BEFORE THE HEARINGS COMMITTEE

IN THE MATTER **of hearings on submissions concerning the Proposed One Plan notified by the Manawatu-Wanganui Regional Council**

SUPPLEMENTARY REPORT OF JON ROYGARD ON BEHALF OF HORIZONS REGIONAL COUNCIL

SUMMARY OF EVIDENCE

1. This supplementary report has been prepared to provide some further technical information in relation to Points 22 to 27 of Chairperson's Minute No. 3. These relate to:
   i. the illustrative map showing the indicative locations of land subject to risk of accelerated erosion for the Regional Policy Statement (RPS);
   ii. the cost and feasibility of undertaking further detailed mapping of areas at risk of accelerated erosion using LiDAR surveying; and
   iii. larger scale maps of the erosion management areas for the Regional Plan (RP).

ILLUSTRATIVE MAP FOR THE REGIONAL POLICY STATEMENT

2. The Chairperson's Minute No. 3 indicates that the Hearing Panel considers there may be merit in including an illustrative map in the RPS, as part of the One Plan, to show indicative locations of land subject to accelerated erosion. We are grateful for the level of specificity provided by the minute for the preparation for this map as per Point 24 of the Minute. We have endeavored to produce what has been requested to the best of the ability of the information and tools available.

3. Point 24 of the Minute indicates that the illustrative map should be based on "Dr Dymond's modelling". We interpret this to mean the Dymond and Sheppard (2006) modelling. To complete the analysis as specified in Point 24 of the Minute, it was determined that the best path was to start from the Dymond and Sheppard (2006) original data again, as opposed to the simplified versions derived from that data and presented to the Hearing Panel earlier in the year.

4. Point 24 of the Minute requests that the map exclude land owned by the Department of Conservation estate (DoC), land held in QEII Trust covenants and Nga Whenua Rahui (NWR) land. The DoC land and QEII Trust land has been identified via layers that exist within Horizons GIS data files. These files are the same as those used in the previously presented analysis. In the analysis below the areas identified as DoC and QEII Trust and have been excluded from the areas identified by Dymond and Sheppard (2006) as highly erodible land (HEL).

5. For Nga Whenua Rahui land, Horizons has been able to obtain a spatial data layer from DoC. However, the data layer has not been maintained since 2006. Horizons technical staff have asked DoC staff and Horizons land management staff including Joe Martin, Environmental Management Officer (plants), about ways of accurately updating this data set. At this stage, we have been unable to update the information provided by DoC. Therefore, the analysis below excludes the information for the Nga Whenua Rahui land identified in the data file provided by DoC.

6. Point 24 of the Minute requests advice on whether land owned by the NZ Defence Force should also be excluded. Following previous (verbal) guidance from the Hearing Panel and aligning with the planning recommendation of Phillip Percy on behalf of Horizons, the analysis below excludes the NZ Defence Force (DF) land. If the Hearing Panel would like this land included in the analysis, this can be done upon request.

7. To further clarify the NZ Defence Force land areas in the Region, Horizons has contacted Rob Owen (Environmental Manager, Property Group, Joint Logistics and Support Organisation, New Zealand Defence Force). The information provided by Mr Owen has resulted in the area of NZ Defence Force land being increased from that previously presented to the Hearing Panel. The area of hill country Erosion Management Areas (EMAs) identified within DF land has increased by 77% (Table 1),

reflecting improved knowledge of the size of the training area around the Waiouru Army Base.

8. Accounting for the newly included areas, the area identified as erosion management areas in Defence Force (DF) land totals 1,702 ha, of which 1,242 ha (73%) are identified as protected and 460 ha (27%) are identified as not protected.

