REPORT

Greater Wellington Regional Council

Wairarapa Water Use Project:
Scheme Options Identification & Analysis
Summary Report

Tonkin & Taylor

ENVIRONMENTAL AND ENGINEERING CONSULTANTS

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Table of contents

Glossary

Abbreviations

GIS	Geographic Information System
GNS	Institute of Geological and Nuclear Sciences Limited
GWRC	Greater Wellington Regional Council
MCA	Multi-Criteria Analysis (a basis for ranking and comparing schemes)
MCM	Million Cubic Metres
QEII	QEII National Trust open space covenants
SAG	Stakeholder Advisory Group (WWUP)
T&T	Tonkin & Taylor Limited
WWUP	Wairarapa Water Use Project

Terminology

Command area	Equivalent to indicative irrigable area as defined below, and used interchangeably for the purposes of the current report
Core allocation	The total amount of water in a catchment that has been authorised for abstraction at any time flow is above the minimum flow (but below the "supplementary flow" (see definition below))
Dead storage	Portion of reservoir volume *un*available for consumptive use
Distribution system	Conveyance structures, comprising existing rivers, canals, races and pipework (located downstream of the reservoir) that transfer flow from the reservoirs to the irrigation command areas
Harvesting	Transferring water to a storage from a nearby stream/river located in a different catchment. Note definition is different from the Proposed Regional Policy Statement, which uses harvesting to refer to on-river storage also.
Headworks	Storage reservoir, dam structures required to impound the reservoir, and any intakes, conveyances and pumpstations (if required) to "harvest" water to fill the reservoir
Gross storage	Sum of dead and live storage
Live storage	Portion of reservoir volume available for consumptive use
Net irrigated area	The portion of indicative irrigable area expected to actually be irrigated, after accounting for buildings, tracks, hedges etc

Off-river storage	Storage filled primarily by “harvesting” i.e. transferring water from a nearby stream/river located in a different catchment
On-river storage	Storage filled primarily by “own catchment infill” i.e. by storing flow from the local catchment of the stream on which the storage is situated
Own catchment infill	Flow available from the local catchment of a stream on which a dam is situated
Reservoir	A natural or artificial pond or lake used for the storage and regulation of water, used interchangeably with “storage” for the purposes of the current report
Run of river take	Abstraction occurring directly from a river or stream and that has no significant storage component
Scheme	Headworks and associated distribution network to transfer water from storages to an indicative irrigable area
Site	Potential water storage site
Storage	Equivalent to “reservoir” for the purposes of the current report, and used interchangeably
Supplementary allocation	The total amount of water in a catchment (in addition to core allocation) that has been authorised for abstraction at times when flow exceeds the “supplementary flow” threshold
Indicative irrigable area	The gross area that could be irrigated, defined for the purposes of the current study using land slope
Uptake	The commitment of water users to use (buy) water from the scheme

1 Introduction

The Wairarapa Water Use Project (WWUP) has been established to support planning for regionally integrated multi-purpose water use based on harvesting, storage and distribution of water in the Wairarapa Valley. Greater Wellington Regional Council (GWRC) and the Ministry for Primary Industries have allocated funding to advance the WWUP. The intention is to advance the WWUP through a series of Phases as follows:

1. Options Identification and Analysis
2. Pre-feasibility
3. Feasibility.

This report summarises the work that has been undertaken during the Options Identification and Analysis Phase (Phase 1), as described more fully below. The initiation of any subsequent phases is dependent on the outcome of each preceding phase. Advancement beyond Feasibility (to Consent Application, Design and Construction) will depend on a range of factors including cost-benefit, potential scheme uptake, and funding. No commitment has yet been made by GWRC to proceed beyond the Options Identification and Analysis Phase, although budget has been allocated.

The WWUP aims to maximise the productive capacity of the Wairarapa Valley through water storage and distribution infrastructure for irrigation and also to meet a range of other environmental and community needs, which might include power generation, municipal water supply, recreational, and Maori cultural purposes.

Tonkin & Taylor (T&T) has been engaged to undertake Phase 1 of the work (Options Identification and Analysis). The current report presents a summary of the outcome of those investigations. A number of potential water storage schemes has been identified, analysed and compared to present a short-list of schemes worthy of further investigation. The information and recommendations presented in this Summary Report (and T&T's full Scheme Options Identification and Analysis Report on which this Summary is based) form one part of the information that the WWUP Project Team and the community will consider in determining whether to proceed with further investigations.

The work to date has drawn on information and experience derived from previous investigations and similar studies elsewhere in New Zealand.

2 Background

2.1 Water Use and the Need for Storage in Wairarapa

GWRC has undertaken extensive investigations of the surface and groundwater resources of the Wairarapa Valley and considers that a carefully conceived and executed water scheme could help restore the balance of the Wairarapa's stressed water resources. This conclusion is reflected in GWRC's over-arching environmental policy directive, the Proposed Regional Policy Statement, which requires regional plans to promote efficient use of water and promote 'water harvesting'; i.e. taking and storing water when the availability is high and using it when there is a soil moisture deficit. Through the current Regional Plan review process, GWRC is looking at appropriate ways in which to allocate water and set minimum flows to protect instream ecosystems, while also managing land use impacts in an environmentally and economically sustainable way.

The current resource consents to take surface water account for nearly all of the available 'core allocation' from the rivers of the Wairarapa Valley; i.e. the existing run-of-river takes are approaching full allocation of the 'core allocation' in most zones identified in the operative Regional Freshwater Plan. Likewise, there is limited additional groundwater available, especially now that recent investigations have confirmed that there is strong interconnection between surface and groundwater in the Wairarapa. Therefore, GWRC has determined that to reliably meet increased water demand in a sustainable manner, water will have to be supplied from storage. As a result, the scheme options developed during this investigations phase and presented in this report all incorporate storage, and in some cases infrastructure to capture water from an adjacent catchment, in addition to water distribution infrastructure.

2.2 WWUP Phases and the Current Report

A range of organisations has previously undertaken investigations into potential water storage schemes in the Wairarapa. These investigations have primarily been driven by water demand in specific areas. GWRC's more recent involvement changed the focus to a broader, valley-wide, holistic and integrated approach. Accordingly the starting point for the GWRC funded investigations, following on from an initial Scoping Study, has been a valley-wide Options Identification and Analysis Phase. It has looked at the overall potential water demand for the entire Wairarapa Valley and the availability of water to meet that theoretical demand, recognising that it is unlikely that the entire valley can be serviced economically.

Key constraints and exclusions were agreed at the beginning of the Options Identification and Analysis Phase. In particular, dam sites in the Tararua Forest Park and on the main stems of the Ruamahanga River, Tauherenikau River, Waiohine River and Waingawa River were excluded for recreational and environmental reasons. The potential to use Lake Wairarapa as the storage component of a scheme is being assessed as part of a separate investigation by GWRC into the hydrology and water balance of Lake Wairarapa, although preliminary comments are provided in the full Scheme Options Identification and Analysis Report.

This Summary Report and the main report on which it is based represent the culmination of the Options Identification and Analysis Phase of the WWUP, which aims to identify and compare storage-based scheme concepts for consideration by the Stakeholder Advisory Group (SAG), Leadership Group and the project team for possible advancement to the pre-feasibility phase of the WWUP investigations, in consultation with landowners. The scheme

arrangements have been developed only to a concept level suitable for comparison of options, and significant modifications to arrangements can be expected during later investigation, consultation and design stages.

3 Study Approach

T&T was initially commissioned by GWRC in August 2011 to undertake a Scoping Study to identify a forward work programme to advance the WWUP to a point where specific schemes have been identified, compared and assessed against project objectives and criteria to enable GWRC to decide on whether and how to proceed with more detailed assessments. The proposed work programme was designed to build on a number of earlier irrigation studies.

The outcome of the Scoping Study was a work programme comprising 10 general stages, referred to collectively as the Options Identification and Analysis Phase. The work to date has been broadly undertaken in accordance with these stages.

Development of a scheme is potentially constrained by many different aspects, including environmental, social and cultural impacts, landownership, geology, topography, hydrology, financial viability, and the planning framework under the Resource Management Act. Leaving aside landownership in the initial stages (while acknowledging it is critical from several perspectives), and accepting the key environmental constraints of no dams on the main rivers or within the Forest Park, T&T applied financial and geological constraints as some of the first 'filters' or considerations. This is because based on experience with past projects, T&T has found financial viability to be one of the more restrictive constraints in terms of identifying possible scheme options at the initial stage of investigations; i.e. a scheme needs to be potentially viable from an economic point of view for it to be even considered worthwhile addressing other potential constraints. In addition, geological and geotechnical constraints are relatively restrictive in the Wairarapa Valley because of the seismic environment and prevalence of limestone.

Identification and comparison of scheme options followed an iterative process, incorporating the full range of 'overlays' (environmental, social, cultural, geotechnical, financial etc). As iterations have progressed, the decision-making process has become better informed by more detailed site-specific assessment. However, even at the completion of the Options Identification and Analysis Phase, the project still remains in the early stages of the overall development process.

The Options Identification and Analysis Phase of the WWUP comprised the following stages:

1. Project scoping;
2. Preliminary determination of water demand (both theoretical and user-based), to provide the basis for what storage volumes may be required;
3. Preliminary determination of water availability, to identify potential water sources and volumes to meet demand while protecting instream values;
4. Storage identification, during which 243 potential storage sites were initially identified and iteratively narrowed to a short-list of 30 sites by overlaying additional constraints and applying a multi-criteria comparison of options;
5. Short-listing of sites for field inspection, by matching of possible distribution infrastructure with the identified storage sites to create "schemes", followed by multi-criteria analysis. This analysis prioritised a number of schemes for site walk-over inspection;
6. Scheme assessments, during which site walk-over inspections were carried out for 10 schemes, followed by identification of potential environmental, community and/or cultural impacts and further development of storage site and distribution

arrangements. Schemes considered unacceptable either from a community or geotechnical perspective were eliminated. A final iteration of multi-criteria analysis was completed to rank the nine schemes remaining as the basis for consideration for further investigation.

