Golder Associates

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Manuherikia Catchment Water Strategy Group
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MANUHERIKIA CATCHMENT FEASIBLITY STUDY: MT IDA DAM SITE

Dear Kate

Purpose

This letter[1] provides a preliminary examination of the proposed Mt Ida dam site following a completion of our geotechnical background review, mapping, test pitting, field testing, and laboratory testing. Work completed to date on the Mt Ida dam site indicates multiple geological challenges that will likely require robust and extensive design mitigation measures, resulting in a substantial increase in construction cost from that estimated by Pickens (2005). The noted geologic deficiencies, including potential foundation faulting, high seismic hazard and soft clay foundation conditions, may also result in difficulties obtaining consent as extraordinary design features may be required. Two conceptual distribution networks associated with the proposed Mt Ida Dam have been developed and are presented in this letter. Two other potential water supply options for the Hawkdun Idaburn Irrigation scheme have been identified which may warrant further investigations. These issues and options are discussed in more detail in the sections below.

Site Description

The dam site is predominately underlain by schist rock, however a portion of the left abutment is underlain by gravel alluvium and clay and sand of the Manuherikia Group. The schist in the river valley, beneath the maximum section of the dam, is overlain by gravel. Schist bedrock is inferred to be at considerable depth along the left abutment section of the dam.

The contact between the schist and the Manuherikia Group sediments is thought to be the Garibaldi Fault, which runs approximately perpendicular to the proposed dam crest. An additional fault, Seagull Hill Fault, thought to strike parallel to the dam crest, has also been potentially identified in the dam foundation and evidence of shearing of this fault is thought to have been observed in one of the recent test pits. No evidence of late Quaternary deformation on either fault has been found at the dam site, though geomorphic evidence of likely late Quaternary deformation of the Garibaldi Fault has been observed 2 km from the dam site. Given this evidence, the Garibaldi Fault is assumed to constitute a foundation fault hazard for the dam requiring specific design mitigation measures. The potential displacements of these faults are inferred to be in the order of one metre during a surface rupturing earthquake, based on empirical relationships (Wells and Coppersmith 1994).
Faulting displacements in the reservoir area are also of concern as it is possible to create a seiche wave which may have the potential to overtop the dam.

[1] This Letter Report is subject to the Report Limitations outlined in Attachment A.

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A deterministic seismic hazard assessment performed by Golder (2014) indicated that the peak ground acceleration at the dam site for the 1 in 10,000 year return event is high, at about 1.0 g.

Based on visual observation and laboratory testing, the clays of the Manuherikia Group are described as silty clay with trace sand to clay with silt. The clays are stiff to firm and are medium to highly plastic. Vane shear tests were performed at two locations and the results indicate the soils are very sensitive and the residual strengths are expected to be low, on the order of 5 kPa. Laboratory testing indicates that the soils have relatively high plasticity index (PI) values; this in combination with the tested water content values indicates the soils may not be highly susceptible to liquefaction or cyclic softening. However, given the potential seriousness of this issue for dam stability, the design will likely assume that the soils are susceptible to cyclic softening and that residual strengths may be achieved during the maximum design earthquake. Additional field investigations and detailed analysis will be required during final design to determine the extent and amount of liquefaction or cyclic softening the clays will exhibit during the maximum design earthquake and what design measures will need to be included to mitigate the effects.

A current feasibility level dam design was prepared by Pickens Consulting Ltd (2005). Plan views and typical sections of the embankment and spillways are available in the report. The overall plan includes a main embankment section through the valley with a left embankment saddle dam that curves upstream to tie into the existing ground. This curve in the dam crest alignment concentrates stresses and may make the dam more susceptible to cracking which can lead to internal deformation/erosion and as a result more robust design features are likely required at this location.

Potential Impacts

Based on the information available at this time, the faulting and soft clays at the site likely create challenging design features which are likely to result in higher costs compared to the Pickens (2005) design.

