USE OF MULTI-CRITERIA ANALYSIS TO IDENTIFY A PREFERRED DAM SITE

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ABSTRACT

How do you make a robust management decision on a preferred site for a new water supply dam when the three short listed locations each have different advantages, disadvantages, issues and costs? How do you compare apples with oranges? When Greater Wellington Regional Council was faced with this dilemma whilst planning future water supply storage for the four cities of metropolitan Wellington, its consultant, MWH NZ Ltd, suggested using multi-criteria analysis as a tool to assist in making this important decision.

Multi-criteria analysis is an analytical approach to assist decision-making that is increasingly being used in New Zealand. However, carrying out the process in a workshop environment, three times, with different groups of participants and with each group identifying its own relevant attributes, applying their own weighting systems and scoring them to identify a preferred option, is unusual. The robustness of the process was confirmed by each group separately determining the same preferred dam site.

While the process provided a clear and defensible preference for one site, it also demonstrated the reliability of the multi-criteria method of analysis, and in this case, the use of facilitated workshops to undertake the analysis.

KEYWORDS

Multi-criteria analysis, attribute, weighting, facilitated workshop, dam site

1 INTRODUCTION

Greater Wellington Regional Council (GWRC) is the wholesale water supplier to the four cities of metropolitan Wellington (Upper Hutt, Lower Hutt, Porirua and Wellington). In 1997 modelling work identified that the existing infrastructure would support predicted population growth to 2020 at the agreed standard of 2% probability of shortfall in any year (1 in 50 year drought) and at existing consumption rates. However, following a significant increase in the reported population and future growth projections in 2005 it became apparent that there was a strong probability the capacity of the system would be reached much sooner.

GWRC decided to commence investigations into water supply development options with a target of supplying water for an additional 60,000 population. MWH NZ Ltd (MWH) was commissioned to carry out a high level review of the options including on-river storage (live storage), off-river storage, run-of-river, groundwater and desalination. The review resulted in the run-of-river, off-river storage and desalination options being discounted due to capacity limitations or unit cost. The review looked at a number of locations for live storage, which were then narrowed down to dam sites in three GWRC-owned water catchment areas, or land designated for future water supply, that could provide sufficient storage and yield. These were on the Pakuratahi and Whakatikei tributaries on the eastern and western sides respectively of the Hutt River catchment; and Skull Gully in the Wainuiomata River catchment.

During 2007 MWH carried out detailed investigations at each of these three locations. Each site was surveyed using aerial survey by LiDar technology to identify potential capacity for a range of specific dam locations and heights. Investigations covered a wide range of aspects, including hydrology and engineering (dam, access roads, treatment requirements and integration into the existing network), geotechnical and seismic analysis, aquatic and terrestrial ecology, archaeological and heritage implications, social and cultural issues, planning and consenting issues, and construction and operational implications. Climate change implications were also taken into account. Preliminary base and 95 percentile cost estimates were produced for each location and preliminary consultation was carried out with stakeholders.