The work undertaken in this initial Scheme Options Identification and Analysis Phase is based on a large number of assumptions and criteria regarding water demand estimates, water availability, scheme service (reliability, water pressure etc) and engineering design criteria, which it is acknowledged have the potential to change during later refinements and more detailed investigations. In addition, GWRC is currently reviewing policies around water allocation and minimum flows as part of its Regional Plan review process. The work undertaken on the WWUP to date has made assumptions on water allocation scenarios that may change. Furthermore, the work undertaken on costing of potential schemes is extremely preliminary due to the number of uncertainties at this early stage of investigation. The costings to date have been developed purely for the purpose of comparing schemes.

4 Scheme Assessments

Nine schemes have been advanced through the full programme of evaluation in this phase of work. The key attributes of these nine schemes are presented in Table 4-1 following. Reservoir storage capacity of each of the schemes ranges from 4 to 77 MCM. The combined storage volume for all nine schemes is 267 MCM.

Figure 4-1 shows the location of the nine reservoir storage sites. The figure also shows the indicative area that could be irrigated if all nine water storage sites, and a combined distribution network, were developed.

Each storage site was considered independently for the purpose of scheme comparison in order to prioritise schemes for further study. The indicative irrigable areas assumed for each individual storage reservoir are shown in Figure 4-2 (further comment on overlap of distribution areas is provided in Section 5.2 below).

The key attributes summarised in Table 4-1 cover:

1. Scheme number and name;
2. Description of general location and the river/stream/valley in which it is located;
3. The source of water for each scheme (either from the stream's own catchment, or harvested from an additional source), and the volume available from those sources during a 1 in 10 dry year;
4. Approximate reservoir capacity (volume);
5. The geotechnical risk associated with each storage site;
6. Whether the indicative irrigable area for each scheme is currently under stress in terms of water availability (i.e. whether investigations have indicated that the area is fully or potentially over-allocated ("under pressure"), and further groundwater takes or surface water takes from core allocation are unlikely; i.e. there are limited alternatives for future take other than the proposed schemes);
7. The approximate number of hectares that could be serviced by each scheme, the general location of the indicative irrigable area, and the flow requirement to service it;
8. Current landownership; i.e. whether private or public land;
9. What existing public infrastructure could potentially be affected by each scheme, focusing on public roads;
10. A description of the general environment and land use in the storage site area, including identifying any significant environmental values, based largely on information from GWRC's GIS database and the site walk-over inspections;
11. Expected significance of the affected storage site area and affected river/stream to Maori, based on information from "Arch Site" and the Draft Cultural Values report for Wairarapa (prepared by Ohau Plants Ltd);
12. Key social issues, focussing particularly on the number of dwellings within the storage area, as well as community facilities, or severance of road connections (where not replaced), based on the site walkover;
13. Assessment of the 'riskiness' associated with each scheme (e.g. whether that risk may be geotechnical, social, community, constructability etc), on a comparative basis;
14. Assessment of the 'opportunities' associated with each scheme (e.g. potential for optimisation of scheme size or dam location, synergies with wastewater re-use, staged development etc), on a comparative basis;
15. Assessment of the relative financial favourability of each scheme (on a comparative basis), based on $\$/m^3$ of water.

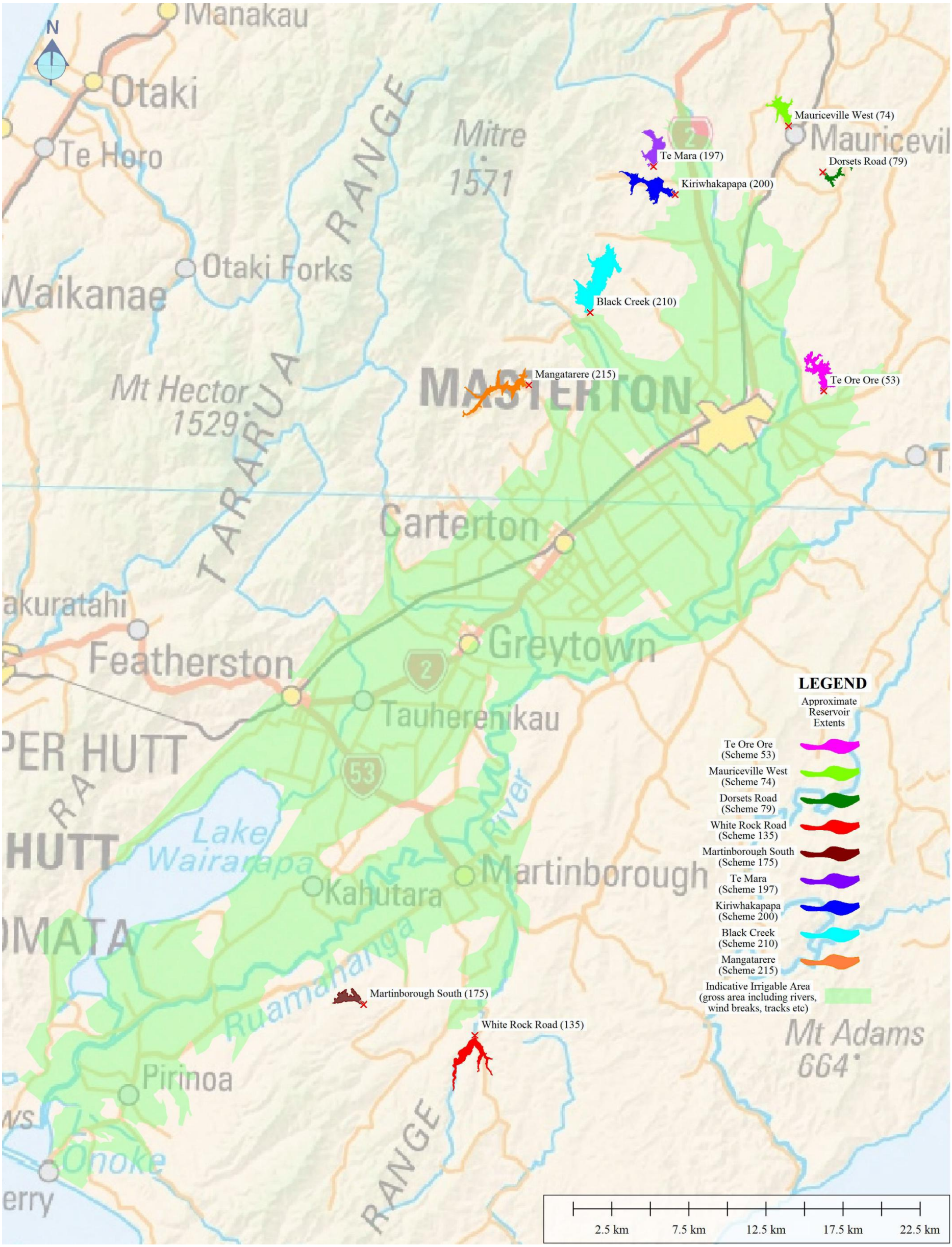

Figure 4- 1 Location of the nine possible short-listed storage sites and combined indicative irrigable area if all storages sites and a combined distribution network were to be developed

