18 March 2014 Reference No. 1378110270-204-LR-Rev0

Manuherikia Catchment Water Strategy Group
C/o Kate Scott
BTW South Limited
P O Box 302
Cromwell 9342

MT IDA DAM HYDROLOGY REVIEW

Dear Kate

1.0 SUMMARY

The Manuherikia Catchment Water Strategy Group (MCWSG) is currently undertaking a feasibility level study of the Manuherikia River catchment to provide water storage and distribution for irrigation. As part of the feasibility study MCWSG requested that Golder Associates (NZ) Limited (Golder) peer review the Mt Ida Dam hydrological investigations and particularly Aqualinc (2013a), Hamilton (2006) and Raineffects (2006). This letter[1] documents Golder's peer review. To optimise and cost the preferred Mt Ida Dam option and to be ready for resource consent applications detailed hydrological information is required. Aqualinc Research Limited's (Aqualinc) existing hydrological model provides a suitable platform from which to derive the necessary hydrological information. However, Golder considers that a number of refinements to the model, the input data and the associated documentation are required. A list of recommended refinements and next steps are provided in Section 5.0 of this letter.

2.0 INTRODUCTION

The Hawkdun Idaburn Irrigation Company Limited (HIIC) and landholders in the Oturehua to Wedderburn area have been investigating options for obtaining a more reliable water supply. They have investigated various options and a dam on the Ida Burn near Seagull Hill, called the Mt Ida Dam, has been selected as the preferred option. Operation of the dam and the associated irrigation scheme is very dependent on inflows from both the catchment and the Mt Ida Race. Two key hydrology studies have been completed for the dam.

1) In June 2006, Raineffects Limited completed a report titled *Upper Ida Burn Irrigation Dam Feasibility Study Hydrology Report* (Raineffects 2006). The hydrological information derived from the Raineffects study was used to inform two further feasibility level studies of the dam and associated irrigation scheme:

    a. A study undertaken by Pickens Consulting Limited which focused on dam design (including hydraulic structures, i.e., spillway, construction diversion, and outlet) and which was documented in a report titled *Feasibility Study Proposed Upper Idaburn Dam* (Pickens 2005).

[1] This letter is subject to the limitations in Attachment 1.

b. A study undertaken by David Hamilton and Associates Limited and documented in a report titled *Mt Ida Dam Investigation Feasibility Study Report including Simulation for Water Storage and Piped Irrigation* (Hamilton 2006) which documented the proposed scheme and included a dam reliability assessment.

2) In September 2013 Aqualinc completed a report titled *Mt Ida Dam hydrology* (Aqualinc 2013a). The objective of Aqualinc (2013a) was to update the earlier Raineffects 2006/Hamilton 2006 studies to include more recent hydrological data.

Aqualinc (2013a) estimated a potential irrigation supply area from the dam which is 25% less than the estimate provided by Hamilton (2006). Reducing the supply area is likely to have significant consequences for the viability of the scheme. The proponents of the scheme, namely HIIC and landholders in the area, have expressed concern regarding the differing supply areas.

Scope of Review

The MCWSG is currently undertaking a feasibility level study of the Manuherikia catchment to provide water storage and distribution for irrigation. An objective of the feasibility study is to be consent ready and it is anticipated that the feasibility reports (including the Mt Ida Dam Hydrology report) will be the key technical documents that will support any future consent application. As part of the feasibility study Golder were asked to undertake a peer review of the hydrology of the Mt Ida Dam and provide guidance on how to proceed. This letter documents Golder's peer review, which is separated into the following sections:

1) Methodology and information sources

2) Discussion points and key issues – which describes the main differences between the two hydrology studies (Raineffects 2006/Hamilton 2006 and Aqualinc 2013a).

3) Recommendations – which provide guidance on how to proceed with the hydrological investigations for the Mt Ida Dam.

Golder understands that the MCWSG plan to co-ordinate a meeting between the various report authors and key stakeholders to discuss the Mt Ida Dam hydrology and determine a path forward. The objective of this letter is to provide background and guidance for that meeting.

3.0 METHODOLOGY AND INFORMATION SOURCES

In completing this review and providing our recommendations we undertook the following four steps:

1) Initial review of the relevant background hydrological material, particularly Aqualinc (2013a), Hamilton (2006) and Raineffects (2006), and subsequent correspondence between the parties.

2) A field visit to the Mt Ida Dam site and a tour on 20 November 2013 of the Mt Ida Race from Ida Burn to Johnstones Weir with Keith Campbell of Aqua Irrigation Ltd (the raceman for HIIC).