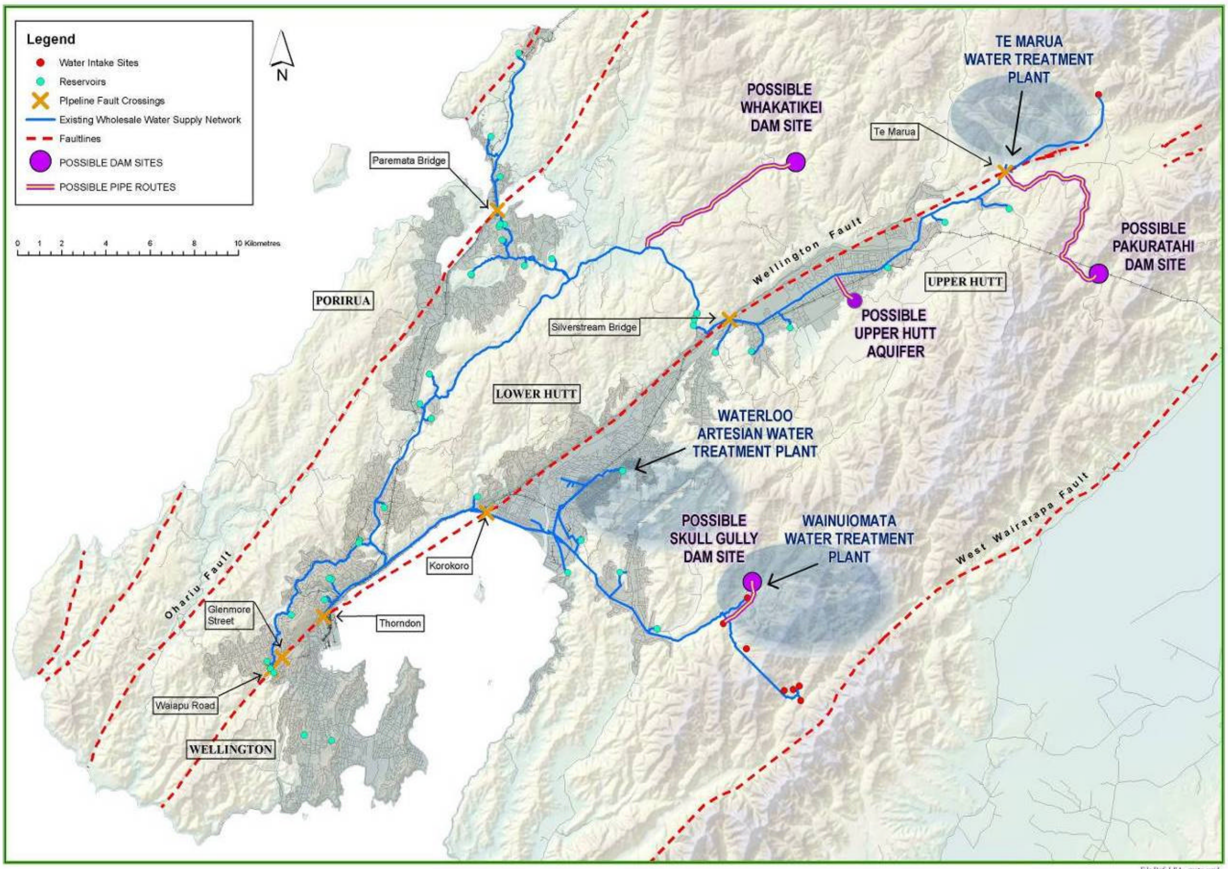
The three options investigated were quite different in terms of the potential issues identified, advantages, disadvantages and cost. The only consistent feature was their ability to provide an adequate supply of water and storage capacity to meet the identified future community needs.

Having gained a large amount of detailed information about each option, the dilemma then was how to systematically evaluate such a diverse range of issues and identify a preferred dam site. One approach would be to calculate the lowest cost by putting a value on each aspect and issue identified, which would have been difficult because of the many intangible values involved, and the results being very open to debate. MWH suggested an alternative approach using multi-criteria analysis, which was seen to be a more appropriate tool, and this was adopted as the evaluation methodology.

2 OVERVIEW OF THE DAM SITES

A substantial amount and diverse range of information was gathered on each of the three sites during the investigations phase. The key elements of this information are covered in this section. Figure 1 below shows the Wellington Metropolitan water supply network serving the cities of Upper and Lower Hutt, Porirua and Wellington. The plan indicates the approximate location of each of the three dam sites in the Pakuratahi, Whakatikei and Wainuiomata catchments. It also identifies the approximate route of the main earthquake fault lines in the area, which has relevance to the network's security of supply.

Figure 1: Metropolitan Wellington Wholesale Water Network and Possible Dam Locations



2.1 SITE ENGINEERING ISSUES

All catchments are able to provide sufficient storage to meet the required water supply yield, although Skull Gully requires the addition of water from the Orongorongo catchment, which would be provided from an existing pipeline. All sites have similar underlying geological conditions and foundations suitable for a dam. A roller compacted concrete dam with a spillway on the downstream face was recommended for all three sites. The same dam height was needed at each location to provide the water yield required, and in all cases the dam could be increased in height to give larger storage and greater yield. The dam concrete volume at Whakatikei was approximately half of the other two sites, but the surface area, length and stored volume of the reservoir formed was considerably greater. No significant landslide issues were identified at any of the sites, although the Orongorongo catchment is prone to landslides.