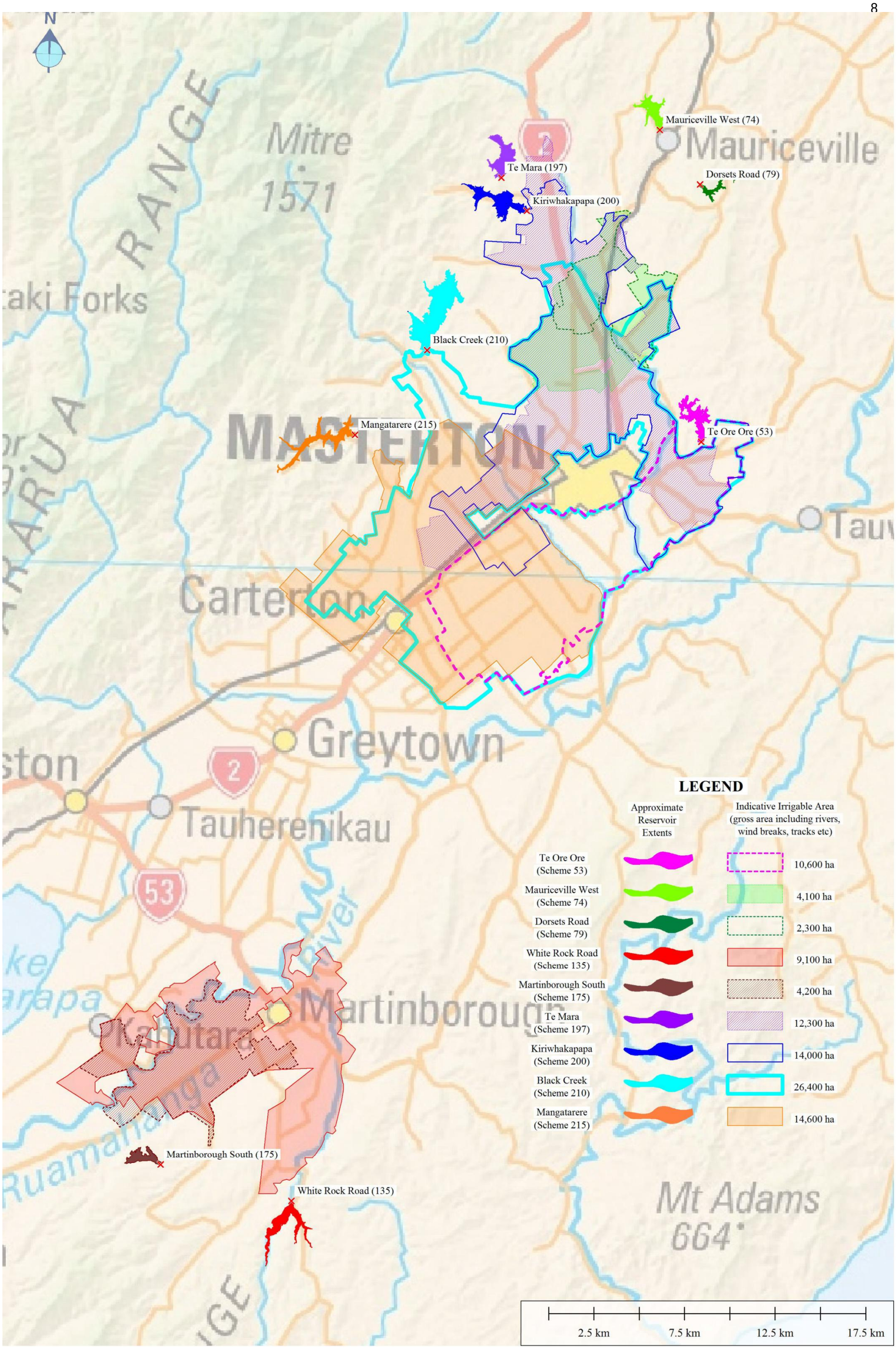

Figure 4- 2 Location of the possible storage sites and indicative irrigable areas assumed for evaluation as individual independent schemes

Table 4-1 Key attributes of nine schemes

Scheme name and number	Location of storage (reservoir)	Water source and water availability in 1 in 10 dry year	Approximate reservoir volume (live storage at dam)	Geotechnical issues (storage site)	Existing water availability in indicative irrigable area	Approximate area serviced (hectares, gross) and flow requirements (l/s)	Landown-ership	Effect on existing public infrastructure	Key environmental aspects	Expected cultural (Maori) significance	Key social aspects	Risks	Opportunities	Financial favourability (based on $/m^3 of water)
"Te Ore Ore" (Scheme 53)	3km east of Masterton, north of Te Ore Ore-Bideford Rd. Unnamed tributary of Whangaehu River	33.7 MCM total water available, 1.7 MCM from own catchment 32.0MCM from harvesting from Ruamahanga River at a peak rate of 5m^3/s	33.7 MCM	Moderate to high risk	Some of indicative irrigable area considered "under pressure"	10,600 ha, south & east of Masterton 3900 l/s	Private	None	Reservoir: pastoral farms No specific issues or sites of significance.	Ruamahanga River highly significant. Urupa nearby – not directly affected	1 dwelling immediately downstream	Moderately favourable	Moderately favourable	Less favourable
"Mauriceville West" (Scheme 74)	Mauriceville West. Unnamed tributary of Kopuaranga River	8.0 MCM available from own catchment, an unnamed tributary of Kopuaranga River	7.9 MCM	Moderate to high risk	Some of indicative irrigable area considered "under pressure"	4100ha, north of Masterton 1200 l/s	Private plus road reserve	Several kilometres of road will require sealing/realign ment, including access to private and community resources	Reservoir: pastoral farms and some exotic plantings. No specific issues or sites of significance. Kopuaranga River has values as aquatic ecosystem.	Nothing apparent. Main Kopuaranga River has some significance.	7 dwellings inundated; direct connection between Mauriceville and Mauriceville West severed; inundation of Mauriceville West community 'centre'; potentially impinge on Lutheran Church cemetery	Moderately favourable to favourable. Potential effect on cemetery	Least favourable to less favourable	Least favourable to less favourable

Scheme name and number	Location of storage (reservoir)	Water source and water availability in 1 in 10 dry year	Approximate reservoir volume (live storage at dam)	Geotechnical issues (storage site)	Existing water availability in indicative irrigable area	Approximate area serviced (hectares, gross) and flow requirements (l/s)	Landown-ership	Effect on existing public infrastructure	Key environmental aspects	Expected cultural (Maori) significance	Key social aspects	Risks	Opportunities	Financial favourability (based on $/m^3 of water)
"Dorsets Road" (Scheme 79)	15km north-east of Masterton, east of Opaki-Kaipororo Rd, near Dorsets Rd. Unnamed tributary of Kopuaranga River	4.1 MCM total water available, 1.7 MCM from own catchment 2.4 MCM from harvesting from Kopuaranga River at a peak rate of 0.25m^3/s	4.1 MCM	Moderate risk	Some of indicative irrigable area considered "under pressure"	2300 ha, north of Masterton (between Opaki & Kopuaranga) 600 l/s	Private	None	Reservoir: pastoral farms. No specific issues or sites of significance. No specific aquatic ecological values associated with tributary.	Nothing apparent. Main Kopuaranga River has some significance.	No dwellings inundated	Moderately favourable to favourable.	Least favourable to less favourable	Least favourable
"White Rock Road" (Scheme 135)	10 km south of Martinborough, at White Rock Road. Confluence of Makara River & Mangapari Stream.	26.1 MCM water available from own catchments: Makara River & Mangapari Streams	26.0 MCM	High risk	Almost all of indicative irrigable area considered "under pressure"	9100 ha south and west of Martinborough 2800 l/s	Private plus road reserve	Length of road will require realignment; some assumed to be abandoned; potential realignment of high voltage power line	Reservoir: pastoral farms, some areas exotic & indigenous bush. Slight impingement on QEII covenanted bush. Streams of some value as aquatic ecosystem.	Nothing apparent at storage site.	4 dwellings inundated (on 1 property)	Less favourable	Moderately favourable to favourable	Most favourable
"Martinborough South" (Scheme 175)	8 km south-west of Martinborough, east of Lake Ferry Road. Unnamed tributary to Dry River.	12.3 MCM total water available, 0.5 MCM from own catchment. 11.8 MCM from harvesting from Ruamahanga River at a peak rate of 1m^3/s	12.3 MCM	Low risk	Almost all of indicative irrigable area considered "under pressure"	4200 ha south-west of Martinborough 1400l/s	Private	None	Reservoir: pastoral farms. No specific issues or sites of significance. No specific aquatic ecological values associated with tributary.	Nothing apparent at storage site. Ruamahanga River highly significant.	No dwellings inundated	Most favourable	Moderately favourable	Moderately favourable

Scheme name and number	Location of storage (reservoir)	Water source and water availability in 1 in 10 dry year	Approximate reservoir volume (live storage at dam)	Geotechnical issues (storage site)	Existing water availability in indicative irrigable area	Approximate area serviced (hectares, gross) and flow requirements (l/s)	Landown-ership	Effect on existing public infrastructure	Key environmental aspects	Expected cultural (Maori) significance	Key social aspects	Risks	Opportunities	Financial favourability (based on $/m^3 of water)
"Te Mara" (Scheme 197)	15 km north of Masterton, west of SH2. Te Mara Stream	27.4 MCM total water available, 16.6 MCM from own catchment 10.8 MCM from harvesting from Ruamahanga River at a peak rate of 1.2m^3/s	27.3 MCM	Low to moderate risk	Some of indicative irrigable area considered "under pressure"	12,300 ha, north, east & west of Masterton 3800l/s	Private, plus road reserve (paper road)	None, apart from paper road.	Reservoir: pastoral farms, with some areas exotic and indigenous bush. Affects QEII covenanted area (man-made wetland). Stream of value as aquatic ecosystem.	Nothing apparent at storage site.	1 dwelling inundated	Moderately favourable	Moderately favourable	Favourable
"Kiriwhakapapa" (Scheme 200)	13km north of Masterton, west of SH2 at Kiriwhakapapa Rd. Kiriwhakapapa Stream	32.6 MCM water available from own catchment: Kiriwhakapapa Stream	32.5 MCM	Low to moderate risk	Some of indicative irrigable area considered "under pressure"	14,000 ha north, east & west of Masterton 4400l/s	Private plus road reserve	Several kilometres of road will require realignment to maintain access to properties and Tararua Forest Park	Reservoir: pastoral farms, patches of exotic & indigenous bush. Stream of value as aquatic ecosystem.	Nothing apparent at storage site.	4 dwellings inundated	Moderately favourable	Less favourable to moderately favourable	Moderately favourable
"Black Creek" (Scheme 210)	11km north-west of Masterton, at Falloon Settlement Rd. Black Creek & Wakamoekau Creek	77.6 MCM total water available, 21.3 MCM from own catchment 56.3 MCM from harvesting from Waingawa River at a peak rate of 13m^3/s	77.2 MCM	Moderate risk	Some of indicative irrigable area considered "under pressure"	26,400 ha encircling Masterton, extends to Carterton to south-west and up Waipoua River valley to the north 9300l/s	Private plus road reserve	Assume abandonment of roads within reservoir footprint.	Reservoir: pastoral farms with some patches of exotic and indigenous bush. Affects QEII covenanted area (wetland). Streams of some value as aquatic ecosystems.	Nothing apparent at storage site.	11 dwellings inundated	Less favourable to moderately favourable	Most favourable	Moderately favourable

Scheme name and number	Location of storage (reservoir)	Water source and water availability in 1 in 10 dry year	Approximate reservoir volume (live storage at dam)	Geotechnical issues (storage site)	Existing water availability in indicative irrigable area	Approximate area serviced (hectares, gross) and flow requirements (l/s)	Landown-ership	Effect on existing public infrastructure	Key environmental aspects	Expected cultural (Maori) significance	Key social aspects	Risks	Opportunities	Financial favourability (based on $/m^3 of water)
"Mangatarere" (Scheme 215)	13km west of Masterton, at Mangatarere Road. Mangatarere Stream	45.8 MCM water available from own catchment: Mangatarere Stream	45.8 MCM	Moderate risk	Some of indicative irrigable area "under pressure", but could be modified (at additional cost) to cover more area "under pressure"	14,600 ha north, east & west of Carterton 5400l/s	Private plus road reserve and some public conservation land	Several kilometres of road will require realignment to maintain access to properties and Tararua Forest Park	Reservoir: pastoral farms, areas of exotic & regenerating indigenous bush. Stream of value as aquatic ecosystem.	Nothing apparent at storage site.	8 dwellings inundated, including commercial lodge	Moderately favourable	Favourable to most favourable	Favourable

5 Key Findings

5.1 Ranking of Schemes

The nine schemes have been subjected to a full multi-criteria analysis (MCA) process.

