BEFORE THE HEARINGS PANEL

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

SECTION 42A REPORT OF MS MAREE ELLEN CLARK
ON BEHALF OF HORIZONS REGIONAL COUNCIL

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1. INTRODUCTION

My qualifications/experience

1. My full name is Maree Ellen Clark. I have a Postgraduate Diploma in Arts (Geographic Information Systems) from Massey University, Palmerston North, and a Bachelor of Science Degree (Geography) from the University of Canterbury, Christchurch. I am currently enrolled as a Masterate Candidate in Applied Science majoring in Natural Resource Management. My research is on the impact of major discharges to the Manawatu River Catchment. I have been a member of the New Zealand Freshwater Sciences Society (formerly the NZ Limnological Society) since 2007.

2. I have been employed by Horizons since May 2004 in the roles of Research Assistant, Research Associate and Environmental Scientist – Water. As part of these roles my duties have ranged from analysing data using ArcMap (GIS[6] software) and processing water quality data through to contributing to the development of the Water Management Zones (WMZs) Framework, Values and Water Quality Standards Framework, and the State of the Environment (SoE) programme design and reporting.

3. Since July 2007, I have held the role of Environmental Scientist - Water within the Regional Planning and Regulatory Group of Horizons. As Environmental Scientist - Water my role includes initiating, scoping, project managing and contributing to many projects relating to water quality and land use interactions with water quality. I have authored and co-authored a range of scientific reports, including water resource assessments and water quality investigations, specifically with Ms Kate McArthur and Dr Jon Roygard. I co-authored the Upper Manawatu, an analysis at low flows technical report, and the Mangapapa baseline monitoring technical report. With Dr Roygard I co-authored the Land Use and Land Use Capability in the Manawatu-Wanganui Region technical report. In relation to the subject at hand, I am the primary "GIS expert" within the team, although it is noted that much of this work is contracted out to experts external to Horizons and the work is done in close collaboration with other Horizons' staff who also have skills in this area. I co-authored with Ms McArthur an analysis of nutrient loads at low flows and, with Ms McArthur and Dr Roygard, I had input into the design of the Discharge Monitoring programme, analysis of the discharge monitoring data, and the design of the Water Quality Website.

4. I have been involved in the Proposed One Plan (POP) since its very early stages. My role has involved scientific advice, GIS analysis and co-authorship of technical reports to provide input into the POP development. I co-authored, with Ms McArthur, Dr Roygard

and Dr Olivier Ausseil the WMZs technical report and delineated the boundaries for the WMZs and Water Management Sub-zones (WMSz) in the Region; I co-authored, with Dr Ausseil, the technical reports for water body values, water quality standards and river classification. With Ms McArthur and Joeseph McGehan, I co-authored the Sites of Significance for Aquatic Biodiversity. All of these are reports that fed directly into the POP.

5. I have read the Environment Court's practice note Expert Witnesses – Code of Conduct and agree to comply with it. It is my intent that the duty to the Environment Court contained in the Code of Conduct be treated as duty to the Hearing Panel for the purposes of this hearing.

Scope of evidence

6. The scope of my evidence includes introducing the concepts underlying the water management framework for the POP, in particular the definition of management units that underpin the framework and the spatial delineation of those management units, the spatial delineation of waterbody values that provide the next tier in the water management framework for the Proposed Plan and how this framework fits into Schedule D in the Proposed Plan.

7. With regard to the management units in the Proposed One Plan I will describe the use of management units in the Region that were considered in the development of the WMZ and WMSz framework, and describe how the boundaries of the Zones and Sub-zones in the POP were determined; the process I undertook to spatially represent the boundaries of the zones; issues with the dataset that was used to create the WMZ and Sub-zones; and how these zones are utilised as a management tool throughout the POP. My evidence also includes an explanation of the naming conventions for the WMZs and Sub-zones.

8. With Regard to Schedule H of the POP and the definition of Coastal Management Zones, this evidence will cover the spatial representation of these zones and the naming conventions for the coastal WMZs.

9. With regard to water body values, the scope of my evidence is to provide a description of the tools and processes used to spatially represent the values in Schedule D and Schedule H of the POP. However, it is outside the scope of my evidence to provide

information on why and where the values are located. The reasoning for the selection of values and their location lies in the evidence of Ms McArthur.

10. With regard to Schedule D of the POP, I put together the tables and maps, along with Ms McArthur, James Lambie and Dr Olivier Ausseil. I have also undertaken a large number of Schedule D assessments since the notification of the POP. I have been involved with Bettina Anderson, Helen Marr and Ms McArthur in trying to make Schedule D more user friendly and I will describe how the water management framework fits within Schedule D of the POP, and discuss proposed changes to Schedule D in order to make it more user friendly and better provide for the integrated water management framework envisaged for the POP.

11. With regard to the spatial referencing of WMZs, sub-zones and values in New Zealand Map Series 260 references, I will discuss the national move to the New Zealand Transverse Mercator projection and how Horizons will deal with this change through the POP.

12. With regard to point source discharges, I will outline the discharge monitoring programme and my involvement in the analysis of the results from this monitoring programme.

2. EXECUTIVE SUMMARY OF EVIDENCE

13. Water Management Zones (WMZs) are the underpinning geographical component of the integrated water management framework in the POP. The approach utilised in the POP recognises the need to manage water bodies within the Region for the different environmental, social and economic values they hold.

14. The delineation of WMZs and Sub-zones for the Region was undertaken in a robust and repeatable manner utilising a nationally recognised tool – the River Environment Classification (REC)(Paragraphs 36-49 and figures Figure 1-6). Although there were limitations associated with the REC dataset (Paragraphs 51-55), these were minor and were overridden by the textual description of each of the WMZs and Sub-zones in the POP.

15. Subsequent to notification of the POP, staff recognised that all activities occurring in the Coastal Marine Area (CMA) needed to be in the Coastal Chapter of the Regional Plan and therefore should not be contained within Schedule D. Within the CMA, Estuary Water Management Zones were defined (Paragraphs 74-77). All values, standards and

reference to water bodies within the CMA were removed from Schedule D of the POP and added to Schedule H of the Track Changes version of the POP.

16. WMZs and WMSzs provide the fundamental building blocks for integrating across all management issues, in order to provide the best environmental outcome for a particular area. Paragraphs 62-71 present the uses of WMZs and Sub-zones in the POP.

17. Recommended changes to WMZs, WMSzs and Groundwater Management Zones (GWMZs) for inclusion in the POP:

- The Coastal Marine Area (CMA) has been separated from the surface WMZs and WMSzs in accordance with the preliminary decision on the Coastal Chapter. The definitions of these Sub-zones will lie in Schedule H and be removed from Schedule D. For further clarification on this see the Section 42A report provided by Ms McArthur. The description of the WMZ and Sub-zones will be amended in Table D2 to reflect these changes.
- The Estuary Water Management Zone for the Ohau River is changed from the Zone shown on Map 12 to extend down to the true river mouth in alignment with all of the other Estuary Water Management Zones.
- The Mangaramarama WMSz is moved from the Mangatainoka WMZ into the Tiraumea WMZ, as presented in Paragraph 82.
- The new Sub-zones that have been created in the Makara, Manganui o te Ao and Waikawa to better align with the revised Water Allocation Framework and National Water Conservation Orders are included in the overall water framework (Paragraphs 83-86).
- The changes to descriptions of WMZs and Sub-zones to reflect the removal of the CMA from Schedule D are undertaken as described in Table 12 of this evidence.
- The additional GWMZs proposed for the Upper Whanganui, Upper Rangitikei and East Coast are included in the GWMZ framework. It is proposed that the existing Eastern GWMZ is renamed to Tararua GWMZ. These changes are shown in Map 17.
- The use of the term Water Management Zone is replaced by Water Management Sub-zone throughout the POP (Paragraph 59).

18. Water body values hang off the Surface WMZs and Sub-zones in the Water Management Framework of the POP as the second level, to recognise the environmental, social, cultural and economic values of each area. Reach-specific and Life Supporting Capacity values have been spatially defined using the same dataset as the WMZs and WMSzs to specified criteria (Paragraphs 95-140).

19. Schedule D of the POP identifies Water Body Values and proposed Water Quality Standards in order to give protection to those values.

20. When staff within Horizons began to use Schedule D, it became apparent that it was difficult to move around, and understand the connection between Schedule D and other sections of the POP. Bettina Anderson (Pukeko Blue) was contracted to help revise Schedule D in order to make it easier to use.

21. Recommendations for Schedule D:

- Because WMZs and Sub-zones and Values are the underpinning framework for water management in the POP, it is recommended that the Surface and Ground water Management Zones, sub-zones and Surface Water Values are removed from Schedule C and Schedule D and placed in a new Schedule in front of Schedule B (Paragraph 145). The altered Schedule is presented as 'Schedule Ba' in the Track Changes version of the POP.
- I recommend that all other changes to Schedule D in the Track Changes version of the POP be adopted as outlined in Table 13 of this S42A Report.

22. Recommendations for Schedule Ba:

- I recommend that all changes to Schedule Ba in the Track Changes version of the POP be adopted. These changes are outlined in Table 12 of this S42A Report.

23. The current scale of the WMZ, WMSz and values maps make it difficult to identify exactly which WMSz an activity is occurring in and what values apply there. There are two options for remedying the issue of scale for using a paper copy of the POP:

a. Including in Schedule Ba a series of 20 1:150,000 scale maps covering the Region for each of the values and one A3 map for each WMZ.
b. Providing an electronic copy of the Schedule that includes all layers[2] in the Schedule and identifying layers[2] such as roads, towns, cities and land parcels.

24. Creating a series of 20 maps for each of the values at 1:150,000 would add an extra 240 maps to the POP as well as 44 additional maps for the larger scale WMZ maps. In my opinion, larger scale paper maps would not make it any easier to find out if a Value applies as it would be difficult to navigate through the maps to find the page required for each Value.

25. An electronic copy of the Schedule with the values and WMZs and Sub-zones pre-loaded can be created, enabling users to zoom into any given location and switch values

on or off to see if they apply in the vicinity of the proposed activity. This method of viewing the values will reflect the way Horizons carries out values assessments currently.

26. Users of an electronic schedule will be able to zoom into their specific area of interest and use an information tool to query what values will apply to the area in which they wish to undertake an activity. This is a very user friendly technology and is easily implemented. User notes would be provided to assist those less familiar with mapping programmes. In my opinion an electronic version of the schedule would be the best option to ensure non-specialists can use it successfully.