All sites required site access roads; reservoir clearing; dam foundation excavation and river diversion; concrete aggregate supplies and stockpiling, delivery of cement, concrete batching and transport to dam site

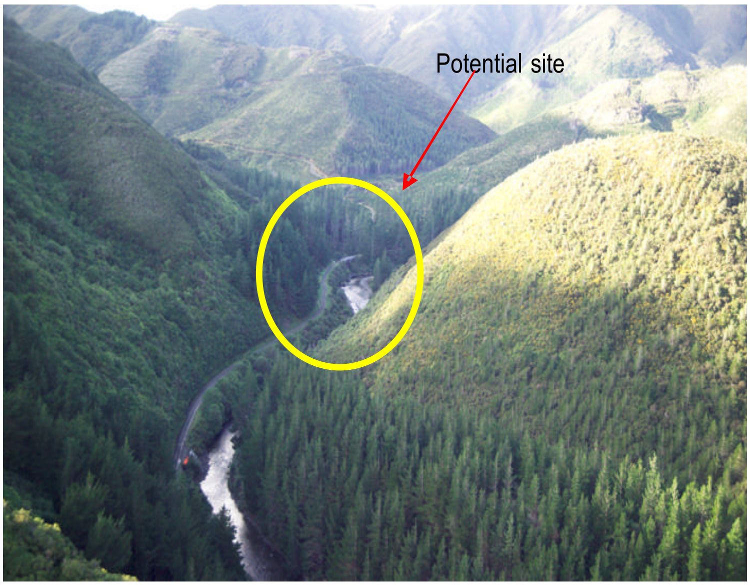
One site (Whakatikei) required a new water treatment plant; the other two sites would utilise augmented existing water treatment facilities.

2.2 ENVIRONMENTAL ISSUES

2.2.1 TERRESTRIAL ECOLOGY

The terrestrial ecology varied at each of the three dam sites. Pakuratahi consists of regenerating low forest, scrub and pine plantation, with a significant Manuka fen wetland area. Pakuratahi has the least amount of indigenous vegetation. There are threatened New Zealand birds and twelve species of indigenous land snail were recorded in the wetland. However, terrestrial values at Pakuratahi are regarded as least affected of the three sites by development of a dam.

Photograph 1: Pakuratahi dam site



Skull Gully is part of one of the largest tracts of unlogged lowland podacarp forests in the lower North Island, and is a site of special wildlife interest as part of a "mainland island" catchment project. Skull Gully has the highest bird life density and several species of threatened birds.

Skull Gully is regarded as the most significant of the three sites investigated in terms of terrestrial ecology.

Whakatikei has regenerating forest types, including pine plantation, and a high degree of naturalness upstream of the dam site. There is significant vegetation and a wetland area. The Whakatikei site provides habitat for threatened birds, lizards and invertebrates

2.2.2 AQUATIC ECOLOGY

Water quality at all three sites is regarded as high or moderate to high, and the ecology at all three sites is pristine. The largest number and density of fish species was identified at Whakatikei downstream of the dam site, the lowest number of fish species was recorded at Skull Gully and the lowest fish density at Pakuratahi. Habitat quality was the highest at Skull Gully but good at all sites. The Pakuratahi and Whakatikei Rivers are trout spawning tributaries of the Hutt River.

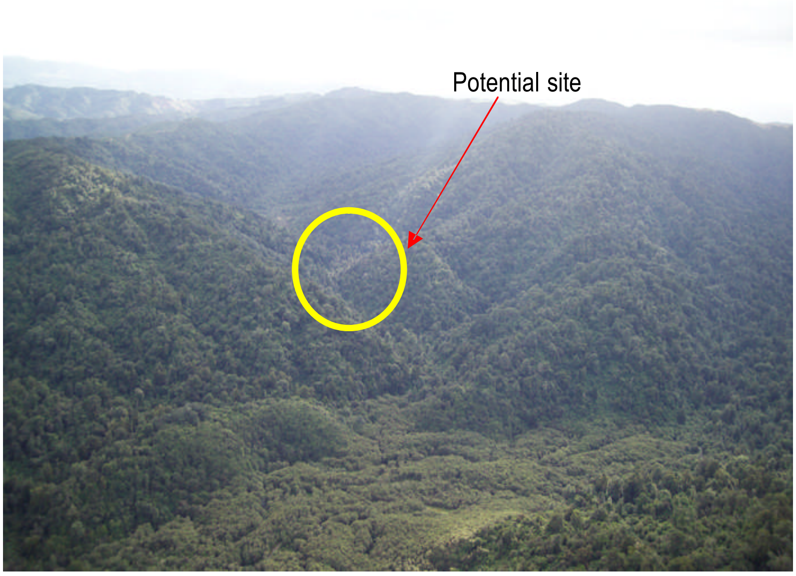
The effects on aquatic ecology were assessed to be least at the Pakuratahi site and greatest at the Whakatikei site.