The MCA was split into five main themes, with some sub-themes. The themes were developed from the four well-beings (social, cultural, economic and environmental) that local government organisations have, until recently, been required to consider in their decision-making processes.

The main engineering/technical aspects of the schemes that dictate the size, form and design of the infrastructure can be converted into a cost (i.e. site characteristics such as topography, geology and geotechnical conditions, and water demand and water availability that contribute to reservoir size and water conveyance/distribution). Therefore they are incorporated into an overall financial theme. The other four themes are non-financial.

The themes are:

- Financial
  - Headworks
  - Distribution
- Social
- Cultural
- Environmental
  - Terrestrial
  - Aquatic
- Risk
  - Headworks
  - Distribution
  - Land tenure

The MCA process was subjected to a sensitivity analysis that places different weighting on the main themes. Based on experience from other projects, it is apparent that the cost of a scheme (in terms of $\$/m^3$ of water supplied to users) is of critical importance in determining its viability. Accordingly, for the purposes of presenting an overall ranking, a weighting scenario of 70% for the financial theme and 30% for the combined environmental/social/cultural themes has been chosen and is set out in Table 5-1. The sensitivity analysis showed that there is no difference in the top five ranked schemes whether the combined environmental/social/cultural themes are weighted 30% or 50%, although the order within those top five changes slightly.

A 1 to 5 scale was used for scoring each theme or sub-theme. This scale is comparative, rather than absolute; i.e. a scheme scoring a 1 is least favourable compared with the other schemes under consideration but is not necessarily unfavourable in a wider context. The comparative scale is described as follows:

1. Least favourable
2. Less favourable
3. Moderately favourable
4. Favourable
5. Most favourable.

The results of the MCA scoring are presented in Table 5-1, which also ranks the schemes in order, based on the combined score for the financial, social, cultural and environmental themes. The table also presents how each scheme scores in terms of opportunities and risks. The details for

each scheme that have contributed to the MCA scores are presented in the tables for each theme in Appendix A. It should be noted that the information presented in the tables is based on preliminary and high level assessments at this early phase of the project.

Table 5-1: Final ranking from MCA

Rank	Scheme	Combined Score for Financial, Social, Cultural & Environmental themes (70%/30% weighting Financial/ Environmental, Social, Cultural)	Opportunities Score	Risk Score
1	135 - "White Rock Road"	4.5	3.3	2.2
2	215 - "Mangatarere"	3.6	4.3	3.0
3	197 - "Te Mara"	3.5	3.1	3.2
4	175 - "Martinborough South"	3.2	2.8	4.7
5	200 - "Kiriwhakapapa"	3.0	2.4	3.1
6	210 - "Black Creek"	2.7	4.6	2.4
7	53 - "Te Ore Ore"	2.5	2.9	2.8
8	74 - "Mauriceville West"	1.9	1.6	3.4
9	79 - "Dorsets Road"	1.9	1.4	3.7

Note: Scores based on a comparative 1 to 5 scale, 1 = Least favourable, 5=Most favourable

5.2 Indicative Irrigable Area Overlap and Gaps

Figure 4-2 shows indicative areas that could be irrigated from each of the nine storages, as defined during this current phase for the purpose of comparing and prioritising schemes as independent, alternative options. Because some of the storages are in close proximity, and the indicative irrigable areas have been developed independently for each scheme to enable comparison, there is some overlap between the indicative irrigable areas associated with the nine short-listed schemes, and hence some apparent gaps between schemes where Figure 4-2 indicates no irrigation.

It is expected that future stages will consider combinations of storages feeding into a combined irrigation area. If two or more overlapping schemes are progressed for further study as a potential combined option, for example Scheme 135 White Rock Road and Scheme 175 Martinborough South, or Scheme 197 Te Mara and Scheme 200 Kiriwhakapapa, the indicative irrigable area for the combined scheme would be modified to show the total area that could be irrigated from the combined storages (ie the overlap will be eliminated). Alternatively, where two schemes overlap, both schemes could be taken forward to pre-feasibility, but with the expectation that one may be abandoned at a future, investigation, consultation or design phase.

Ultimately, if all the storages were developed and linked to a combined valley-wide distribution system, there would be sufficient water available to irrigate most of the valley as shown in Figure 4-1. However, due to the more spread out distribution network that this would entail, it is expected that a combined scheme would result in higher costs per cubic metre of water than the more cost-effective individual schemes.

Figure 4-2, which shows the nine schemes superimposed on one plan and demonstrates the overlap in indicative irrigable areas when considering schemes in isolation, also indicates potentially irrigable areas that are not covered by any of the nine indicative irrigable areas, especially in the vicinity of Greytown and Featherston. This is because the scheme options in these areas generally appeared less favourable in the multi-criteria analysis than the final nine schemes. However, as mentioned above, it does not mean these areas cannot be irrigated from the identified storages.

Schemes involving storages in the Tauweru River valley were not investigated fully in the current phase of work at GWRC's instruction; because of their location and scale two larger storage sites in the Tauweru River valley were considered to have unacceptable community and property implications. Accordingly, potential indicative irrigable areas for the schemes with storages on the Tauweru River system have only been considered on a qualitative preliminary basis. However, preliminary assessment indicates that some alternative smaller storage options on the Tauweru River with lesser community impacts could be amongst the most cost-effective storages. In addition, they could possibly service some of the area south-east of Greytown and Featherston.

For completeness of the process and to ensure that potential servicing of most of the Wairarapa Valley has been considered, it is considered that some smaller options on the Tauweru River system (three or four storage sites, one intake site and distribution area ranging in size to match storage) should be subjected to the same level of assessment as the nine schemes that have undergone full evaluation in this Phase.

It is expected that further stages of the study will consider in more detail such factors as likely farmer uptake of irrigation, and potential productivity increases, and these factors may justify extension of the distribution system into high value areas even if this increases the cost of the distribution network. Alternatively, if the increase in distribution cost is too much, a local, more expensive, but closer storage could be considered.

5.3 Potential to Include Existing Infrastructure

The work to date also indicates that:

- Based solely on relative location, there is potential for further considering the incorporation of treated municipal wastewater from Masterton, Carterton or Martinborough wastewater treatment plants in five schemes (Schemes 53, 135, 175, 210 and 215).
- Based solely on relative location, there is potential for further considering the incorporation of parts of the existing water races system for five schemes (Schemes 53, 197, 200, 210 and 215).

6 Recommendations and Next Steps

6.1 Selecting schemes to progress to further investigations

The scheme ranking and commentary contained in this report provides one facet in the project team's and the community's decision-making process regarding which schemes should progress to further investigation. The final decision as to which sites should be subject to pre-feasibility investigation will need to include a wider context, incorporating additional aspects such as:

- The views and circumstances of the owners of land in the possible storage site areas
- Potential land use changes
- Community and stakeholders' views
- On-farm cost benefit analysis
- Social, community, and cultural character of potential indicative irrigable areas and whether appropriate/receptive to increased irrigation
- Farmer support for irrigation in potential indicative irrigable areas
- Likely 'uptake' of the scheme by potential water users in different indicative irrigable areas
- Soil suitability for irrigation in demand areas, including land use intensification effects
- Degree of existing water allocation in indicative irrigable areas.

At this early stage of the project, the potential effects of land use intensification have not been investigated, but it is recognised that this will be a key aspect during any further investigation phases.

It is expected that the final decision on the schemes to progress to pre-feasibility will be based on the following:

i. The scheme ranking and commentary in the current Options Identification and Analysis Phase (and summarised in this report)
ii. SAG's preferences / feedback on the above
iii. Leadership Group's feedback on (i) and (ii) above
iv. A preliminary cost/benefit analysis
v. Landowner views and potential effects on community issues
vi. GWRC's and the Ministry for Primary Industries' confirmation of funding subsequent phases of the WWUP investigations programme
vii. The level of interest among potential water users in the indicative irrigable areas.

6.2 Recommendations

Based on T&T's technical work to date, the outcome of the MCA as represented in this report, level of costing, and comments from peer reviewers, T&T considers that there is a good rationale for taking more schemes, rather than fewer, to the next stage of investigation. The process has refined the number of schemes from a large number down to a top nine. However, based on the early indications of the potential financial favourability of smaller schemes in the Tauweru River valley, and given the uncertainty at this stage of the study in key factors such as cost estimates[1] and water availability, the relative ranking of the top nine schemes could change following more detailed investigation and analysis. However, there is clearly a balance to be struck between the

[1] It is noted that cost accuracy is only +/-50% at the current stage, and there is only 56% difference between all nine schemes in terms of $/m^3$ of water

number of schemes to be considered in the next stage, and the available time and budget to complete the work.

It is considered that rather than proceeding immediately to a pre-feasibility phase, there is merit in refining some aspects of the work to date to reduce some areas of uncertainty including the potential to provide water to areas that are not able to be serviced by the current nine top schemes. Completion of this 'options refinement' would provide a stronger basis from which to determine schemes that should proceed to full pre-feasibility assessment (following consideration of the additional aspects as noted in Section 6.1).

