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OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
CAMP CREEK DAM
DAM BREACH REPORT

Prepared for:

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11 April 2011

OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
CAMP CREEK DAM
DAM BREACH REPORT

EXECUTIVE SUMMARY

1. Construction of the proposed Camp Creek Water Storage Dam will provide water storage of 1.4Mm³ of water.

2. A dam breach study have been undertaken to determine the effects of a hypothetical breach under both sunny day and flood induced (1 in 100 AEP flood event) conditions. The initiating event for a sunny day failure would most likely be an earthquake.

3. The results of the dam breach study have been used to assess the Potential Impact Classification (PIC) of the Camp Creep Dam. The PIC has been assessed in accordance with the Building (Dam Safety) Regulations 2008. The PIC for both sunny day and flood induced conditions is assessed to be low.

4. It is important to distinguish between the hazard potential (i.e. the effects of a dam breach were it to occur) and the risk or probability of a dam breach occurring. The risk of failure for a dam designed, constructed, operated and maintained in accordance with NZSOLD Dam Safety Guidelines would be extremely low.

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1.0 INTRODUCTION

Oceana Gold (New Zealand) Limited (OceanaGold) propose to construct a water storage dam to store water for mining operations. The proposed dam, called Camp Creek Dam, will be located on the lower part of Camp Creek and will have a storage capacity of $1.4Mm^3$.

Engineering Geology Ltd (EGL) has been contracted by OceanaGold to assess the feasibility of the dam and to prepare a Technical Report to support an application for a Resource Consent (Ref.1). The requirements for design, construction and operation of dams in New Zealand are documented in Guidelines published by the New Zealand Society on Large Dams (NZSOLD) (Ref.2). The requirements are related to the Potential Impact Classification (PIC). The PIC is dependent on the incremental losses that could arise as a result of failure. The incremental losses are assessed by undertaking a dam breach study which involves evaluating the effects of a hypothetical breach of the dam. This report documents the results of a dam breach study of the proposed Camp Creek Dam. The study assesses the extent and depth of inundation associated with a breach under sunny day and flood induced conditions. The incremental effects of a breach are evaluated and an assessment of the PIC is provided.

2.0 DAM DESIGN STANDARDS AND REQUIREMENTS FOR DAM BREACH STUDY

The New Zealand Society on Large Dams (NZSOLD) publication ‘New Zealand Dam Safety Guidelines’ is the basis for design, construction and operation of dams in New Zealand. Requirements for design, construction and operations are related to the Potential Impact Classification (PIC). Four different potential impact categories are defined (very low, low, medium and high). The categories are based on the incremental losses which a failure might give rise to. Incremental losses are those additional losses that might have occurred for the same natural event if the dam had not failed. In assessing which category is appropriate consideration needs to be given to the consequences of failure (life, socio-economic, financial and environmental). To assess the incremental losses associated with dam failure it is necessary to undertake a dam breach study. Such a study considers a hypothetical breach of the dam and normally considers failure under both sunny and flood induced conditions. The extent of the flooding is determined and the incremental consequences resulting from the breach are assessed.

3.0 LOCATION

The location of the proposed Camp Creek Dam is shown in Figure 1. A larger scale plan of the dam is shown in Figure 2. It is located on the lower part of Camp Creek. Camp Creek flows in a southern direction and joins Deepdell Creek about 1.7km from the proposed dam. Deepdell Creek flows in a north eastern direction and joins the Shag River about 14.7km (distance measured along the gully) from the Camp Creek – Deepdell Creek confluence. It is noted that the plan grid on Figure 1 is New Zealand Map and the grid on Figure 2 is based on mine north which is approximately 45 degrees anti-clockwise from true north.

There are no permanently inhabited structures (i.e. residential dwellings) situated along the Camp or Deepdell Creeks that would be affected by a breach of the proposed dam. The Golden Point Historic Mining Reserve is located approximately 6km downstream of the proposed dam adjacent to Deepdell Creek. It includes the old Manager's house and a Stamper Battery. The old Manager's house is located about 50m south and about 3m vertically above Deepdell Creek. The Stamper Battery is immediately adjacent to Deepdell Creek. There are a number of dwellings located adjacent to the Shag River that historically have been affected by floods and could be affected by a breach of the Camp Creek Dam. They are shown in Figure 3. The grid on Figure 3 is in terms of Observation Point 2000. The closest dwellings potentially at risk are located at Waynestown, approximately 37km downstream of the Camp Creek Dam. Some houses here have been affected by historic floods. Deepdell Creek is culverted beneath Golden Point Road approximately 5km downstream of the proposed dam. Currently Golden Point Road is a mine Haul Road, but will revert back to a public road following closure of the mine. There are also a number of bridges or culvert crossings across the Shag River that are potentially at risk and these are also shown in Figure 3.