3) A meeting with Peter Brown of Aqualinc on 9 December 2013, and a phone conversation (and subsequent email correspondence) with David Hamilton of David Hamilton and Associates Limited, and similar contact with David Stewart of Raineffects. These were conducted to further clarify the scientific analysis that was undertaken.

4) Documentation of the review process and its key findings in this letter.

In completing this review Golder considered numerous documents, a list of which is provided in Attachment 2.

In completing this letter, we note that we have not reviewed the hydrological models that were used by either Aqualinc or David Hamilton and Associates Limited when preparing their reports. Similarly while we have looked at the spreadsheets used by Raineffects to prepare their report (Raineffects 2006) we have not reviewed them in any detail. This review is principally based on the written documentation and discussions with the respective authors.

4.0 DISCUSSION POINTS AND KEY OBSERVATIONS

4.1 Scope of Studies

Feasibility assessment of irrigation storage reservoirs and irrigation schemes requires two key types of hydrological information.

1) A hydrological model is required which simulates operation of the scheme and allows various scheme layouts and management options to be assessed. Usually a water balance model is used which considers both water demand and water supply. These models generally should cover the reservoir (particularly inflows and outflows) and the irrigation scheme and extend downstream to allow potential downstream flow changes to be assessed. The model will be principally surface water based, but should consider groundwater changes associated with irrigation (i.e., increased recharge and potentially higher groundwater levels and spring flows). The model must allow climate fluctuations to be assessed, and usual practise is to develop a daily water balance model which considers water supply and demand, is based on historic climate and hydrological information that includes a variety of climatic conditions (i.e., wet year, dry years, etc.).

2) Detailed flood information is required for design of spillways and construction diversions. The flood information is also used when undertaking dam break assessments.

The two hydrological studies (Raineffects 2006/Hamilton 2006 and Aqualinc 2013a) each develop a hydrological model for the Mt Ida Dam and irrigation scheme, and both provided estimates of flood flows at the dam site. However both studies provide very limited comment on the potential change to downstream flows and neither model considers groundwater.

4.2 Comparing the Hydrological Models

4.2.1 Time-step and duration

Hamilton (2006) developed a spreadsheet based monthly water balance model for the Mt Ida Dam and irrigation scheme for the approximately 24-year period, January 1975 to January 1994 and December 1998 to April 2004. Aqualinc (2013a) developed a daily hydrological model for the 39-year period June 1973 to May 2013. As the two models span different time periods direct comparison of projections is difficult. For reservoir sizing, assessing reservoir operation, and determining potential irrigation supply areas it is necessary to consider both wet and dry periods and it is preferable to use reservoir water balance models that are based on a daily time-step. Monthly models, such as the one used by Raineffects, often do not identify the implications of critical periods of peak water demand.

A key assumption in both models is that future climatic conditions are likely to be similar to historic records. When considering future climate, both climate change and climate variability need to be addressed. Neither model considers climate change and both address climate variability by using long historic records (24 and 39 years respectively). Aqualinc prepared a report on climate change (Aqualinc 2012a) for the MCWSG which indicated that irrigation demand is likely to increase due to a combination of increased temperatures and lower summer rainfall, and that the occurrence of extreme floods would increase.

Due to its daily time-step and longer duration Golder recommends that the Aqualinc model be the basis for any future assessment of the Mt Ida Dam and irrigation scheme. However consideration should be given to updating the model to include climate change factors which allow the effect of: increased temperatures, reduced summer rainfall, increased winter rainfall, crop demand, and other related factors to be assessed.

4.2.2 Operation of the Hawkdun-Idaburn Irrigation Scheme and the Mt Ida Water Race

In developing the Mt Ida Dam, current operation of the Hawkdun-Idaburn Irrigation Scheme will have priority and the water supply reliability that current irrigators experience will need to be maintained. Current operation of the Hawkdun-Idaburn Irrigation Scheme and the Mt Ida Water Race needs to be well understood and included in the model.

Hamilton (2006) provides a thorough description of the Hawkdun-Idaburn Irrigation Scheme and the Mt Ida Race, and their operation and presents historic water-use and operational data from the scheme.

Aqualinc (2013a) does not present historic water-use and operational data from the scheme, but estimates that irrigation demand for the existing Hawkdun-Ida Burn irrigation scheme. Figure 4 of Aqualinc (2013a) ranges from a maximum of 41 head (1,160 L/s) in November through March to a low of 7 head (198 L/s) in May through August, the basis for the estimate is not documented.