GWRC has also indicated an interest in exploring, at a high level, the concept of on-farm storage in the investigations programme considering, for example, the opportunities for linkages with the existing water races system as well other on-plain storage to increase reliability. Such storages could potentially serve more than one farm.

The following approach is therefore recommended:

i. Proceed with an Options Refinement Phase that includes:

   a. The top nine schemes particularly focusing on reducing the uncertainty associated with key aspects of the schemes that may affect the ranking (e.g. hydrology and cost estimates);
   b. Reconsideration of the Tauweru Valley catchment and, on confirmation, bring investigation of some smaller schemes up to the same level as the other nine sites;
   c. Consideration of the concept of on-plain storage to complement the larger storages;
   d. Consideration of opportunities for optimisation, and flexibility for sizing (such as for Scheme 210 Black Creek).

ii. Based on the outcome of the Options Refinement Phase, and consideration of the additional aspects noted in Section 6.1 above, following confirmation by GWRC and the broader WWUP Working Group, the Stakeholder Advisory Group and the Leadership Group, undertake pre-feasibility investigations on a smaller number of schemes that have been selected with improved information and confidence.

It is emphasised that even if GWRC (as client) decides to proceed to the next phase of investigations, this level of assessment is still an early stage of any project development and does not imply any commitment to seek resource consents or proceed through to construction.

7 Acknowledgements

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We are especially grateful to those landowners who gave permission for our team members to enter their properties during the site walk-over inspections.

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9 Applicability

This report has been prepared for the benefit of Greater Wellington Regional Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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Appendix A: Detailed Tables for Multi-Criteria Analysis of Nine Schemes

Financial Theme

Site number	Name	Financial score based on $/m^3 *(based on volume supplied on farm in a 10% AEP drought year after distribution losses but not allowing for on farm efficiency)*
53	Te Ore Ore	2.2
74	Mauriceville West	1.5
79	Dorsets Road	1.0
135	White Rock Road	5.0
175	Martinborough South	2.9
197	Te Mara	3.8
200	Kiriwhakapapa	2.9
210	Black Creek	2.9
215	Mangatarere	4.0

Environmental (Terrestrial) Theme

Site Number	Name	RAP	QEII Covenant	High Value Terrestrial Biodiversity Site	Landscape Character Area	NZ Geopreservation Inventory	Combined District Plan annotations	Comment	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	no	no	no (touches 1 patch)	no	no	no	pasture, scattered totara, manuka, willow. Slight impingement on areas with indigenous biodiversity value	4
74	Mauriceville West	no	no	no	no	no	no	pasture, plantation forest (pines, eucalypts, amenity). No apparent areas of biodiversity value.	5
79	Dorsets Rd	no	no	no	no	no	no	pasture. Riparian of willows poplars. 1 small area native in middle reservoir	4.5
135	White Rock Rd	no	yes - 1 (small part touches)	no	no	Mangopari Miocene-Pleistocene paleomagnetic section	no	mostly pasture. impinge on lower part native vege (QEII). Scattered natives at dam site in gorge area	3.5
175	Martinborough South	no	no	no	no	no	no	pasture. Scattered totara & manuka side slopes. Construction area may affect totara patch at dam site true right. Wetland grasses?	4.5
197	Te Mara	no	yes - 1 within	no	no	no	no	pasture. Significant planted areas - amenity plus native. Native in upper reservoir	2.5
200	Kiriwhakapapa	no	no (but a few immediately downstream)	no	no	no	no	pasture. Scattered totara, kahikatea, cabbage trees. Significant native downstream of dam	3
210	Black Creek	no	yes - 1	no	no	no	no	pasture. Some plantations. Wakamoekau dam area manuka totara	2.5
215	Mangatarere	no	no	yes - small part of upper reservoir	no	no	Significant natural area (Carrington Creek Stewardship Area)	pasture, pines, regenerating natives	1

Environmental (Aquatic) Theme

Site Number	Name	River	On river?	Distribution	Trout Fishery	Aquatic Migratory spp	Aquatic Threatened spp	Wetlands	Combined District Plan annotations	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	unnamed tributary to Whangaehu	no - ephemeral stream. infill from Ruamahanga River	Pipeline from reservoir	F&G advises Whangaehu River is spawning and popular fishing	no. Ruamahanga: long-fin eel, redfin bully, koaro, banded kokopu, short fin eel	no. Ruamahanga: long-fin eel, redfin bully, koaro, brown mudfish (declining)	1	no	5 (dam not on permanently flowing stream)
74	Mauriceville West	Tributary of Kopuaranga River	yes	Into stream below dam, to Kopuaranga Stm for approx 5 km, then picked up by pipeline	Kopuaranga River is impt trout habitat (RFP). F&G advises Kopuaranga River is spawning and very popular fishing	no (GIS layer). Kopuaranga River: FWF database records long-fin eel, torrentfish, short fin eel	no (GIS layer). Kopuaranga River: FWF database records long-fin eel, torrentfish (declining)	no	no	3
79	Dorsets Rd	unnamed tributary of Kopuaranga River	yes, but very small stream. infill from Kopuaranga River	Into stream below dam, to Kopuaranga Stm for approx 3.5 km, then picked up by pipeline	Kopuaranga River is important trout habitat (RFP). F&G advises Kopuaranga River is spawning and very popular fishing	no (GIS layer). Kopuaranga River: FWF database records long-fin eel, torrentfish, short fin eel,	no (GIS layer). Kopuaranga River: FWF database records longfin eel, torrentfish (declining)	no	no	4
135	White Rock Rd	confluence of Makara/Mangapari	yes	Pipeline from reservoir	F&G advises Makara River is spawning; Mangapari probable spawning; extent of fishing unknown or infrequent	no (GIS layer). No specific records in FWF database. Huangarua River:long-fin eel, torrentfish,inanga, short fin eel, common bully	no (GIS layer). No specific records in FWF database. Huangarua River:long-fin eel, torrentfish,inanga (declining)	no	no	2 (two streams)
175	Martinborough South	unnamed tributary to Dry	no - ephemeral stream/drainage channel. infill from Ruamahanga River	Pipeline from reservoir	Dry River: F&G advises spawning unknown. Fish reported up in bush but river often dry in summer.	no (GIS layer). No specific records in FWF database for Dry River. Ruamahanga River: long-fin eel, redfin bully, bluegill bully, torrentfish, giant kokopu,lamprey, short fin eel, common bully, smelt	no (GIS layer). No specific records in FWF database for Dry River. Ruamahanga River: long-fin eel, redfin bully, bluegill bully, torrentfish, giant kokopu,lamprey (declining).	no	no	5 (dam not on permanently flowing stream)
197	Te Mara	Te Mara Stm	yes. Plus infill from Ruamahanga River	Pipeline from reservoir	Important trout habitat (RFP); Highest value reach for fish; fish spawning & recruitment (Cawthron). F&G advises spawning; fishing popular	no (GIS layer). No specific records in FWF database for Te Mara Stm. Ruamahanga: long-fin eel, redfin bully, koaro, banded kokopu, short-fin eel	no (GIS layer). No specific records in FWF database for Te Mara Stm. Ruamahanga: long-fin eel, redfin bully, koaro, brown mudfish (declining)	1	no	3
200	Kiriwhakapapa	Kiriwhakapapa Stm	yes	Pipeline from reservoir	Important trout habitat (RFP); Highest value reach for fish; fish spawning & recruitment (Cawthron); F&G advises spawning; fishing popular	no (GIS layer). FWF database lists long-fin eel, lamprey, short-fin eel, crans bully	no (GIS layer). FWF database lists long-fin eel, lamprey, dwarf galaxias (declining)	no	no	2.5
210	Black Creek	Black Creek & Wakamoekau Ck	yes plus infill from Waingawa River	Pipeline from reservoir, from both dams	Wakamoekau Ck impt trout habitat (RFP). F&G advises Black Creek spawning; Wakamoekau probable spawning; extent of fishing unknown or infrequent	no (GIS layer). FWF database lists long-fin eel, common bully for Black Creek. Waingawa River = long-fin eel, redfin bully,koaro, common bully	no (GIS layer). FWF database lists long-fin eel for Black Creek. Waingawa River= long fin eel, redfin bully,koaro (declining)	no	no	2.5 (on two streams)
215	Mangatarere	Mangatarere Stm	yes	Pipeline from reservoir	Important trout habitat (RFP); Highest value reach for fish; fish spawning & recruitment (Cawthron). F&G advises spawning; fishing very popular	yes (GIS layer). FWF database lists long-fin eel, lamprey, short fin eel, common bully, inanga, torrentfish	yes (GIS layer). FWF database lists long-fin eel, lamprey, inanga, torrentfish, dwarf galaxias (declining)	no	Significant natural area (Carrington Creek Stewardship Area)	1