4.0 DAM BREAK SCENARIO

The dam break scenario assumes a hypothetical uncontrolled release of water from the dam due to a breach of the dam. It is hypothetical because a dam designed, constructed and operated in accordance with modern practice would not be expected to fail. No assumptions are made about the mode of failure and it takes no account of the risk of failure or the type of failure.

Two different initiating events have been considered for a hypothetical breach of the Camp Creek Dam. They are breaches under sunny day and flood induced conditions. In a sunny day failure the normal operating volume of water (1.4Mm^3) is assumed to be stored in the dam, and flows in the downstream creeks and rivers are assumed to be at normal levels. In a flood induced situation the maximum volume of water that could be impounded in the reservoir (1.684Mm^3) is assumed and the downstream creeks and rivers would be at flood levels. The most likely initiating event for a sunny day failure of the dam is a large earthquake. For the flood induced condition a 1 in 100 Annual Exceedance Probability (AEP) flood event has been assumed.

5.0 BREACH HYDROGRAPH

A hydrograph for the breach is required to predict the potential effect of the water released from the reservoir. This requires estimates of peak flow, time for the full breach to form (time to failure) and volume of water released.

Under the sunny day condition the dam is assumed to be storing the 'Normal Operating' volume (1.37Mm^3 at RL439.5) with a 26m head of water. Under the flood induced condition the dam is assumed to be storing water up to crest level (volume of 1.68Mm^3 at RL441.5) with a 28m head of water.

The dimensions of the breach are based on the assumption that the whole embankment in the valley would be washed away. In this case the width of the breach at the base of the dam would correspond to the width of the valley which is 15m. The sides of the breach are assumed to be 1:1 (H:V), as reported in a number of cases (Ref.3).

The time to failure was estimated by comparing estimates from three empirical methods; Froelich (Refs.4 and 5), MacDonald and Langridge-Monopolis (Ref.6) and Bureau of Reclamation (Refs.7 and 8). The time to failure varied from 12 minutes to 1 hour. A breach time of 30 minutes was adopted after taking into consideration the type of embankment and the time it would take to empty the dam.
The peak flows were estimated with BOSS DAMBRK, a flood routing computer software programme using the reservoir height – storage relationship, the adopted value of time to failure and breach width. The peak flows were estimated to be 1600m^3/s for the sunny day condition and 1680m^3/s for the flood induced condition.

6.0 STREAM FLOWS AND LEVELS WITHOUT DAM BREACH

In order to analyse the incremental effect of a hypothetical dam breach of the Camp Creek Dam it is necessary to establish the flood levels in both Deepdell Creek and the Shag River that would exist downstream of the dam in the same conditions without a breach.

The flow in Deepdell Creek under sunny day conditions at the location of the Golden Point Road crossing and the Golden Point Historic Mining Reserve is about 0.09m^3/s. The 1 in 100 AEP flood flow is estimated to be about 155m^3/s. These flows are insignificant compared to the flows associated with a dam breach (1600m^3/s for sunny day and 1680m^3/s for flood induced).

The Shag River emanates from the Kakanui Mountains and flows for about 62km to the sea. It has a catchment area of about 548km^2. The catchment is bounded by the Kakanui Mountains, Horse Range and Razorback Range to the north east and by the Taieri Ridge to the south (Ref.9).

The flow in the Shag River is monitored at two locations; The Grange for high flows and Craig Road for flows that are less than 10m^3/s. The ORC operates a flood warning system using the flow monitoring system at The Grange. Affected residents downstream are warned when there is an increase of the water level to 1.4m or about 31m^3/s (Ref.10).

In the sunny day breach condition, flows in the Shag River are assumed to be normal, which are less than 1m^3/s at The Grange. The mean annual flood flows at The Grange and Dunback are estimated to be about 147m^3/s and 160m^3/s respectively (Ref.11). The flow under sunny day conditions is therefore much lower than the mean annual flood flow.
In order to estimate flow levels in the Shag River under the 1 in 100 AEP flood conditions, a HEC-RAS flood routing model was utilised. Ground levels were determined from an aerial survey specifically undertaken for the dam breach study over the potential flood plain. The model was calibrated against historic flood levels compiled by the Otago Regional Council (ORC) (Refs.9 and 11).

ORC have identified areas of historic flooding from witness accounts, photograph records and physical evidence. There also have been expert estimates of flows during floods at specific locations (Ref.9). There are records for three recent significant floods. The flood of 5 June 1980 is considered as the recent worst flood with an estimated flow at Dunback of 590m³/s. The flood of 13 March 1986 had an estimated flow at Dunback of 445m³/s (Refs.9 and 11). The 22 December 1993 flood was measured at The Grange to have a maximum flow of 472m³/s (Ref.12).

A Stage to Flow rating chart has been developed for The Grange Station and the 1 in 100 AEP flow has recently been estimated to be 958m³/s (Ref.12). This has been adopted as the 1 in 100 AEP flood flow in the flood induced breach scenario.