Golder understands that HIIC installed water level sensors on the Johnstone and East Eweburn weirs, and continuous data on actual scheme flows and water use is available since 2007. This data should be used in conjunction with the data in Hamilton 2006 to create a realistic time series for existing scheme water-use and to check the model projections of the existing operation of the Mt Ida Race.

It is clear from both models that inflows from the Mt Ida Race are critical to the successful operation of the proposed Mt Ida Dam. The two models provide different estimates for the potential inflows from the Mt Ida Race. The Mt Ida Race is a contour race that will intercept overland flow from all up-gradient catchments unless there is specific infrastructure (e.g., culverts, syphons, pipes, or flumes) which prevent the overland flow entering the race.

For the first part of the race (start down to the Ida Burn catchment) both studies assume that the race only receives inflow from the 15 tributaries that have consents to take water which are listed in Table 4.1 on page 17 of Hamilton (2006). Golder notes that Raineffects (2006) included a 16th catchment: an unnamed left bank tributary of Pierces Gorges Creek, shown in an orange-pink colour in Figure 2 of Raineffects (2006). From discussions with David Hamilton it was clarified that this 16th catchment should not have been included. Neither study included the various other small hillside catchments which do not have infrastructure excluding interception of overland flow. Both studies indicated very similar potential inflows from the first part of the race.

For the second part of the race within the Ida Burn catchment, Raineffects (2006) assumed all of the catchment above the race would contribute flow to the race whereas Aqualinc assumed that the race would only receive inflows from the tributaries that have take consents. This difference results in different potential inflow estimates and is the principal cause of the different irrigation supply areas. It is our opinion that Aqualinc underestimates the runoff from the Ida Burn catchment that could be captured by the proposed Mt Ida Dam.

Both models consider both the residual flow requirements of the various specified takes that contribute to the Mt Ida Race and the race capacity and its ability to by-wash excess water. Hamilton (2006) does not consider race leakage whereas Aqualinc (2006) included an allowance for leakage losses from the race (16 L/s from first part of the race; start down to Johnston Weir and 20 L/s between the Johnston and Wedderburn weirs) although the basis for these estimates is not documented.

The operation of the Mt Ida Race (current and proposed) and how it should be modelled needs to be further discussed with those who are most familiar with its operation, namely David Hamilton, John Anderson[2] and Keith Campbell. There is need to confirm the catchments that feed into the Mt Ida Race, both via specified take points and via general overland flow. As part of confirming the current operation of the Mt Ida Race we suggest that the consents authorising its operation be reviewed to determine if there is reference to the general overland flow captured by the Mt Ida Race. Similarly, losses from the Mt Ida Race should be further assessed and if possible quantified through measurement.

4.2.3 Mt Ida Dam irrigation demand

Hamilton (2006) assumed a peak irrigation demand of 0.45 L/s and a constant seasonal demand of 600 mm/year. Monthly demand was assumed to vary from 100% of peak in December to 5% of peak in May through August. It is unclear in the report but Golder expects that the 5% winter demand represents stock water. Irrigation use will vary considerably from year to year due to climatic conditions i.e., wet year versus dry year. The fixed annual demand used in Hamilton (2006) is likely to overestimate demand during a wet year.

Aqualinc (2013a) developed a daily irrigation demand time series for the irrigation area to be supplied from the proposed Mt Ida Dam. Unlike Hamilton (2006), Aqualinc (2013a) does not consider stockwater. The method used to develop the irrigation time series was documented in Aqualinc (2012b) which indicates that

[2] John Anderson - director of Aqua Irrigation Ltd who are contracted to operate the Hawkdun Idaburn Irrigation Scheme.

irrigation demand calculations used the AusFarm model coupled with a custom irrigation component developed by Aqualinc. It is unclear from the documentation how the irrigation component developed by Aqualinc works, although Golder understands that it schedules irrigation based on a soil moisture model which considers climatic, crop, soil type, and irrigator characteristics. Golder supports the use of a soil moisture model to estimate irrigation demand; however we have the following concerns regarding the input values that were used.

Climatic data

Aqualinc (2013a) used evapotranspiration data from Lauder EWS (Site 5535) and rainfall data from both Lauder Flat (Site 5537) and Blackstone Hill (Site 5252) to represent climatic conditions in the potential irrigation supply area. The potential irrigation supply area is split into two areas: an area in the Ida Burn Valley near Oturehua and an area surrounding and south of Wedderburn. The Blackstone Hill raingauge is located near the Ida Burn Valley part of the potential supply area. However, Lauder is situated some distance away in a different valley and is at an elevation at least 100 m lower than the potential irrigation supply area.