27. As of September 2009, all New Zealand Map Series (NZMS) 260 topographic maps will replaced by a new "Topo 50" map series in the New Zealand Transverse Mercator (NZTM) projection[1]. The new topographic maps, as well as having a different co-ordinate system, will be A1 portrait sheets instead of the landscape sheets of the NZMS 260 maps. Horizons will begin changing the organisational fundamental data layers[2] into the NZTM projection in September 2009 to align internal electronic datasets with national systems. It will take longer for paper maps to be changed for all users.

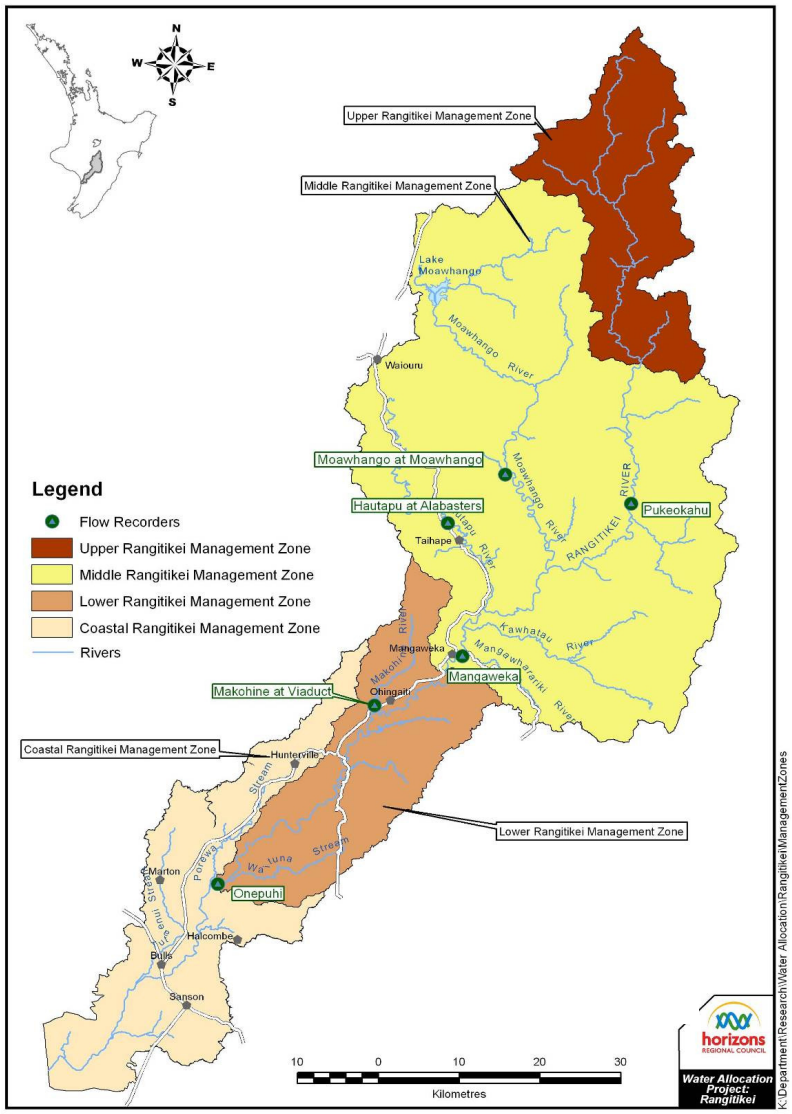
28. As a result of this, the NZMS 260 Map references will become redundant over time and this may have implications for the map references used throughout the POP. Due to the manual nature of changing the coordinates in Schedule Ba, there has not yet been any move to change the references from NZMS to NZTM, although it can be done if required. Internally Horizons can easily convert maps and work with both projections, however, non-specialists do not have this ability. It should be noted that the Land Information New Zealand website provides a coordinate conversion tool that can convert coordinates and map references between NZMS 260 and NZTM. However, this is still a manual process allowing five coordinates to be manually entered at a time to the website, which are then translated to a coordinate in NZTM and then need to be further calculated into a map reference.

[1] A projected co-ordinate system is any system designed for a flat surface such as a printed map or a computer screen because the earth is spherical a projection is required to transform the spherical data to fit the purpose of the display.

3. EVIDENCE

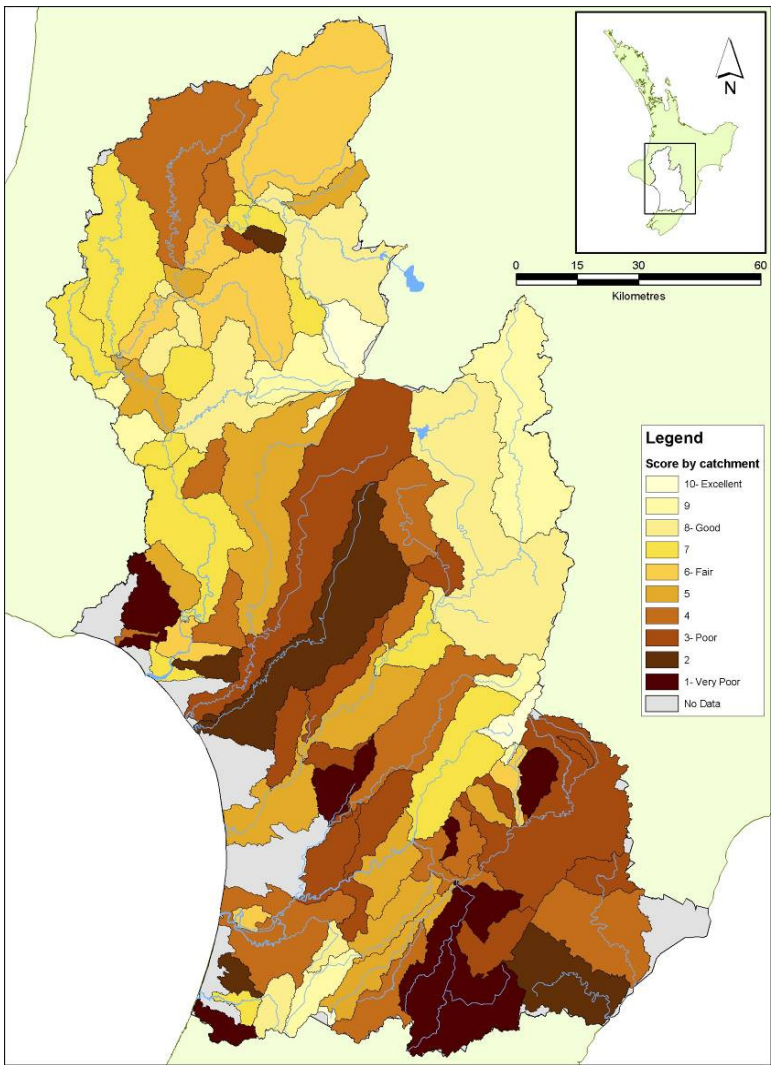
29. WMZs are the underpinning geographical component of the integrated water management framework in the POP. The approach taken in the POP recognises the need to manage water bodies within the Region for the different environmental, social, and economic values they hold.

30. The concept of WMZs as a resource management unit in the Region was first presented by Horizons in December 2004 through the Rangitikei River Water Allocation Project (Roygard and Carlyon, 2004; Chapter 3.2.1). This project divided the Rangitikei Catchment into four management units based on differences in geology, climate, hydrology, and the Rangitikei River National Water Conservation Order (Map 1).



Map 1. Rangitikei Catchment Management Zones developed in 2004, as presented in Roygard and Carlyon (2004) page 126.

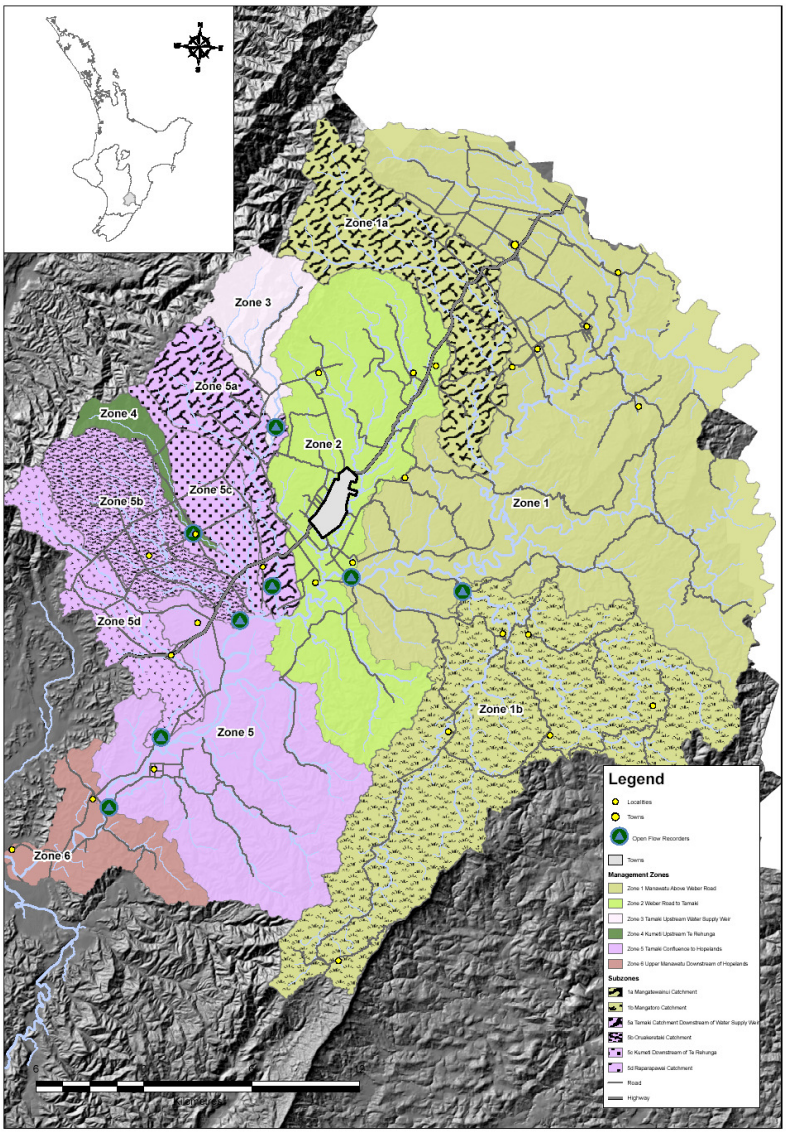
31. It was evident that the concept of Management Zones was a practical method to spatially divide catchments into units for targeted management. This concept was further developed in 2005, when WMZs and Sub-zones were utilised for the presentation of water quality results in Horizons' State of the Environment Report (Map 2). However, at this stage the units were not utilised for management purposes and they and differ from the Management Zones described by Roygard and Carlyon (2004).