Social Theme

Site Number	Name	Dwellings Affected	Community Facilities Affected	Recreational Value	Effects on Connectivity	Combined District Plan annotations	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	assume 1 (below dam), plus potentially two near spillway route	no	Not a recognised swimming or kayaking river. Ruamahanga popular swimming spot near intake site, and kayaked throughout length (but not whitewater)	no	no	4
74	Mauriceville West	8	Yes - community 'heart'. Access to Lutheran Church, cemetery, & historic school affected but assumed replaced.	Not a recognised swimming or kayaking river.	yes. Connection between Mauriceville & Mauriceville West cut. Replacement assumed but long round trip and severs connection between 2 connected settlements. Realignment - some bits easy, some difficult	no	1
79	Dorsets Rd	0	no	Not a recognised swimming or kayaking river.	no	no	5
135	White Rock Rd	4 - Birch Hill Station	no	Not a recognised swimming or kayaking river.	yes - affects White Rock Rd, major access route to Tora and White Rock coastal areas & Haunui Windfarm. Realignment assumed but challenging.	no	3
175	Martinborough South	0	no	Not a recognised swimming or kayaking river. Ruamahanga kayaked throughout length (but not whitewater)	no	no	5
197	Te Mara	1	no	Not a recognised swimming or kayaking river. Ruamahanga kayaked throughout length. Whitewater section u/s of intake location.	no	no	4
200	Kiriwhakapapa	4	no	Not a recognised swimming or kayaking river.	yes - Kiriwhakapapa Rd, including access to Tararua Forest Park and associated camping ground, and 10 dwellings. Realignment assumed, albeit complicated.	no	2.5
210	Black Creek	11	no	Black & Wakamoekau not recognised swimming or kayaking river. Waingawa popular for swimming at intake location, and kayaking u/s of intake.	no - affects road but not access to properties outside those directly affected. Assume abandon	no	1.5
215	Mangatarere	7, plus commercial accommodation lodge	no	Not a recognised swimming or kayaking river.	yes including access to Tararua Forest Park plus 2 houses and commercial lodge. Assume realignment, albeit realignment technically challenging.	Significant natural area (Carrington Creek Stewardship Area)	2

Cultural Theme

Site Number	Name	River	Cultural Value (noted in CVA)	Recorded archaeological / historic sites	Intercatchment Transfer/Harvest	Combined District Plan annotations	Comment	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	unnamed tributary to Whangaehu	Ruamahanga River - yes. Very significant	no (but urupa on top of bluff immediately downstream)	yes - infill from Ruamahanga River	no	proximity to urupa - area may have wider value? Ruamahanga River	1
74	Mauriceville West	Tributary of Kopuaranga River	Kopuaranga River - yes	no	no - own catchment	no	nothing apparent	4
79	Dorsets Rd	unnamed tributary of Kopuaranga River	yes	no	yes (infill from Kopuaranga River)	no	nothing apparent	3
135	White Rock Rd	confluence of Makara/Mangapari	yes - Huangarua	no	no	no	nothing apparent. Potential for low flow enhancement in Huangarua	4
175	Martinborough South	unnamed tributary to Dry	Ruamahanga River - yes. Very significant	no	yes - infill from Ruamahanga River	no	Ruamahanga River	2
197	Te Mara	Te Mara Stm	Ruamahanga River - yes. Very significant	no	yes - infill from Ruamahanga River	no	Ruamahanga River	2
200	Kiriwhakapapa	Kiriwhakapapa Stm	no	no	no	no	nothing apparent	4
210	Black Creek	Black Creek & Wakamoekau Ck	yes Waingawa	no	yes - infill from Waingawa River	no	Waingawa River	3
215	Mangatarere	Mangatarere Stm	no, but Waiohine is	no	no	Significant natural area (Carrington Creek Stewardship Area)	nothing apparent. Potential for low flow enhancement	5

Opportunities Theme - Headworks

	Raw	Adjusted
Minimum	1.0	1
Maximum	3.8	5

Scheme		Hydropotential *Plant Capacity Factor (PCF) indicates benefit to cost in terms of the amount of energy likely to be generated relative to the size of plant that is purchased.*	Opportunities for optimisation *Storage size, dam location*	Raw opportunity score for headworks	Adjusted opportunity score for headworks *(1=Least favourable, 5=Most favourable)*
Weighting		30%	70%		
53 - 33.7 MCM	Te Ore Ore	1 Least favourable -PCF=25% approx -1.61 GWhr -0.70 MW	4 Favourable -A smaller size dam with less pumping could potentially be more economic & avoid dam break effects associated with northern saddle dam	3.1	4.0
74 - 7.9 MCM	Mauriceville West	2 Less favourable -PCF=50% approx -0.55 GWhr -0.13 MW	1 Least favourable -Limited opportunity for optimisation of dam size (cost per cu.m likely to increase with reducing reservoir size based on preliminary analysis, and cannot be made bigger because of impact on cemetery)	1.3	1.4
79 - 4.1 MCM	Dorsets Road	1 Least favourable -PCF=35% approx -0.12 GWhr -0.04 MW	1 Least favourable -Limited opportunity for optimisation of dam size (cost per cu.m likely to increase with increasing reservoir size based on preliminary analysis and already close to minimum limit worth considering in this study)	1.0	1.0
135 - 26 MCM	White Rock Road	3 Moderately favourable -PCF=50% -2.80 GWhr -0.64 MW	3 Moderately favourable -A smaller dam (Site 142 - 17.4MCM) located approximately 5km upstream, could potentially be free of limestone (none in QMAP but not inspected on ground) improving favourability in terms of geotech risk and cost (though distribution component of cost could increase) -Preliminary analysis indicates the cost per cu.m increases marginally with decreasing reservoir size (currently at hydrological limit) -Could take advantage of existing road cutting for spillway	3.0	3.9
175 - 12.3 MCM	Martinbourough South	1 Least favourable -PCF=25% -0.29 GWhr -0.13 MW	3 Moderately favourable -A smaller size dam with less pumping could potentially be more economic	2.4	3.0
197 - 27.3 MCM	Te Mara	2 Less favourable -PCF=40% -1.78 GWhr -0.51 MW	4 Favourable -A smaller size dam with potentially *no* pumping could be more economic & have better hydropotential as well as less complexity and risk	3.4	4.4

Scheme		Hydropotential *Plant Capacity Factor (PCF) indicates benefit to cost in terms of the amount of energy likely to be generated relative to the size of plant that is purchased.*	Opportunities for optimisation *Storage size, dam location*	Raw opportunity score for headworks	Adjusted opportunity score for headworks *(1=Least favourable, 5=Most favourable)*
Weighting		30%	70%		
200 - 32.5 MCM	Kiriwhakapapa	3.5 Moderately favourable -PCF=50% -3.66 GWhr -0.83 MW	3 Moderately favourable -A smaller size dam could potentially be more economic & have better hydropotential since not at hydrological limit	3.2	4.1
210 - 77.2 MCM	Black Creek	1 Least favourable -PCF=30% -5.06 GWhr -1.82 MW	5 Most favourable -Reservoir modelling may allow us to remove extension of harvesting pipe to saddle -A smaller size reservoir could potentially be more economic and require less pumping	3.8	5.0
215 - 45.8 MCM	Mangatarere	5 Most favourable -PCF=50% -7.82 GWhr -1.78 MW	2 Less favourable -Limited opportunity for optimisation of dam size (cost per cu.m decreases only marginally with reducing dam size)	2.9	3.7

Notes on scores

1 Least favourable
2 Less Favourable
3 Moderately Favourable
4 Favourable
5 Most favourable

Opportunities Theme - Distribution

Site number	Name	Synergies with wastewater re-use	Synergies with stock water race networks	Opportunities for optimisation	Opportunities to use existing rivers for conveyance that are not currently adopted because of lack of information	Opportunities for staged development	Overall Score
53 - 33.7 MCM	Te Ore Ore	4 The scheme lies reasonably close to the Masterton WwTW, but passes uphill of it. As such pumping would be needed to augment this scheme with WW.	4 There is good overlap with the stock water races to the south of masterton and there should be scope to augment these or use these for conveyance at a local level.	4 A canal may provide cost improvements to a piped network and would be suitable given the topography and flow. This would push up land purchase costs.	1 None. Water could be dropped into the Ruamahanga, but it would be difficult to re-extract.	2 Possible to build the network to the east of the Ruamahanga, this would be simple and would cover about 1/3 of the area. But, the pipes would have to be hugely oversized for future expansion, so as a stand alone scheme it would not be good value.	2.7
74 - 7.9 MCM	Mauriceville West	1 The scheme is upstream of all WwTW so is not suited to integration with the WwTW and reuse of waste water.	2 Some but limited overlap with stock water races, so little scope to generate significant scheme savings or efficiencies from using stock water races.	1 Pipes are likely the best option here, so few significant core improvements likely to be available. Minor improvements certainly possible.	1 None beyond the current usage.	4 Would be possible to construct each branch in isolation without disproportionate over-sizing of the first network.	1.0
79 - 4.1 MCM	Dorsets Road	1 The scheme is upstream of all WwTW so is not suited to integration with the WwTW and reuse of waste water.	2 Some but limited overlap with stock water races, so little scope to generate significant scheme savings or efficiencies from using stock water races.	1 Pipes are likely the best option here, so few significant core improvements likely to be available. Minor improvements certainly possible.	1 None beyond the current usage.	4 Would be possible to construct each branch in isolation and then expand the network to the north west at a later date if this was designed for.	1.0
135 - 26 MCM	White Rock Road	5 The Martinborough WwTW could be used to supply the network. Pumping costs would be incurred but the WwTW is close to the network so could be accessed with comparative ease.	1 No overlap with any known stock water races so no scope for integration with any new distribution network.	3 Canals could be used for some of the supply as the topography to the southwest of Martinborough is favourable for these.	5 It may be possible to use the river to convey water over the first part of the route. However, from the identified river intake site a gravity system would be difficult due to the topography. This would need to be investigated.	1 No opportunities for staged development exist as the majority of the cost would be in the initial pipeline from the dam to the demand area.	2.8
175 - 12.3 MCM	Martinbourough South	5 The Martinborough WwTW could feed the northern end of this network with comparative ease it is envisaged. Some pumping would be required.	1 No overlap with any known stock water races so no scope for integration with any new distribution network.	3 Canals could be used to the southwest of Martinborough and should be considered.	1 Not likely to be suitable or necessary. Certainly if the pumped storage main was to be used in supply, it would need to run right to the dam.	5 As the distribution network is broadly 'radial' it would certainly be feasible to build each branch or arm in turn in phases, without having to oversize infrastructure excessively.	2.4