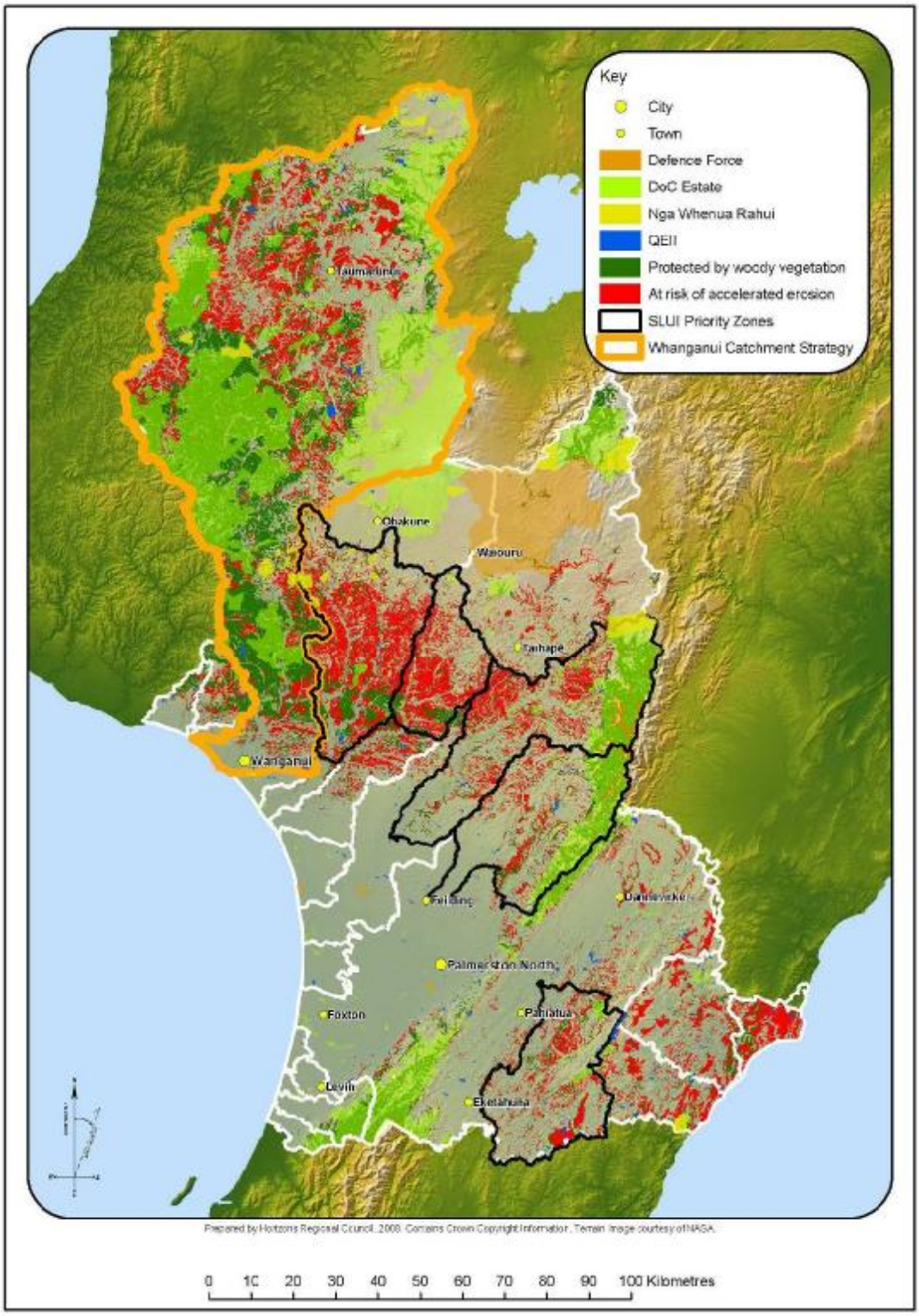
Table 1: Comparison of erosion management areas within the boundaries of Defence Force (DF) land from the previous analysis and following the inclusion of newly identified areas (see text for details).

	Protected	**Not protected**	**Total**
DF (previously identified) (ha)	635	329	964
DF (new totals) (ha)	1242	460	1702
Difference (ha)	607	131	738
Difference (% increase)	96%	40%	77%

9. The total areas of the DoC, QEII Trust, Nga Whenua Rahui, and Defence Force land that were excluded are shown in Table 2 and Map 1. In summary:
   i. A total 207,590 ha (31%) of the land identified as Erosion Management Areas (EMAs) by Dymond and Sheppard (2006) is removed by excluding the DoC, QEII, NWR and DF land that has been identified in the Region.
   ii. Of these 207,590 ha, 197,258 ha (95%) are identified as protected. Of the remaining 10,322 ha that are not protected, 9,250 ha (over 89%) are identified as being within DoC boundaries.
   iii. Removing DoC, QEII, NWR and DF land from the Dymond and Sheppard (2006) information removes 51% of the area Dymond and Sheppard (2006) identified as protected and 4% of the area Dymond and Sheppard (2006) identified as not protected
   iv. Removing DoC, QEII, NWR and DF land from the Dymond and Sheppard (2006) information provides a new map with 453,701 ha of EMA identified. Of this 190,643 (42%) are identified as protected, 263,068 (58%) are identified as not protected.

Table 2: Summary of the total area of EMA identified by Dymond and Sheppard, 2006 (D&S) and the amount of land removed from this analysis via Department of Conservation (DoC), QEII, Nga Whenua Rahui (NWR) and Defence Force (DF).

	Protected (ha)	Not Protected (ha)	Total (ha)	Protected (%)	Not Protected (%)
D&S (2006)	387,832	273,527	661,359	59%	41%
Converted D&S 2006 (converted to polygon format from raster format)	387,901	273,390	661,291	59%	41%
DoC	187,595	9,250	196,825	95%	5%
QEII	1,948	225	2,203	88%	12%
DF	1,242	460	1,702	73%	27%
NWR	6,473	387	6,860	94%	6%
Subtotal DoC + QEII+DF +NWR	197,258	10,322	207,590	95%	5%
New map (Dymond and Sheppard minus the subtotal for DoC + QEII+NWR +DF)	190,643	263,068	453,701	42%	58%
	Percentage of total (661,291 ha) converted D&S (2006)				
	Protected	Not protected	Total		
Subtotal DoC + QEII+DF +NWR	51%	4%	31%		
New map (Dymond and Sheppard minus the subtotal for DoC + QEII+NWR +DF)	49%	96%	69%		



Map 1: Areas identified as Department of Conservation (DoC Estate), QEII Trust, and Nga Whenua Rahui land and Defence Force land, overlaid over the area identified by Dymond and Sheppard (2006). The white lines on the map indicate major catchment boundaries

10. Point 24 of the Chairperson's Minute requests the illustrative map be based on Dr Dymond's modeling which is based on the slope thresholds outlined in Table 1 of the Dymond and Sheppard (2006) report. This table is reproduced below as Table 3. As the Dymond and Sheppard (2006) data includes slope thresholds that are less than 25 degrees the illustrative map only presents a proportion (or subset) of the originally identified Highly Erodible Land.

11. Further to this it is noted that the Dymond and Sheppard (2006) map does not include all land that is greater than 25 degrees. One reason for this is that two of the slope thresholds used by Dymond and Sheppard (2006) were greater than 25 degrees (Table 3). The second reason is that some areas with slopes ≥ 25 degrees may not have been identified as EMA.