Rainfall and evaporation data is also collected at Ranfurly (Sites 18593 and 5280) which is significantly closer to the Wedderburn part for the potential irrigation supply area and is at a similar elevation. The Otago Regional Council's (ORC) growOTAGO programme produced very detailed estimates of climate throughout Otago and we suggest that the climate data used by Aqualinc be reviewed to ensure that it reflects the local conditions within the potential irrigation supply area.

Aqualinc (2013a) developed irrigation demand time series for the period June 1972 through May 2013. Golder notes that the Blackstone Hill raingauge was closed in June 2007 and evapotranspiration measurements began at Lauder EWS in 1985. Aqualinc (2012b) indicates that the missing records were filled using Aqualinc's climate extension software. This software is not explained and it is unclear how representative the filled climatic records are.

Crop type

Aqualinc (2012b) indicates that 100% pasture was modelled. From discussions with Peter Brown it is understood that a crop coefficient of 0.95% was used and that irrigation was scheduled to maximise grass production. Golder agrees that it is appropriate to model a pasture based system but it is important that water demand estimates are based on expected crop rotations. The crop rotations used by local irrigators are likely to involve regular re-grassing, use of green feed crops, and potentially use of lucerne. Lucerne, due to its deep roots, can access water from lower in the soil profile therefore potentially requires less irrigation water. Such crop rotations are likely to have a lower irrigation demand than a rotation that is based on 100% pasture. Similarly it is unclear if the current irrigation demand estimates consider pasture management and the effects of grazing and different levels of canopy cover.

Stockwater

Unlike Hamilton (2006), Aqualinc (2013a) does not consider stockwater. A decision needs to be made whether or not the scheme will include the supply of stockwater. While piped irrigation distribution systems can provide stockwater, given the much smaller volume required and the need to supply stockwater year round separate systems are often used.

4.2.4 Potential irrigation supply area and supply reliability

Both models are designed to estimate the potential irrigation supply area and to assess supply reliability. The models use a fixed reservoir size (operational live storage of 14.6 Mm^3) which is based on the dam design outlined in Pickens (2005). Aqualinc (2013a) modelled 100% supply reliability whereas Hamilton (2005) modelled various supply reliabilities but based its conclusions on a 90% supply reliability[3]. While high water supply reliability is preferred, it is usually not economic to design irrigation schemes to achieve 100% supply reliability and irrigators generally accept some supply restrictions. In order to determine the acceptable level of supply restrictions, potential irrigators require information on the severity of supply restrictions which is a function of:

[3] Hamilton 2006 equates a 90% supply reliability to a 10% chance of failure (i.e. storage not able to meet full irrigation demand) with chance of failure calculated as follows: Chance of failure = years when storage not able to meet full irrigation demand / years modelled.

- Size – The amount of restriction (e.g., no water available versus a 20% cutback)
- Frequency – How many times a year are restrictions to be expected or in how many years?
- Duration – How long do the restrictions last?
- Timing – When in the season do the restrictions occur?
- Warning – How much notice of upcoming restrictions is given? How predictable are the restrictions?
- The irrigation infrastructure and physical environment (crop type, soil type, etc.)

Neither Hamilton (2006) nor Aqualinc (2013a) discuss supply restrictions in any detail. Future dam hydrological modelling should provide information on the severity of supply restrictions associated with a variety of potential irrigation supply areas.

4.2.5 Mt Ida Dam reservoir losses

The Aqualinc (2013a) model includes consideration of both leakage from the dam (50 L/s) and evaporation from the reservoir surface (20 L/s). It is understood (pers. comms. Peter Brown, 9 December 2013) that the leakage estimate of 50 L/s is to allow for leakage from the dam, residual flows and to ensure that there is sufficient water passing the dam to satisfy downstream users and to fill the downstream Idaburn Dam. Hamilton (2006) provided a residual flow allowance of only 7 L/s, which covers a downstream priority right. Golder understands that the Ida Burn regularly goes dry downstream of State Highway 85 and there is no residual flow requirement attached to HIIC's consent to take water from the Ida Burn. Similarly the Idaburn Dam is predominantly filled from earlier discharges from the Mt Ida Race, namely via "R" race and "A" race. Given this actual drying and the lack of a need to provide residual flows, we consider the 50 L/s residual flow allowance in Aqualinc's model to be overly conservative and should be reviewed.