Site number	Name	Synergies with wastewater re-use	Synergies with stock water race networks	Opportunities for optimisation	Opportunities to use existing rivers for conveyance that are not currently adopted because of lack of information	Opportunities for staged development	Overall Score
197 - 27.3 MCM	Te Mara	1 Located well upstream of Masterton WwTW, there seems to be no opportunity for incorporating treated waste water into the distribution network.	3 There is some overlap with stock water races to the north west of Masterton and to the north, which may allow some limited integration for localised distribution.	3 Sections of canal may offer savings towards the south of the scheme.	1 Unlikely, particularly if the rising main was also used in distribution. The savings in pipework by dropping water into the Ruamahanga to abstract it later are expected to be minor.	2 This scheme has two distinct branches so it may be beneficial to stage the construction, but it would lead to the first section being heavily oversized if it were considered as a stand alone scheme.	1.5
200 - 32.5 MCM	Kiriwhakapapa	1 Located well upstream of Masterton WwTW, there seems to be no opportunity for incorporating treated waste water into the distribution network. It is possible that the very south-eastern section of the network could be augmented by flow from the WwTW.	3 There is some overlap with stock water races to the north west of Masterton and to the north, which may allow some limited integration for localised distribution.	2 Limited scope for optimising this scheme, though there may be some possibilities with canals for aspects towards the south.	1 Unlikely. The savings in pipework by dropping water into the Ruamahanga to abstract it later are expected to be minor.	2 This scheme has two distinct branches so it may be beneficial to stage the construction, but it would lead to the first section being heavily oversized if it were considered as a stand alone scheme.	1.1
210 - 77.2 MCM	Black Creek	3 The south-eastern section of the network could possibly be augmented by flow from the WwTW.	5 There is good overlap with the stock-water race network to the west of Masterton particularly, and there should be good opportunities to integrate the systems.	5 There appears to be good scope for improving the scheme to better balance the available head and refine pipe diameters. Reducing them if possible. Canals should also be considered if possible.	3 Sections of the Waipoua river may both be used, and should be considered, though it may not prove economic when re-abstraction costs are incorporated.	5 This scheme (essentially two schemes) is ideal for a phased development, with many discreet branches which could be added over time.	5.0
215 - 45.8 MCM	Mangatarere	4 It may be possible to augment the distribution network with flow from the Carterton and Masterton WwTW. Pumped obviously.	5 There is good overlap with the stock-water race network to the west of Masterton particularly, and there should be good opportunities to integrate the systems.	5 It is likely that this scheme could be improved to better balance the head at the farm gate, and canals towards the lower end of the networks or integration with stock-water races also seems possible.	3 Some smaller rivers may be incorporated into the scheme, but it appears likely that any significant benefits would be offset by river intake costs. It may be worth further investigation.	3 Given the radial nature of the layout it lends itself to building branches in stages. However, the pipe diameters at the upstream end, driven by the full scheme could well render parts of the scheme unaffordable in their own right.	4.5

Opportunities Theme - Social, Cultural and Environmental

Site Number	Name	Flow enhancement opportunities	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow base of dam. Very small contributing catchment (main source is infill from Ruamahanga). Approx 4km natural stream channel to Whangaehu. 2.5km from Whangaehu to Ruamahanga. Assume that residual flow from natural catchment would be insignificant contribution to Whangaehu.	1
74	Mauriceville West	Stored water released to unnamed tributary of Kopuaranga, providing potential augmnetation of summer flows. Potential to benefit approx 5km of Kopuranga	3
79	Dorsets Rd	Stored water released to unnamed tributary of Kopuaranga, providing potential augmentation of summer flows. Potential to benefit approx 3.5km Kopuranga	3
135	White Rock Rd	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow base of dam. Could benefit the natural flows of the Huangarua	3
175	Martinborough South	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow base of dam. Could benefit the natural flows of Dry River	3
197	Te Mara	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow at base of dam. Could benefit the natural flows of Te Mara Stream over 2-3 km stretch before confluence with Waipoua	3
200	Kiriwhakapapa	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow at base of dam. Could benefit the natural flows of Kiriwhakapapa Stream though only a short distance to Waipoua River (0.5km), where relative contribution is likely to be small.	1
210	Black Creek	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow base of dams. Could benefit the natural flows in Black Creek (though only a short distance to Waingawa River where relative contribution is likely to be small). May be more benefit to Wakamoekau Creek	3
215	Mangatarere	Piped distribution - no benefit from storage water input to natural stream. Flow enhancement possible only from residual flow at base of dam. Could benefit the natural flows of Mangatarere, which is known to run dry in vicinity of Andersons' Line during low flow periods combined with groundwater abstraction and losses	5

Risk Theme - Headworks

	Raw	Adjusted
Minimum	1.5	1
Maximum	3.9	5

Scheme		Geotechnical complexity & uncertainty *Higher complexity & uncertainty creates greater risk of costs being higher than allowed for, will increase design and investigation costs, and will involve greater consenting cost and risk*	Sedimentation *If the sedimentation allowance is a very small proportion of live storage, even if the sedimentation expected changes by several fold, it will not impact the viability of the scheme. The current estimates are expected to be conservative for low land rivers but potentially unconservative for upper catchment rivers. The current estimates are based on sediment loads in the general catchment, but additional sediment could also be generated in the reservoir due to slope instability triggered by changing water levels - so site observations re reservoir stability are also included.*	Complexity of arrangement *Requirement for and size of harvesting infrastructure, complexity of spillway and diversion arrangements, outlet works and road realignment. Note that the size of own catchment floods relative to reservoir size (and thus possible attenuation via routing) has already been accounted for in the base cost of spillways.*	Available area for batching, lay down and spoil disposal	Raw risk score for headworks	Adjusted risk score for headworks *(1=Least favourable, 5=Most favourable)*
	Weighting	40%	15%	30%	15%		
53 - 33.7 MCM	Te Ore Ore	2 Moderate to high risk -Limestone in upper reservoir, likely to be "leaky" requiring some treatment -Complex relationship between disconnected limestone blocks -Active fault mapped within 200m downstream dam though location of trace uncertain on site -Significant subexcavation has been allowed for (because of ZST instability & backflooding of gravels) so there may be an opportunity for saving if less required	2 Moderate to high risk -Dead storage 0.2% of live storage based on WRENZ estimate -Relatively low in catchment so WRENZ estimate conservative wrt to bedload allowance -Reservoir instability up to 5m deep observed on site	3 Moderate risk -Some harvesting requirements (7-8% of scheme cost) and ongoing operational costs (NPV 5-6% of scheme cost). 2.5MW pumpstation, $5m^3/s$ peak flow, 41m high lift, 490m long riser main. -Treatment to prevent leakage in upper reservoir allowed for in base costing (1-2% of scheme cost) but not well defined (note already addressed under Geotech Complexity)	4 Favourable -Reasonable space downstream if dwelling purchased	2.6	2.9
74 - 7.9 MCM	Mauriceville West	2 Moderate to high risk -Bedding related (possibly) lineament through abutment with active fault within 400m downstream	2 Moderate to high risk -Dead storage 3.0% of live storage based on WRENZ estimate -At a low to intermediate elevation in catchment -Shallow instability in tertiaries	4 Low to moderate risk -Risk of requiring an additional road to connect Mauriceville to Mauriceville West	3 Moderately favourable -Space upstream of dam but limited space downstream of dam for spoil disposal	2.8	3.2
79 - 4.1 MCM	Dorsets Road	3 Moderate risk -Displaced material on right abutment (some allowance already made) -Upper part of left abutment and some of left side side of reservoir rim located in limestone. Karstic LST is present in the general area. An allowance for lining has been made already in base estimates.	2 Moderate to high risk -Dead storage 2.3% of live storage based on WRENZ estimate -At an intermediate to high elevation in catchment so WRENZ estimate potentially unconservative wrt to bedload allowance -Shallow instability in tertiaries	3 Moderate risk -Significant harvesting requirements relative to reservoir size (15-16% of scheme cost). 0.2MW pumpstation, $0.25m^3/s$ peak flow, 204m high lift, 2.8km riser main. -Treatment to address limestone in left abutment allowed for in base costing (2-3% scheme cost) but not well defined (note already addressed under Geotech Complexity)	1 Least favourable -Limited space downstream of dam for spoil disposal. And limited flat space both upstream and downstream for laydown and batching	2.6	2.8
135 - 26 MCM	White Rock Road	1 High risk -Limestone present in left abutment (& top of right abutment if not realigned) and left side of reservoir. Not expected to be karstic. An allowance for treatment has been made in base estimates, but there is still risk it could require more than allowed for. -Limestone present in upper right abutment, may require dam alignment to be adjusted at greater cost than currently allowed for, to avoid limestone -Bedding dips downstream so uplift pressures under dam to be considered	1 High risk -Dead storage 11% of live storage based on WRENZ estimate -At an intermediate elevation in catchment -Shallow instability in tertiaries	2 Moderate to high risk -Realignment of road very expensive (10% of scheme cost) and may not be financially feasible because of steepness and landslippage -Risk of requiring an additional farm track to connect across very steep unstable ground to maintain connection to airstrip -Treatment to prevent leakage through left side of reservoir allowed for in base costing (7-8% of scheme cost) but not well defined (note already addressed under Geotech Complexity)	2 Less favourable -Space upstream of dam and at higher levels, but no space downstream of dam at river level for spoil disposal	1.5	1.0