The estimated peak ground accelerations are large during the 1 in 10,000 year event, which constitutes the maximum design earthquake. These high ground accelerations could impact the embankment in multiple ways including shaking leading to slope failures, deformation or liquefaction of the embankment or foundation soils, reservoir landslides, seiche wave formation, cracking of the embankment or foundation soils, or earthquake induced piping. Mitigation of these hazards will require multiple defensive measures that are not currently presented in the feasibility design. The features will likely include flattened slopes, removal of liquefiable material and materials susceptible to cyclic softening, flattening and monitoring of the reservoir rim, overbuilt filter zones and transition zones including chimney, blanket, and “crack filler” zones, overbuilt core section, wide embankment crest, and additional freeboard. With a fault under the embankment, there is concern over potential embankment rupture and for the current stage of the project it will be necessary to allow for defensive features in the design to potentially accommodate 1 m of offset during rupture of the Garibaldi Fault. A comprehensive study of the Garibaldi Fault during detailed design may prove that the likelihood of embankment rupture is sufficiently low to require fewer defensive features, but we consider it essential to include such design features at this stage. Designing for such a significant rupture is a challenge and will likely require increasing the overbuilt core, filters, transition, and “crack filler” zones as well as increasing freeboard and crest width.

Due to the combination of the very sensitive clays, high groundwater at the site, and the high peak ground accelerations during the maximum design earthquake, the soils may reach the reduced residual strengths. If these low strength soils are left in place below the embankment, deformations, likely greater than 1 m, are anticipated. If mitigation of these soils is required, it would likely involve removal or in-situ treatment, such as soil mixing. The thickness of these soils may extend tens of meters below the ground surface with treatment or removal required up to 5 or more meters. The Manuherikia Group sediments likely underlie a few hundred meters of embankment length, based on current limited investigative data.

Overtopping failures due to inadequate spillway capacity is one of the most common dam failure mechanisms (Fell et al 1992). A properly designed spillway that is capable of passing the inflow design flood, which may be up to the PMF for the Mt. Ida dam site, is an essential design feature of the dam.

The current feasibility design includes a service spillway with an unsupported concrete chute and a riprap lined auxiliary spillway. The preliminary spillway design will likely be more robust, such as a side channel and chute spillway founded on rock at the right abutment. These features will likely require more excavation and concrete than what is proposed in the current feasibility design.

Estimating impacts to cost depends on the location and extent of mitigation required. The cost impacts of the design features mentioned above cannot be fully assessed but a single representative feature was selected as an example. The current feasibility level filter design will need to be extended and widened in the preliminary design. Both a chimney and blanket drain will be required to reduce the phreatic water surface in the embankment, to direct water away from the embankment, and to reduce particle migration (internal erosion or piping) between embankment and foundation zones. With the large anticipated peak ground accelerations, potential for fault rupture under the embankment, and precedent from recent projects, a filter width of 3 m may be an appropriate thickness. Increasing the required chimney filter width to 3 m and adding a blanket drain could increase the required filter material by over 5 times compared to what is currently presented in the feasibility design (Pickens 2005; it is noted that all dimensions of the filter are not presented in this report).

We believe the estimated cost in the feasibility level filter design (Pickens 2005) significantly underestimates the final costs due to an error in the feasibility study cost spreadsheet; item 4.1 should be increased from $170,000 to $1,700,000. The feasibility level design anticipates that onsite valley floor gravels may be used as filter materials but if the filter volume is significantly increased, this option will have to be reassessed to determine the availability, accessibility, and compatibility of the onsite soils. Even if the cost for the filter conservatively doubles, the impact is a multi-million dollar increase in construction costs. Combining the filter with other mitigation efforts required to address anticipated hazards on the site will have a significant impact to construction costs.

