the two regions, Kaipara and Mid-North (Opus *et al.*, 2015). The project team have again chosen to undertake a multi-criteria analysis (MCA) to assess and compare each of the scheme options against a range of criteria

12.1 Objectives

The primary objective of the MCA is to provide a structured framework to discuss and document the comparison of the four proposed scheme options.

It aims to prioritise the four proposed scheme options and present a single preferred option in an ordered list. However the main benefit is to compare the schemes and assess their relative strengths and weaknesses. This provides information about where there may be opportunities to review and adapt each of the scheme options to that the attributes align more with the essential scheme attributes.

An important part of the process is to initially determine the important attributes followed by ranking their relative importance to the ultimate success of the scheme.

The process has therefore also highlighted attributes that this study was not commissioned to review directly, however should be considered in future stages.

This MCA is not a screening process to determine feasibility; and it does not provide the final answer. It will inform decision-making on the relative future viability of the schemes

12.2 Process

12.2.1 Structure

A multi-criteria analysis follows a simple and well understood process. The adopted pre-defined methodology is detailed below:

1. Determine the criteria. The criteria on which decisions are made should first be established by defining desirable aspects of the scheme. The community stakeholder engagement has informed this stage as well as lessons learnt from other schemes in New Zealand.

2. Apply weightings to the criteria. In general, each of the criterion are not equally important. This second step allows greater importance to be placed on certain criteria during the decision making process.

The project team has determined weightings again informed by conversations within the community. These are largely subjective and will be subject to sensitivity testing.

3. Assess the options. Information about each scheme is submitted to participants who are then asked to score each scheme against the criteria using a numerical value. This is the part of the process that will require your participation.
4. Determine the final 'result' for each option. This is done by using the weighting (step 2) and the scores (step 3). The results shows the priority of the options.
5. Provide feedback. The outcomes are discussed and the process documented. The final scores will be subjected to a sensitivity analysis and feedback provided to the participants.

A copy of the proposed MCA questions are included in Appendix K.

12.2.2 Participants

The MCA was undertaken in early June 2017 by eight participants. The participants were:

- Members of the project team.
- Representatives from Northland Regional Council, Northland Inc. and Crown Irrigation Investments Limited.

The participants have been selected from outside of the communities of Kaipara and the Mid-North to remove conscious or unconscious bias towards a particular scheme. Additional people can be invited to undertake the MCA, however it is recommended that they remain independent and utilise this document as an information resource.

12.2.3 Criteria

The focus for comparison of the scheme options is on ensuring that implementation of the scheme would have support from the local communities. It is felt that obtaining the social licence to implement an irrigation scheme will, alongside environmental and cultural considerations be the critical factor in its success once the science, engineering solutions, market development and funding opportunities have been established.

The criteria has been determined based on discussions with the participants of the 'working group' meetings in early 2017. A list of 20 criteria have been proposed and are shown in Table 12-1.

12.2.4 Weighting

A key outcome of the community stakeholder engagement was a list of criteria and an assigned relative importance. The criteria falls into four key areas of non-negotiable attributes; environmental and cultural; scheme feasibility; future and ongoing success of the scheme; and the wider community impacts.

The weighting of the criteria has been determined based on the findings of this stakeholder engagement. There is some subjectivity to these values and a sensitivity analysis will be undertaken.

12.2.5 Confidence

There may have not been enough information to respond to every question in the MCA at this stage. However it is felt that the important attributes should still be included to highlight critical gaps and focus any subsequent studies.

The participants were also asked to provide a confidence level (High, Medium, and Low) alongside each of the criteria. This was related to how confidently the participant felt they could answer the questions. Alternatively, if participants didn't feel able to answer the question, it could be omitted.

Table 12-1 provides supporting information where the project team felt the participants would be restricted with their answers at this stage.

