greater WELLINGTON
REGIONAL COUNCIL

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Committee **Regional Sustainability Committee**
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Stuart Macaskill Lakes seismic security upgrade

1. Purpose

To report on the evaluation of options to improve the seismic performance and security of the Stuart Macaskill Lakes.

2. Significance of the decision

The matters for decision in this report **do not** trigger the significance policy of the Council or otherwise trigger section 76(3)(b) of the Local Government Act 2002.

3. Background

Changes were made to the Building Act in 2008 related to dam safety and dam safety regulations were published. The next comprehensive safety review of the Stuart Macaskill Lakes due in 2012 will be carried out within the requirements of this new legislation.

Dynamic analysis of the lake embankments using criteria in the new legislation (i.e. a Wellington Fault earthquake) identified that the seismic loading produced by a movement of the Wellington Fault is likely to cause damage to the lining of the lakes and high rates of leakage. Internal erosion and concentrated leakage as a result of damage to the lining is also likely to occur. This may compromise the impounding ability of the lakes and is a higher level of risk than required by the dam safety legislation and regulations.

It has previously been reported to the Committee that mitigation measures at an approximate cost of $6 Million will be necessary to achieve compliance with the legislation, including partial lining of the internal face of the lake embankments.

The analysis by our consultants determined that this risk currently exists and is not materially affected by increasing the level of the lakes.

Following a large earthquake, water stored in the Stuart Macaskill Lakes will be strategically important for water supply. It would be undesirable for this water to leak away. Fully lining the embankments would avoid this and ensure containment of the water.

Capital expenditure of $10 million was approved in the 2009/19 LTCCP to carry out both the seismic mitigation measures and to fully line the embankments of both lakes. The sum includes cost savings achieved by carrying out the mitigation work at the same time as the lake levels are raised. The project to raise lake levels at a cost of $5.5 Million was also approved in the LTCCP.

Although the funding approved covers the full lining of the embankments of both lakes, it is considered prudent to evaluate whether this is the appropriate solution, or if suitable security of supply would be achieved by fully lining the embankments of only one lake.

The level of importance of the water in the Stuart Macaskill Lakes after a Wellington Fault earthquake will be influenced by the impact of the earthquake on the Kaitoke source and intake works; the rate of water consumption; and the availability of water from other sources.

4. Kaitoke source

4.1 General

There are a number of seismic risks associated with the Kaitoke source:

- Collapse of the hillside above the weir or immediately upstream
- Collapse of, or major damage to, the Flume Bridge
- Roof collapse within one or both of the generally unlined aqueduct tunnels between Kaitoke and Te Marua
- Possible damage to the concrete pipeline between the Flume Bridge and the Strainer Building at Kaitoke

4.2 Hillside collapse

The hillsides above and upstream of the weir are very steep and may be subject to failure during an earthquake. The hillside above the access road to the weir has experienced minor rock falls over recent years and a small slip above the road occurred on 24 July this year.

A consultant's report on the stability of these hillsides concludes:

a) The most likely scenario in a Wellington Fault event is the generation of numerous small and medium scale shallow seated landslides, which would result in a series of small to medium sized landslide dams. The dams would fill and overtop and cascade progressively downstream. It is likely that there would be some usable flow at the intake about one month following a Wellington Fault event.

b) The maximum foreseeable size of a landslide in the Kaitoke Gorge above the weir would result in a landslide dam of up to 60 metres in height. Based on the mean river flows, such a landslide would overtop in approximately 2 weeks. Events of this size are possible in high intensity earthquakes but there is no evidence that similar events have occurred in the catchment in the past.

c) There will be a very large amount of bedload and suspended sediment in the river for an extended period of time after a Wellington Fault event and the intake will require ongoing clearance.

These findings suggest that for two to four weeks following a Wellington Fault event there will be only a small flow of water available at the intake from flow through debris dams and from side catchments. As debris dams are breached the bed load will be large and likely to further disrupt operation of the intake.

4.3 Flume Bridge

The flume bridge was strengthened in 1993 to the seismic standards of the day. The work was comprehensive and included rock bolting the footings, strengthening the piers against lateral load and strengthening the superstructure. However the close proximity of the bridge to the Wellington fault (it is within approximately 1.5 km) and recent seismic information from GNS Science may mean that further strengthening of the bridge is required. A consultant will be appointed to investigate this issue.

4.4 Aqueduct tunnels

The aqueduct tunnels between the Kaitoke Intake and the Flume Bridge and between the Strainer House and the Te Marua WTP are inspected regularly by an engineering geologist. The most recent inspection was in 2007.