It is understood that Aqualinc's 20 L/s allowance for evaporation is based on a calculation of reservoir area and evaporation rates. Evaporation from the reservoir will vary both seasonally and annually with climatic conditions and with the surface area of the reservoir. Rather than assuming a fixed evaporation loss Golder recommends that the model be adjusted to consider both evaporation from and rainfall on the reservoir surface on a daily basis. Golder acknowledge that this change is unlikely to significantly alter the functioning of the model, however we consider it appropriate to ensure that the model matches the physical situation as closely as possible. Golder notes that the Hamilton (2006) model included a monthly calculation of evaporation based on mean monthly evaporation rates and reservoir surface area.

4.2.6 Model extent and downstream flows

Construction and operation of the Mt Ida Dam and associated irrigation scheme will alter flow both in the Ida Burn downstream of the dam and in the Manuherikia River. The proposed scheme will result in increased utilisation of the Mt Ida Race with more water being exported out of the Falls Dam catchment. To assess the effect of the proposed scheme it is necessary to understand any potential changes to downstream flows. Both models are focused on operation of the reservoir and do not extend below the reservoir. The two reports contain very limited comment on the potential changes to downstream flows.

Aqualinc (2013a) states that *"…the Mt Ida Race captures at most 17% of the potential Falls Dam yield, during the critical period November to April. The Mt Ida Dam and changes to the Mt Ida Race would have minimal impact on existing Falls Dam irrigators, since the race would not be able to harvest any more water during dry periods than occurs at present."*

We agree that the operation of the Mt Ida Dam is unlikely to significantly reduce inflows to Falls Dam during the peak of the irrigation season; however it will reduce inflows during the spring months of September and October. Given that options to increase the size of Falls Dam are currently being assessed it is considered appropriate that the hydrological model for the Mt Ida Dam be integrated with the hydrological model for the Manuherikia River so that the cumulative impact of a joint scheme involving both the raising of Falls Dam and construction of the Mt Ida Dam can be assessed.

4.2.7 Development of dam inflow data

To determine potential dam inflows, both studies (Aqualinc 2013a and Raineffects 2006/Hamilton 2006) developed synthetic flow records for various sites using a combination of measured data, correlation with neighbouring records, and catchment scaling with consideration of mean catchment rainfall. Golder generally supports the methodologies used, however we note that the two studies used slightly different methodologies and different flow records as outlined below.

Raineffects (2006) based their assessment on two key flow records. Site I75358, Ida Burn North Branch, (flow data available from March 1973 through December 1976 and from July 1983 through December 1984) was considered the in-catchment site. Site I75251, Manuherikia D/S Forks, (flow data available from May 1975 through January 1994 and from December 1998 through April 2004) was considered the neighbouring "primary" site which was used to correlate and extend the Ida Burn North Branch record. Initial comparisons of mean daily flows at the two sites, indicated that, when the full overlapping record was considered, there was a poor correlation. However, when parts of the record (especially periods of receding flows) were considered a strong correlation was found. Given the proximity of the sites, that they are located within the same general climatic region and that they have generally similar catchments (accepting the size difference), Golder would expect there to be a good relationship between flows at the two sites (as confirmed by parts of the record having a strong correlation). Golder suspect that the poor correlation between the full flow records is due to a combination of errors (measurement and calculation) in the recorded data, localised weather patterns, and the different response times due to the different catchment sizes. To develop a relationship Raineffects (2006) reverted to simply comparing mean flow from the period of overlapping records. This simplistic approach will reduce the accuracy of the derived flow estimates.

Aqualinc (2013a) also used flow records from the Ida Burn North Branch as an in-catchment site, although they considered the initial period of data (March 1973 through December 1976) to be unreliable and it was removed. Aqualinc (2013a) also used flow records from a site called Ida Burn U/S Dam (flow data available from October 2009 through July 2011) as an in-catchment site. The Ida Burn U/S Dam flow monitoring site was established as a temporary site focused on assessing low flows. The site was located in an area of active bed movement where development of an accurate rating curve would have been very difficult. Golder understands that no flood flows were gauged and the accuracy of the high end of the rating curve is likely to have been poor. It is noted that this data was not available for the Raineffects (2006) study.

Aqualinc (2013a) extended the two in-catchment records through correlation with a record of inflows to Falls Dam for the period June 1973 through May 2013 which had previously been developed in Aqualinc (2012c). Golder notes that the inflows to Falls Dam record is itself a synthetic flow record having been developed using data from a number of sources. Aqualinc (2013a) indicates that the extension of the records was completed using correlations developed for each month to allow seasonal differences at different sites to be captured. The report did not provide information on the strength of these various monthly correlations.