Table 12-1 Supporting information for criteria in the MCA

	Criteria	Proposed Weighting (%)	Supporting information
Environmental and cultural	The scheme must not have major detrimental impact to the environment.	7 %	It is not felt that there is enough information available to confidently answer this question at this stage. An Assessment of Environmental Effects (AEE) will need to be undertaken relatively early in the next stage of the process. However this is some information surrounding the water takes, and storage locations available which will allow a comparison to be made in the MCA.
	The scheme must not adversely impact culturally significant sites	7 %	Although the project team has gained some insight into the cultural importance of water for each of the schemes during the stakeholder engagement, further communication with the communities will be essential. An assessment of the impact to cultural sites should be undertaken early in the next stage of the process. Although the confidence in the answers may not be high, the known information should be suitable for a high level comparison to be refined as more information becomes available.
	The scheme must have environmental benefits	5 %	Some environmental benefits have been discussed during the stakeholder engagement meetings, however similarly to the detrimental impacts, the extent of this has not been fully explored in this study to date.
	The scheme must be resilient to climate change.	4 %	Adopting an intergenerational view has to take adaptation to climate into consideration. A complete review of the predicted effects of climate change for Northland has not been undertaken for each scheme proposed in this study; however the availability of water has been assessed. Additionally, it is well known that sea levels for New Zealand are predicted to rise and significantly impact coastal settlements; and the accepted change in rainfall is expected to lead to increased drought conditions alongside more frequent flooding events. The areas where the schemes are proposed already suffer from some of these issues that are predicted to worsen into the future.
	The scheme must provide some flood protection.	2 %	A compatible initiative of an irrigation scheme can be to provide flood mitigation. These opportunities have not been explored in this study and the storage options have only considered water takes from the river, not in river.
Feasibility	The community must be supportive of the process.	7 %	The current level of support from the community for each of the schemes can be compared after discussions within the community that have occurred as art of this study. Although this study has begun the discussions with the community, it is not felt that this is where it should end. Comparison of the future support for the schemes can be aided by considering the pathway of communication during subsequent stages as well as the perceived willingness of the communities to progress this work.
	The scheme must be affordable to users.	7 %	This study has completed a high level assessment of the affordability of the proposed schemes. Although further refinement of the costs associated with construction, maintenance and operating the scheme is required in a pre-feasibility study, the estimates are based on similar assumptions and therefore can be compared.
	The producers must become more profitable.	5 %	This study has not assessed the level to which the individual properties would become more profitable; however specific crops benefit more from irrigation which has been discussed.
	The scheme must be technically feasible.	4 %	This study has presented four scheme options which are technically feasible to implement. Comparison of solutions should consider the extent of the scheme, the pumping requirements and any possible alternatives.
	The scheme design must be easy to gain permissions.	2 %	This has not been specifically reviewed as part of this study, however information critical to the process has been identified. i.e. pipe routes, storage requirements, and location and volume of water take required.
Future success	The local community must have a presence within the ownership structure.	7 %	Discussion with the 'working groups' highlighted the desire of the communities to participate in ownership of the scheme. The study has explored a range of possible ownership structures.
	The scheme must enable economic development.	7 %	The study has investigated the impact of irrigation schemes on the economy in terms of employment and GDP.
	The scheme must have government support through infrastructure and market development.	5 %	The study has identified that such irrigation schemes do not need to be financially supported by the government in order to proceed and succeed. However, it is essential that there is support for the markets being expanded or developed as well as transport links for produce. The commission of this and the previous studies indicate significant government support for irrigation opportunities.
	The scheme must have an appropriate management structure.	4 %	The study has identified potential management structures that are feasible to be implemented in Northland. It is not felt that they can be confidently assessed as the management of each of the schemes can be approached in many different ways.
	The scheme must be adaptable to changes in markets.	2 %	An assessment of the market demand for current and potential irrigated crop production now and into the future has been undertaken as part of this study. The analysis has determined suitable crop types. However the willingness of the farmers to adapt to produce such crops has not been reviewed in detail at this stage.
Wider community benefits	The scheme must significantly increase employment opportunities for local people.	7 %	The number of people that could potentially be employed by the irrigation scheme has been estimated in this study. This does not include all of the related activities associated with packing houses and transport, or construction of the infrastructure, however there is sufficient information for comparisons to be made. Wider social improvements are considered separately.
	The scheme must create positive social change within the community.	6 %	This criterion is important but extremely subjective and there may not be sufficient information to answer the question posed in the MCA. However, consideration of the current situation within the local communities and the social differences that increased employment opportunities could generate.
	The scheme must not restrict other local opportunities and initiatives.	5 %	The study has identified some other initiatives within the region that could be complementary to development of irrigation schemes and some that may directly compete for water. Although all possible linkages have not been explored within this study, the other opportunities are relatively well understood.
	The local people employed by the scheme's properties must have appropriate skills or access to training.	4 %	It is not felt that this can be fully assessed at this stage, however consideration of what skills are required versus what skills or familiarity with the specific crop types proposed the community currently has. Additionally, the availability of training facilities can be considered.
	The scheme must provide a water supply for other uses outside of irrigation.	3 %	Other uses of water must be considered alongside the requirements for irrigation. Typically industrial and urban uses are a small in comparison; however this study has identified some significant users that would also benefit from a water supply with increased reliability in close proximity to some of the proposed schemes.

12.2.6 Structure

The participants were be provided with 20 questions based on the criteria in Table 12-2. They were required to respond to each question with a 'score'; a numerical value between zero and five. This value would be based on their opinion of how that scheme performs against that specific criteria. Table 12-2 presents the guidance for scoring.

Table 12-2 MCA scoring guidance.

Value	Guidance
0	The proposed scheme **does not meet** the criteria.
1	The proposed scheme meets the criteria, but **does not perform well.**
2	The proposed scheme meets the criteria, and **performs adequately.**
3	The proposed scheme **performs reasonably well** against the criteria.
4	The proposed scheme **performs well** against the criteria.
5	The proposed scheme **performs extremely well** against the criteria.

12.3 Results

The results below are presented to inform discussion at the final NRC Councillor workshop. They do not provide the final answer with regards to prioritisation of the schemes; it is only one aspect of determining the viability and ranking of the schemes.

12.3.1 Results

Each of the schemes have been scored and the results scaled to be out of a possible 100 (%). These results are as follows and are shown in Figure 12-1. There is little to distinguish between Kaipara, Mid-North A and Mid-North B and therefore further analysis was undertaken (Section 12.3.2)