2.3 SOCIAL AND RMA ISSUES

2.3.1 SOCIAL ISSUES

Pakuratahi has extensive recreational use by a range of type and age of user. Whakatikei has recreational use for walking, cycling, horse riding and permitted motorised recreation. Skull Gully has restricted public access but there are significant social concerns from recognition of its high ecological values.

Photograph 2: Skull Gully dam site



2.3.2 TANGATA WHENUA VALUES

Some interest was expressed in all sites, particularly in term of the efficient and respectful use of water resources. Iwi were neutral towards Pakuratahi, but would require further archaeological investigation.

Skull Gully was least favoured in recognition of its terrestrial ecological values. Whakatikei was the most preferred site by iwi.

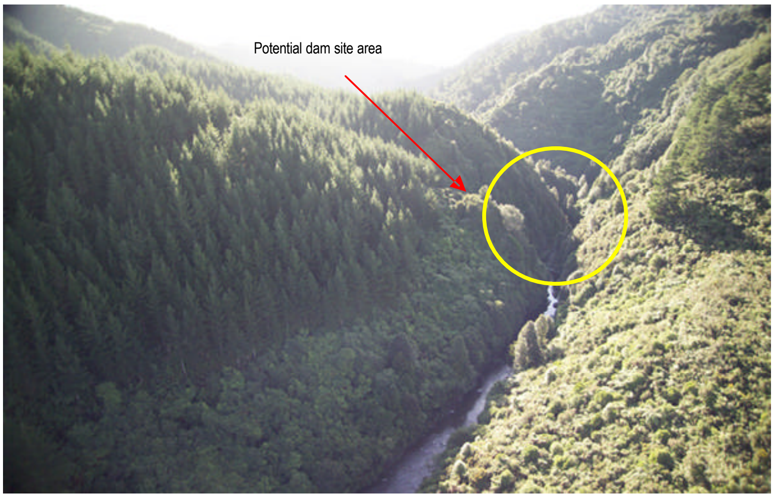
2.3.3 CULTURAL AND HERITAGE VALUES

Pakuratahi has national heritage values associated with its historic railway line formation that would be partially submerged by a reservoir lake and the historic Ladle Bend Bridge would be inundated. The rail alignment would also be affected by the pipeline route. A new section of track would need to be constructed around the edge of the lake, but this would not mitigate the heritage values. A number of heritage stakeholders, including the Historic Places Trust, are strongly opposed to any interference with the area.

2.3.4 RECREATIONAL OPPORTUNITIES

Skull Gully is in a secure catchment and part of a "mainland island" project, therefore recreational opportunities would continue to be controlled and limited. The Pakuratahi catchment currently has open access for recreation, particularly to the rail trail, which is used for walking and cycling, and it would be difficult to restrict future access. Whakatikei has open access for non-motorised recreation and permitted access for managed motorised recreation. Whakatikei may provide an opportunity for recreational access to and around a reservoir lake but the level of access that would be permitted has not yet been considered by GWRC Councillors.

Photograph 3: Whakatikei dam site



2.3.5 CONSENTING AND DESIGNATION ISSUES

While all sites are designated in the relevant district plans for catchment, water supply or water collection purposes, none of the current designations were found to be broad enough to provide for the development of a large dam and storage reservoir. Processes to either modify the designation for the preferred option or seek consent under the district plans would be needed in all cases.

In addition, numerous consents would be needed under regional plan provisions.

Regional plans contain a range of policies and rules which present challenges in each of the options, including recognition of natural state waterways, natural character and ecological values.