Map 2. Contact Recreation Score by Catchment. An example of the use of WMZs and Sub-zones in the 2005 State of the Environment Report. (Source: Horizons, 2005, Chapter 4).

32. The concept of having larger Management Zones and sectioning those zones into smaller management units (Sub-zones) was first applied in the Upper Manawatu Water Allocation Project (Roygard *et al.*, 2006; Chapter 4.8) whereby the Upper Manawatu

catchment (defined as the Manawatu catchment upstream of the Tiraumea confluence) was split into six WMZs with a further six Sub-zones identified (Map 3). The boundaries of the Zones and Sub-zones were developed based on currently operating long-term flow recorders, in order to manage allocations in each of the Zones and Sub-zones.



Map 3. Water Management Zones and Sub-zones in the Upper Manawatu Catchment as presented in Roygard *et al*. (2006); page 238.

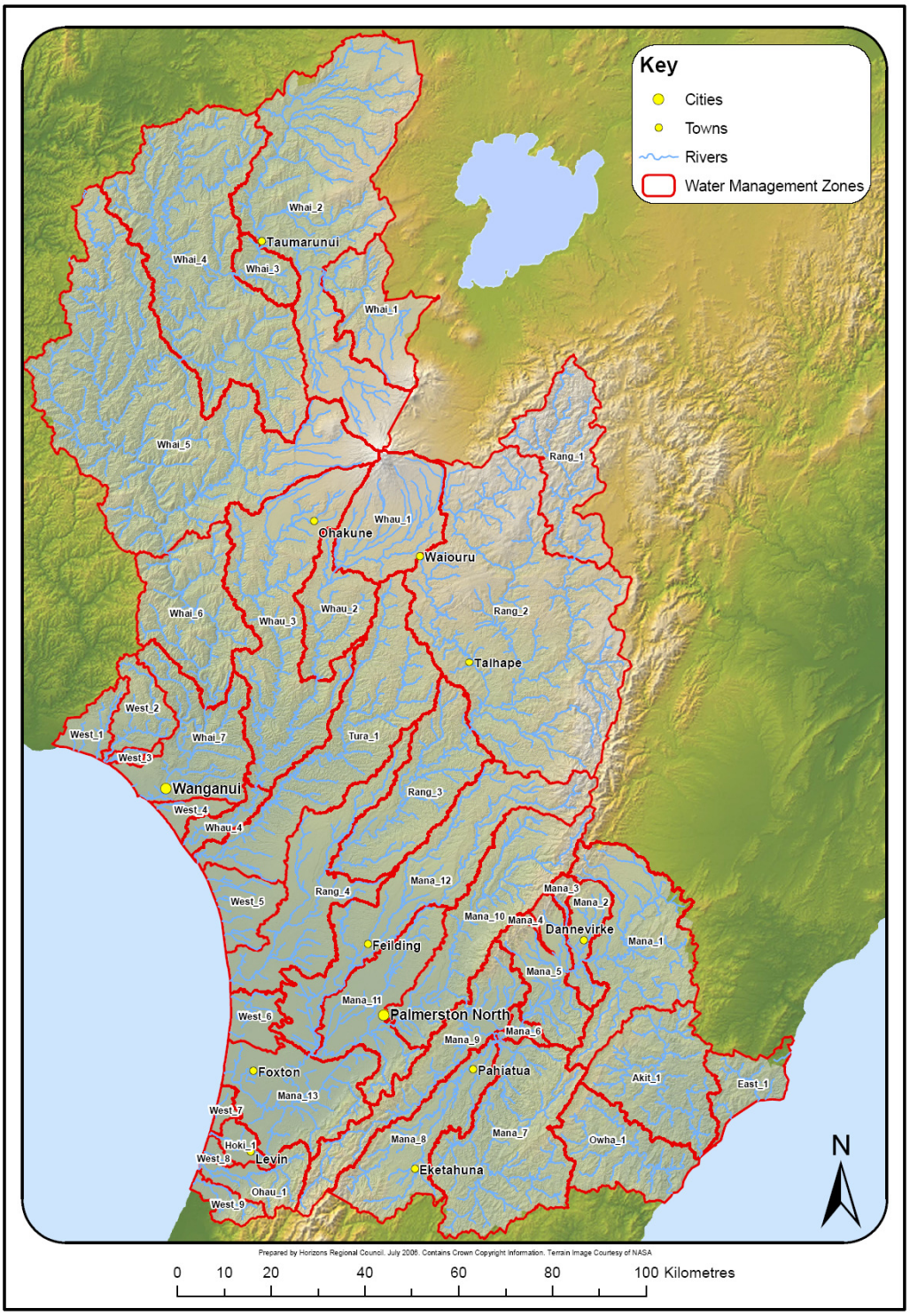
33. Further development of the WMZ and Sub-zone framework continued in 2006 to provide the underpinning management units for the POP.

34. As identified in Chapter Two of McArthur *et al*. (2007), the main variables for the determination of WMZ and Sub-zone boundaries are presented in Table 1. The overriding factors in determining WMZ and Sub-zone size were the existing management requirements of National Water Conservation Orders and Local Water Conservation Notices and the existence of pre-defined management units in the existing Water Resource Assessments (paragraphs 30 and 32). Physical variables, pressure and data availability were the other factors influencing the determination of size and location, the most important of which was following natural watershed boundaries.

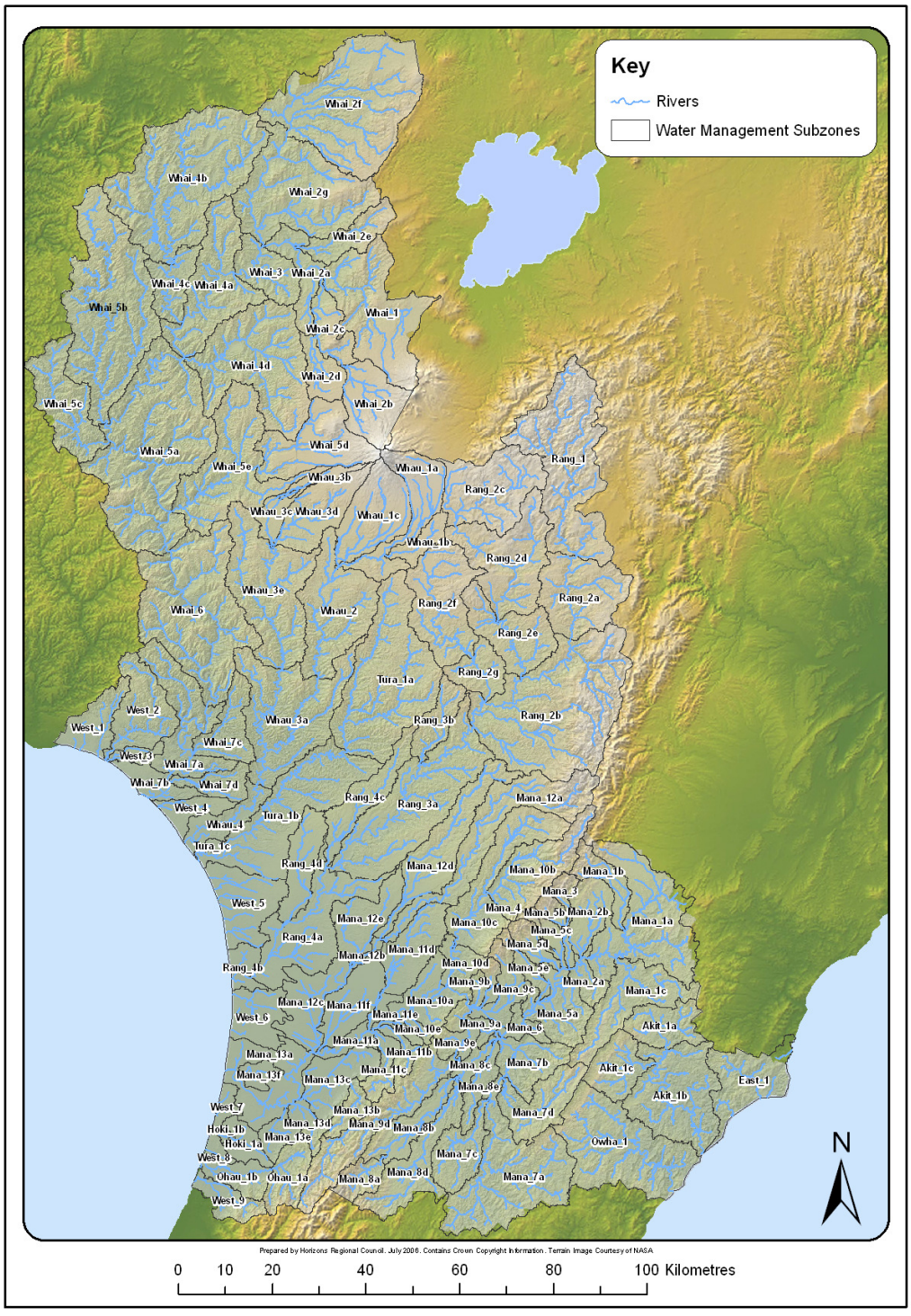
Table 1. Variables considered in the determination of Water Management Zone and Sub-zone boundaries

Management Variables	Physical Variables	Pressure/use	Data
• Existing management requirements such as National and Local Water Conservation Orders and Notices; • Existing Management Zone definitions from the water allocation projects in the Rangitikei (Roygard & Carlyon, 2004; Chapter 3.2.1), and Upper Manawatu (Roygard *et al.*, 2006; Chapter 4.8 Rivers)	• Identifying the natural watershed/catchment boundaries • Known hydrological peculiarities such as groundwater exchange or recharge • The underlying geology • Land use homogeneity • Major changes in instream habitat or aquatic ecosystem structure • Tidal influences	• The presence of major and/or multiple discharges • The intensity of pressure on the water resource • Catchment land use type and intensity • Major water abstractions • The potential for future increases in resource pressure (ie. conversion of forestry to pasture)	• The availability of the monitoring data (ie. periodicity and record duration) • The location and permanence of flow sites (ie. long or short term) and whether the sites were currently in operation • The ability to obtain flow data for water quality sites where data is not currently available (ie. by way of modelled flow)

35. This resulted in the delineation of 43 WMZs (Map 4) and 117 Sub-zones (Map 5).



Map 4. Water Management Zones Horizons' Region (source McArthur *et al.*, 2007).