- Kaipara – 76%
- Mid-North A – 75%
- Mid-North B – 74%
- Mid-North C – 65%

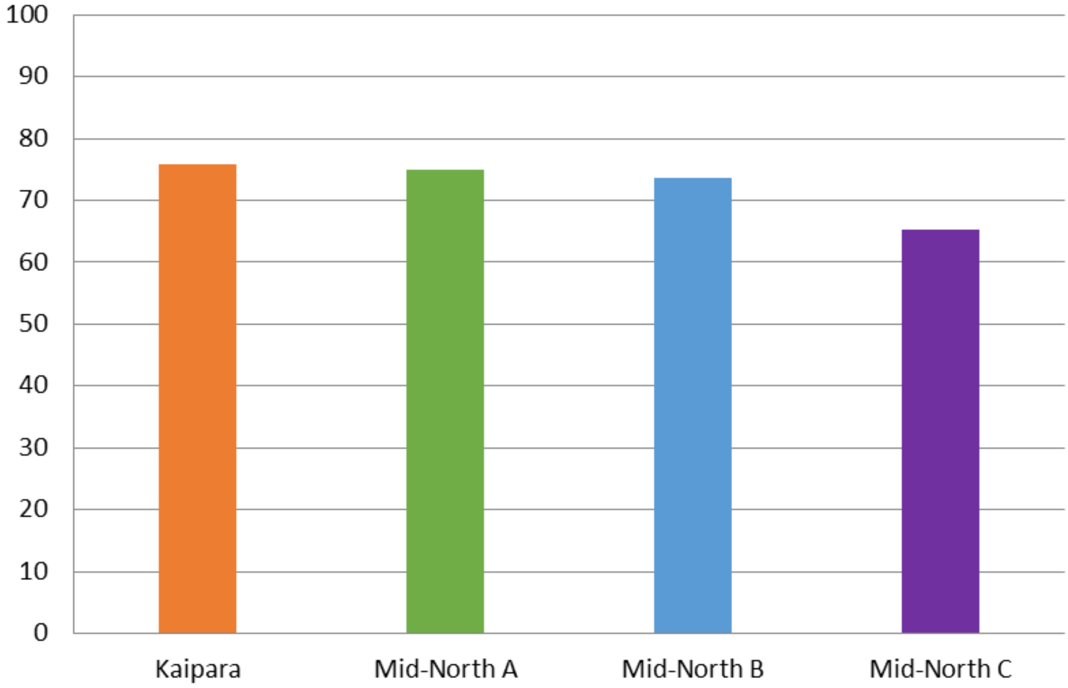


Figure 12-1 Results of the MCA using the weighting determined by the local communities.

12.3.2 Sensitivity

At each point in this study decisions have been made based on information available. This process can be repeated as more information becomes available, or adapted at area level to assess different technical irrigation scheme solutions.

The initial results of the MCA did not show a significant front-runner in the prioritisation process. Therefore a series of sensitivity analyses have been undertaken to better understand the data. This has included:

- Adjustments to the weighting values relative to other values.
- Adjustment to the weighting based on confidence.
- Adjustment to the weighting based on financial feasibility and success of the scheme.
- Analysis based on individual focus areas: environmental; feasibility; future success; and wider community benefits.
- Analysis omitting environmental and wider community benefits i.e. farmer focussed

Table 12-3 highlights the results from the sensitivity analysis. The blue highlights the highest score for each sensitivity analysis; the red highlights the worst performing scheme against the criteria for each of the sensitivity scenarios; and the green highlights those high scores above 75%, whether highest or not. The range is included to determine the significance in the highest and lowest scores.

Table 12-3 Results of the sensitivity scenarios

Sensitivity scenario	Kaipara	Mid-North A	Mid-North B	Mid-North C	Difference in top 2	Range
Original weighting	***76%***	***75%***	***74%***	***65%***	***1***	***11***
Confidence – based	77%	75%	74%	65%	2	12
Environmental only	75%	72%	73%	63%	2	12
Feasibility only	71%	76%	75%	68%	1	8
Future success only	72%	69%	69%	66%	3	6
Wider community benefits only	85%	83%	79%	64%	2	21
Financially weighted	70%	80%	78%	68%	2	12
No Environmental consideration	76%	76%	74%	66%	0	10
No Wider community benefits consideration	73%	72%	72%	65%	1	7
No Environmental or wider community benefits consideration	71%	72%	72%	67%	1	5

12.4 Summary

The initial results of the MCA did not show a significant front-runner in the prioritisation process. However the following points have been observed:

- Kaipara, Mid-North A and Mid-North B only show minor difference in the originally weighted scores
- Although the Mid-North C scheme scores highly on individual aspects such as existing skills, management and local ownership due to the existing Kerikeri Irrigation Scheme operation, it consistently scores significantly lower than the other three potential scheme options overall.
- The difference in percentage scores between the top two scheme options for each scenario was no greater than 3%

- The confidence was low when considering the environmental impact, implying that more detailed assessments should be undertaken to enable these questions to be revisited. The potential for environmental benefits was led by the schemes in Kaipara and Mid-North B. Excluding environmental benefits resulted in Kaipara and Mid-North A both on 76% (Table 12-3).
- In most cases, it was difficult to separate Mid-North A and Mid-North B. This may be due to their close proximity to each other and the potential to use the same water source.
- The confidence was high around the impact that these schemes would have on the wider community and the range of scores was high (Mid-North C at 64% and Kaipara at 85%). Kaipara and Mid-North A scored higher than Mid-North B, likely due to the proximity to, and impact they could have on Dargaville and Kaikohe respectively; and Mid-North C trailed behind, likely due to ability to influence a "step-change" within the Kerikeri community.
- One sensitivity scenario excluded wider community benefits and again showed no significant front-runner, although Mid-North C trailed behind the other three potential scheme options.
- The smallest range of scores was for the success of the scheme, implying that there are currently no perceived fatal flaws for any of the scheme options.
- Reviewing only financial and economic success of any scheme, Mid-North A and Mid-North B were significantly higher than Kaipara. This is likely to be because of the capital costs of the scheme in the Kaipara; the influence of a larger portion of high value crops to be grown in the Mid-North on the profitability of farmers; and the potential use of Lake Omapere.
- It is likely that if the Ngawha area had been included in Mid-North A rather than Mid-North B that several questions, specifically to the potential industrial park, would have been scored differently resulting in Mid-North A scoring slightly higher, and Mid-North B lower.

13 Discussion and conclusions

It is certain that the development of a community irrigation, or water management, scheme will have substantial positive social and eceonomic effects within a community. There are sufficient examples of this around New Zealand and overseas to give substance to this statement.

Water storage and irrigation could potentially also result in environmental benefits such as managing stream low flows, reducing ground water takes, and reducing erosion through sustaining ground cover through the dry months.