Although this inspection did not specifically address the performance of the tunnels under seismic conditions, it concluded that there were only very small localised areas that showed any indications of instability. The report states that any rock falls would be less than 1 cubic metre and unlikely to significantly interrupt the flow of water from Kaitoke.

4.5 Damage to the concrete pipeline

A consultant's assessment carried out a number of years ago concluded that while there was a possibility of landslides on the hill above the pipe, it was unlikely that the pipe would be damaged.

5. Water consumption

The rate of water consumption following the earthquake will be affected by damage to the wholesale water network and the timing of repairs.

A 300 mm diameter pipe has been installed across the fault at Te Marua in parallel with the trunk main to facilitate repair relatively quickly after the earthquake and allow a reduced flow of water. The pipe has a capacity of approximately 40 million litres/day (MLD).

Our analysis of water supply restoration times following the Wellington Fault movement suggests it will be approximately eighteen days before full supply is restored to Upper Hutt City, although supply may be reinstated to the northernmost supply points more quickly. The demand for water from Te Marua will gradually increase as the supply is progressively restored to Porirua, the Wellington northern suburbs and Karori.

The supply limitation of 40 MLD is not expected to be a constraint until around thirty-four days after the earthquake. During these thirty-four days it is unlikely that more than 300 million litres of water will be supplied from Te Marua. It is expected that it will take sixty-six days to restore the water supply from the Waterloo treatment plant through to Wellington. This means that water supply from Te Marua will be critical for at least a further thirty-two days. Over that thirty-two day period, it would be prudent to provide for supplying 1,280 million litres of water (ML). When full, Lakes 1 and 2 collectively hold 3,000 ML of useable storage at present.

A partial supply should be available from the Kaitoke weir after the first thirty days, however ongoing water quality issues in the Hutt River at Kaitoke may cause the supply to be intermittent and also extend the time that stored water will be relied on. Taking a conservative approach, the Stuart Macaskill storage lakes will need to be able to supply the estimated 1,580 ML of water required over the sixty-six day period, with additional spare capacity to provide an adequate level of contingency.

6. Security upgrade options

Fully lining the embankments of the lakes will ensure containment of stored water after the Wellington Fault earthquake. Without this security upgrade it is highly likely the lakes will leak but not in dangerous way. Fully lining the embankments can be carried out to Lake 1 or Lake 2 or both lakes. These options are discussed below.

a) Upgrade Lake 1 only

Lake 1 is the operational lake for water supply, and whilst frequently full it is more likely to be partially empty after summer or an extended period of wet weather. After the water level is raised Lake 1 will have a usable capacity of approximately 1,485 ML.

The cost of upgrading Lake 1 with fully lined embankments is estimated at $1.71 million.

Even if Lake 1 was full, it will not have sufficient capacity to provide the estimated 1,580 ML of water required during the first sixty-six days after the earthquake without input from the Kaitoke source or water from Lake 2.

b) Upgrade Lake 2 only

Lake 2 is used operationally as a back up to Lake 1 and is generally maintained full. After the level is raised Lake 2 will have a usable capacity of approximately 1,905 ML. Occasionally, following a very dry summer or 1080 poison withholding period, Lake 2 would not be full and could drop to around 80% full or 1,524 ML.

The cost of upgrading Lake 2 with fully lined embankments is estimated at $2.1 million

It is likely that Lake 2 would be able to provide the estimated 1,580 ML of water required during the first sixty-six days after the earthquake without additional supply from the Kaitoke source or Lake 1. However, by itself Lake 2 would have very little spare capacity to cover contingencies.

Upgrading only Lake 2 would be acceptable if some water can be relied on from Kaitoke or Lake 1, or another water source was also available.

c) Upgrade both Lake 1 and Lake 2

The combined storage of both lakes after the levels have been raised will be approximately 3,390 ML. This would drop to around 2,700 ML after an average summer.

At the reduced level of storage both lakes would be more than adequate to provide the estimated 1,580 ML of water supply needed during the first sixty-six days after the earthquake, plus spare capacity to cope with longer disruptions to supply without relying on the Kaitoke source.

The cost of upgrading both lakes with fully lined embankments is estimated at $3.92 million.

7. Other water sources

Development of the Upper Hutt Aquifer would meet the water supply needs of Upper Hutt and could be operational within days of the earthquake, following pipework repairs and subject to the availability of power. That would reduce the early demand on the Stuart Macaskill Lakes and allow a greater percentage of water to be supplied to Porirua, Wellington northern suburbs and CBD.

With the Whakatikei Dam in place, Upper Hutt would be supplied from Te Marua with the remaining flow adding to the Whakatikei supply to Porirua, Wellington northern suburbs and CBD.