2.4 SECURITY OF SUPPLY AND OPERATIONAL ISSUES

All existing wholesale water supply pipelines cross the Wellington fault line before reaching Wellington City. A fault movement event will affect water supply from Te Marua, Waterloo and Wainuiomata treatment plants. In addition, the pipelines from Wainuiomata and Waterloo treatment plants traverse the Petone shoreline, which is prone to liquefaction during a severe seismic event.

The Whakatikei catchment is on the western side of the Wellington fault line and will be less effected by a fault movement enabling quicker reinstatement of the water supply to Wellington and Porirua. Skull Gully and Pakuratahi would both utilise existing or augmented treatment facilities. Whakatikei would require an additional water treatment plant, which would increase treatment capacity and provide greater security of supply.

2.5 CAPITAL AND OPERATIONAL COSTS

A base cost estimate and a 95 percentile estimate was prepared for each dam site. The 95 percentile estimate was adopted for budgetary purposes. As at September 2007 the 95 percentile estimates (including associated distribution system upgrades) were approximately Pakuratahi \$163M; Skull Gully \$81M; Whakatikei \$137M.

Operational costs were estimated to be similar at all sites, with Skull Gully and Pakuratahi having slightly lower costs than Whakatikei. The overall difference was less than \$0.5 million per annum.

3 WHAT IS MULTI-CRITERIA ANALYSIS?

Multi-criteria analysis is a methodology that helps in decision-making between options where there are many variables of different types that may be either non-tangible or cost variables. Traditional cost benefit analysis generally involves assigning a monetary value to specific aspects of each option. This creates difficulties in areas such as the environment and social impacts, where the perception of value varies throughout the population and reliable costing is often not possible. Multi-criteria analysis was developed as a tool for evaluating options without the need to assign a monetary value to those types of attributes. However there are some aspects of every analysis that can be adequately valued in terms of dollar costs and benefits, and multi-criteria analysis is able to incorporate these into the overall analysis.

3.1 METHODOLOGY

The methodology uses a process that identifies the relevant aspects or attributes that need to be taken into account in the decision, weights the attributes (if appropriate), and applies a scoring system to the attributes for each option, to give a combined weighted attribute score for each option. There are a number of ways of undertaking the process, with the involvement of an informed group of people through one or more facilitated workshops being a generally preferred method. The workshop method involves developing a shared understanding of the issues through information sessions before identifying the relevant issues or attributes that can be applied to the options, weighting (if appropriate) and scoring each attribute for each option. The total weighted score for each option indicates the ranking of the options and the preference of the workshop. Identification of any 'fatal flaws' and sensitivity analysis to test the robustness of outcomes, are both essential parts of the process. Identification of a 'fatal flaw' would lead to the abandonment of that option.

The method relies on a transparent and systematic evaluation of relevant aspects of options in any decision circumstance. While the method can be applied by a single analyst, it gains more credibility when multiple participants with a range of backgrounds are involved. Early research internationally (R.M. Cooke, 1992, J. Won, 1990) demonstrated that, given the same information, diverse groups of people in workshop situations are likely to reach the same preferences if multi-criteria analysis is applied. There are a number of base-line requirements however for the workshop process to be effective. These include adequate information presented in a way that can be absorbed and understood by all participants, so the opportunity to ask questions and discuss the information is important. If any important information gaps are identified, then the opportunity needs to be available for the information to be obtained and 'workshopped' into the analysis at a later date. It is also important that the workshop is managed in a way that ensures all participants are able to express opinions in an open way and to contribute at each stage of the analysis – dominant personalities thus have to be controlled, and the skill and independence of the facilitator is paramount. Sufficient time for discussion, debate and reflection is also needed, and reconvening and reviewing processes may be desirable.

3.2 IDENTIFICATION OF ATTRIBUTES AND SCORING

Attributes need to be identified and then carefully defined, so that during scoring all participants relate to the same attribute scope. It is important to work with no more than about twelve attributes, as a large number can lead to a smoothing of the outcome. The scoring system, regardless of whether a scale of three, five or ten is used, needs to be described so that all participants understand it. A scale of 5 is manageable for most people, whereas larger numbers do not necessarily reflect real differences between scores. Weighting systems can be the most controversial aspect of multi-criteria analysis, and it is important to consider whether weighting of attributes is needed. If there is, the logic behind it needs to be explained – for example weightings based on expressed community outcomes, or resource management considerations may be appropriate.