Through the stakeholder engagement it was clear that there was concern over the long-term future and prospects for many communities with the need to entice new industry and businesses to the areas. The pointed question asked “can we afford not to do this” within the stakeholder workshops indicate the lack of confidence in the long-term sustainability of communities. In Kaikohe and Dargaville this is evident through the static population.

Irrigation could pay a key part in a societal step change in the communities above, with the exception of Mid-North C who possessing an existing irrigation scheme is already reaping benefits due to the strong horticulture presence and generally thriving community.

Irrigation will do this through change in land use but it will take time for uptake to occur. Not having a reliable reticulated water supply is often seen as a deterrent to potential new industry so the development of water storage can only be positive in enticing other industry into town. This is currently an issue for Dargaville and will be an issue for the potential industrial park at Ngawha on the edge of Kaikohe.

Opportunities for these communities will go a miss without a reliable water supply for multiple purposes.

13.1 Social and economic benefit

The findings of this scoping study confirm the stage 1 findings that there are substantial social and economic opportunities to be realised through irrigation scheme development. However these numbers, estimated from scoping the proposed scheme options, are considerbly larger than the stage 1 estimates. The reasons for this are numerous with the main two reasons being the stage 1 work was mainly based upon industry data rather than on the ground specifics, and secondly that two of the key industries have made or experienced major changes in the last two years.

The 4 identifiable schemes and the potential benefits estimated in terms of value added and employment are summarised below in Table 13-1

Table 13-1 Potential Scheme GDP and employment increase.

	Kaipara	Mid-North A	Mid-North B	Mid-North C	Total
Total employment	950	500	650	600	2,700
Regional GDP ($ million per year)	$85	$70	$75	$96	$326

The stage 1 industry data gave conservative averages including the less intensive ‘heritage’ producers, sometimes characterised as ‘mom and pop’ producers. For the detailed investigation of the proposed scheme options the production realities of opportunities and current innovative practices on the ground have been investigated.

In the 2014-15 season, when the stage 1 research was being undertaken, the recent market and production experience for two main horticulture crops namely kiwifruit and avocados meant the long term outlook was not so good. Kiwifruit was still recovering from PSA uncertainty and avocados had a high volume exported driving the average export price down from $5,400 in 2013-14 to $4,600 per tonne FOB.

In the 2016-17 season, the prospects for both crops are very significantly better with Zespri having announced a significant expansion target, and some Northland growers showing the ability to significantly increase yields with production improvements such as fertigation. These increases in production are necessary to cover the increasing licence cost per hectare for kiwifruit.

Similarly the avocado industry is aggressively marketing cordinated export opportunities. This includes funding with a Primary Growth Partnership, assisting development especially of the Asian market. The average export value was $5,700 per tonne FOB in 2015-16. The new avocado orchard developments are planting at a higher density of trees per hectare.

These major improvements will result in higher volumes of product from kiwifruit and avocados per hectare and higher returns per tray exported. The higher volumes have increased the labour requirement in terms of reduced hectares handled per employee. The significant increase in the scale and value of horticultural activity will increase the range of upstream and downstream activities in the value chain, and thus the economic multipliers benefitting the region. The commercial reality also is that these improvements are expected to be reflected in the operations of most of the growers developing production under irrigation. These are reflected in the commercial assessments in Section 9 of this report.

13.2 Timing and momentum

Many elements, often with different or conflicting drivers, need to align for many projects or initiatives to get off the ground. An irrigation scheme is no different – timing is everything.

A recent example of this is there is already a lost opportunity in the Mid-North in regards to Top Energy who is constructing their own water storage for their geothermal expansion at a cost of ~$8 million dollars for 100,000m^3 of storage. This was a potential cornerstone customer for a scheme in the Mid-North.

Various farming and other initiatives requiring or involving water have been and gone, or are underway in the Kaipara and Mid-North. Too often these occur in isolation and/or parallel with each other with a compromise outcome the resultant effect. It should however, be appreciated that aligning local and central government timing and objectives with farmers, iwi, community groups etc. is not an easy feat. However, they all have important roles to play.

The risk is in regards to timing and/or loss of momentum specifically to irrigation infrastructure is that potential stakeholders get frustrated and/or impatient and look to develop private schemes. This not only causes potential conflict and/or competition for resources but it robs a community of the best outcome, the scheme of potential customers and great leaders with their drive to make something happen. Care needs to be taken not to dampen enthusiasm as the momentum these people can generate is important both from community and commercial perspectives.

Another consideration is that the Regional Plan is currently being updated. Ensuring alignment objectives of the Regional Plan, and future water storage schemes, could save the community considerable cost, time and frustration in the future so undertaking the next stages of investigations sooner rather than later could help inform new policy decisions.

The timing and cycles of the District Councils LTP processes need to be considered as there are likely synergies and interest between current district council projects and potential irrigation schemes. District Councils should want to understand and be involved in the process.

It has been observed that the indicative time frame that the TTEAP assigned to construction of an irrigation scheme, should it stack up, was 3 to 5 years which given the February 2016 release of the TTEAP means 2019 -2021. Given this was an ambitious timeframe, forward thinking and planning is required to seamlessly transition from this prioritisation stage to prefeasibility to enable this target date to be met.

Communication, forward planning and transparency are critical to achieve the best outcome.

13.3 Schemes

The findings within this study indicate that the likely cost of development of any of the schemes are not prohibitive to progressing further. It is believed there are no fatal flaws at this point in time, however there are many community and environmental expectations and considerations that need to be taken into account.

13.3.1 Affordability

Preliminary scheme costs have been derived through some large, but expert based, assumptions at this early stage. Based upon these conservative assumptions, it is shown that the total scheme capital is significant and the scheme water costs will probably not be affordable to all users if the entire scheme was to be funded by the water users.