Receiving resource and building consent for the dam will require that the dam satisfies dam safety and public safety requirements. The geological features at the site need to be well understood so that a robust dam can be built by conventional means using well established methodologies without resorting to extraordinary means or measures. The potential faults under the dam site may be considered to be extreme geologic features and extraordinary means will be required to address the potential dam safety risks that a foundation fault represents.

Based on the available information, the earthquake hazards along with very weak foundation soils indicate that a more robust design is likely required than what is proposed in the current feasibility level design (Pickens 2005). Detailed exploration and testing programs along with detailed analysis (probabilistic seismic hazards, seepage, stability and seismic stability analyses, etc.) will be required during final design to verify these preliminary findings.

Alternative Sites

The trace of the Garibaldi Fault is suspected to follow the valley floor through the left abutment of the proposed dam site and into the reservoir. Moving the dam upstream will potentially reduce or remove the undesirable curve in the dam alignment, but the fault hazard will not be removed and an upstream alignment will likely be founded on more of the potentially soft and sensitive clays. Moving the dam upstream will likely result in a much longer dam as the valley widens and it is likely that storage volume will be lost.

The dam could be moved downstream, but the Seagull Hill Fault runs perpendicular to the valley and should be avoided. If the dam is moved downstream of the Seagull Hill Fault, the dam will likely be founded entirely on the soft and sensitive clays of the Manuherikia Group. The move downstream will also likely require a significant reduction in dam height because of the lack of topography in the area and this will result in a reservoir storage loss. It may be possible to construct a smaller dam downstream, avoiding the Seagull Hill Fault, on the schist rock foundation but the storage capacity would be very limited. The high design peak ground accelerations cannot be avoided by a move upstream or downstream.

Distribution Network

The proposed Mt Ida Dam lies within the command area of the Hawkdun Idaburn Irrigation Scheme. The scheme uses run of river takes (mostly associated with the Mt Ida Race) and storage in the Eweburn and Idaburn Reservoirs to irrigate approximately 3,600 ha within a command area of over 23,000 ha in the catchments of the Manuherikia and Taieri Rivers. Water is supplied to the irrigated area using an extensive network of open water races. Overall the scheme is very water short, hence the desire to increase scheme storage via the Mt Ida Dam which is expected to provide 14.6 Mm^3 of usable storage.

The proposed Mt Ida Dam is located below the Mt Ida Race and pumping would be required to feed the stored water back into the main race network. Hamilton (2006) indicated that the proposed Mt Ida Dam could supply irrigation water to approximately 2,000 ha below the dam via a piped distribution network. Meetings with local farmers have highlighted a strong desire for the new reservoir to be used to improve supply reliability to existing irrigators within the Hawkdun Idaburn Irrigation Scheme. This can only be achieved if the storage in the new reservoir is used to supplement or replace water supply on areas which are currently supplied from the scheme. However doing so may require a more extensive and potentially more expensive distribution network. Two possible distribution options are:

1) Development of a new piped scheme that spray irrigates the 2,000 ha of irrigable land closest to the dam, approximately 1,000 ha in the Idaburn Oturehua area and approximately 1,000 ha in the Wedderburn area. Where possible, water will be pressurised but some on-farm pumping is expected immediately below the dam. This option represents the most efficient use of the water but the benefits are limited to a small area.

2) Development of an open race based system that directs water from the Mt Ida Dam back into the existing distribution network, to improve the supply reliability of existing scheme water users, particularly from D, E, F, G and possibly H races. This option will not be a highly efficient use of the water but the benefits will be spread over a larger area and potentially the whole of the Hawkdun Idaburn Irrigation Scheme.

Both distribution options will be investigated during the current study.

Alternative water supply options

The current investigations have identified the following two further potential water supply options for the Hawkdun Idaburn Irrigation Scheme which are not included in the current Manuherikia Catchment feasibility assessment. Both options aim to maximise the use of existing infrastructure and eliminate or significantly reduce the storage needs at Mt Ida Dam.