Golder considers it important that when undertaking correlations and the developing synthetic flow records, care is required to minimise correlation errors. Correlation against already synthetic records is not good practice and can lead to compounding errors. Standard practice when assessing hydrological data is to undertake the following steps.

1) Collect all available flow information both continuous records and instantaneous flow gauging. Note it is unclear if instantaneous flow gauging data was considered in either Raineffects (2006) or Aqualinc (2013a).

2) Review the data, asses its accuracy, and determine the reliable data which can subsequently be used. Usually this involves reviewing the site establishment records, any site visit records, reviewing the rating curves particularly any rating changes, and assessing the overall data processing and data management.

3) Sites are then separated into "primary" sites, which have long reliable records, and "secondary" sites which have shorter records often with gaps.

4) Records at a "secondary" site are then extended through correlation with a "primary" site. Relationships with a coefficient of determination (R^2) of at least as high as 0.8 are preferable.

5) Uncertainties associated with both the original data and the correlation process are then assessed to provide an estimate for the overall accuracy of the extended record.

The uncertainties associated with the synthetic flow records developed by Raineffects (2006) and Aqualinc (2013a) are not well documented in the respective reports. That lack of assessment of uncertainties and the use of different flow data means that it is not possible for Golder to determine which of the synthetic dam inflow series (Raineffects 2006 or Aqualinc 2013a) is the most representative.

4.2.8 Model availability and documentation

The final hydrological report associated with the Mt Ida Dam will be a key technical document that will support any future consent application through the hearing processes. Both the report and the underlying models are likely to be reviewed for their technical robustness during the consenting process. To facilitate a defensible review the model needs to be in a form which is readily available and model documentation needs to be complete. It is unclear what software the Aqualinc model used and the ease at which the model can be reviewed. The spreadsheet of model scenario outputs provided by Aqualinc simply shows the projections and provides limited guidance on how the values were derived.

Final model documentation should include:

- A full description of the model including how it conceptualises and represents the physical system.
- A description of the input data used and its source.
- All modelling assumptions.
- A discussion of the model limitations and uncertainties.
- A description of calibration and validation methodology and the results achieved.
- A description of the scenarios modelled and various model projections.

4.3 Flood Flow Estimation

Both Raineffects (2006) and Aqualinc (2013a) provide estimates of flood flows in the Ida Burn at the proposed Mt Ida Dam site. Both studies utilise the methodology outlined in McKerchar and Pearson (1989) although the two studies differ in their approach and interpretation of the methodology.

McKerchar and Pearson (1989) included three flow sites within the Manuherikia catchments (Site I75251 Manuherikia D/S Forks, Site I75253 Manuherikia at Ophir, and Site I75257 Dunstan Creek at Gorge) in the 343 reference sites they used to develop their methodology.

Raineffects (2006) used updated flow data from the Manuherikia D/S Forks site to update McKerchar and Pearson's estimate of the variable $Q/A^{0.8}$ (mean flood flow/catchment area$^{0.8}$). Raineffects (2006) then adjusted the variable slightly to account for the expected lower flows in the Ida Burn at the Mt Ida Dam site and then followed the McKerchar and Pearson (1989) methodology to estimate flood flows with a return period (1/AEP) of up to 200 years and then extended the methodology to estimate larger return interval floods. Golder discussed the derivation of the flood flow estimates with David Stewart and we support the methodology that was used.

Aqualinc (2013a) estimates flood flows in the Ida Burn at the proposed Mt Ida Dam site using flood flows previously estimated for Falls Dam with an adjustment for the differing catchment areas. The area adjustment used by Aqualinc relies on the variable $Q/A^{0.8}$ (flood flow/catchment area$^{0.8}$) being constant for the two catchments. Catchment yield is controlled by many variables including local climate conditions, the nature of the water course (i.e., presence of wetlands or springs) elevation, topography, aspect, vegetative cover, soil type and rock type. While the Ida Burn catchment is located near the Fall Dam catchment there are significant differences and Golder considers it unlikely that the variable $Q/A^{0.8}$ will be the same for the two catchments. McKerchar and Pearson's original 1989 calculations indicated significant difference between the Manuherikia D/S Forks, Manuherikia at Ophir, and Dunstan Creek at Gorge site, with the variable $Q/A^{0.8}$ for mean annual flood being 0.93, 0.41, and 0.62 respectively at the three sites.