Essentially, the higher value horticulture crops can absorb and cover the costs whereas, only the most profitable pastoral farmers will be able to turn a profit. It should be noted however, that the best fit for irrigation water within pastoral farming in Northland is not yet defined, or well understood, but expected to consist of partial or tactical use of water within the farm system. If this partial area of irrigation will bring benefits to the entire farm, and an argument could be made that the cost of irrigation should then be spread across the entire property, in turn, changing the affordability of irrigation within a pastoral sense within a northland context.

Two scenarios have been considered within the hydrological analysis and used as the basis for storage size comparison – one considering NRCs proposed water harvesting rules, and the other assuming sufficient water could be stored outside of irrigation season on an annual basis.

Table 13-2 summaries the different aspects of each of these schemes regarding size, water demand and cost.

Table 13-2 Scheme comparison

		Kaipara	Mid-North A	Mid-North B	Mid-North C	Total
Command area (Ha)		19,000	2,300	2,800	5,000	29,100
Irrigable area (ha/% command area)	***Within Proposed Harvesting Policy***	2,900 (15%)	1,300 (56%)	400(14%)	600 (12%)	5,200
	Assuming Annual Replenishment	6,300 (30%)	1,600 (70%)	1,700 (60%)	2,000 (40%)	11,600
Max irrigation demand (m^3/ha/year)		4,700	3,500	3,900	3,600	
Average irrigation demand (m^3/ha/year)		3,400	1,800	1,900	1,500	
Storage volume (Mm^3)	***Within Proposed Harvesting Policy***	15	6	2	2	25
	Assuming Annual Replenishment	30	6	7	7	50
Total capital cost ($M)	***Within Proposed Harvesting Policy***	$62	17	6	6	$91
	Assuming Annual Replenishment	$108	$18	$29	$27	$183
Capital cost ($/ha)	***Within Proposed Harvesting Policy***	$21,600	$13,600	$16,000	$10,100	
	Assuming Annual Replenishment	$17,300	$11,100	$15,900	$13,600	
Operational cost ($/ha/year)	***Within Proposed Harvesting Policy***	$570	$170	$230	$120	
	Assuming Annual Replenishment	$390	$180	$210	$320	

Developing further detailed storage and distribution scenarios for each scheme for evaluation and comparison would be expected to yield more confidence on what the scheme could look like and their costings. This allows the viability to properly be assessed for a 'scheme' in terms of financial, environmental and cultural aspects.

13.3.2 Sensitivity

At this early stage it is obvious that storage is going to be the most sensitive component of an irrigation scheme, both in regards to total cost, consenting requirements, and the physical ability to pragmatically harvest the water.

Further investigations within the prefeasibility stage will likely indicate that it would be beneficial to take water during high flushing or flood flows to enable replenishment of storage on an annual basis. This approach would fall outside of the currently proposed harvesting rule however will greatly influence the development possibilities in each command area. This approach may also encourage the possibility of harvesting additional water for environmental reasons whether it be supplementing environmental low flows or reducing flooding downstream.

Through considering different risk profiles for irrigation reliability, water sources, distribution methods and harvesting regimes, it should be possible to find a “sweet-spot” in regards to scheme cost (capital and operational), scheme area, and environmental requirements. It may also have positive implications for the ability to stage work i.e. if one big dam is found to be the solution rather than a series of smaller dams.

This could be particularly critical in the Kaipara, particularly to bridge initial slow uptake, and the fact that the annual demand for water is substantially higher and more regular than the Mid-North.

When these considerations are all taken into account in parallel, it may be found that the “sweet-spot” is a completely different size or shape to preliminary command area and distribution network. For example, in the Kaipara it could show that the scheme would benefit from being much larger and that water could be supplied both further north and south of the existing command area shown. In the Mid-North it could show that Lake Omapere could only service the Mid-North A area and that the other Mid-North areas would be best serviced from the existing Kerikeri Irrigation Scheme.

For a scheme to work, particularly a staged development, careful master planning would be required to ensure that all development happened in a co-ordinated approach and outside influences didn’t preclude future stages from occurring i.e. subdivisions, politics. Master planning is critical regardless of the scheme size of shape as it allows investment within farms and communities to happen within a targeted manner with a view to the future i.e. build it once and built it right.

13.3.3 Optimisation

It is suggested that the area within and adjacent to the existing Kerikeri Irrigation Scheme not be considered in the next stages of work for the following reasons:

- Higher price of land unlikely to encourage horticultural use.
- Adjacent land owners to scheme could simply approach KICL if they wanted access to water.
- Generally fragmented land with exception of a few large land holdings which wouldn’t need assistance from this initiative to get connected if they had a demand.

Rather than discard the entire command area of Mid-North C, the upper reaches of this area could be incorporated in to the Mid-North B area which is in close proximity.

Specific focus in the Mid-North needs to be given to Lake Omapere to determine its suitability as a water resource, including size of resource, as well as ensuring alignment with other drivers in its vicinity. As it is not envisioned that this resource is sufficient for the needs with the entire wider Mid-North area, other sources need to be considered in parallel to enable the best solution to be determined.

These other sources could include the following as a minimum:

- Determining available water within the existing Kerikeri Irrigation Scheme.
- Consideration of the merits of a dual purpose dam(s) in upper catchment of Kerikeri River. Concepts for a flood detention dam in lower catchment near Waipapa is currently being proposed by NRC.
- Catchment wide detailed analysis of water sources and storage sites to determine actual localities for assessment.

Specific focus in the Kaipara needs to be given to determining potential water source and storage locations. The high cost of storage is potentially going to have a large impact on the shape of the outcome due to the likely irrigable land use and greater climatic demand for water than the Mid-North. More water per hectare needs to be stored in Kaipara but typically for lower value use.