Table 3: Land Use Capability (LUC) units comprising Highly Erodible Land in hill country modified from Dymond and Sheppard (2006). The modification is the notes re comparison with Page et al. (2005).

NZLRI region	**Taranaki–Manawatu**	**Southern Hawke's Bay–Wairarapa**	**Wellington**	
Terrain (and main erosion type)	**LUC units**			**Slope threshold (degrees)**
Mudstone hill country (landslide)	6e3, 6e4, 6e5, 6e7, 6e8, 6e21 7e1, 7e2, 7e7, 7e9, 7e20, 8e3	6e2, 6e3, 6e7, 6e8 7e1,7e2, 7e12		24
Mudstone hill country (earthflow)	6e19, 6e20 7e12, 7e14	6e10, 6e12 7e6, 7e7, 7e8, 7e9, 8e3		24
Consolidated sandstone hill country (landslide)	6e2, 6e3, 6e4, 6^{e}10, 6e12, 6e13, 6e14, 6e15, 6e17, 6e23 7e3, 7e4, 7e5, 7e11, 7e13, 7e17, 7e23, 8e3	6e9 7e4, 8e1, 8e2		28
Moderate to unconsolidated sandstone hill country (landslide, gully)	6e11, 6e13, 6e14 7e6, 7e16, 8e2			22[A]
Greywacke hill country (landslide, scree)	6e16 7e8, 7e10	6e11 7e10	6e6, 6e8, 6e10 7e1, 7e2	32[B]

[A] Identified as 26 degrees by Page et al. (2005).
[B] Identified as 28 degrees by Page et al. (2006).

12. We note that the slope thresholds from Page et al. (2005) and Dymond and Sheppard (2006) are intended to be the same. Therefore, different numbers in the Page et al. (2005) report appear to result from typing errors. The slopes in the Dymond and Sheppard (2006) report are correct (John Dymond pers. comm.). The slopes used in Dymond and Sheppard (2006) are also considered to be more appropriate by Horizons' Land Management Team (Grant Cooper[1], pers. comm., Environmental Manager – Land, Horizons Regional Council).

13. Beyond the exclusion of the areas of land identified in the points above (ie., DoC, QEII, NWR and DF), Point 24 of the Minute requests that the illustrative map identify areas of protected and not protected land with more than a 25 degrees slope. This required separating the result of the Dymond & Sheppard (2006) into groupings, where slopes

[1] Grant Cooper is the Horizons Manager responsible for implementation of the SLUI programme

were below 25 degrees and those that were ≥ 25 degrees, whilst maintaining the ability to identify protected and not protected land. To achieve this, it was determined that the best path was to start again from the Dymond and Sheppard (2006) original data and work through a new analysis method as shown below. While more efficient methods are theoretically possible, the experience of considerable GIS processing time trialing various methods resulted in the method described being adopted.

Original method

Dymond and Sheppard (2006) data (raster format, 15m^2 pixels)

↓

Convert to polygon format (polygon format)

↓

Separate into protected and not protected (polygon format)

↓

Remove DoC, DF and QEII land (polygons)

↓

Output from the new analysis is Table 2

New method

Dymond and Sheppard (2006) data (raster format, 15m^2 pixels)

↓

Compare to slope pixels from DEM (raster format, 20 m^2 pixels)

↓

Output (Table 4) is modified data separated into <25 degrees from ≥ 25 degrees (raster format, 20 m^2 pixels)

↓

Convert output to polygon format

↓

Remove DoC, DF and QEII land (polygon format)

↓

Convert the remainder to raster to enable separation of protected and not protected (Output is Table 5)

14. The results of the split of the Dymond and Sheppard (2006) data into < 25 degrees and ≥ 25 degrees are shown in Table 4 below. Processing of the data into the separate slope classes has introduced a small amount of error and therefore the total numbers of land area identified as highly erodible are slightly different from the Dymond and Sheppard (2006) report. In summary:
    i. Of the total 661,520 ha, 271,147 ha (41%) were identified as having a slope than ≥ 25 degrees.
    ii. Of the 387,941 ha of land identified as protected, 181,431 ha (47%) was identified as having a slope of ≥ 25 degrees.
    iii. Of the 273,579 ha of land identified as not protected, 89,716 ha (33%) was identified as having a slope of ≥ 25 degrees.

Table 4: Areas of highly erodible land identified by Dymond and Sheppard (D&S) (2006) that are < 25 degrees and ≥ 25 degrees split into protected and unprotected.

Processed D&S 2006 (Raster format data processed into slope classes)	**Protected (ha)**	**Not protected (ha)**	**Total (ha)**	**Protected (%)**	**Not Protected (%)**
D&S (2006)	387,832	273,527	661,359	59%	41%
Processed D&S 2006 raster format separated into slope classes	387,941	273,579	661,520		
< 25 degrees slope (ha)	206,510	183,863	390,373	53%	47%
≥ 25 degrees slope (ha)	181,431	89,716	271,147	67%	33%
Total (ha)	387,941	273,579	661,520	59%	41%
% < 25 degrees slope	53%	67%	59%		
% ≥ 25 degrees slope	47%	33%	41%		
	Percentage of total ha (661,520) identified in processed D&S (2006)				
	Protected	Not Protected	Total		
% < 25 degrees slope	31%	28%	59%		
% ≥ 25 degrees slope	27%	14%	41%		
Total	58%	42%	100%		

15. The results of the analysis of slope data show a significant proportion (390,373 ha, [59%]) of the land identified as EMA, has slopes of less than 25 degrees. To clarify why this is the case, John Dymond has provided the following explanation to Horizons '*The slope rules were applied on a pixel basis to all the 15m pixels in the digital elevation model, that is, all pixels over the defined slope threshold without woody vegetation cover were assigned to be HEL. When this is done many hill slopes have a 'salt and pepper' appearance of HEL and non-HEL land. It is difficult for land managers to manage land in such great detail. They tend to manage hill slopes as single entities. Hence, some generalisation of the salt and pepper HEL land is required on a hillslope basis. The generalisation performed was to identify units of land of 2 ha in area (on a given hillslope) and to assign the whole 2 ha unit to HEL if more than 25% of the pixels in the unit were HEL.*' (John Dymond, pers. comm).