Map 5. Water Management Sub-zones in Horizons' Region (Source McArthur *et al.*, 2007*).*

Selecting an appropriate Geographic Information System tool for waterbody classification and digitising Water Management Zones and Sub-zones

36. Ausseil and Clark (2007a) Chapter 2.1 (Potential River Classification Tools) provides context as to the tools available for environmental classification of water bodies. The three potential classification tools were:

- The River Environment Classification (REC).
- Land Environments of New Zealand (LENZ).
- Freshwater Environments of New Zealand (FWENZ).

37. The REC developed by the National Institute for Water and Atmospheric Research (NIWA) for the Ministry for the Environment (MfE) was utilised in the development on WMZs and Sub-zones.

38. The REC was considered the most appropriate tool currently available for the water framework in the POP, as LENZ was focused primarily as a classification for terrestrial ecosystems and FWENZ was still very much a research tool and was not released for public use until 2008. The REC was also the only tool available that provided natural watersheds for easy delineation of catchment boundaries.

39. The REC is recognised by the MfE as the "only classification used for national environmental reporting on the state of freshwater in New Zealand" (MfE website, accessed 12 June 2009, Snelder *et al.,* 2004). The development of the REC was supported by the MfE, Regional Councils and other research institutes (Snelder *et al.,* 2004)

40. The REC groups river systems based on environmental factors that influence the rivers' physical and ecological characteristics, expressed as information layers[2] (Table 2), as outlined in Ausseil and Clark (2007a) and Snelder *et al* (2004).

[2] A layer is a display file of objects in geographic space

Table 2. The River Environment Classification (REC) information layers[2] (environmental factors), number of categories per layer[2], and examples of categories relevant to Horizons' Region (Source Ausseil and Clark, 2007a; Chapter 2.1).

Layer[2]	Categories per layer[2]	
	Number	Examples (relevant to the Region)
Climate	6	• Warm-Wet • Warm-Dry • Cool-Extremely Wet • Cool-Wet
Source of Flow	8	• Mountain • Hill • Low Elevation • Lake
Geology	7	• Alluvium • Hard Sedimentary • Soft Sedimentary • Volcanic Acidic
Land Cover	9	• Indigenous Forest • Scrub • Exotic Forest • Pastoral • Tussock
Network Position	3	• Low Order • Middle Order • High Order
Valley Landform	3	• Low Gradient • Medium Gradient • High Gradient

41. The REC represents rivers as a network of sections of the upstream catchment (Snelder *et al.,* 2004) and is created from a 15 m grid cell[3] Digital Terrain Model[4].

42. The database provided with the REC includes river lines, network/hydro junctions (the point where two river lines intersect) and watersheds (a polygon[5] area of the surrounding landscape between two river sections that contributes water to that particular reach). Map 6 provides an example of what a user would see when adding the REC to a Geographic Information System[6].

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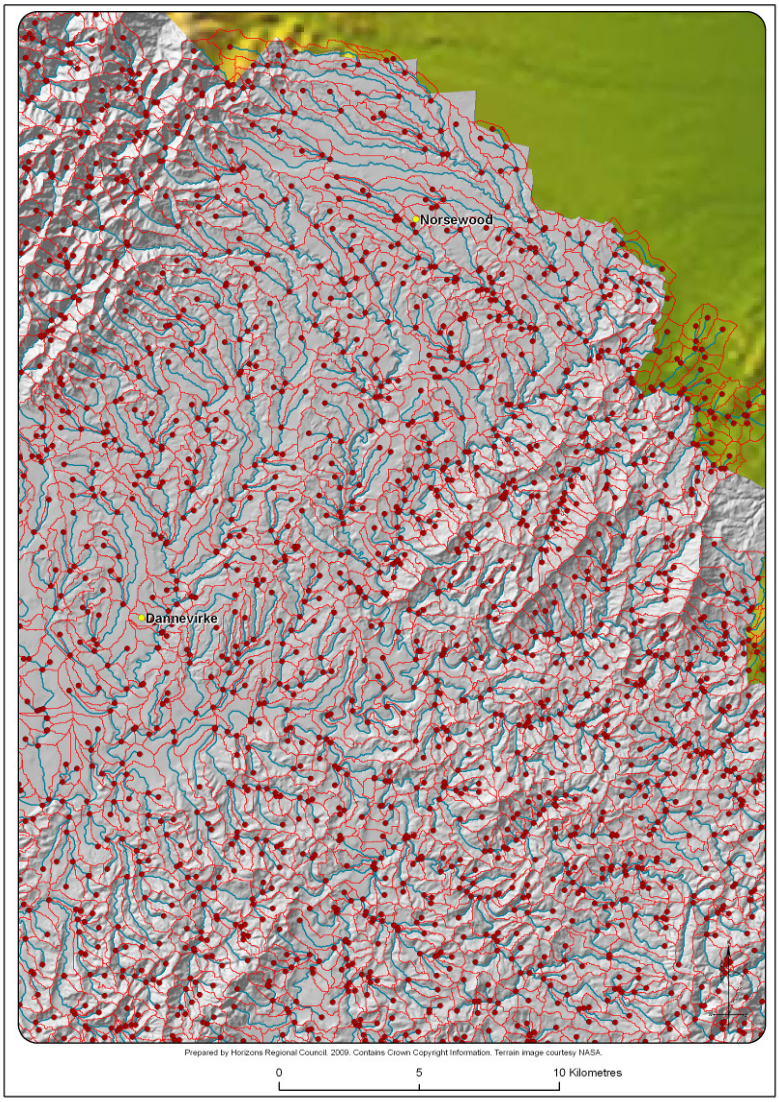
[3] A 15m grid cell refers to the area each pixel of a map, in this case each pixel would be 15mx15m
[4] Also known as a Digital Elevation Model is represented as a grid of squares (Raster) and is a digital representation of the ground surface in terms of topography and relief.
[5] A shape that is bound by a closed circuit often used to represent an area in GIS.
[6] Captures, Stores, analyses, manages and presents data linked to location.



Map 6. Information in the River Environment Classification (REC). NB: this is a sub-section of the REC. Water bodies are shown in blue, hydro junctions (where two water bodies join) are indicated by brown/red dots and water sheds are indicated by red polygons.

Defining Water Management Zones in GIS[6]

Surface Water Management Zones

43. In order to spatially delimit Management Zones and Sub-zones, the Utility Network analyst tool in ArcMap 9 (GIS[6] mapping software) was used. This was a five-step process.

44. Step One: a flag was placed at the defining point of the proposed Management Zone at a junction or in the middle of the reach (Figure 1). When there were other catchments upstream that I did not want to select, I went through the same process of selecting a flag but also added a barrier on the upstream side of the flag so the waterbodies that I did not want to capture were excluded.

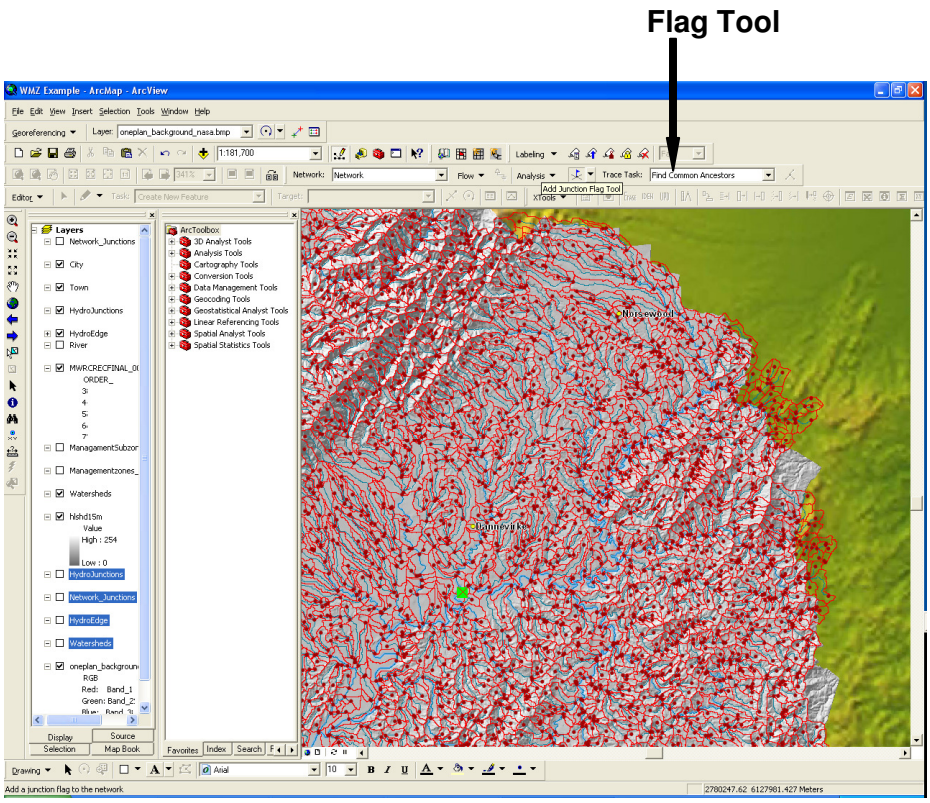


Figure 1. Placement of a flag on the appropriate network junction. The flag is depicted by the green square on the junction of the two Water Management Sub-zones