These investigations need to assess the following as a minimum:

- Catchment wide detailed analysis of water sources and storage sites to determine actual localities for assessment.
- Sufficient investigation to support or discard the concept of utilising the Northern Wairoa River as a source of water through a barrage, treatment facility or other means.

This study only considered water sources in sufficient detail to ensure there were no fatal flaws to progressing to the next stages. The additional detailed assessment is important to ensure that should the developments be done in a staged manner that initial decisions made on water sources don't preclude other schemes or stages from being developed in the future i.e. the risk of first in first served not being optimal.

In parallel to considering storage the distribution and pump networks need to be optimised. Whilst the capital cost of distribution and pumping may be much smaller than that of storage it is this component that has the greatest effect on the operational and whole of life costs of a scheme.

The following as a minimum need to be assessed:

- Sensitivities between large single dam vs a series of smaller dams vs on-farm storage
- Different conveyance options, pumping scenarios, network configurations and routes
- Ability to undertake construction in a staged manner i.e. to defer cost.

13.4 Irrigated land use and environment

It is certain that the availability of water for irrigation will drive change in land use, often through change in land ownership. A real consideration regarding Treaty Settlements, and/or Maori freehold land is that some of the land that iwi have available for productive use may be unencumbered with debt. Thus, the requirement for high financial returns may be less and therefore, the decision to invest in water infrastructure more attractive.

Through the stakeholder workshops there was a strong desire indicated for case studies to understand what water could actually mean at farm level i.e. how it compliments their existing farm systems through irrigation or to encourage a change in land use decisions. Without this community buy-in and uptake it will be difficult to justify, specifically in the pastoral sense, as the possibilities are currently not quantified.

Undertaking case studies of this nature aligns with Recommendations 4 and 5 from the Northland Strategic Irrigation Infrastructure Stage 1 Study which suggested a need to undertake these on selected farms and to establish model or "Demonstration" farms. To ensure water use uptake from future community irrigation schemes there is a need to improve understanding what making water available does to farm level affordability as well as the options that are available. Farmers learn by "looking over the fence", using hands on and seeing with their own eyes, and the stakeholder engagement meetings indicated there was a desire to see demonstration farms set up within the region.

These case studies are believed to be critical to educating existing land owners and encouraging uptake. Through the development of these, there needs to be regular communication and open-days held around these to foster interest and buy-in. Specific focus should be given to the following:

- Suitable land use options within Northland i.e. not just accept status quo, what could be grown.
- Profitability of different irrigation land use and the reliability of water required.
- Fit for pastoral farming systems in a Northland context.
- Opportunities that only exist with specific types of land holdings i.e. Maori Free Hold Land.
- Value of water for other uses i.e. industrial parks and ability to service higher value use.
- Environmental impacts.

The fragmentation of the land for lifestyle blocks has had a large impact upon the operation of Northland's current two irrigation schemes, almost to the extent where the potential that once existed is gone. Land within the existing schemes must be protected from further fragmentation, as well as protect land within proposed areas, some of which are already under threat, from suffering the same fate.

Something also to note, based on experience in other parts of the country, is the exclusion of nutrient limits within current NRC rules, both existing and proposed. With the development of further irrigation schemes this is likely to be raised through various forums as it gives a solid frame work for land use change decisions to be made.

13.5 Who should pay

It is possible to account for the other benefits in the economy that are driven by new schemes that allows others to make money other than farmers or other water users. Often the question is asked; why should the total cost therefore fall just to the farmers as water users?

It is suggested the funding should be from the public sector as well as the water users. Schemes that have progressed in New Zealand have had a champion in the community that sees the long term outcomes for the community and not just a short term financial gain.

The hapū view point has often reflected the need to meet those long term outcomes whilst not eroding their base capital. They are accepting of some risk of low direct cash flow if that allows the hapū land to be utilised and the agri-sector to prosper without the encumbrance of making money from the sale of water itself.

The issue of rights and interests (iwi, Crown and/or public ownership) in water is not addressed in this study and it was not attempted to incorporate a water charge or resource rental that is often mooted by some ENGO's. The water charges that were used are only the capital servicing and direct operational costs.

The returns may take a long time to be realised as uptake may be staggered and the ability to generate revenue from the water takes investment in primary, secondary and tertiary activities not just the cost of the scheme itself. Where irrigation does not already exist or where land use change occurs, each farm needs to spend nearly as much for on-farm irrigation systems as is spent on the infrastructure to get water to their gate. Some farms will also need substantial investment in other on-farm infrastructure such as fencing, roadways, dairy sheds, harvesters, or effluent management systems.

Secondary industries will need critical mass before there is justification to build local processing plants. They may be reluctant to build factories that sit at 50% capacity for an undefined period. Tertiary support services such as transport upgrades, schools and retail will take a while to build up. Measuring the value of those additions to the economy needs to be attributed against the original scheme costs. Anecdotally, it is known that they do happen, and Timaru is an example. Irrigation increased land use change that lead to secondary food processors and new community facilities such as sports stadiums, where previously schools were struggling to fill rolls.

There is a question on what asset that lenders take a security over. It could be the physical infrastructure or the consent to take water. One is virtually worthless without the other. So if the community want to take collective ownership of their destiny and hold onto the consent as well as the physical infrastructure, this may remove a security options to attract external funding. Sometimes the desire for control has meant communities place limits on having external equity partners join their projects where that is seen as loss of control especially where that investor requires a governance role.

You can take a "rationalist" view and look at the capital and operational cost items directly associated with the scheme and delivery network. Can you use "water charges", maybe on a volumetric billing basis, for total cost recovery from the direct water users? This raises questions about risk on the return on investment, cash flow of the capital expenditure and the timing of generating revenue from the sale of water.