16. To complete the requested illustrative map, the data that had been processed for slope analysis required the removal of the areas of DoC, QEII, Nga Whenua Rahui and Defence Force land. The results of this analysis are shown in Table 5 and Map 2.

17. The reprocessing of the data did introduce a further level of error, and also introduces some changes to the final numbers in each category as shown in Table 5. The relative errors in this process are larger than the previously discussed tables as the number of processes has increased. As an example, the total identified land when removing DoC, QEII, NWR and DF land is 10,715 ha, or 2.4% less than identified by the analysis presented in Table 2.

18. In summary, the results of this analysis are:
    i. The total area of land at risk of accelerated erosion identified by Dymond and Sheppard (2006) that remains after removing DoC, QEII, DF land totalled 442,986 ha.
    ii. Within this total, 158,726 ha (36%) of the areas are identified as having ≥ 25 degree slope.
    iii. These 158,726 ha are the land identified for inclusion in the illustrative map.
    iv. Of these 158,726 ha, 78,958 ha are identified as not protected.

    Comparing these totals to the original analysis for the region by Dymond and Sheppard (2006):
    i. The identified 158,726 ha equates to 23% of the originally identified area of land at risk of accelerated erosion.
    ii. The 78,958 ha equates to 28% of the originally identified land at risk of accelerated erosion that was not protected.

Table 5: EMA's identified by Dymond and Sheppard (2006) (D&S) excluding areas identified as DoC, QEII trust, NWR and DF land that are < 25 degrees and ≥ 25 degrees split into protected and not protected.

Processed D&S 2006 (Raster format data processed into slope classes)	**Protected (ha)**	**Not protected (ha)**	**Total (ha)**	**Protected (%)**	**Not Protected (%)**
Processed D&S 2006 (Raster format data processed into slope classes) (from Table 4)	387,941	273,579	661,520	59%	41%
New Map D&S minus the subtotal for DoC + QEII+NWR +DF)	190,643	263,068	453,701	42%	58%
Processed D&S 2006 (Raster format data, processed into slope classes, reformatted into polygon with DoC+QEII+NWR+DF removed, then data reconverted to raster)	188,668	254,318	442,986	43%	57%
< 25 degree slope (ha) (Map 2)	108,900	175,360	284,260	38%	62%
≥ 25 degree slope (ha)	79,768	78,958	158,726	50%	50%
Total (ha) (Map 3)	188,668	254,318	442,986	43%	57%
% < 25 degree slope	58%	69%	64%		
% ≥ 25 degree slope	42%	31%	36%		
	% of total ha (442,986) identified in processed D&S (2006)				
	Protected	Not Protected	Total		
% < 25 degree slope	25%	40%	64%		
% ≥ 25 degree slope	18%	18%	36%		
Total	43%	57%	100%		

19. For comparison purposes, Map 3 shows the Dymond and Sheppard (2006) land outside DoC, QEII, NWR and DF boundaries that is protected and not protected, including all slopes.