5.0 RECOMMENDATIONS

The recommendations outlined are aimed at providing guidance to MCWSG regarding the hydrological assessment for the Mt Ida Dam. The recommendations are provided in what Golder considers a logical progression toward finalising the hydrological assessment for the Mt Ida Dam; their position in the list below does not reflect their relative importance.

1) Use the Aqualinc (2013a) reservoir water balance and irrigation scheme model as the basis for the assessment, but update it to ensure that it is based on the best available input data and assumptions. Specifically the following items need to be addressed:

   a) ***Critical for completion of project*** The operation of the Mt Ida Race and how it should be modelled, needs to be further discussed with those who are most familiar with its operation, namely David Hamilton, John Anderson and Keith Campbell.

      i) There is specifically a need to confirm the catchments that feed into the Mt Ida Race both via specified take points and via general overland flow.

      ii) As part of confirming the current operation of the Mt Ida Race we suggest that the consents authorising its operation be reviewed.

      iii) Losses from the Mt Ida Race should be further assessed and if possible quantified through measurements.

      iv) The finalised model should have the capacity to model various sized sections of the Mt Ida Race.

   b) ***Critical*** Data from HIIC water-use records and recently installed water level sensors should be used to refine the existing use estimates for the Hawkdun-Ida Burn irrigation scheme.

   c) ***Critical*** Modelled irrigation demand for the proposed Mt Ida Dam must be based on local climatic conditions and expected crop rotations. The climatic estimates developed through the growOTAGO programme should be used as the basis for determining local climatic conditions. Crop rotations and management practises used by local irrigators should form the basis for estimating potential irrigation demand.

   d) The model should be updated to allow various potential irrigation supply areas and the severity of supply restrictions to be assessed.

   e) A decision is required on whether or not the scheme will supply stockwater and if so the model should be updated to include stockwater.

   f) The model should be adjusted to consider both evaporation from and rainfall on the reservoirs surface on a daily basis.

   g) ***Critical*** The residual flow requirements and potential leakage from the dam should be reviewed and appropriate estimates included in the model.

   h) ***Critical*** The model should be updated to allow potential downstream flow changes (due to the new reservoir, increased use of the Mt Ida Race and increased irrigation) within the Manuherikia catchment. The updated model should allow the cumulative effect of both the proposed Mt Ida Dam and the various options to raise Fall Dam to be assessed.

   i) In updating the model, consideration should be given to including climate change factors which allows the effect of climate change (increased temperature, reduced summer rainfall, increased winter rainfall, etc.) to be assessed.

   j) ***Critical*** Uncertainties in the input data (particularly the synthetic flow records developed to assess inflow into the proposed reservoir), modelling process, and the model projections need to be well understood and documented.

2) For flood flow estimates for the dam site, Golder supports the methodology used in Raineffects (2006) and we recommend that the calculation be updated to take into account the recent flow data from within the catchment and to provide a description of the uncertainties associated with the flood estimate.

3) ***Critical*** MCWSG should co-ordinate a meeting of the key stakeholders (MCWSG and HIIC) and technical advisors (Aqualinc, David Hamilton, and Golder) to confirm items 1) and 2) above.

4) Following updating, the model should be re-run with the projections discussed by the technical advisors (Aqualinc, David Hamilton, and Golder) prior to being briefly documented. Following this brief documentation of model projections MCWSG should co-ordinate a second meeting of the key stakeholders (MCWSG and HIIC) and technical advisors (Aqualinc, David Hamilton, and Golder) to discuss the implications of the model projections and to confirm next steps.

5) ***Critical*** Final model documentation should be to a level that allows external technical peer review of the model and its projections. This documentation should also include:

   a) A full description of the model including how it conceptualises and represents the physical system.

   b) A description of the input data used and its source.

   c) All model assumptions.

   d) A discussion of the model limitations and uncertainties.

   e) A description of calibration and validation methodology and the results achieved.

   f) A description of the scenarios modelled and the various model projections.

6.0 CLOSING REMARKS

We trust this letter provides direction in regard to the hydrological assessment for the Mt Ida Dam. If you wish to discuss any of the above please contact Ian Lloyd (illoyd@golder.co.nz or telephone 03 377 5696).

Yours sincerely

GOLDER ASSOCIATES (NZ) LIMITED

Ian Lloyd
Senior Water Resource Engineer

Attachments: 1. Report Limitations
2. List of documents reviewed and source

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Attachment 1: Report Limitations

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Attachment 2: References, Documents Considered and Source

Brown P., 2013a. An email, subject *Ida Burn hydrology report update* sent by Peter Brown of Aqualinc to Kate Scott of BTWSouth, dated 7 September 2013 and forwarded to Ian Lloyd of Golder on 22 September 2013.