Scheme		Geotechnical complexity & uncertainty *Higher complexity & uncertainty creates greater risk of costs being higher than allowed for, will increase design and investigation costs, and will involve greater consenting cost and risk*	Sedimentation *If the sedimentation allowance is a very small proportion of live storage, even if the sedimentation expected changes by several fold, it will not impact the viability of the scheme. The current estimates are expected to be conservative for low land rivers but potentially unconservative for upper catchment rivers. The current estimates are based on sediment loads in the general catchment, but additional sediment could also be generated in the reservoir due to slope instability triggered by changing water levels - so site observations re reservoir stability are also included.*	Complexity of arrangement *Requirement for and size of harvesting infrastructure, complexity of spillway and diversion arrangements, outlet works and road realignment. Note that the size of own catchment floods relative to reservoir size (and thus possible attenuation via routing) has already been accounted for in the base cost of spillways.*	Available area for batching, lay down and spoil disposal	Raw risk score for headworks	Adjusted risk score for headworks *(1=Least favourable, 5=Most favourable)*
	Weighting	40%	15%	30%	15%		
175 - 12.3 MCM	Martinbourough South	5 Low risk -Active fault at head of reservoir but has been allowed for in base costing (extra 0.5m freeboard) -Peat in valley & relatively large depth of gravels to be removed at dam site (has already been allowed for in base costing) -Inactive fault immediately downstream of dam marking a change in geology	5 Low risk -Dead storage 0.2% of live storage based on WRENZ estimate -In an intermediate to high elevation in catchment so WRENZ estimate potentially unconservative wrt to bedload allowance -Slumping of loess overlying greywacke	2 Moderate to high risk -Significant harvesting costs (20% of scheme cost) and ongoing operational costs (NPV 28-29% of scheme cost). 0.8MW pumpstation, $1m^3/s$ peak flow, 189m high lift, 1.8km riser main (harvesting only) and utilising 7.7km of distribution network.	3 Moderately favourable -Space upstream of dam but limited space downstream of dam for spoil disposal	3.8	4.9
197 - 27.3 MCM	Te Mara	4 Low to moderate risk -Leakage through possible paleovalleys on left side of reservoir (some allowance made for localised lining, but not at all locations) -Crushed zone in right abutment, associated with springs -Potential for sliding at the tertiaries/terrace gravel interface to be considered	4 Low to moderate risk -Dead storage 0.7% of live storage based on WRENZ estimate -At a low to intermediate elevation in catchment -Potential for sliding at the interface of terrace gravels and tertiaries (probably only in EQs)	3 Moderate risk -Some harvesting costs (6-7% of scheme cost). 0.7MW pumpstation, $1.2m^3/s$ peak flow, 92m high lift, 1km riser main (harvesting only), and utilising 3km of distribution network.	5 Most favourable -Abundant flat space downstream of dam site	3.9	5.0
200 - 32.5 MCM	Kiriwhakapapa	4 Low to moderate risk -Wedge failures at left abutment. Stability to be investigated but likely ok if abutment cut at a slope less than friction angle of 28-30deg. -Active fault within 500m downstream -Potential for sliding at the tertiary/alluvial gravel interface	4 Low to moderate risk -Dead storage 1.1% of live storage based on WRENZ estimate -At a low to intermediate elevation in catchment -Potential for sliding at the interface of terrace gravels and tertiaries (probably only in EQs)	4 Low to moderate risk -Road realignment considered likely to be feasible based on present information but challenging (greywacke and steep) (6-7% of total scheme cost)	3 Moderately favourable -Some room downstream of both dams.	3.9	5.0
210 - 77.2 MCM	Black Creek	3 Moderate risk -Consider potential for leakage through right abutment of Black Creek dam into ancient landslide -Potential for sliding at the tertiary/alluvial gravel interface (including at the Black Creek dam right abutment - significant subexcavation has been allowed here) -Possible inactive fault aligned with river at the Black Creek dam -Wedge failure downstream of right abutment of Wakamoekau dam	3 Moderate risk -Dead storage 0.3% of live storage based on WRENZ estimate -At a low to intermediate elevation in catchment -Potential for sliding at the interface of terrace gravels and tertiaries, some evidence of instability on this surface already evident	1 High risk -Two outlets required. -Significant harvesting costs (17% of scheme cost) and ongoing operational costs (3% of scheme cost). 11.3MW pumpstation, $13.2m^3/s$ peak flow, 70m high lift, 4 no. 1km long riser main plus 2.8km long low pressure extension to saddle. Also utilising 1km of distribution network.	3 Moderately favourable -Wakamoekau Dam in steep location. Some room downstream of both dams though.	2.4	2.6
215 - 45.8 MCM	Mangatarere	3 Moderate risk -Complex faulting and tectonic environment -Bedding related lineaments observed in the left side of valley at dam site -Low angle joints may transmit uplift pressures under the dam -Gravel terraces upstream of gorge section may indicate uplift/tilting of the block on which the dam is located (considered less likely than other explanations, but still a risk)	4 Low to moderate risk -Dead storage 1.5% of live storage based on WRENZ estimate -At an intermediate elevation in catchment -Greywacke scree common	4 Low to moderate risk -Road realignment likely to be feasible based on present information but challenging (greywacke and steep) (9% of total scheme cost)	1 Least favourable -Steep site, limited space downstream of dam for spoil disposal.	3.2	3.8

Risk Theme - Distribution

Site number	Name	Pressure supplied at farm gate	System complexity	Storage distance from supply area	Overall Score
53 - 33.7 MCM	Te Ore Ore	1 Pressure is poor, less than 5m in many areas due to flat area served.	3 Two river crossings and large pipe diameters make for moderately difficult construction, but acceptable.	3 15km or so. But very linear. A more radial system would give better pressures and smaller pipes.	2.1
74 - 7.9 MCM	Mauriceville West	5 Pressure is good. In excess of 5m in almost all cases, but not excessive such that controlling flows may become difficult.	4 River crossings and rail line crossings add complexity, but the reduced pipe diameters make the construction more achievable.	4 All within around 10km and with three distinct branches, which provides good value for the investment.	5.0
79 - 4.1 MCM	Dorsets Road	3 Pressure is good, at or around the target value of 5m in most cases. The eastern branch could be improved by increasing the pipe diameters slightly.	4 River crossings and rail line crossings add complexity, but the reduced pipe diameters make the construction more achievable.	4 All within around 10km and with two distinct branches, which provides good value for the investment.	3.9
135 - 26 MCM	White Rock Road	5 Pressure is very good to all areas of the network.	2 The upper sections will likely be complex, costly and difficult to construct. Although, an access track is likely to be required for dam construction, which could double as a pipe track, so savings may be possible.	1 It is in excess of 20km from the furthest ends of the network, and approximately 10km from the start of the key irrigable area. This adds to the cost quite considerably.	3.1
175 - 12.3 MCM	Martinbourough South	2 Too high essentially so some cost in reducing pressures to workable levels will be required.	5 There are no known obvious impediments to construction. The crossing of the Ruamahanga should also be achievable due to the smaller diameter pipe and available head to support a pipe bridge.	5 A compact scheme, broadly radial and within 10km of the source of supply (generally)	4.2
197 - 27.3 MCM	Te Mara	2 Too high essentially so some cost in reducing pressures to workable levels will be required.	1 Some or all of the crossings will lead to highly complex engineering works in their own right.	1 Well over 20km from end to end, the conveyance costs to move the large volumes of water over this distance will be excessive.	1.0
200 - 32.5 MCM	Kiriwhakapapa	2 Too high essentially so some cost in reducing pressures to workable levels will be required.	1 Some or all of the crossings will lead to highly complex engineering works in their own right.	1 Well over 20km from end to end, the conveyance costs to move the large volumes of water over this distance will be excessive.	1.0
210 - 77.2 MCM	Black Creek	3 Very variable around the networks, which essentially comprise two discreet networks. The target pressure is achievable in all areas but in some areas the pressure is excessive and would need to be reduced.	1 Some or all of the crossings will lead to highly complex engineering works in their own right.	3 Although large at around 15km from end to end, the layout is reasonable. Radial rather than linear.	2.1
215 - 45.8 MCM	Mangatarere	3 Variable. Always above the target but in some places too high, so the cost of pressure reduction could become a factor. This may be reduced by refining the network.	2 The Waingawa River crossing may be complex, as might the road and rail crossing as the pipeline is quite large at this point. Not perceived as too high a risk though or unachievable.	3 Although large at around 15km from end to end, the layout is reasonable. Radial rather than linear.	2.6

Risk Theme - Social, Cultural, Environmental

Site Number	Name	DOC Land	QEII Covenanted Area	Cultural Values	Community	Consent risk (based on activity status)	Changed water allocation and min flow regime (Regional Plan change)	Overall Comment	Score (1= Least favourable, 5= Most favourable)
53	Te Ore Ore	no	no	burial site nearby	no	nothing specific	Ruamahanga - more likely to change?		4
74	Mauriceville West	no	no		reservoir level relative to cemetery; 'hub' of Mauriceville West community	nothing specific		significant community risk	1
79	Dorsets Rd	no	no		no	nothing specific			5
135	White Rock Rd	no	yes - 1 (small part touches)		small risk due to realignment of road	nothing specific			3
175	Martinborough South	no	no		no	nothing specific	Ruamahanga - more likely to change?		5
197	Te Mara	no	yes - 1 within		no	nothing specific		QEII = risk but area is man-made wetland rather than significant natural area	3
200	Kiriwhakapapa	no	no (but a few immediately downstream)		small risk due to realignment of road; number of dwellings affected	nothing specific			2.5
210	Black Creek	no	yes - 1		number of dwellings affected	nothing specific	Waingawa - more likely to change?	QE II = pond - not clear whether man-made or natural. Number of dwelllings	2.5
215	Mangatarere	yes. Small part encroaches into Tararua Forest Pk & Carrington Creek Conservation Area, plus substantial lengths of Mangatarere Valley Marginal Strip	no		number of dwellings affected	nothing specific	Mangatarere - most likely to change?	DOC land, number of dwelllings	2

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