The 1 in 100 AEP flows at other locations downstream of The Grange have been estimated by relating the flow at The Grange to its catchment area and then using the Regional Flood Procedure to determine flows at other locations with different catchments (Ref.13). The flows obtained for each location were compared with and adjusted if necessary. Summaries of the 1 in 100 AEP flood levels at house and bridge sites identified in Figure 3 are presented in Tables 1 and 2 respectively. The flood levels at bridge sites could be higher than indicated in Table 2 because the flood levels have been determined ignoring any constriction to flow caused by the presence of the bridges. The results in Table 1 indicate that the 1 in 100 AEP flood event on its own will result in water levels exceeding floor level at 12 houses. This is not surprising as historically a number of properties are known to have been affected by lesser floods. The results in Table 2 indicate that the 1 in 100 AEP flood event on its own will result in water level exceeding bridge deck level at 8 bridges or culvert crossings.

7.0 BREACH FLOOD FLOWS AND LEVELS

Flood routing to determine the flood flows and levels from a hypothetical breach was carried out using HEC-RAS. The peak breach flow associated with a sunny day failure is estimated to be 1600m³/s. This flow would attenuate significantly and by the time it reached Waynestown (37km downstream of dam) is estimated to be less than 250m³/s. This flow is equivalent to a 1 in 10 AEP flood event. The analyses indicate that under these conditions a breach of the Camp Creek Dam would not inundate any houses. The Golden Point Road crossing at Deepdell Creek would be overtopped by about 3m and considerable damage could be expected. Currently this is a mine Haul Road. Water levels would rise above the decks of the Grange Hill Road and Craig Road bridges by 2.7m and 1.7m respectively. These bridges have been overtopped, without failure, by significantly larger historic flood flows. At the Golden Point Historic Mining Reserve the water level would be about 5m above the floor of the old Manager’s House and the Stamper Battery would also be inundated.

The depth of water associated with a breach for the flood induced condition has been evaluated by attenuating the breach hydrograph from a flood induced failure on top of the 1 in 100 AEP flood water levels along the Shag River. A summary of flood levels at the house sites for the 1 in 100 AEP flood event on its own and with a dam breach is presented in Table 1. Maps showing the extent of the flood plain associated with the 1 in 100 AEP flood induced dam breach are presented in Appendix A. In assessing the PIC of a dam the incremental effect of a dam breach is what must be considered. In the flood induced breach condition the incremental depth of water in the Shag River varies from between 0.26m to 0.43m where the 12 houses that are impacted by a 1 in 100 AEP flood event are located. An additional two houses are inundated by a flood induced breach, but the depth of water above floor level in these cases is less than 0.17m.

In the flood induced breach condition the incremental depth of water above bridge deck level varies from between 0.26m and 0.37m. A summary of flood levels at the bridge and culvert sites for the 1 in 100 AEP flood event on its own and with a dam breach is presented in Table 2. At the Golden Point Historic Mining Reserve the consequences of a flood induced breach would be similar to that associated with a sunny day breach (i.e. water level would be about 5m above the floor of the old Manager's House and the Stamper Battery would be inundated).

8.0 ASSESSMENT OF PIC

8.1. Criteria for Assessment of PIC

The PIC is dependent on the damage levels and the population at risk (PAR). Criteria for assessing damage levels are defined in Table 1 of the Building (Dam Safety) Regulations 2008 (Ref.14). Four different categories of damage are specified (residential house, critical or major infrastructure, natural environment and community recovery time). The PIC is determined from Table 2 of the Regulations.

8.2. Sunny Day Breach

The level of damage due to breach under sunny day conditions is assessed to be minimal for residential houses and critical or major infrastructure. The flow in the Shag River where houses are present is assessed to be no more than a 1 in 10 AEP flood event and below existing house floor levels.

The Golden Point Road culvert crossing at Deepdell Creek would be overtopped and severely damaged, but it is not regarded as critical. At present it is a mine Haul Road but it will revert to a public road following closure of the mine. However, it has little traffic and there are alternative roads. The Loop Road culvert will also be overtopped by about 4m. The level is lower than historic floods and there are alternative access routes if the culvert did fail. Water levels would rise 2.7m and 1.7m above the bridge deck levels of the Grange Hill Road and Craig Road bridges respectively. These bridges have been overtopped by greater depths in historic floods without failure.

Damage to the natural environment would be greatest in Deepdell Creek as the dam breach flows are much greater than historic flood flows. Significant physical and ecological damage to Deepdell Creek would be expected as a result of the high flows and erosion of the banks of the stream, and the Golden Point Historic Mining Reserve would also be badly damaged. We assess the environmental damage to be moderate based on our assessment that the damage in Deepdell Creek would be significant but recoverable.

The community recovery time from a sunny day breach is assessed to be very short (days to weeks) as any damage would not be expected to have much impact on the community as a whole. Consequently damage under this criterion is assessed to be minimal.