Answering those questions could be solely from the viewpoint of the owner of the asset looking to make money from the sales of the water, i.e. becoming a water service provider. The owner would be looking at the ratio of equity and debt against the value of the asset, what the lending options were and what expectation of the profit to be made based on the risk they were taking. Some irrigation schemes in New Zealand and Australia have been implemented on this basis, or at least conceptualised.

An alternative view may be taken if the infrastructure and the rights to extract water encompassed in the resource consent are owned, governed and managed by the community through some form of cooperative structure where multiple stakeholders, often just a large number of water users themselves, are the shareholders. They may also look at the scale of their individual investments and the risk they are taking but normally also taking into consideration their ability to profit from the water supply through their own agri-sector production. So, there is a slightly different expectation of a return on investment.

A further model may be where substantial public sector funding is used to implement a scheme, where the return to the investor is not necessarily about the financial returns but more about the wider economic stability and buoyancy that the investment enables.

13.6 Pathway forward

Our consortium believes that the most fit for purpose development entity for these next stages, based upon discussions previously within this document, is the one that takes a portfolio approach i.e. collectively takes schemes forward together. This is based upon the fact that Northland land and industry is often fragmented due to both ownership and topography. This will enable economies of scale to be realised and lessons learnt.

There needs to be strong iwi and community ownership and participation within the development entity, complete with leadership from “champions”, within the scheme areas for the development of a scheme to be successful. Council should be an enabler and supporter, rather than a leader of this initiative. There are substantial lessons that can be learnt from other irrigation companies and developers, including the local Kerikeri Irrigation Scheme which would have a wealth of knowledge within its board and customers.

Concern was raised within stakeholder groups around the economic development in Northland being led out of Whangarei and as such, the level of commitment and support that might be provided on the journey to the other parts of the region who sometimes feel neglected. Care needs to be taken to manage this perception.

This being said, the entities/s needed to progress these initiatives will need structure, governance, and effectively a mandate to develop the scheme in the best interest of the community. This doesn’t happen overnight and requires specialist skillsets and understanding to implement. The Northland Inc website states:

> *The primary objective of Northland Inc is to provide services for the community or social benefit rather than making a financial return. Accordingly, Northland Inc has designated itself as a public benefit entity (PBE) for the purposes of New Zealand equivalents to International Financial Reporting Standards (NZ IFRS).*

It is the consortiums belief that providing the support in getting this over the line is one of the core responsibilities of Northland Inc and Northland Regional Council.

Careful consideration needs to be given to what is chosen here, ultimately transparency and alignment with community drivers and values is going to be paramount. There also needs to be the sufficient flexibility within a development entity to embrace any opportunities should they arise.

Leadership needs to come from within the communities with support from outside both in terms of funding, support and skills. It is important for the council to be seen as an enabler through support (financial and otherwise) and not slowing the project up unnecessarily through analytical processes.

For the communities to realise the potential benefits of irrigation one of the largest capital investments in infrastructure in Northland is going to be required (Table 13-3). There is the potential for any water storage initiative to occur quickly with community support. The capital injection required for this to happen could come in the form private, government, foreign, iwi or contractor entities (BOOT or PPP models).

Table 13-3 Potential pathway forward.

Phase	Description	Purpose	Indicative timing	Indicative cost
1	Strategic Assessment	Determine if fits	Completed	$130k
2	Scoping Study	Define what the project could be	Current	$320k
3	Prefeasibility study	Define what the project should be	6-12 months	$1-2 million
4	Feasibility Study	Determine what the project will be	12-24 months	$5-10 million
5	Project Commitment	Execute procurement strategy	12-24 months	$2-5 million
6	Construction		18-36 months	$100-$300 million
7	Operation		INTERGENERATIONAL	

14 Recommendations

14.1 Prioritised list

The primary objective of this scoping study was to provide a clear pathway forward for the development of further irrigation schemes in Northland by establishing a prioritised list of scheme options to take forward. The study has highlighted four possible schemes that whilst at this stage of the investigation have no obvious fatal flaws, they still require a detailed level of investigation in prefeasibility studies.

Outlined below are a series of recommendations that it is believed, based upon the consortiums combined expert opinion and experience, will provide a pathway through the pre-feasibility stage of the development of irrigation schemes in both the Mid-North and Kaipara communities.

14.2 Recommended actions

14.2.1 Recommendation 1: Confirmation of NRC priorities

Whilst a prioritised list has been produced, the key recommendation is to advance further investigations on the three top priorities namely Kaipara, Mid-North A and Mid-North B. NRC may apply criteria in addition to those that have been used gleaned from the community stakeholders in the MCA process and choose to investigate only one scheme option at this stage, maybe simply due to financial or other constraints. It is encouraged that any decision takes into account drivers and desired outcomes from both the community and regional perspectives.

The prioritisation exercise undertaken in Section 12 indicates that the priority depends on what is considered most important. That may be stating the obvious, however, in almost every sensitivity scenario the Kaipara Scheme option showed out as a first priority with Mid-North A and B close behind and Mid-North C behind those.

If financial constraints result in only one scheme being taken forwards through to pre-feasibility stage the Kaipara, due to the higher costs associated with the development of the scheme itself may in fact be less desirable. In this case, Mid-North A will be a more suitable option. However, if wider community benefits and economic development are the priority of this exercise then Kaipara should be investigated further.

The main recommendation that has developed from this study is the need to consider a holistic view for the schemes. It is clear that all of the schemes should be considered further and development of any individual scheme should be considered as a part of a larger regional development. It is likely that it will require all schemes to be progressed to prefeasibility stage under a single umbrella entity to provide the scale required to “turn the dial” for Northland.