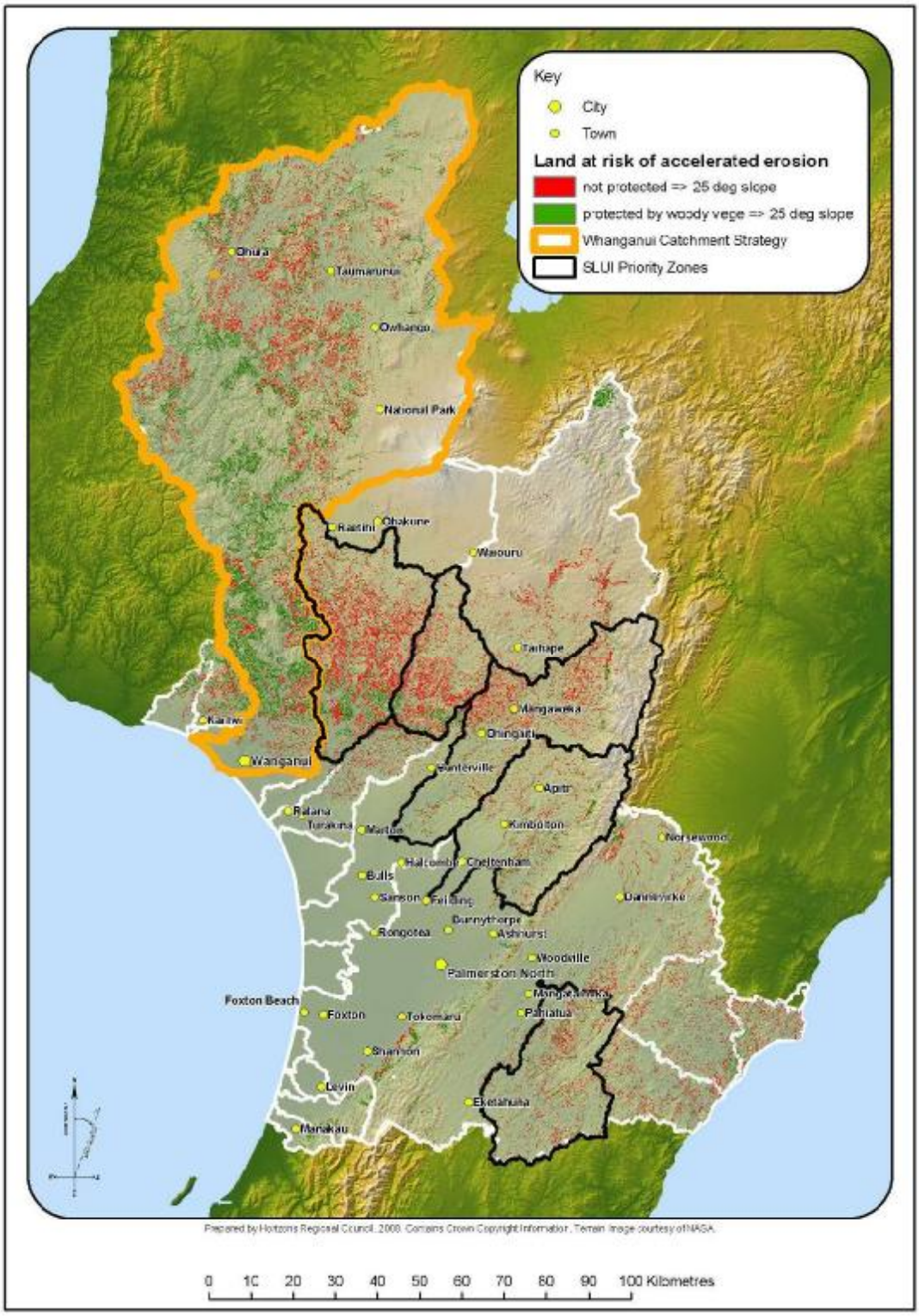
FURTHER INFORMATION ON THE COST AND FEASIBILITY OF LIDAR

20. In Point 23 of the Chairperson's Minute No. 3, the Hearing Panel requested further information on the cost and feasibility of undertaking further detailed mapping of at-risk areas using LiDAR surveying.

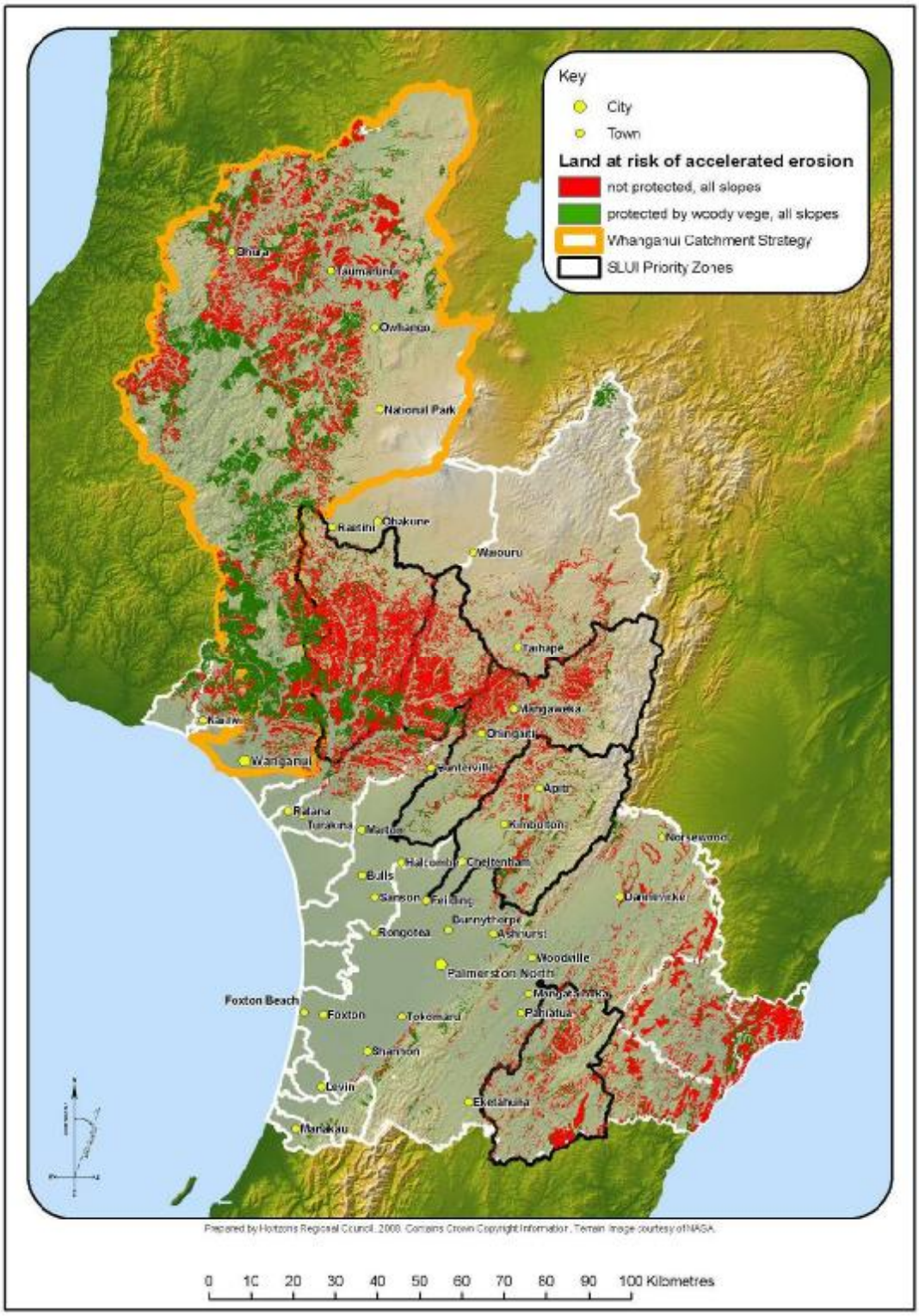
21. The information presented in relation to this has been prepared in consultation with Jeff Watson of Horizons Resource Data team. Mr Watson has managed and led the LiDAR mapping that has been done to date for Horizons. If the Hearing Panel would like to speak directly to him, this can be arranged.