A discussion of the PAR associated with a sunny day breach follows. People present in Camp or Deepdell Creeks and in the Shag River (e.g. swimming or fishing) or crossing Deepdell Creek (via Golden Point Road), the Loop Road culvert or the Grange Hill Road and Craig Road bridges could be at risk due to the short warning time associated with a breach under sunny day conditions. The Camp and Deepdell Creeks have no to minimal recreational use as many sections of the water courses are only accessible from private land. In the Shag River the number of people potentially at risk is very low because the expectation is that people would move away if they saw the water level rising. Similarly, drivers would not be expected to drive across the Deepdell Creek culvert crossing at Golden Point Road, the Loop Road culvert or the bridges at Grange Hill Road and Craig Road if they were under water. Consequently we assess the PAR to be less than 5 and the PIC for a sunny day breach is therefore low according to Table 2 of the Dam Safety Regulations (PAR of less than 5 and moderate damage). The moderate damage assessment arises due to the potential environmental consequences in Deepdell Creek, not as a result of risk to people.

8.3. Flood Induced Breach

A breach under flood conditions is predicted to result in a rise of up to 0.43m on top of the 1 in 100 AEP flood level in the Shag River where houses or bridges are at risk, except at the Golden Point Road culvert where the incremental rise is 2.4m. Incremental damage to houses and bridges has been assessed by considering the incremental change in parameter ‘dv’ where d is the depth of flow above house floor or bridge deck level and v is the velocity of water. Summaries of the damage parameter ‘dv’ for the houses and bridges for the 1 in 100 AEP flood event on its own and with a breach of the Camp Creek Dam are provided in Tables 1 and 2 respectively. The incremental change in ‘dv’ as a result of a flood induced breach is relatively small. Estimates of damage and potential hazard to life based on ‘dv’ are provided by Reiter (Ref.15) and Amos et al. (Ref.16) and are presented in Tables 3 and 4 respectively.

In the 1 in 100 AEP flood event 12 houses are estimated to have water levels above floor level. With a breach another 3 houses are predicted to have water levels above floor level, but only by up to 0.17m. The analyses indicate that there are 8 houses in a 1 in 100 AEP flood event (i.e. without a dam breach) where dv >1.0 and there would be significant danger to life according to the criteria recommended by Amos et al. (Ref.16). A breach of Camp Creek Dam does not result in an increased number of houses with significant danger to life (i.e. no other houses have dv > 1.0 as a result of a dam breach). There are 2 houses where there is some danger to life in a 1 in 100 AEP flood event (0.5 < dv <1.0) and 2 where there is no danger to life (dv <0.5). A breach of Camp Creek would result in 1 house moving from the no danger level to some danger resulting in 3 houses where there is some danger to life. There would be a total of 4 houses in the no danger level. This indicates that the incremental effect of a dam breach on houses is minimal.

In a 1 in 100 AEP flood there are seven bridges or culvert crossings across the Shag River where the water level exceeds bridge deck level (refer to Table 2). We note that the two most important bridges, which are part of the state highway (SH85 Dunback-Morrison Road and SH1 Hampden–Palmerston Road), would not be inundated by the 1 in 100 AEP flood event and neither with a dam breach. All other bridges are on minor roads. The analysis indicates that the incremental increase of ‘dv’ for the inundated bridges due to the breach of the Camp Creek Dam is not significant and so the incremental effect of a dam breach on the bridges is minimal. The Golden Point Road crossing at Deepdell Creek would be severely damaged, but it is not regarded as critical (crossing has little traffic and there are alternative roads). Consequently the incremental effect of a flood induced dam breach on critical or major infrastructure is minimal.

The incremental damage to the natural environment would be greatest in Deepdell Creek as the dam breach flood flows are much greater than historic flood flows. The situation is much the same as for the sunny day breach and so overall we assess the damage to the natural environment to be moderate based on our assessment that the damage in Deepdell Creek would be significant but recoverable.

The community recovery time from a flood induced breach would be expected to be very short (days to weeks) as damage would not be expected to have much impact on the community as a whole. Consequently damage under this criterion is assessed to be minimal.

The incremental PAR is assessed to be less than 5 because in a flood induced condition it is highly unlikely that there would be any recreational users present in Deepdell Creek or Shag River, the dam breach analysis does not indicate a significant incremental effect and because the ORC have a warning system that is activated when flood events occur (Ref.10). Consequently the PIC for a flood induced breach is low according to Table 2 of Dam Safety Regulations (PAR of less than 5 and moderate damage). The moderate damage assessment arises due to the potential environmental consequences in Deepdell Creek, not as a result of risk to people.

8.4. Summary

In summary the PIC for a hypothetical breach of the dam under both sunny and flood induced conditions is **low.**

9.0 DAM BREAK MITIGATION

This section provides information on the potentially inundated areas and warning time.

9.1. Inundation Area

The largest inundation occurs for the flood induced breach condition. Maps indicating the extent of inundation are provided in Appendix A.