14.2.2 Recommendation 2: Update the Community

In any consultation process it is important that stakeholders be kept informed on where their information and inputs landed. The consortium feels that it is very important to make the findings of this study available to the Northland community as soon as practical in the interests of transparency and respect to those people who have been involved in the process. There are also those who have current initiatives who are potentially impacted by the findings of this study and the subsequent steps that could be taken that affect their commercial decisions. This update needs to clearly articulate the planned next steps and associated timing. It is important to make ensure timing aligns with other parties and initiatives i.e. input into the following years LTP.

There is an opportunity to leverage off the momentum that has been established and build further community support for initiatives.

14.2.3 Recommendation 3 Form a Development Entity

An appropriate development entity should be designed and implemented to source funding and provide overarching support to progressing irrigation schemes in the Kaipara and Mid-North. The following key steps are recommended:

- Ensure communities and stakeholders are a primary part of the next steps as without them the projects will face unnecessary hurdles
- Set up an entity that allows those who want to participate to take an active role. It needs to be multilateral i.e. able to accommodate wide view points and sources of funds with varying objectives. The complexity of this exercise should not be underestimated.
- Establish a working budget in the order of $1M to progress pre-feasibility studies
- Identify the potential beneficiaries and/or scheme investors, taking into account the whole of life costs vs whole of economy returns, to determine scheme affordability\

14.2.4 Recommendation 4: Undertake Pre -Feasibility Studies

Substantial investigations, modelling, analysis and stakeholder engagement needs to occur to develop and optimise scheme options to take forward to an investment case. This requires the following key steps to be undertaken, often in parallel work streams as they are interrelated:

- Undertake case studies of what can be done at farm level with a reliable water supply, showing the impact of land use change, likely demographic change and ownership changes on the community.
- Undertake hydrological and engineering analysis to determine sensitivity, and subsequently viability, in respect to key parameters associated with an irrigation scheme such as policy, volumes, locality, construction materials and ability to develop infrastructure in stages.
- Undertake engineering and hydraulic analysis to optimise potential any water distribution network configurations in respect to key parameters such as taking of water, capital cost, operational cost and ability to develop infrastructure in stages.
- Undertake preliminary environmental impact and cultural assessments to identify opportunities and risks
- Produce the next level of confidence on capital and whole of life costs

14.2.5 Recommendation 5: Develop an Investment case for Feasibility Study/s

Investigations from the pre-feasibility stages should be framed and presented in a manner to gain community buy-in to enable an investment case to be built. Success will not be achieved without community buy-in.

This investment case will synthesise all available information to provide a recommendation on option to be examined further through feasibility stage where the following key work streams will need to be funded and resourced to the stage where project commitment would be expected:

- Management and Governance
- Financing and Funding
- Uptake Demand and Revenue
- Technical and Engineering
- Regulatory and Environmental
- Social and Cultural
- Commercial and Operations

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Glossary and acronyms

Term	Description
AEE	Assessment of Environmental Effects.
Application depth	Depth of applied water i.e. irrigation.
BOOT	Build, Own, Operate and Transfer. A type of contractor entity.
CC1	Climate Change Scenario 1. Scenario using lowest rainfall and highest PET (RCP 8.5)
CC2	Climate Change Scenario 2. Scenario using highest rainfall and lowest PET (RCP 2.6)
CIF	Community Irrigation Fund.
Cluster areas	These are the large clusters of possible scheme areas focussed around two sites; Kaipara and Mid-North.
Command areas	These are 12 preliminary areas for possible schemes. Six each within the Kaipara and Mid-North 'cluster areas'.
Demand	Demand/need of water usually over a particular time period.
ENGO	Environmental Non-Governmental Organisation
FAO	Food and Agriculture Organization
FDE	Farm Dairy Effluent.
FNDC	Far North District Council. Council encompassing Opononi, Kaikohe, Kerikeri and Cape Reinga.
GIS	Geographic Information Systems. A system designed to capture, manipulate and manage spatial or geographic data.
IAF	Irrigation Acceleration Fund. MPI funding support for irrigation development.
IPCC	Intergovernmental Panel on Climate Change.
Irricalc	Modelling software that models the water balance.
MBIE	Ministry of Business, Innovation and Employment
MCA	Multi-criteria analysis

MPI	Ministry for Primary Industries.
NIWA	National Institute of Water and Atmospheric Research.
NRC	Northland Regional Council. Council encompassing Whangarei, Dargaville, Opua and Kaitaia.
PAW	Plant Available Water at field capacity.
PET	Potential Evapotranspiration. Loss of water from the soil by both evaporation, and transpiration from the plants growing on the soil
Possible schemes	These are four possible schemes refined and consolidated from the 12 preliminary areas.
PPP	Private Public Partnerships. A type of contractor entity
RCPs	Representative Concentration Pathways. Greenhouse gas concentration trajectories adopted by IPCC.
Reliability	The reliability of a water source for irrigation i.e. 90%.
Return period	Period of time between water applications for the same area.
SFF	Sustainable Farming Fund. An MPI investment into applied research and projects led by farmers, growers or foresters.
SFFs	Silver Fern Farms. Cattle slaughter and beef processing plant in Dargaville.
SME	Small to Medium Enterprise. Used in relation to business
Stage 1	Northland Strategic Irrigation Infrastructure Study. Completed by Opus, BERL, Aqualinc and Bob Cathcart (2015).
Stage 2	Scoping of Irrigation Scheme Options in Northland. Current report being completed by Opus, BERL, Deloitte, Aqualinc and Bob Cathcart (2017).
Tai Tokerau Study	Regional growth study for Northland (2015). For more information and to read the report: http://www.mbie.govt.nz/info-services/sectors-industries/regions-cities/regional-growth-programme/northland.
TTEAP	Tai Tokerau Economic Action Plan
Value of Output	The goods and services produced by an enterprise during an accounting year constitute its output.
VCS	Virtual Climate Station. A virtual climate station using data sourced from NIWA.

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