6.0 SUMMARY AND CONCLUSIONS

1. When GNS was carrying out the work required for their 2002 report, it became apparent that there was no accepted method in use for assessing the risk of subsidence collapse craters migrating to the ground surface from underground mine workings, so a method for doing this was developed and used.

2. A review has been carried out of the methodologies used in the August 2002 GNS report for estimating sink-hole hazard zones above the old underground mine stopes at Waihi. In our assessment, the methodologies used are appropriate and can be tested deterministically in the places where sink-holes have occurred. To date all observed chimney caves have formed over the high hazard zone derived from the model. Therefore for consistency in our reporting, and because there appears to be no viable alternative, the same void migration calculation methods have been used for deriving the probability of sink-hole collapse over the "Martha" (North Branch, Mary, No. 2 and Martha) stopes in this report. The new estimates (Table 1) can therefore be directly compared with those for other stopes (Edward South, Royal and Empire) in the August 2002 GNS report.

3. The risk of ground subsidence developing from chimney collapses into unfilled, mined out stopes in the "Martha" lodes (Table 1) has been carried out using the @Risk simulations of sinkhole index probabilities, as developed for the study of ground collapse in the August 2002 GNS report. The basic model was calibrated by checking the predicted sinkhole indexes against this previous work.

4. High, medium and low sink hole hazard zones have been established over the "Martha" lodes lying in the NE quadrant beyond the perimeter of the open pit (within Figure 5) using the procedures of the August 2002 GNS report. The historical large subsidence craters and the chimney caves found during excavation of the Pit 64 cut back, are all located in the high hazard zones, which supports our hazard model.

5. The risk of sink-hole collapse from the "Martha" stopes was specifically not included in the work brief for the August 2002 GNS report.

6. Risk assessment evaluations suggest that vehicle, cycle and pedestrian access is acceptable on roads or tracks established through high sink-hole hazard areas.

7. The August 2002 GNS report was focused on the risk of sink hole collapses from the Edward South, Royal and Empire lodes and did not fully recognise the possible extent of low hazard, long-term creep movements associated with underground and open pit mining.

8. We expect that creep deformations due to both the old underground and the open pit mines will occur in adjacent parts of Waihi. However, without accurate monitoring information it is difficult to accurately predict the extent of creep movements..

9. Slow creep movements are influenced by subsurface rock mass properties and by through-going rock mass defects such as shears and faults. Using engineering judgement guided by observed ground cracking, we estimate that the creep movements may extend as far as the angle of draw (~30º from the vertical) from the underground

mine workings or as far as the open pit depth from the pit rim, whichever extends the furthest from the mine workings on the southern and eastern sides of the open pit. The creep movements are presently causing relatively small deformation of roads, footpaths and a few properties in Seddon and Haszard Streets and are considered to be low risk, meaning they are regarded as causing some economic damage rather than posing a threat to safety. Should the movements continue, increase or become more extensive the HDC may have to assess the introduction of resilient building and service construction methods in the movement areas.

10. To establish the extent and context of movements, we recommend that movement monitoring survey lines are established in the areas of Waihi that may be most affected by long term creep movements. These monitoring lines extend out from and along the southern and eastern pit rim and from the underground mine stopes. We also recommend that the survey monitoring lines are established without delay so that changes in movement rates which could be attributed to on-going works, such as the south wall cut back and/or lake filling are recorded and assessed. Once lines are established, the survey monitoring frequency can be adjusted to suit movement rates being observed and their locations.

11. Once accurate monitoring data is available from repeat surveys of the recommended survey monitoring lines, it can be used to assess whether the surveys need to be adjusted, either extended or reduced, to suit the actual ground movements being recorded.

12. Pit wall monitoring by NWG indicates that the “northern” pit wall is generally stable and not moving.

7.0 ACKNOWLEDGEMENTS

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8.0 LIMITATIONS OF THE REPORT

Our study has approximations and limitations that are inherent in attempting to model and understand complex geological processes and ground conditions. We are attempting to forecast future subsidence movements and are unable do that with any precision. We have applied our engineering and geological judgement to an imperfect knowledge of subsurface ground conditions and past events. The estimated probability of various subsidence events has a relatively high level of uncertainty because of the uncertain nature and properties of

the ground in which movements occur and through which voids migrate before they reach the surface. In addition, a lack of accurate knowledge of the processes by which voids migrate increases the uncertainty. However, our model for void migration has been tested and validated against the subsidences that have occurred. We are satisfied that the void migration model gives good indicative and useable hazard assessment results.

The report findings are made on consideration and analysis of the best information available to us.

9.0 REFERENCES

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