22. To date Horizons has flown a total area of approximately 1020 km^2 of LiDAR data. The cost of this information is in the order of $700-900 per km^2. Horizons is aware that costs for future LiDAR flights in the future may be higher and have been conservatively estimated to be in the order of $1,000 or more per km^2.

23. Costs of obtaining data for the entire Region costs can be estimated as follows. Assuming the total area of the Region to be 22,297 km^2, the remaining total to be flown in LiDAR is (22,297 - 1,020) = 21,277 km^2. At a rate of $700 to $1,000 per m^2 this would equate to $14,893,900 to $21,277,000, although some cost savings may result from the large scale of such a data acquisition project.



Map 2: Illustrative map as requested by the Chairperson's Minute No. 3 for the RPS. Note the map includes land identified as HEL by Dymond and Sheppard (2006), excluding land in DoC estate, QEII covenant, Nga Whenua Rahui covenant and Defence Force land. Land where HEL was identified with slope is > 25 degrees is shown on the map as either protected or not protected.



Map 3: Areas with potential for accelerated erosion as identified by Dymond and Sheppard (2006), that are outside of the DoC estate, QEII covenant, NWR covenant and Defence Force land. This map includes land of all slopes identified by Dymond and Sheppard (2006) as having potential for accelerated erosion.

24. Costs of obtaining data for all "hill country" in the Region can be estimated as follows. Using Land Use Capability (LUC) Class 5 to Class 8 land as an indicator of hill country and assuming the total of area of Class 5 to Class 8 land is 16,551.51 km^2 (Class 5, 38.95 km^2, Class 6, 8242.00 km^2, Class 7, 6093.70 km^2, Class 8, 2176.86 km^2, at a cost of $700-$1,000 per km^2, this would cost in the order of $11,586,057 to $16,551,510. This identification of hill country probably under-estimates the area that would need to be flown as flight paths would not necessarily include only Class 5 to Class 8 land.

25. Costs associated with LiDAR go beyond the actual collection of the data. There are significant computing and labour costs associated with the handling and processing of this data. No attempt has been made to quantify these costs for the examples above, although initial estimates indicate the collection of a large LiDAR set for the Region would produce a dataset that would be close to the total amount of electronic information currently stored by the Horizons.

26. Horizons' LiDAR surveys to date have been flown specifically for flood plain mapping, to produce hydrologically correct models of the ground surface. ALS or airborne LiDAR survey has been undertaken by other organisations and some districts within this Region, to varying resolutions and specifications. LiDAR data collected for Horizons to date, has been flown to an accuracy of 1 m in the horizontal axis and 150 mm in the vertical axis. The resolution of the data is potentially at the 1 m^2 level. Technically, the data is not stored directly as a 1 m^2 grid as the data is stored in a way that reduces storage requirements. Basically, the system stores only the information that is necessary to describe the terrain.

27. It is anticipated that any reduction in cost resulting from LiDAR data acquisition at a resolution of 5 m^2 rather than 1 m^2 would be minimal. Some savings in data storage would occur if data was collected at a coarser resolution, although these potential cost savings are difficult to quantify. Collecting LiDAR data at a coarser resolution reduces its value for other purposes.

28. LiDAR can provide very detailed information about ground slope and vegetation cover. The collection of a large amount of LiDAR data on its own does not necessarily progress the knowledge of land in the Region that is at risk of accelerated erosion. Horizons has flown LiDAR in hill country and this provides a dataset (along with those from other regional councils) for the Crown Research Institutes to continue research on the use of this data, alongside other key parameters, for understanding hill country erosion processes. It is understood that Landcare Research are trialing some research in this area.

29. In summary, LiDAR information has the potential to refine slope information, which is one of the key datasets used in models that determine land at risk of accelerated erosion. It would of course provide a dataset that would be more prescriptive around slope.

30. It terms of erosion modelling, slope is only one of the parameters that is used in the models to determine land at risk of erosion, and any refinement in the models would have to deal with the resolution and accuracy of other key parameters, eg. geology and soil type.

FEEDBACK ON RPS MAPPING APPROACH

31. In Point 25 of the Chairperson's Minute, the Panel requests feedback from officers and submitters on the merits or otherwise of the approach outlined for the RPS. It is my view that a map derived based on the Dymond and Sheppard (2006) map is sufficient to illustrate where accelerated erosion may be an issue. The simplification of the map based on the 25 degree slope classes considerably reduces the amount of land identified by experienced erosion researchers (Page et al., 2005 and Dymond and Sheppard 2006) as having potential for accelerated erosion. If the purpose of the map being considered for the Regional Policy Statement is to be illustrative of areas with potential for accelerated erosion, a more technically correct option might be to consider a map similar to that presented in Map 1. Map 1 shows the full dataset of Erosion Management Areas identified by Dymond and Sheppard (2006) with the areas of DoC land, QEII covenants, Nga Whenua Rahui covenants and Defence Force land overlaid in a slightly transparent manner. I believe that this map is suitable for inclusion in the RPS. It identifies that Erosion Management Areas that occur within the various zones identified, eg. DoC, QEII, NWR and DF land, and provides the full context of the scale of the issue within the Region. It could further demonstrate that the management mechanisms within those areas make them different from other land uses. A similar approach could be taken with the Regional Plan maps.