45. Step Two: The Trace Upstream option was selected on the Utility Network Analysis toolbar (Figure 2).

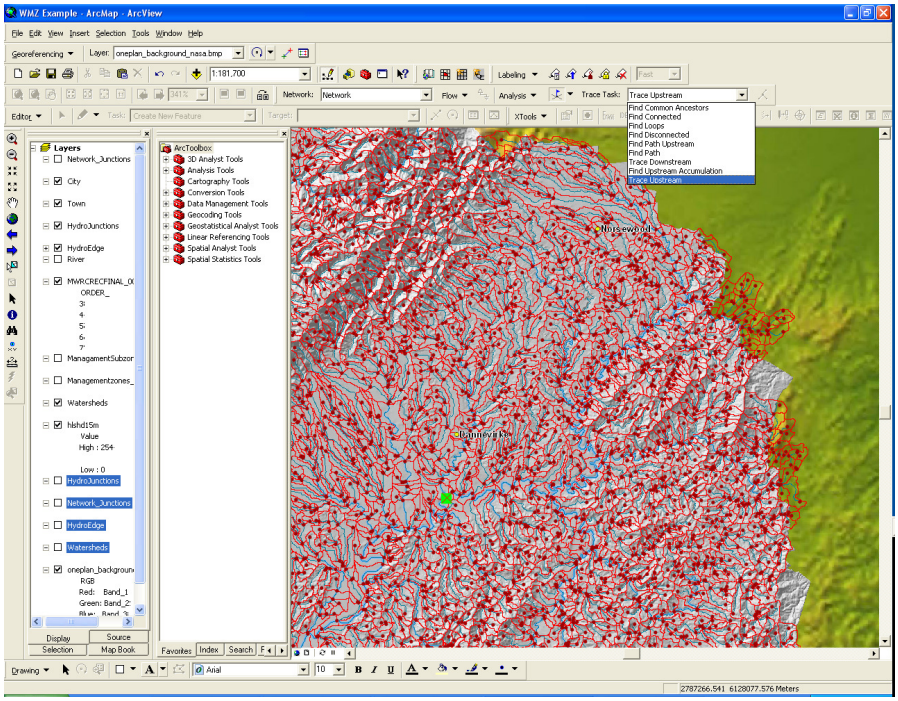


Figure 2. Selection of the Trace Upstream option

46. Step Three: The Trace button was pressed and all of the reaches upstream of that point were highlighted in bright green (Figure 3).

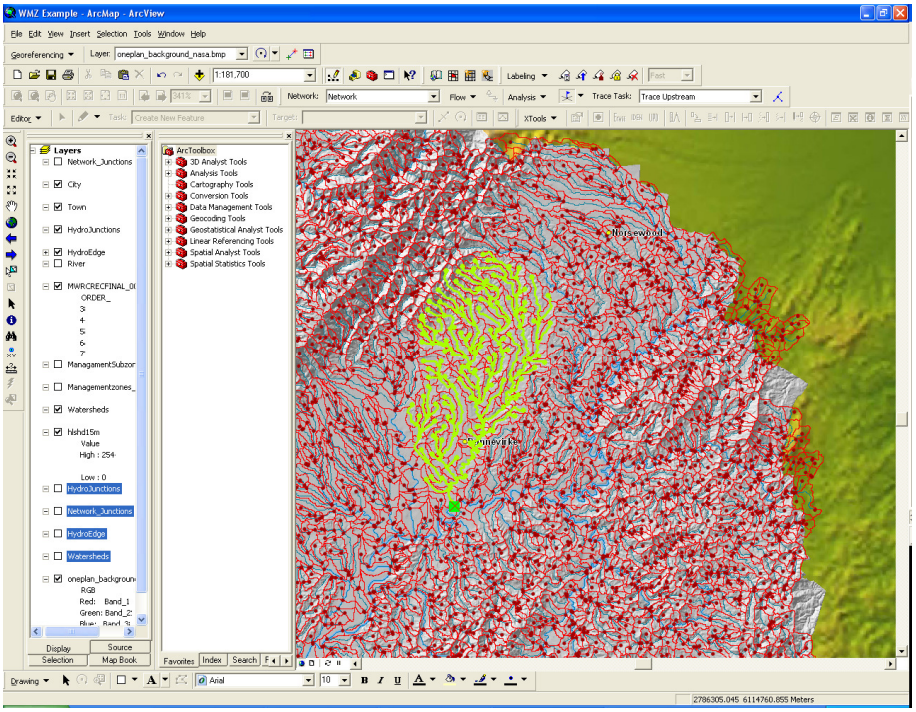


Figure 3. The reaches upstream of that point highlighted in bright green.

47. Step Four: The select tool was then utilised to select watersheds where the River line was highlighted in bright green.

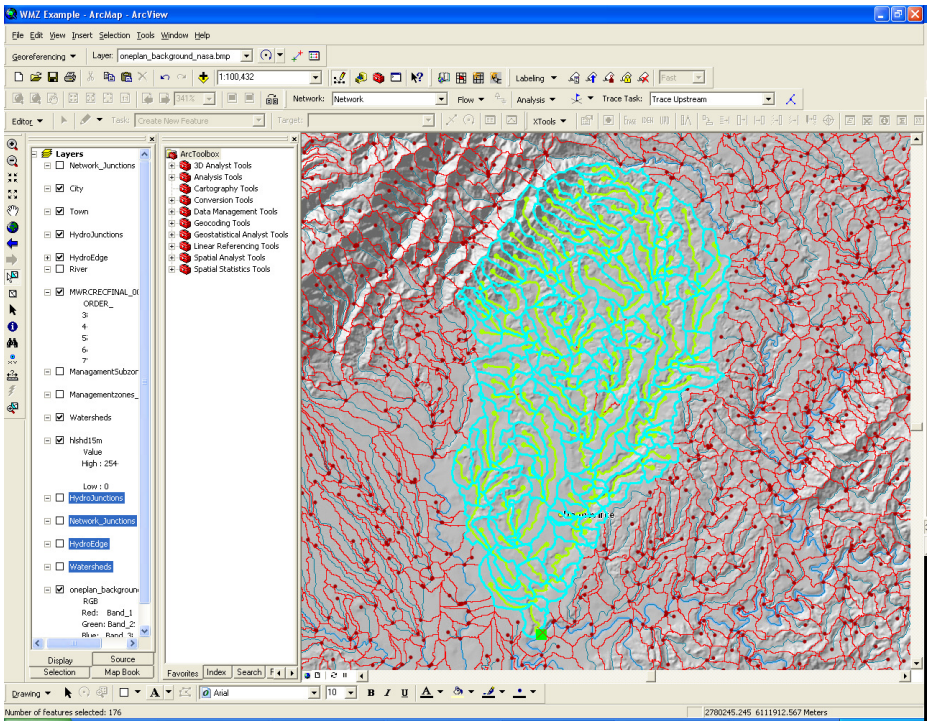
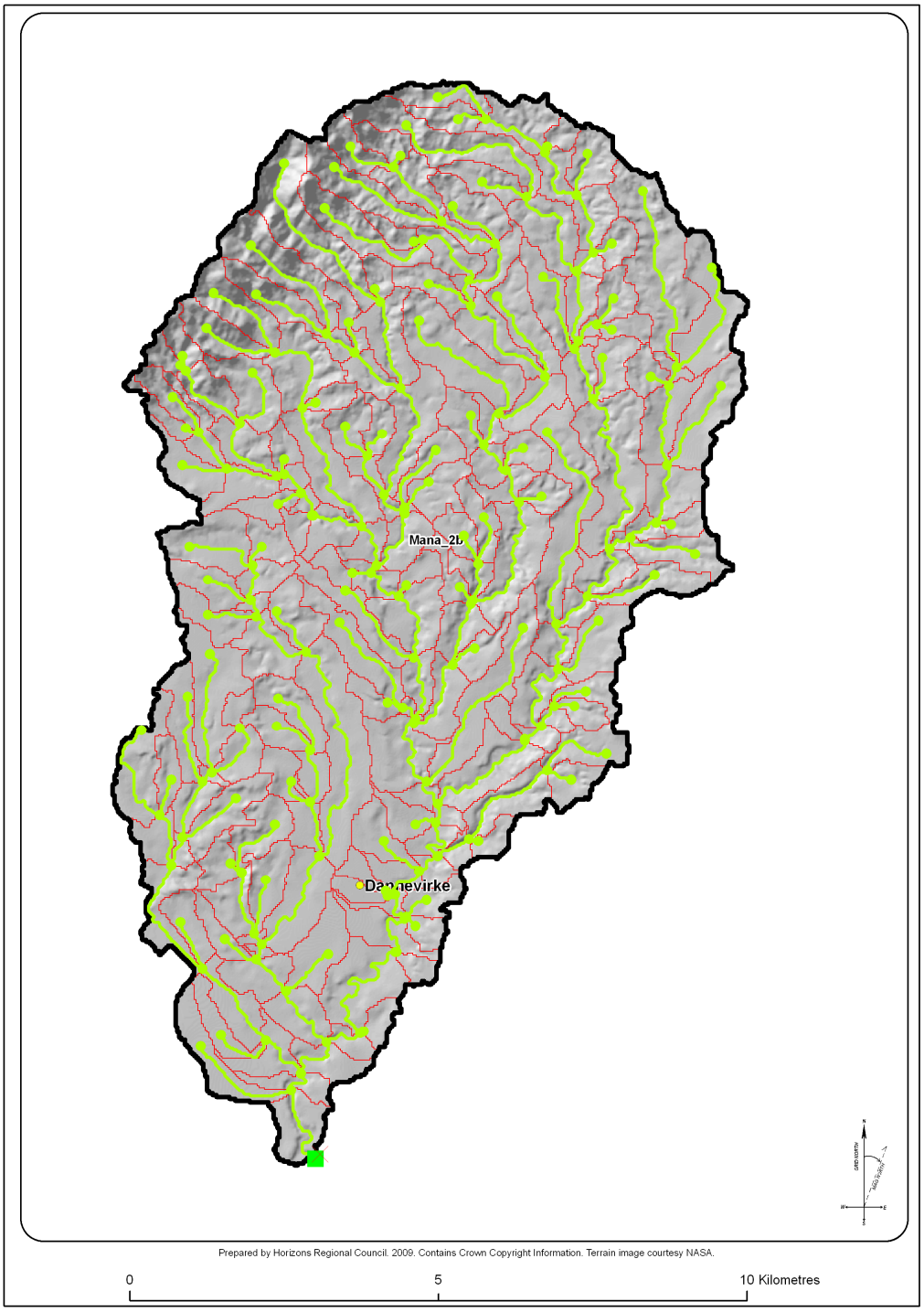


Figure 4. Selected watersheds shown in bright blue.

48. Step Five: The selected watersheds were copied into the WMSzs shapefile and merged together from a number of watersheds to create one larger catchment shape for the Sub-zone. The resultant Sub-zone from this example is the Mangatera (Mana_2b) (Map 7).