Properly applied, and subject to sensitivity reviews in terms of both scores and weights, multi-criteria analysis is a useful and reliable technique to assist decision-making. It overcomes many of the problems inherent in other methods of analysis.

4 PROCESS ADOPTED BY GWRC

GWRC was keen to ensure that its decision process in determining the preferred dam option was based on a robust and transparent analysis and that several groups contributed to the eventual decision by elected representatives. It also wanted to ensure that those determining the preferred option were fully informed and engaged in the process.

Three separate workshops involving individual groups were arranged to carry out the multi-criteria analysis to identify the preferred dam site. The groups comprised GWRC senior staff, staff from the four City water supply customers, and GWRC Councillors. The workshops were undertaken in a two-stage process, with stage 1 workshops in November 2006 and stage 2 workshops in June/July 2007. MWH advisors facilitated all workshops and presented technical information at all workshops, but did not contribute to the decision processes. GWRC officers were fully involved in the decision process in their workshop, but the role of officers in the other two workshops was to present information and answer queries only.

4.1 STAGE 1 WORKSHOPS

The first workshop for each group was undertaken before the detailed studies of the three dam sites had been completed. One of the benefits of holding workshops at this stage was the opportunity to identify whether any studies additional to those already under way would be needed, as well as confirming the relevance of those that were under way. Each of the three groups was provided with a comprehensive description of the three dam site options, and the background and preliminary information available at the time relating to each option. They were then asked to 'brainstorm' the issues that participants thought may be relevant to a decision, and as far as practicable, to group them into clusters of issues that could form the basis of an attribute. The attributes were then pulled together and described back to the participants for their preliminary agreement.

Each workshop identified between thirty to forty issues in the 'brainstorming' session, which were then organised into attributes for the later analysis. Whilst each workshop provided a slightly different list of issues, there was a relatively high degree of agreement on the attributes. The differences were primarily around the scope and therefore the significance of attributes – for example, Workshops 2 and 3 identified "future proofing" as a separate attribute, while Workshop 1 incorporated the ability to add further capacity as part of the attribute of "security of supply". This latter consideration was included as a separate attribute in Workshops 2 and 3. In contrast, Workshops 1 and 2 identified "terrestrial ecology" and "aquatic ecology" as separate attributes in their analyses, whereas Workshop 3 incorporated both aquatic and terrestrial ecology as a single "ecology" attribute.

There were also significant differences around how the different workshops handled capital and operational costs. Workshop 2 chose to work with 11 attributes, while Workshops 1 and 3 identified 10 each.

Table 1: Example of Issues and Attributes Identified - Workshop 3

Attributes	Issues identified
Cost & Economics	Capital cost, cost & economics, capital cost/litre storage
Environmental	Fauna and flora, loss of habitat, wetlands lost/gained, loss of native vegetation, fauna impact, pests, plant and animals, aquatic habitat, river health, trout, native fish, environmental, non-native fish, landscape, archaeological, downstream impacts, mitigation (e.g. wetlands)
Security of Supply	Natural disasters, security of supply, terrorism, vulnerability to climate change, security of pipeline (incl terrorist), additional WTP, pollution of water supply, seismic risk
Future Proofing	Scaleability, future proofing, potential to increase storage capacity, potential to supply Kapiti
Construction	Construction issues, construction impact, buildability, sustainability of construction, time
Operational Costs	Operational costs
Associated opportunities/ multiple use	Spin-off opportunities (e.g. hydro-power), recreational opportunities, multi-users of area/site, consequential development, opportunities for enhancement
Social Issues/Public values	Fit with regional strategy, population supplied and location fit to population, change in recreational use, social issues, accessibility (public) – lost/gained, recreational value, downstream impacts of failure, TLA/social/public perception, cultural issues, heritage value, Tangata Whenua, end users
Consentability	Consentability (difficulty – cost and time), designation change, land issues (access/consenting)
Operational Issues	Accessibility (operational), fit with existing infrastructure, accessibility, vulnerability to siltation, catchment management, relative heads, flood mitigation potential, operational impacts, water quality and pollution

Figure 2: Example of Relative Weighting of Attributes - Workshop 3

Attribute Refs:	A	B	C	D	E	F	G	H	I	J
10										
9										
8										
7										
6										
5										
4										
3										
2										
1										
0										
Attributes	Cost and economics	Environment	Security of supply	Future proofing	Construction	Operational cost	Associated opportunities/ multiple use	Social issues/ public values	Consentability	Operational issues
Weight:	10	10	9	6	5	8	4	8	8	7

4.1.1 WEIGHTING

In this multi-criteria analysis, weighting of the attributes was important due to the number and different impact of intangible issues and the wide variation in capital cost between sites.