In each case the strategic importance of the Stuart Macaskill Lakes is reduced by development of these other sources, but the lakes will remain a valuable resource that could hasten the recovery of the region from a fault earthquake, by increasing the quantity of water available for supply - particularly during the critical first sixty-six days.

8. Discussion

8.1 Kaitoke source

It is clear that operation of the Kaitoke intake following a Wellington Fault earthquake will be problematic, mainly due to the possibility of landslides blocking the river upstream and the high debris loads disrupting the operation of the intake. However the risk of damage to the transmission assets between the intake and Te Marua treatment plant is low or, if necessary, can be mitigated by further strengthening of the Flume Bridge.

Our consultant's opinion is that river blockage will not persist beyond about a month, although there could be ongoing operational problems caused by high bedload at the intake. It is expected that at least a partial but intermittent flow of water could be achieved after this time.

8.2 Network repair and water supply needs

Our analysis of wholesale water network repair times at fault crossings and other vulnerable points indicates that without an alternative water source (such as the Upper Hutt Aquifer or Whakatikei Dam) water supply to Upper Hutt, Porirua and Wellington (northern suburbs and CBD) will be heavily reliant on the Stuart Macaskill Lakes for the first sixty-six days after a Wellington fault earthquake. During that period the amount of water that will be available from Kaitoke is uncertain.

8.3 Lake upgrade options

a) Option to upgrade only Lake 1

Lake 1 is normally used in water supply operations and is therefore more likely to be below full level, particularly after summer or an extended period of wet weather in the catchment. If only Lake 1 is upgraded it will have insufficient capacity to provide the water supply estimated to be required for the sixty-six days without relying on water from the Kaitoke source or Lake 2.

Since neither of these sources can be relied on, upgrading only Lake 1 to the enhanced security standard is not considered a suitable option.

b) Option to upgrade only Lake 2

Lake 2 is generally full and holds a greater volume of water than Lake 1. Lake 2 would contain sufficient water to provide the restricted water supply over the first sixty-six days after the earthquake when it is full. However, there would be little spare capacity to cover any contingencies such as continued difficulties at Kaitoke or slower reinstatement of the supply from Waterloo to Wellington.

Any requirement for water beyond that estimated would have to be supplied from Kaitoke, Lake 1 or another source if only Lake 2 is made secure.

c) Option to upgrade both lakes

Upgrading both lakes to the enhanced security standard would provide adequate storage, even after an average summer, to provide the estimated 1,580 ML of water supply needed over the sixty-six day period, plus spare capacity to cope with longer disruptions to supply. This would be achieved without relying on the Kaitoke source.

If one of the lakes is not upgraded then it is highly likely to leak after a fault earthquake but not in dangerous way. It may be possible to use some of this water for the emergency water supply before using water from the upgraded lake, although there would be 18 days of water leakage before the pipework to allow supply is repaired. This leakage could add to the difficulties of repairing broken pipes over the fault line.

Upgrading both lakes would ensure that all stored water is available for water supply and not wasted by leakage.

8.4 Development of other sources

The development of other water sources such as the Upper Hutt Aquifer or the Whakatikei Dam will reduce the strategic importance of the Stuart Macaskill Lakes, such that Lake 2 storage would be adequate for emergency water supply.

It is clear that the security upgrade of Lake 2 should proceed with the remedial and level raising work for the lake. However the need to fully line the embankments of Lake 1 will be influenced by what other water sources are developed. At this time the certainty and timing of development of these other sources is not known.

8.5 Contractual issues

It is intended that a single contract will be let to carry out the mitigation work, raise the lake levels and carry out the seismic upgrade to Lake 2 and possibly Lake 1. Therefore a decision will need to be made on whether to upgrade Lake 1 by October 2010.

It would be very disruptive to lake operations, more expensive and technically difficult to upgrade the lining of Lake 1 as a separate contract after the maximum water level in Lake 1 has been raised.

9. Communication

The capital projects to raise the level of the Stuart Macaskill Lakes and carry out the seismic upgrade work are included in the 2009/19 LTCCP and the information is therefore already publicly available. An article on the work also featured in Hutt Valley local news journals. Further communication on the project at this time is not believed necessary.

10. Recommendations

That the Committee:

1. ***Receives*** *the report.*

2. ***Notes*** *its contents.*

3. ***Agrees*** *that the seismic security of Lake 2 should be enhanced by fully lining the lake embankments at an estimated cost of $2.1 Million. This work is funded in the 2009/19 LTCCP to be carried out in conjunction with mitigation work to comply with legislation and to raise the lake level.*

4. ***Agrees*** *that the decision on whether or not to upgrade Lake 1 to a similar standard to Lake 2 is deferred until October 2010 when there may be more clarity on a number of water supply options that could influence this decision.*

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