Map 7. The Mangatera Sub-zone showing the Sub-zone boundary (black outline), the selected streamlines (bright green) from Step Three and the watersheds (red polygons).

49. In order to create the Management Zones, I utilised a copy of the Sub-zone shapefile and selected Sub-zones within a WMZ then merged them together to form one larger catchment.

Groundwater Management Zones

50. I created the layer for GWMZs in the POP by merging the Surface WMZs that were identified as being within a GWMZ (Table 3).

Table 3. Surface Water Management Zones within Groundwater Management Zones.

Ground Water Management Zone	Surface Water Management Zones within GWMZ
Whanganui	Lower Whanganui (Whai_7)
	Northern Coastal (West_1)
	Kai Iwi (West_2)
	Mowhanau (West_3)
	Southern Wanganui Lakes (West_4)
Whangaehu	Upper Whangaehu (Whau_1)
	Middle Whangaehu (Whau_2)
	Lower Whangaehu (Whau_3)
	Coastal Whangaehu (Whau_4)
Turakina	Turakina (Tura_1)
Rangitikei	Lower Rangitikei (Rang_3)
	Coastal Rangitikei (Rang_4)
	Kaitoke Lakes (West_5)
	Northern Manawatu Lakes (West_6)
Manawatu	Middle Manawatu (Mana_10)
	Lower Manawatu (Mana_11)
	Oroua (Mana_12)
	Coastal Manawatu (Mana_13)
Horowhenua	Lake Horowhenua (Hoki_1)
	Ohau (Ohau_1)
	Waitarere (West_7)
	Papaitonga (West_8)
	Waikawa (West_9)
Eastern	Upper Manawatu (Mana_1)
	Weber – Tamaki (Mana_2)
	Upper Tamaki (Mana_3)
	Upper Kumeti (Mana_4)
	Tamaki – Hopelands (Mana_5)
	Hopelands (Mana_6)
	Tiraumea (Mana_7)
	Mangatainoka (Mana_8)
	Upper Gorge (Mana_9)

Limitations of the dataset for delineating Water Management Zones and Sub-zones

51. The REC Dataset utilised for the creation of WMZs and Sub-zones and also used for the definition of reach-specific values (see Paragraph 107) in Schedule D was, and still is, the best tool available for the development of such a framework. However, it has limitations that are outlined in the following paragraphs.

52. The REC dataset is limited mainly by the size of the Digital Terrain Model (DTM^4) it uses. The DTM^4 used for the REC is a 15 metre pixel size which means that the resolution of the data is in 15 metre changes in height. In the Region's lowland basin, change in altitude is slight and because of this small change (less than 15 m) in altitude, some of the water bodies are not as well defined as they are in upper catchments.

53. Some of the watersheds in the REC have been found to not match exactly with the joins in river line (Figure 5). This can lead to catchments not being accurately defined in space; however, this is a minor error and is overcome by the textual description of each of the zones.

54. The REC catchment dataset did not always align with the Horizons Regional Council Boundary on the outer catchments. If the boundary line included areas that were not within the catchment at that point, it was decided to include them in the nearest WMSz and, by default, WMZ. This was done by digitising a polygon along the Horizons Regional Council statutory boundary and merging the new polygon with the closest WMSz.

55. There are known limitations to this dataset and its use for determining catchment boundaries. However, these are minor and the REC is still the best tool available to Horizons for classifying WMZs. Overriding these errors is the textual description of where each of the WMZs and Sub-zones are located.

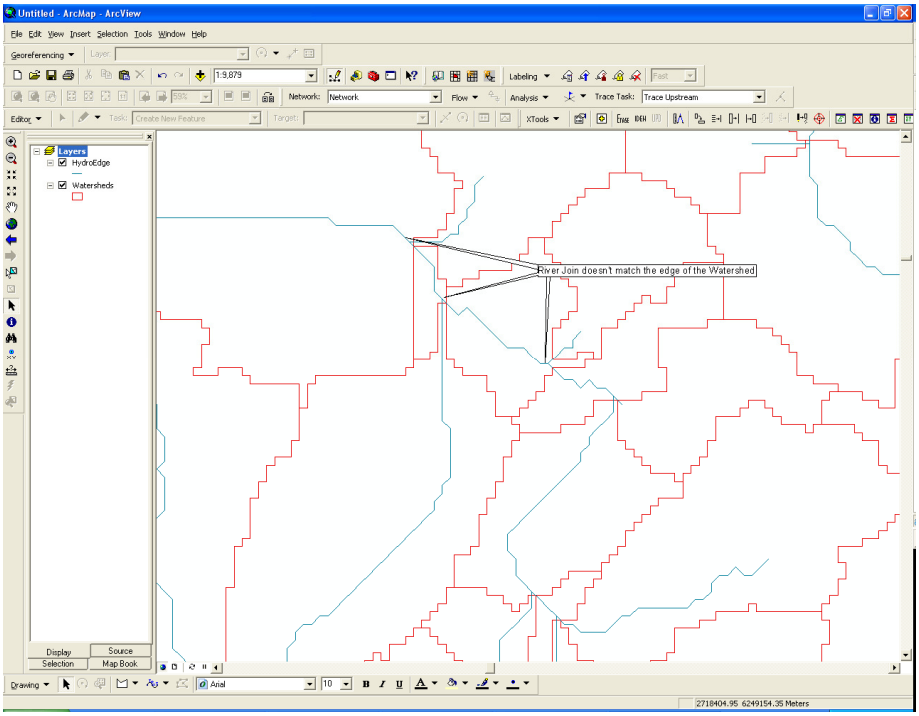


Figure 5. An example of a section of REC hydro edges and watersheds not matching up with stream confluences.

Naming conventions for the Water Management Zones and Sub-zones

Surface Water Management Zones and Sub-zones

56. To make the WMZs and Sub-zones identifiable across the Region, they were each assigned a name and a zone code.

57. Each WMZ was grouped relating to its parent catchment (eg. Manawatu or Whangaehu) (McArthur *et al*., 2007) and assigned a label using the steps outlined in Paragraphs 58-59. These labels were attributed to the shapefile by adding two fields[7] to the attribute table[8] and populating them with the defined names and codes.

58. The WMZs were labelled in order, from the catchment source to the coast and including all major inflowing tributaries. The labels are abbreviated codes of the parent catchment they belong to, eg. Management Zones in the Manawatu Catchment are labelled with Mana and Management Zones in the Whanganui catchment are labelled as Whai. They

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7 In GIS a field is a column of data in the Attribute Table[8] that provides information about the shapes (spatial features) within the layer.

8 An attribute table is a table that contains information on the associated shapes (spatial features).

are then given a numerical value for the order the zone falls into, moving from the source to mouth.

59. The Sub-zones were labelled using a similar technique, but the Management Zone number was included in each of these and then a letter to denote a Sub-zone. The Sub-zones in the mainstem were labelled first from source to mouth. The tributary Sub-zones were then labelled in order from source to confluence with the mainstem.

60. An example of the Upper Manawatu WMZs and Sub-zones is provided in Table 4. For a full list of the Zones and Sub-zones see McArthur *et al.* (2007); pg 20, and Schedule D of the POP.

Table 4. An example of the naming conventions for Water Management Zones and Sub-zones in McArthur e*t al. al*. (2007) and Schedule D of the POP

Parent Catchment	Management Zone	Management Sub-zone
Manawatu	Upper Manawatu (Mana_1)	Upper Manawatu (Mana_1a)
		Mangatewainui (Mana_1b)
		Mangatoro (Mana_1c)

Groundwater Management Zones

61. Unlike Surface WMZs and WMSzs, there was no naming convention for GWMZs. The GWMZs were labelled based on the geographical area in which they are located.

Use of Water Management Zones and Sub-zones

62. WMZs and Sub-zones provide a common catchment unit into which all aspects of Horizons water management can feed.

63. WMZs and Sub-zones provide the fundamental building blocks for integrating across all management issues, in order to provide the best environmental outcome for a particular area.

64. Water body Values hang off the WMZ and Sub-zones in the Water Management framework of the POP as the second level, to recognise the environmental, social, cultural and economic values of each area.

65. The WMZ framework allows for the recognition that not all Values will occur everywhere. Therefore, the use of Zones and Sub-zones allows for diversity of Values in a framework that can then be utilised to provide only for the values in that Zone.

66. WMSzs are used in the Water Allocation Framework on both an individual Sub-zone allocation limit, cumulative limits within WMZs, and cumulative zone allocation limits (Section 42A Report of Jon Roygard and Section 42A Report of Raelene Hurndell).

67. Surface WMZs are also used to determine GWMZs. These are a combination of a number of Surface WMZs and provide a groundwater-specific framework (see the Section 42A report of Hisham Zarour).

68. The Water Quality Standards in Schedule D of the POP take the values outlined for each WMSz and assign the most stringent standard for a parameter, depending on what Values are present in the Sub-zone (Ausseil and Clark 2007c). For further clarification of this see the Section42A report of Ms McArthur.

69. Having a monitoring network tied to Zones and Sub-zones also means that policy performance monitoring can be carried out on smaller scale (using WMSzs) and larger scale (using WMZs) or on a catchment scale. A key aspect in the design of the WMZ and Sub-zone framework was the presence of monitoring stations for flow and water quality. This gives the ability to present State Of The Environment information in a manner similar to that reflected in the 2005 State of the Environment Report and depicted in Map 2.

70. The WMZs framework is set up to make selecting targeted catchments for both regulatory and non-regulatory policies easier, because the level of detail in monitoring is greater. For example, WMSzs are identified in Table 13.1 for the roll out of the proposed rules for control of landuse activities (see the S42A Report of Dr Rogyard for further detail).

71. WMZs and Sub-zones are used in the POP to set common catchment expiry dates (Table 11-2 in the POP). Common catchment expiry dates will allow for assessment of consented activities in a cumulative way rather than assessing each application

individually. This will allow for better management of the water resource (see the S42A Report of Dr Roygard for further detail).

Coastal Water Management Zones

72. After notification of the POP Horizons staff recognised that all activities occurring in the Coastal Marine Area (CMA) needed to be managed by the provisions in the Coastal Chapter of the Regional Plan, and therefore should not be contained within Schedule D.

73. This meant all of the WMZs containing a CMA, as identified in Schedule H of the POP, required the CMA section of the WMZ to be split into a new Management Zone.