LARGER SCALE MAPS FOR THE REGIONAL PLAN

32. Point 26 of the Chairperson's Minute discusses larger-scale maps as part of the Regional Plan. These maps have been produced as per the Minutes request, with the areas of DoC, QEII, and NWR excluded. As discussed in the sections above, the Defence Force land has also been excluded. The maps have been produced based on the advice of the Minute assuming "*where there is land that is subject to a risk of accelerated erosion as discussed in relation to the RPS map*". This implies the land identified as HEL by Dymond and Sheppard (2006) that has a slope threshold greater than 25 degrees is considered to be subject to risk of accelerated erosion. Due to the methodology used above, the map uses data that is ≥ 25 degrees. Where land with a slope of ≥ 25 degrees is located within a cadastral boundary, the area within the cadastral boundary has been shaded. The annotations included in the maps have been provided by the planning team. An example of the resultant map is appended to this report as Appendix 1. An overview map has also been provided to show how the 20 maps would cover the Region.

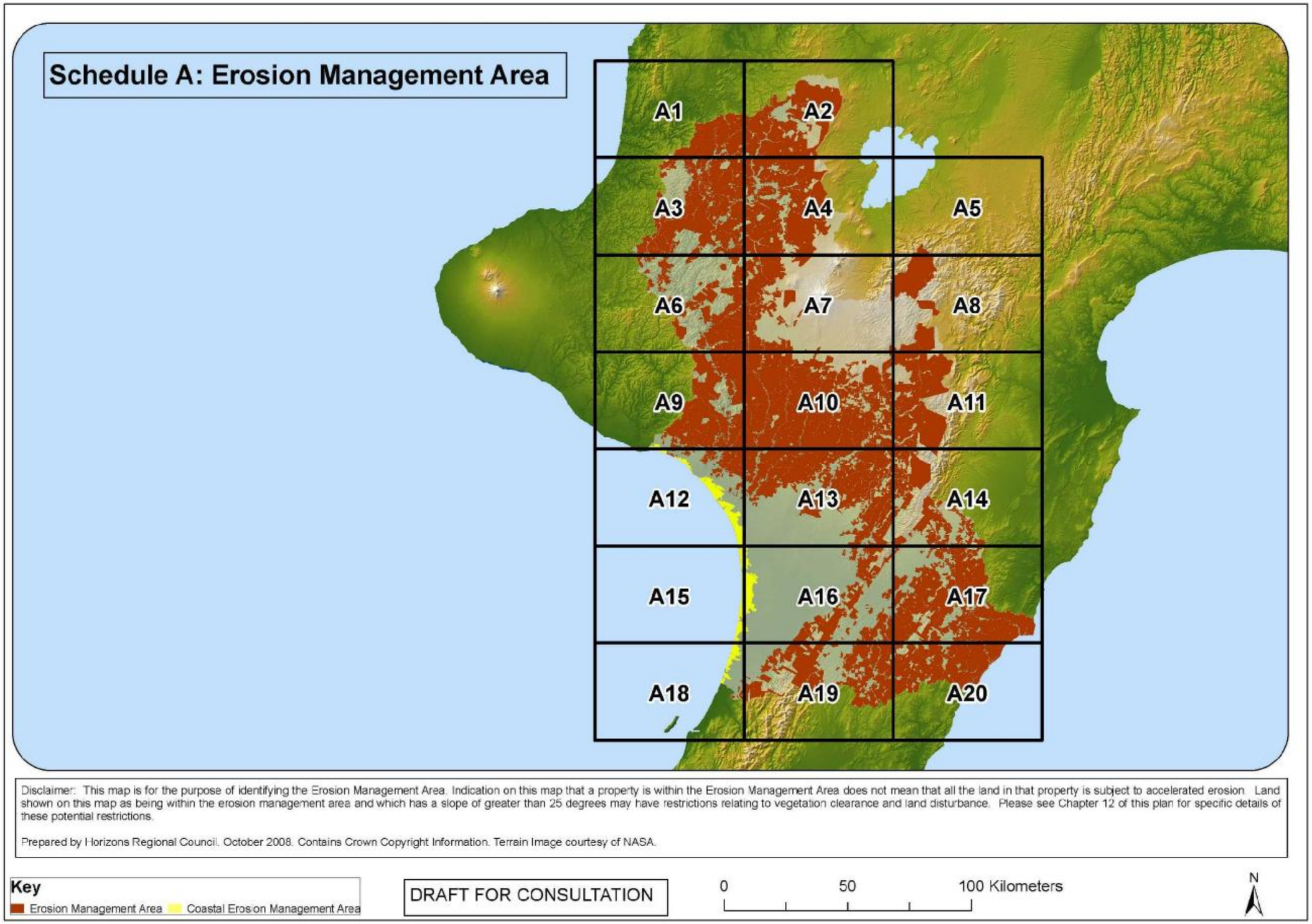
33. The analysis to produce the Regional Plan maps requested, identifies a total property area (Erosion Management Area) of 1,256,820 ha. If the same analysis is completed but all slopes identified by Dymond and Sheppard (2006) are included, then this area increases by less than 3%.