The weighting of attributes was carried out with the help of a graphic spreadsheet that visually demonstrated the relationships between the attributes as a result of the weighting. The benefit of this method was that all participants could view and consider the relativity of the weightings, and the effect of adjustments could be immediately tested.

The graphic spreadsheet used a scale of ten units for the weighting of each attribute. The weights obtained were then normalized to sum to 1.

Any disagreement in weighting was recorded for future sensitivity analysis. The first round of workshops concluded with completion of the preliminary identification of attributes and a preliminary weighting.

4.2 STAGE 2 WORKSHOPS

The second series of workshops was carried out following completion of the more detailed specialist studies. The second round of workshops involved the same participants and a full day for each group. Information from the more detailed studies was presented and participants reviewed the outcomes of their earlier workshop (to ensure that the attributes they had identified and described were still considered relevant and comprehensive, and they were comfortable with the weightings they had allocated for each).

Working through the information relevant to each attribute, each workshop then scored their attributes for each of the dam site options. This stage again requires considerable discussion and ideally a consensus score is reached. In the occasional situation when consensus cannot be reached, the majority score is used, with the minority being noted for use in later sensitivity analyses. Each of the three dam site options was scored against each attribute on a scale of 1 to 5 (1= few difficulties or issues in terms of the attribute being scored; 5 = extreme difficulties or issues in terms of the attribute being scored), and the scores, modified by the agreed weighting system, were totalled for each dam site. The lowest score indicated the most preferred option. A check of sensitivity was subsequently carried out using both minority scores and alternative weightings. This included the few scores where a diversity of views had been recorded. The outcome from each workshop was found to be reliable when sensitivity analysis was applied.

Table 2: Attributes, Scores and Weightings from Workshop 3

Site	Cost and economics	Environment	Security of supply	Future proofing	Construction	Operational cost	Associated opportunities/multiple use	Social issues/public values	Consentability	Operational issues	Overall score (weightings applied)
Weighting	0.133	0.133	0.120	0.080	0.067	0.107	0.053	0.107	0.107	0.093	
Pakuratahi	4	2	4	2	2	2	3	3	4	3	**2.973**
Skull Gully	2	5	5	2	3	2	3	4	5	2	**3.413**
Whakatikei	4	3	2	1	2	2	3	2	3	1	**2.387**

Note: a lower score indicates a more preferred option

5 RESULTS FROM THE ANALYSIS

The results of the analysis are shown in table 3 below. As can be seen, there was a clear preference from all three workshops, and therefore across all three groups involved, for the Whakatikei option. In all cases there was a significant margin to the next preference. The multi-criteria analysis tool had produced a conclusive result that gave GWRC the information necessary to enable a recommendation to be made to Greater Wellington Councillors without the need for further investigation and analysis.

Table 3: Total scores by workshop for each dam site

Dam Site	Workshop 1	Workshop 2	Workshop 3	Average All Workshops
Pakuratahi	3.716	3.175	2.973	**3.288**
Skull Gully	3.493	3.667	3.413	**3.524**
Whakatikei	2.000	2.351	2.387	**2.246**

However, table 3 also demonstrates that the second preference varied between workshops, with workshop 1 preferring the Skull Gully option but the other two workshops preferring the Pakuratahi option. This would pose problems if for any reason the Whakatikei option was rejected at a later date.

Had the first preference varied between the three workshops, it would have been necessary to examine each of the analyses with great care, to try to understand the basis for and nature of the differences in the preference. From a preliminary review of the results in relation to the second preference, it is apparent that Workshop 3 applied lower scores than the other two workshops to the difficulties likely to be associated with heritage values in relation to the Pakuratahi site (see table 2, where the attributes of 'consentability' and 'social issues/public values' are given only a 4 and a 3 respectively). The other two workshops gave similar attributes a 5 each. Workshop 1 considered these difficulties to be close to a 'fatal flaw'. The difference between Workshop 2 and Workshop 1 preference for the second site appears to have resulted from different weighting systems, rather than the initial scores.