9.2. Warning Time

The warning time has a significant influence on the loss of life in a dam breach event. It has no bearing on the PIC but is important for emergency planning. Brown and Graham (Ref.17) indicate that the loss of life can vary from 0.02% of the population at risk when the warning time is 90 minutes to 50% of the population at risk when the warning time is less than 15 minutes.

Table 5 presents a summary of the time from the start of the dam breach to the time the flood wave would arrive at different locations downstream of the dam. Table 5 also shows the time it would take from the start of the breach for the peak flow to occur. The times are expected to be similar for both a sunny day or flood induced breach. In the unlikely event of a dam breach it would take approximately 75 minutes for flood waters to reach the nearest dwelling at risk at Waynestown and about 115 minutes for peak flows to occur.

10.0 CONCLUSIONS

The dam breach study shows that the proposed Camp Creek Water Storage Dam should be categorised as low PIC. This assessment is largely driven by the assessment of damage to the natural environment, a result of the effects of physical and ecological damage in Deepdell Creek.

In the unlikely event of a dam breach it would take approximately 75 minutes for flood waters to reach the nearest dwelling at risk at Waynestown and about 115 minutes for peak flows to occur.

It is important to distinguish between the hazard potential (i.e. effects of a dam breach were it to occur) and the risk or probability of a dam breach occurring. The risk of failure for a dam designed, constructed, operated and maintained in accordance with modern standards (e.g. NZSOLD Dam Safety Guidelines (Ref.2) would be extremely low.

Report Prepared by
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TABLES

Table 1. Summary of 100 Year and Dam Breach Flood Levels at Houses

House	Estimated House Floor Level	100yr Flood Level	100yr Dam Break Flood Level	Depth for 100year flood level	Depth for 100yr & Dam Break Floods	Velocity for 100 year flood	Velocity for 100 year and dambreak	Damage Parameter (dv) for 100 year flood only	Damage Parameter (dv) for 100 year flood and Dam Break
A	61.25	62.86	63.28	1.61	2.03	1.32	1.33	2.12	2.70
B	61.12	62.62	63.05	1.50	1.93	1.42	1.42	2.13	2.74
C	51.69	51.58	51.86	-0.11	0.17		1.28		0.22
D	51.97	51.58	51.86	-0.39	-0.11				
E	53.02	51.58	51.86	-1.44	-1.16				
F	53.39	51.58	51.86	-1.81	-1.53				
G	47.64	47.80	48.10	0.16	0.46	0.82	0.87	0.13	0.40
H	50.51	47.80	48.10	-2.71	-2.41				
I	44.3	43.58	43.99	-0.72	-0.31				
J	43.6	43.58	43.99	-.02	0.39		1.09		0.42
K	43.88	43.58	43.99	-0.30	0.11		1.09		0.12
L	38.38	36.66	37.51	-1.72	-0.87				
M	34.55	33.58	34.00	-0.97	-0.55				
N	31.91	33.32	33.65	1.41	1.74	0.56	0.56	0.79	0.98
O	31.13	33.32	33.65	2.20	2.53	0.56	0.56	1.23	1.41
P	30.59	32.70	33.00	2.11	2.41	1.27	1.32	2.68	3.18
Q	30.64	32.54	32.80	1.90	2.16	1.09	1.14	2.08	2.47
R1N	30.35	31.84	32.20	1.49	1.85	1.00	1.06	1.49	1.96
R	30.28	31.84	32.20	1.56	1.92	1.00	1.06	1.56	2.03
R2	30.36	31.84	32.20	1.48	1.84	1.00	1.00	1.48	1.84
S	30.18	30.88	31.20	0.70	1.02	0.88	0.93	0.62	0.95
T	28.79	29.37	29.70	0.58	0.91	0.66	0.68	0.38	0.62

Table 2. Summary of 100 Year and Dam Breach Flood Levels at Bridges and Culvert Crossings

Bridge/Culvert	Stream	Estimated Bridge Deck Level	100yr Flood Level	100yr & Dam Break Flood Level	Depth for 100year flood above Bridge Deck level (m)	Depth above Bridge deck level for 100yr & Dam Break Floods (m)	velocity for 100 year flood (m/s)	velocity for 100 year and Dam Break (m/s)	Damage Parameter (dv) for 100 year flood only	Damage Parameter (dv) for 100 year flood and Dam Break
Golden Point Road Culvert	Deepdell Creek	352.	353.2	355.62	1.2	3.62	1.7	5.7	2.04	20.6
Loop Road Culvert	Shag River	106	112.8	113.2	6.8	7.2	3.85	4.29	262	30.9
SH85-Dunback-Morrison Rd Bridge	"	67.6	65.71	66.22	-1.89	-1.38				
Murphy Street Walk Bridge	"	51.0	51.59	51.90	0.59	0.90	1.96	1.85	1.16	1.67
Domain Road Bridge	"	46.6	47.64	48.00	1.04	1.40	2.83	2.38	2.94	3.33
Grange Hill Rd Bridge	"	37.7	43.30	43.67	5.60	5.97	2.49	2.27	13.94	13.55
McLew Rd Bridge	"	36.5	36.66	36.83	0.16	0.33	2.41	2.52	0.39	0.83
Craig Rd Bridge	"	27.4	32.70	33.0	5.3	5.6	2.95	2.95	15.6	16.5
Switch Back Rd Bridge	"	15.5	16.14	16.40	0.64	0.90	2.05	2.09	1.31	1.88
Horse Range Rd Bridge	"	12.65	10.76	10.86	-1.89	-1.79				
SH1- Hampden Palmerston Rd Bridge	"	7.1	4.91	4.95	-2.19	-2.15				