1) Increased use of Mt Ida Race during peak summer periods through maximising the existing water harvesting, reducing leakage losses and potentially harvesting water from additional catchments.

2) Increasing the storage within Falls Dam and pumping part of this storage over Home Hills Saddle to suppliant flows in R race and inflows into Idaburn Dam.

During the peak irrigation period, the capacity of the Mt Ida Race is not fully utilised due predominantly to insufficient inflows. If the capacity of the race could be more fully utilised during the peak of the season the water supply reliability of the irrigators would be significantly improved. Inspection and flow measurements along the upper section of the Mt Ida Race down to Pierces Gorge Creek suggest that for much of its length the upper Mt Ida Race is reasonably well sealed. However, a number of areas of high leakage and/or incomplete harvesting of potential flows have been identified. A document summarising the race inspection and flow measurements is currently being prepared. Race and intake improvements to maximise water harvesting and minimising leakage are likely to be achievable within the scheme’s current resource consents.

A conceptual desk top exercise assessing contour maps and aerial photos indicated that it might be possible to harvest flows from the East Manuherikia River (near it confluence with Camp Creek) and or Mutton Creek into the existing Mt Ida Race at an elevation of approximately 800 m RL. Further work and a ground inspection are required to verify if this is a feasible concept. Extending the race to harvest flows from other catchments would require new consents. Given the highly allocated nature of water in Falls Dam the harvesting of additional catchment is only likely to be achievable if storage in Falls Dam is significantly increased.

A large 27 m raise of Falls Dam is currently being investigated which would increase the crest level of the reservoir to approximately 588 m RL. Such a raise of Falls Dam would allow an estimated 90 Mm^3 of usable storage with a lowest supply level of approximately 561 m RL. The Hills Creek Saddle between the Manuherikia Valley and northern end of the Ida Valley has an elevation of approximately 600 m RL. Under a large raise of Falls Dam considerable water would be released for downstream use during the irrigation season.

Hydropower generated from the irrigation releases could be used to power a pump to lift a proportion of the water over Hills Creek Saddle. A pumping lift ranging from approximately 12 m to 40 m (excluding distribution losses) depending on the reservoir level would be required. Once over Hills Creek Saddle the water could be used to suppliant flows in R race, supplement inflows into IdaBurn Dam and / or for irrigation of new areas.

Conclusion and Recommendations

The current background data review, field and laboratory investigations, and estimate of seismic hazards at the Mt Ida Dam site has identified and highlighted geologic hazards that have not been accounted for in the current feasibility level design. The potentially soft and sensitive clays and the faults under the dam create challenging and costly mitigation design features. This will also increase the estimated construction costs of Mt Ida Dam. Not only will the cost be impacted but these features may require what is deemed to be extraordinary design features; broadly, this adds significant risk and uncertainty to any future permitting (consenting) stages of the project.

Hydrological investigations have identified two alternative water supply solutions which are likely to better utilise the current infrastructure or, take advantage of the Falls Dam raise and, eliminate or significantly reduce the storage needs at Mt Ida Dam. Given the anticipated difficult design and construction of Mt Ida Dam we recommend that the alternative water options be investigated further.

Closing Remarks

We hope this letter adequately highlights the relatively recent additional concerns with respect to dam construction and the associated costs and, that it identifies two practical alternative water supply options that could eliminate or significantly reduce the storage needs at Mt Ida Dam. If you wish to discuss any of the above please contact Rebecca Allen or Ian Lloyd (reallen@golder.co.nz, illoyd@golder.co.nz or telephone 03 377 5696).

Kind Regards

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Attachments: A) Report Limitations
B) References

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Attachment B: References

David Hamilton and Associates Limited, (2006). “Mt Ida Dam Investigation Feasibility Study Report including Simulation for Water Storage and Piped Irrigation.” Report prepared by for the Hawkdun Idaburn Irrigation Company Limited dated June 2006.

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