74. This was done by digitising[9] the mainstem of each river with a specified CMA boundary in Schedule H between the CMA boundary and the true river mouth, with the exception of the Whanganui River CMA boundary, which was extended to the moles.

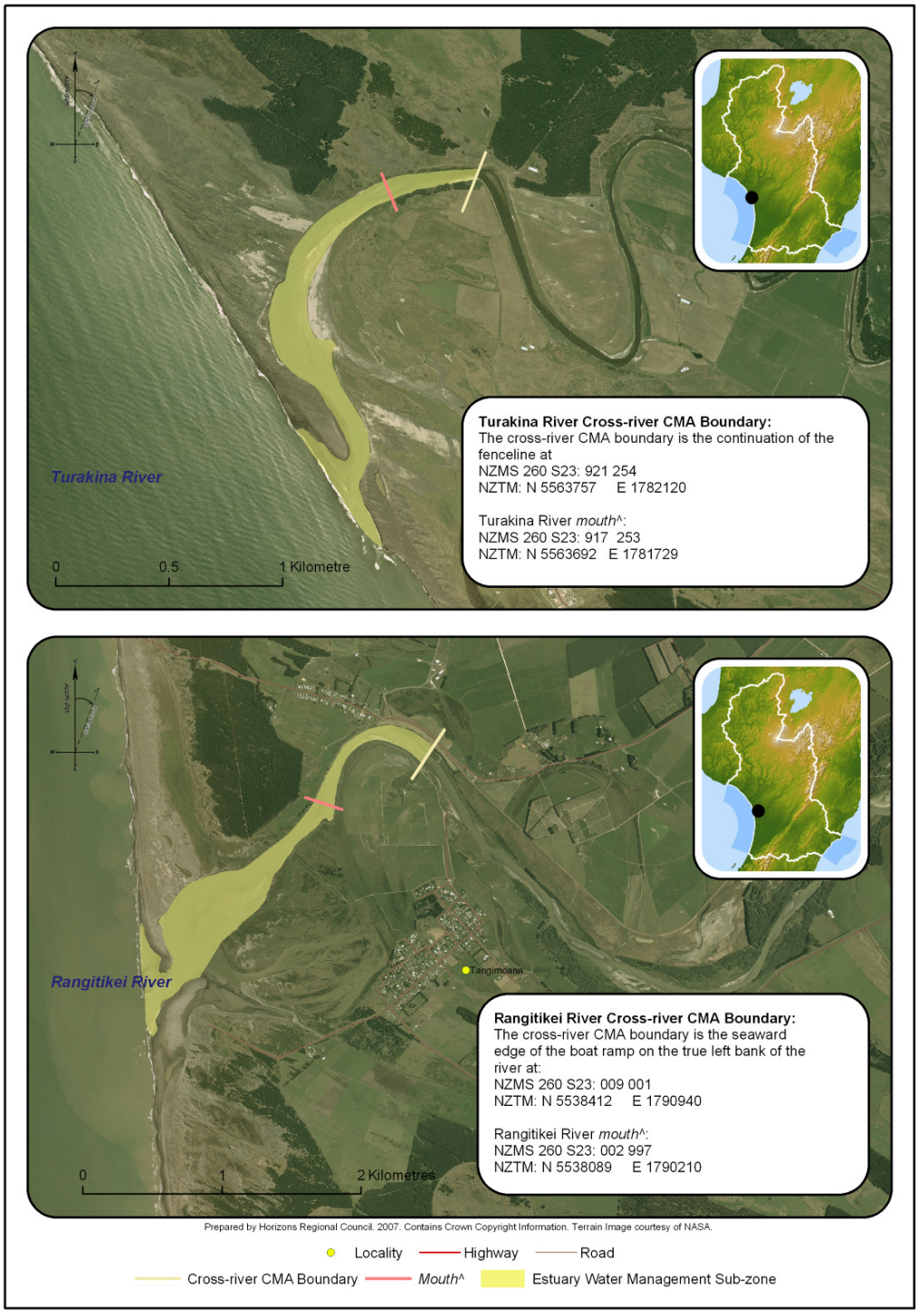
75. Upstream Estuary boundaries are determined using the "cross-river" CMA boundary as determined in Schedule H of the POP.

76. Estuary WMZs from the provisional determination of the coastal chapter of the POP (pages H8-H20) are presented below (Map 8-11).

[9] Drawing an object using a set of points in this case the points were drawn to form a polygon.[5]

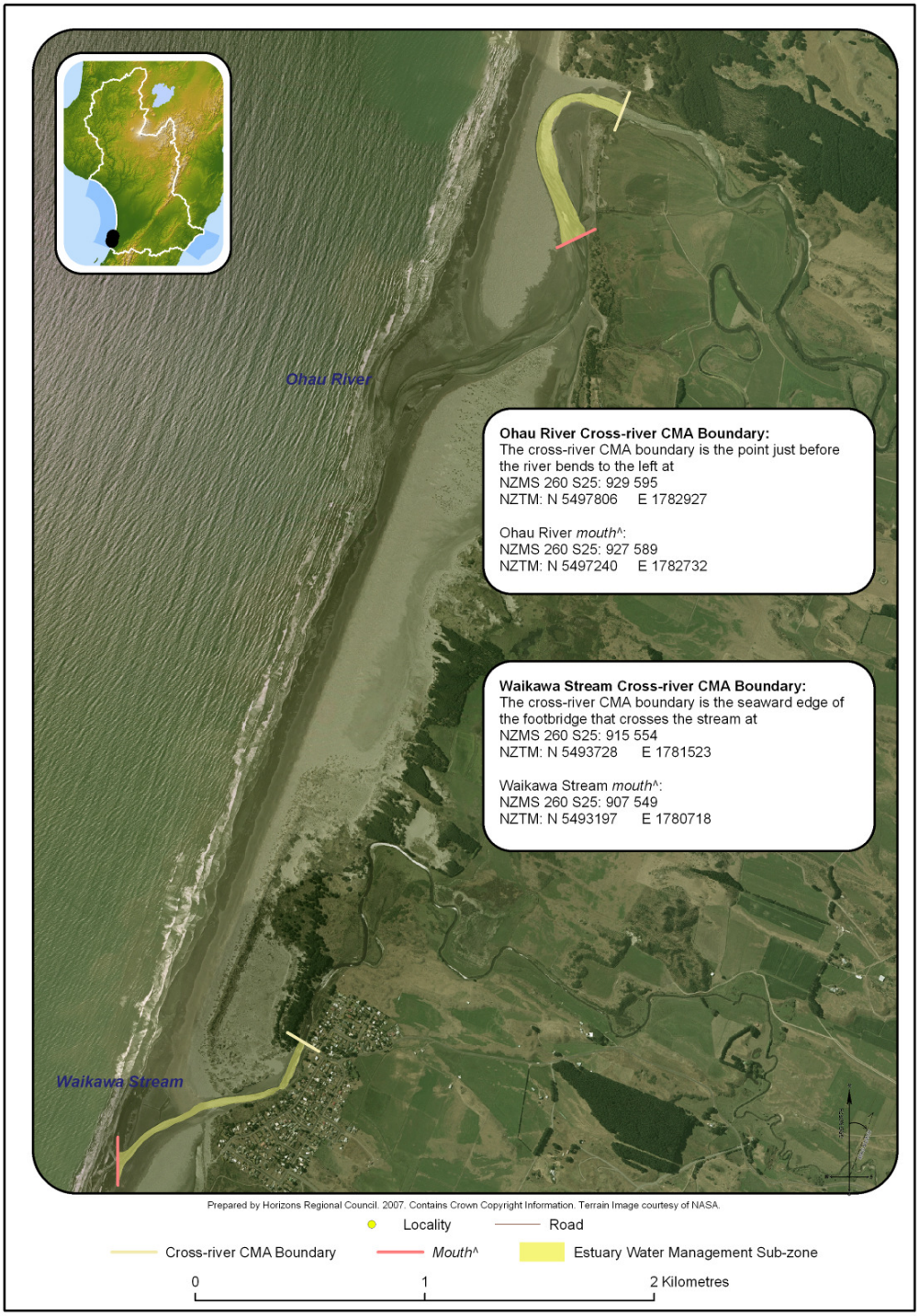
Map 8. Location of the Kai Iwi Steam and Mowhanau Stream Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the mouth is represented by a peach line, and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].

Map 9. Location of the Whanganui River and Whangaehu River Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the mouth is represented by a peach line, and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].