Table 3. Critical Structural Damage and Loss of Life Parameters (Reiter, Ref.15)

Risk for loss of life classes of houses	Damage Parameter *dv* (m^2/s)		
	Small damages, small danger	**Medium damages, medium danger**	**Total damages, very high danger**
Lightly constructed detached one family house	<1.5	1.3-2.5	>2.5
Well Constructed wooden houses	<2.0 (v>2.0m/s)	2.0-5.0 (v>2.0m/s)	>5.0
Brick houses, concrete structures	<3.0 (v>3.0m/s)	3.0-7.0 (v>2.0m/s)	>7.0

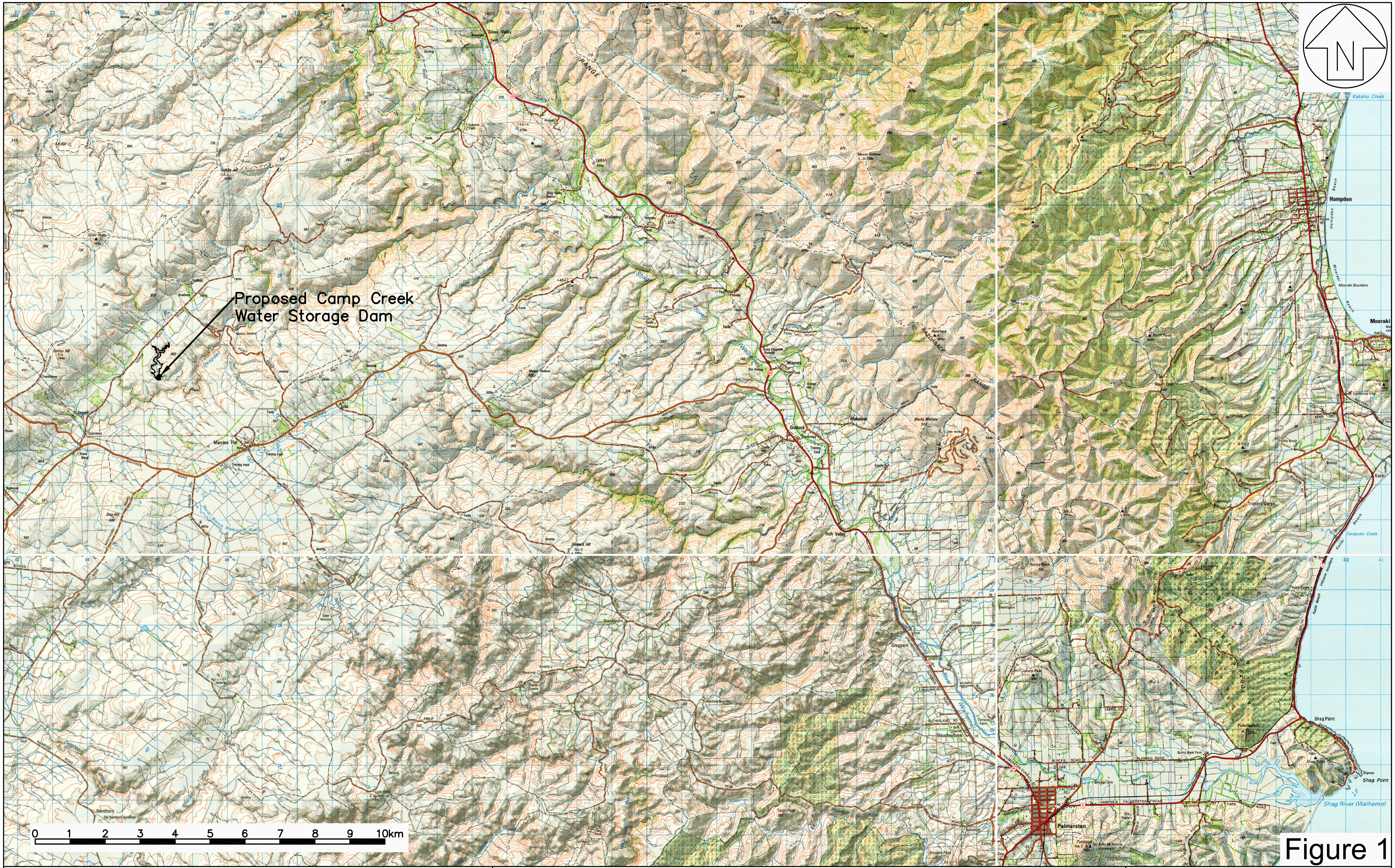
Table 4. Potential Hazard (Amos et.al, Ref.16)

dv	Potential Hazard
dv < 0.5	No danger to life
0.5<*dv*<1.0	Some danger to life exists
dv>1.0	Danger to life significant