Because of the clear nature of the first preference, the issue of conflicting preferences has not arisen. However it does indicate that had there been a disagreement in first preference between the three workshops a detailed examination of the scores and weighting would have been necessary.

6 ADVANTAGES AND DISADVANTAGES OF THE PROCESS

6.1 ADVANTAGES

Fully informing and involving the group in the decision making process produces a result that is highly defendable legally both in terms of the Resource Management Act and Local Government Act processes. Carrying out this process with three separate groups and achieving the same identified preference demonstrates the strength of the multi-criteria analysis, and confirms the robustness of this approach.

Multi-criteria analysis provides a methodology to consider intangibles that do not require a dollar cost to be assigned, which avoids debate on the reliability of the cost and is therefore able to accommodate the differing values of separate groups.

The process requires a good level of understanding of all the issues and aspects associated with the decision to be made. It is a very open and transparent process that requires all individuals in the group to be highly involved at all stages, and this involvement is more likely to produce a higher degree of ownership of the results achieved.

6.2 DISADVANTAGES

While the multi-criteria analysis process is information-hungry, arguably equal or more information would be needed to support other decision techniques such as cost benefit analysis or the less formal processes of discussion and debate that may be used in local government or asset agency decision-making. The multi-criteria analysis process using the workshop approach can however be time-consuming and therefore can add a relatively costly component to the overall work on a project in terms of participant's time, facilitation and venue. In GWRC's case there was a significant amount of preparation time required for presentation material for the workshops, organising and running the workshops, and reporting on the results. These costs though were small in terms of the potential expenditure of $81M to $163M.

Due to the time commitment it is not necessarily an appropriate methodology to assist in making an urgent decision or a decision within a short timeframe. Similarly, it is not necessarily an appropriate method when only a small number of considerations need to be brought to bear on a decision (for example, if a single site was being considered and the differences were only those of capacity and cost).

It is also relevant to note that any multi-criteria analysis has a 'shelf life', and may need to be repeated if a project does not proceed. Information and costs may change over time to the extent that the preference from multi-criteria analysis would be different if the process was carried out at a later time. The preference of a group is based on the information available at the time the process is carried out. It may be appropriate to review the attributes, weightings and scores for a decision if there is a significant change in information or cost. This comment would however apply equally to most other decision-making techniques.

6.3 FURTHER COMMENTS ON THE PROCESS

On the face of it, multi-criteria analysis can appear to be more rigorous than it is. It uses simple mathematical processes of summation but it is important to note that the analysis has neither mathematical nor statistical validity, and thus it should not be subjected to scrutiny by such techniques. Rather it should be seen for what it is - a simple, transparent and comprehensible method of identifying the perceptions and values held by the participants.

It is important to recognise that multi-criteria analysis does not in itself make a decision, but is a structured and auditable aid to making a decision. Whilst the final decision made may be different from the preference identified by multi-criteria analysis, that decision would be made after deliberating on the preferences identified from any multi-criteria processes that have been used.

If a "fatal flaw" is identified during the multi-criteria analysis process, it may be necessary to include an option that has been rejected at an earlier stage in the process to ensure that a sufficient range of options are considered in the analysis.

7 CONCLUSIONS

An unusual aspect of this particular application of multi-criteria analysis was that the process was duplicated by the participation of three completely different groups of participants in separate workshops. Despite each group identifying a slightly different list of issues and attributes, assigning their own weightings to attributes and separately scoring the attributes, each group identified the same preference for a dam site. The process has therefore proved to be a valuable and robust tool for decision-making.

For GWRC, the multi-criteria workshops did not make the decision on a dam site, but it allowed each group to identify its preference for a site using a structured and defendable process. The actual decision on the preferred dam site was made by GWRC Councillors taking into account the recommendation of officers based on the results of the workshops, consultation with the four City Council water supply customers, and public response through the 2009/19 draft LTCCP consultation process. Following this consultation Greater Wellington Council has approved Whakatikei as the preferred site for a dam when one is required.

ACKNOWLEDGEMENTS

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