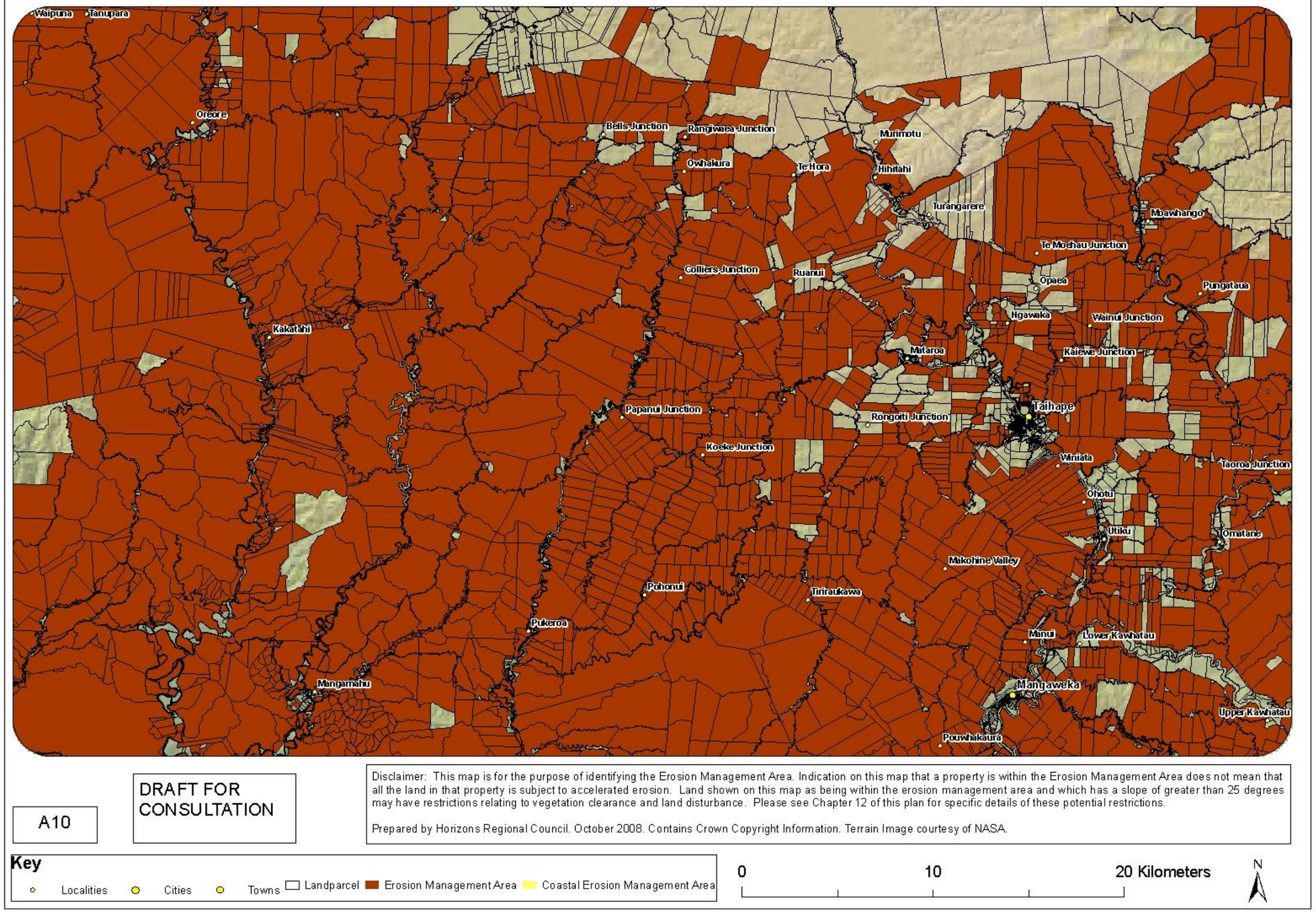
REFERENCES

Dymond J., and Shepherd J. 2006. Highly Erodible Land in the Manawatu-Wanganui Region, Landcare Research, Report No. 2006/EXT/749

Page M., Sheppard, J., Dymond J, and Jessen, M. 2005. Defining Highly Erodible Land for Horizons Regional Council. Landcare Research Contract report: LC0506/050.

Appendix 1: Example of the maps requested by the Minute for inclusion in the Regional Plan.




Waipuna
Tanupara
Oreore
Bells Junction
Rangiwaea Junction
Murimotu
Owhakura
Te Hora
Hihitahi
Turangarere
Moawhango
Te Mochau Junction
Colliers Junction
Ruanui
Opaea
Pungataua
Ngawaka
Wainui Junction
Kakatahi
Mataroa
Kaiewe Junction
Papanui Junction
Taihape
Rongotiti Junction
Koeke Junction
Winiata
Taoroa Junction
Ohotu
Utiku
Ormatane
Makohine Valley
Pohonui
Tiriraukawa
Pukeroa
Manui
Lower Kawhatau
Mangamahu
Mangaweka
Upper Kawhatau
Pouwhakaura
DRAFT FOR CONSULTATION
A10
Disclaimer: This map is for the purpose of identifying the Erosion Management Area. Indication on this map that a property is within the Erosion Management Area does not mean that all the land in that property is subject to accelerated erosion. Land shown on this map as being within the erosion management area and which has a slope of greater than 25 degrees may have restrictions relating to vegetation clearance and land disturbance. Please see Chapter 12 of this plan for specific details of these potential restrictions.
Prepared by Horizons Regional Council. October 2008. Contains Crown Copyright Information. Terrain Image courtesy of NASA.
Key
Localities
Cities
Towns
Landparcel
Erosion Management Area
Coastal Erosion Management Area
0
10
20 Kilometers
N