Table 5. Summary of Time for Flood Wave to Arrive and Time for Peak Water Depth

Location	Distance Downstream of Dam (km)	Time for Flood Wave to Arrive (minutes)	Time for Peak Water Depth to Occur (minutes)
Golden Point Road and Historic Mining Reserve	5	15	45
SH85 Dunback-Morrison Road Bridge (B1-Figure 3)	36	65	108
Waynestown	37	68	110
Dunback	42	100	150
SH1 Hampden-Palmerston Bridge (B10-Figure 3)	62	150	220

FIGURES



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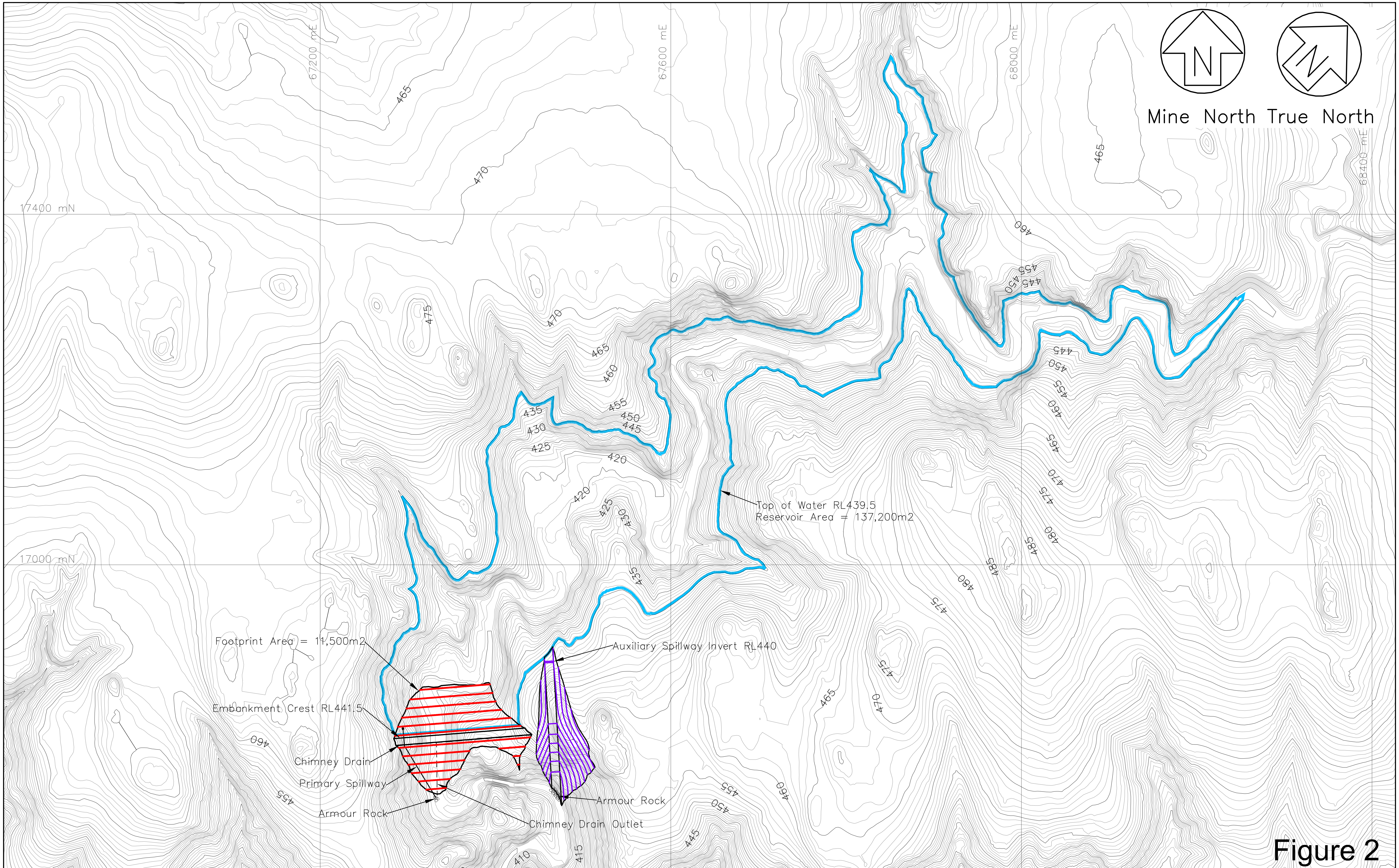
OCEANA GOLD (NZ) LTD, MACRAES GOLD PROJECT
Camp Creek Water Storage Dam Breach Study
Locality Plan