Brown P., 2013b. An email, subject *MCWSG Hydrology* sent by Peter Brown of Aqualinc to Kate Scott of BTWSouth, dated 9 October 2013 and forwarded to Ian Lloyd of Golder on the same day.

Brown P., 2013c. An email, subject *Hawkdun and Manuherikia Hydrology Reports* sent by Peter Brown of Aqualinc to Gary Kelliher, dated 20 November 2013 and subsequently forwarded by Kate Scott of BTWSouth to Ian Lloyd of Golder on the same day.

Aqualinc, 2013a. *Mt Ida Dam Hydrology.* Report numbered C14000/2 prepared for the MCWSG, dated 17 September 2013. Electronic copy (file name IdaValleyHydrology_FINAL.pdf) attached to an email from Kate Scott of BTWSouth to Ian Lloyd of Golder, dated 22 September 2013.

Aqualinc, 2013b. A spreadsheet titled *Manuherikia Valley model outputs for Golder* which was sent by Kate Scott of BTWSouth to Ian Lloyd via Golder's secure file transfer system on 20 December 2013. It is understood that Aqualinc will prepare a similar spreadsheet for their Mt Ida Dam hydrology assessment once the assessment is finalised.

Aqualinc, 2012a. *Climate change Impact of Climate change on the Manuherikia Irrigation Scheme*, Report numbered C12119/10 prepared for the MCWSG, dated 6 December 2012. Electronic copy (file name Climate_Change_FINAL.pdf) available from the MCWSG website, www.mcwater.co.nz.

Aqualinc, 2012b. *Manuherikia Catchment Study: Stage 1 (Land).* Report numbered C12040/1 prepared for the MCWSG, dated 12 November 2012. Electronic copy (file name Manuherikia_Stage 1_Land_FINAL.pdf) available from the MCWSG website, www.mcwater.co.nz.

Aqualinc, 2012c. *Manuherikia Valley: Detailed Hydrology.* Report numbered C12040/3 prepared for the MCWSG, dated 22 September 2012. Electronic copy (file name Manuherikia_Valley_Hydrology_FINAL.pdf) available from the MCWSG website, www.mcwater.co.nz.

Hamilton, 2013a. *Mt Ida Dam Hydrology Comments on Draft Aqualinc Report C14000/2 September 2013*. Document prepared by David Hamilton of David Hamilton and Associates Ltd for the Hawkdun Idaburn Irrigation Company Limited dated 13 September 2013. Electronic copy (file name CommentsHydrology_130913LR.pdf) attached to an email from David Hamilton to Kate Scott of BTWSouth, dated 13 September 2013 and forwarded to Ian Lloyd of Golder on 22 September 2013.

Hamilton, 2013b. Two spreadsheets titled *CD daily & hourly flows and PMF calcs* and *Floods Calcs for cd* which were included on a CD supplied by David Hamilton to Ian Lloyd of Golder on 21 November 2013.

Hamilton, 2006. *Mt Ida Dam Investigation Feasibility Study Report including Simulation for Water Storage and Piped Irrigation*. Report prepared by David Hamilton and Associates Ltd for the Hawkdun Idaburn Irrigation Company Limited dated June 2006. Electronic copy (file name MtIdaDamIrrigationReport060702.pdf) attached to an email from Kate Scott of BTWSouth to Ian Lloyd of Golder, dated 11 November 2013.

McKerchar A.I.and Pearson C.P., 1989. *Flood Frequency in New Zealand.* DSIR Publication No. 20 of the Hydrology Centre, Christchurch.

Pickens, 2005. *Feasibility Study Proposed Upper Idaburn Dam* prepared by Pickens Consulting Ltd for the Hawkdun Idaburn Irrigation Company Limited dated February 2005. Electronic copy (file name gap080205.Idaburn feas.study.pdf) attached to an email from Kate Scott of BTWSouth to Ian Lloyd of Golder, dated 11 November 2013.

Raineffects, 2006. *Upper Ida Burn Irrigation Dam Feasibility Study Hydrology Report*. Report prepared by David Stewart of Raineffects Limited for David Hamilton and Associates Ltd , dated June 2006. Electronic copy (file name Idaburn.pdf and Title page–Ida Burn Hydrology.pdf) included on a CD supplied by David Hamilton on 21 November 2013.