Drawing No.	6914-Figure 1
Date:	22 Mar 2011
Drawn:	BL
Scale:	1:100000 (@A3)
Filename:	6914-Figure 1.dwg



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Layout Plan

Drawing No.	6914–Fig 4
Date:	21 Jan 2011
Drawn:	BL
Scale:	1:4000 (@A3)
Filename:	6914–Fig 4.dwg

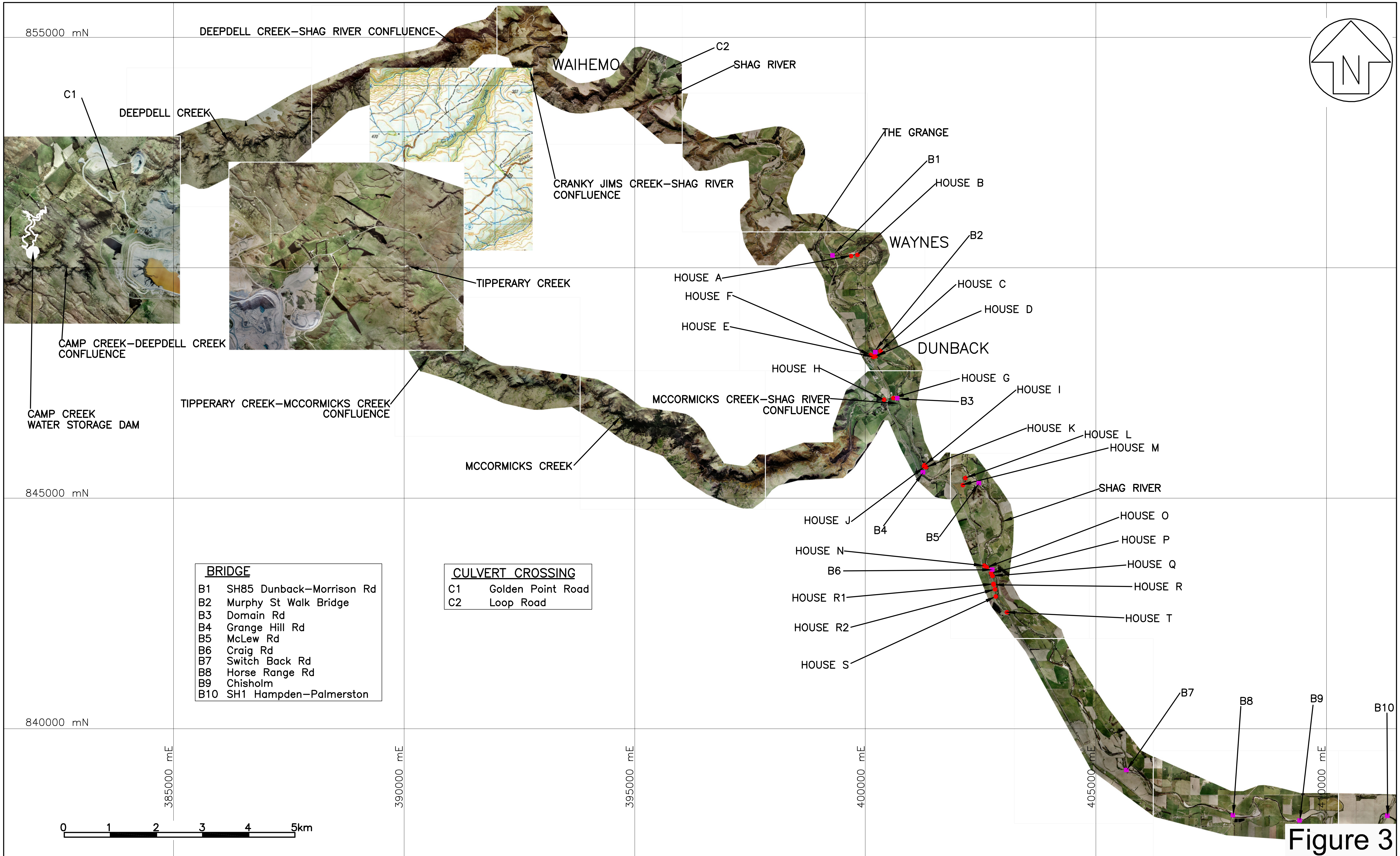

Figure 3

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Camp Creek Water Storage Dam Breach Study

Site Plan

Drawing No.	6914–Figure 3
Date:	25 Mar 2011
Drawn:	BL
Scale:	1:75000 (@A3)
Filename:	6914–Figure 3.dwg