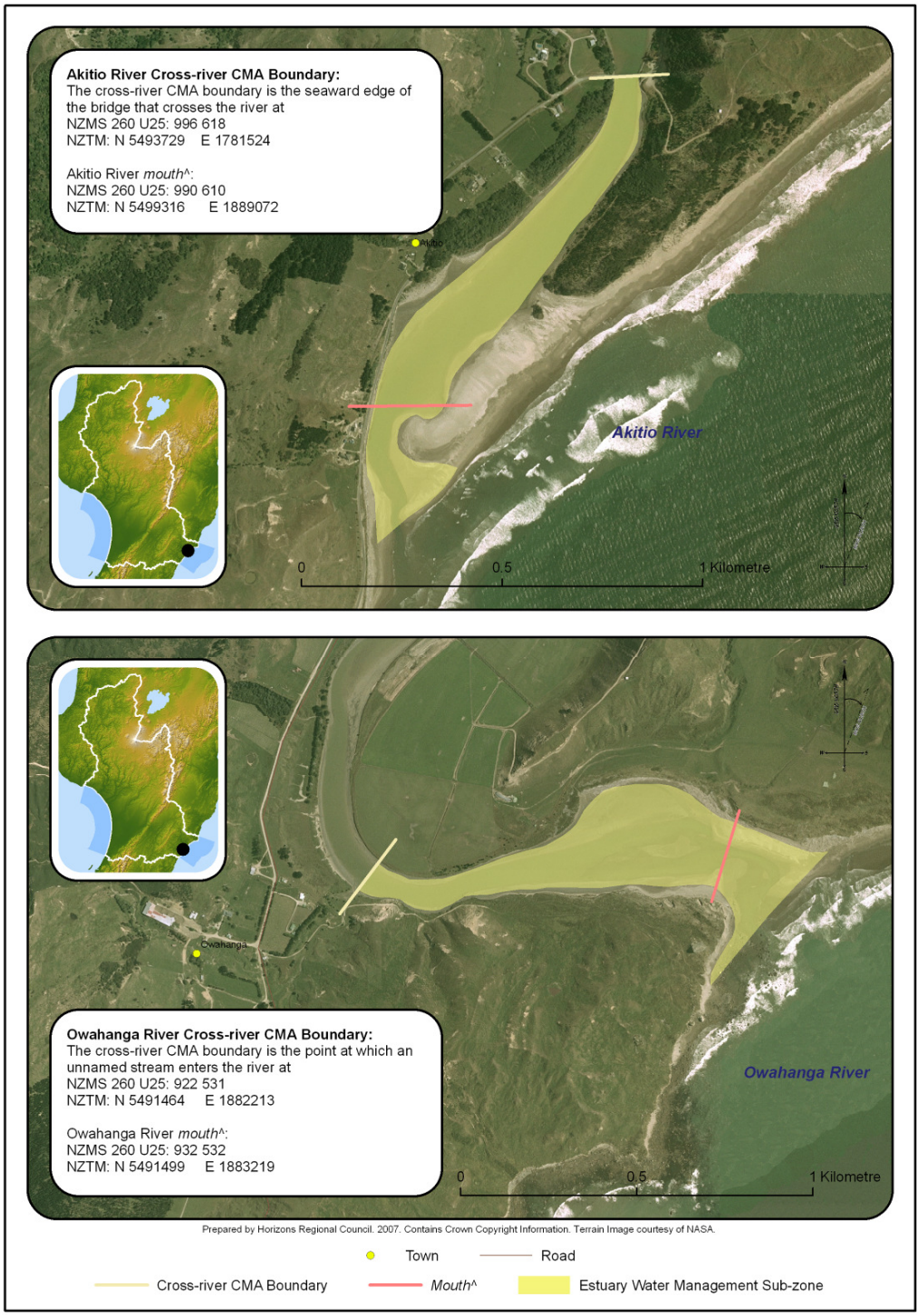


Map 10. Location of the Turakina and Rangitikei River Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the Mouth is represented by a peach line on the map and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].

Map 11. Location of the Manawatu River and Hokio Stream Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the mouth is represented by a peach line, and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].



Map 12. Location of the Ohau River and Waikawa Stream Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the mouth is represented by a peach line, and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].



Map 13. Location of the Akitio River and Owahanga River Estuary Water Management Sub-zones. The Cross-river CMA Boundary is represented by a yellow line on the map, the mouth is represented by a peach line, and the Estuary Water Management Sub-zone is represented by a yellow polygon[5].

Naming Conventions for Coastal Marine Area (CMA) Water Management Zones

77. The proposed naming convention for the Coastal Marine Area (CMA) Water Management Zones (WMZs) follow the naming conventions for WMZs and Sub-zones, and be named by the WMZ in which they are located, eg. the Manawatu River CMA WMZ will still be Mana_13. However, the code denoting a Sub-zone will be changed to CMA. Therefore, the Manawatu River CMA WMZ (Table 5), is named Mana_13CMA as it is found at the seaward end of the Mana_13 Water Management Zone known as 'Coastal Manawatu'. The estuary Sub-Zone has the label Mana_13CMA to differentiate it from the upstream river Water Management Sub-zone Mana_13a 'Coastal Manawatu' or from the adjacent Foxton Loop Water Management Sub-zone 'Mana_13f'.

Table 5. Proposed CMA Water Management Zone Names and Zone Codes

Parent Catchment	CMA Water Management Zone	CMA Water Management Zone Code
Manawatu	Manawatu CMA	Mana_13CMA
Rangitikei	Rangitikei CMA	Rang_4CMA
Whanganui	Whanganui CMA	Whai_7CMA
Whangaehu	Whangaehu CMA	Whau_4CMA
Turakina	Turakina CMA	Tura_1CMA
Ohau	Ohau CMA	Ohau_1CMA
Owahanga	Owahanga CMA	Owha_1CMA
Akitio	Akitio CMA	Akit_1CMA
Kai Iwi	Kai Iwi CMA	West_2CMA
Mowhanau	Mowhanau CMA	West_3CMA
Waikawa	Waikawa CMA	West_9CMA
Lake Horowhenua	Hokio CMA	Hoki_1CMA

Proposed Changes to Water Management Zones and Sub-zones

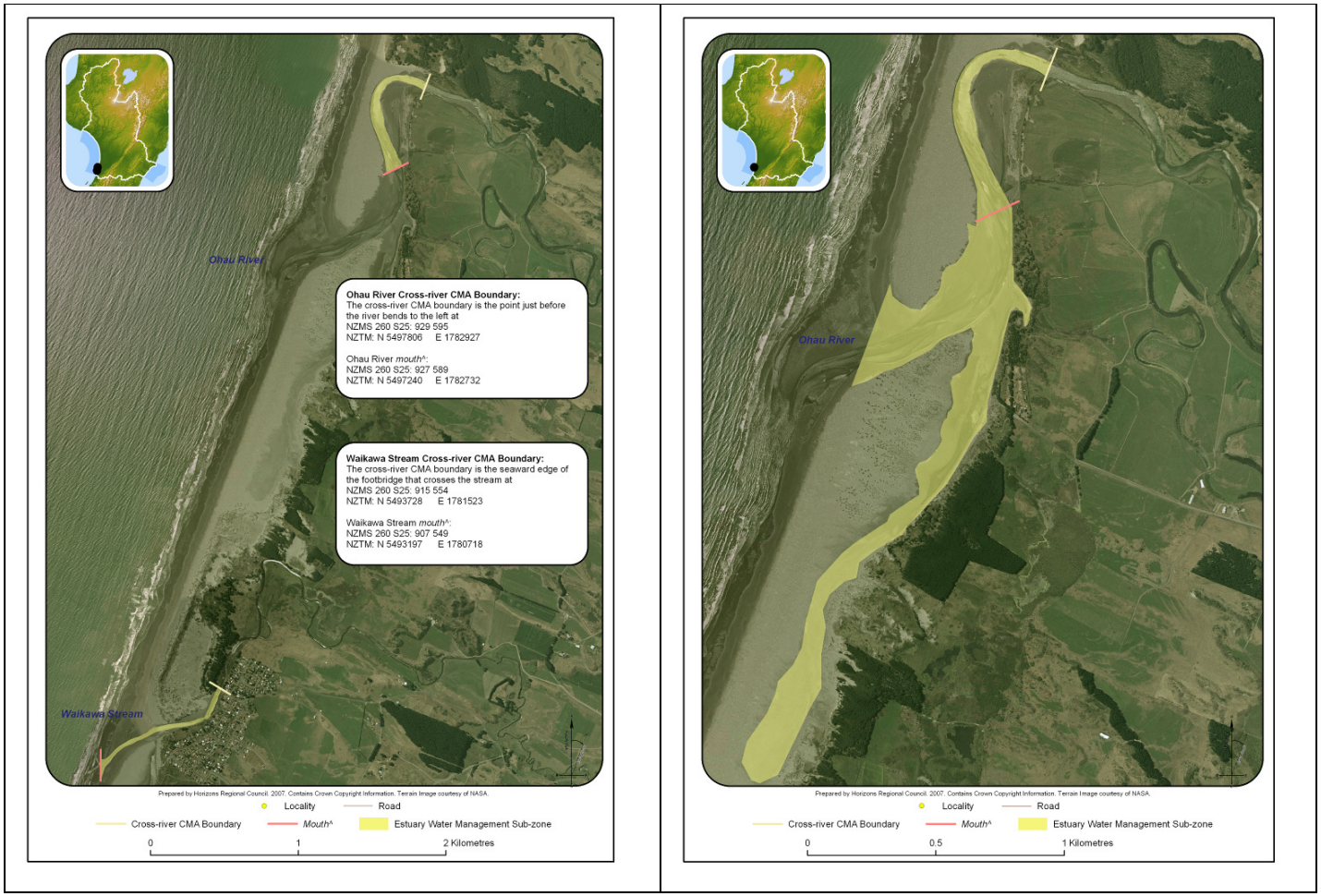
78. The proposed changes to the WMZs and Sub-zones cover the following areas:

- CMA.
- Mangaramarama Sub-zone.
- Upper and Lower Manganui o te Ao Sub-zones.
- Makara Sub-zone.
- Waikawa Sub-zone.
- Additional GWMZs.
- Terminology.

79. The Coastal Marine Area has been separated from the surface WMZs and WMSzs in accordance with the provisional determination on the Coastal Chapter. The definitions of these Sub-zones will lie in Schedule H and be removed from Schedule D. For further clarification on this see the Section 42A Report provided by Ms McArthur. The description of the WMZ and Sub-zones will be amended in Table D2 to reflect these changes.

80. The Estuary Water Management Zone for the Ohau catchment needs to be extended to the true river mouth in order to align with the other Esturine Water Management Zones. I have extended the Ohau Estuary Water Management Zone to include a coastal lagoon flowing on the southern side of the Ohau River within the CMA.

81. Map 14 presents these changes.



Map 14. Proposed changes to the Ohau Estuary Water Management Sub-zone. The map on the left shows the Estuary Water Management Sub-zone from the provisional determination and the map on the right shows the proposed extension to the sub-zone and the addition of an Estuary lagoon, which also should be included in the Estuary Water Management Sub-zone.

82. The Mangaramarama WMSz has been moved from the Mangatainoka WMZ into the Tiraumea WMZ. As a result of the data in the River Environment Classification and on old aerial photographs, the Mangaramarama Creek was originally thought to flow into the Mangatainoka River. Since the development of the WMZs framework, more recent aerial photography shows that the Mangaramarama Creek is flowing into the Tiraumea River and has done in the past; the change in flow path is associated with high flow events changing the course of the stream. In either case, the confluence for the Mangaramarama Creek is very close to the confluence between the Tiraumea River and its tributary, the Mangatainoka (Figure 6). It is recommended that the Mangaramarama Creek be treated as a tributary of the Tiraumea and therefore removed from the Mangatainoka WMZ and placed into the Tiraumea, with the WMSz code Mana_7e. Further information on the implication of this change for the water allocation framework can be found in the evidence of Raelene Hurndell. Changes to the values that apply to the Mangaramarama Creek as a result of this shift can be found in Table 12 of my evidence.

Figure 6. Left: the River environmental classification shows the Mangaramarama Creek entering the Mangatainoka River. Right the aerial photo (2005) shows the Mangaramarama Creek confluence to the Tiraumea River. An old channel where the Mangaramarama enters the Mangatainoka can also be observed.

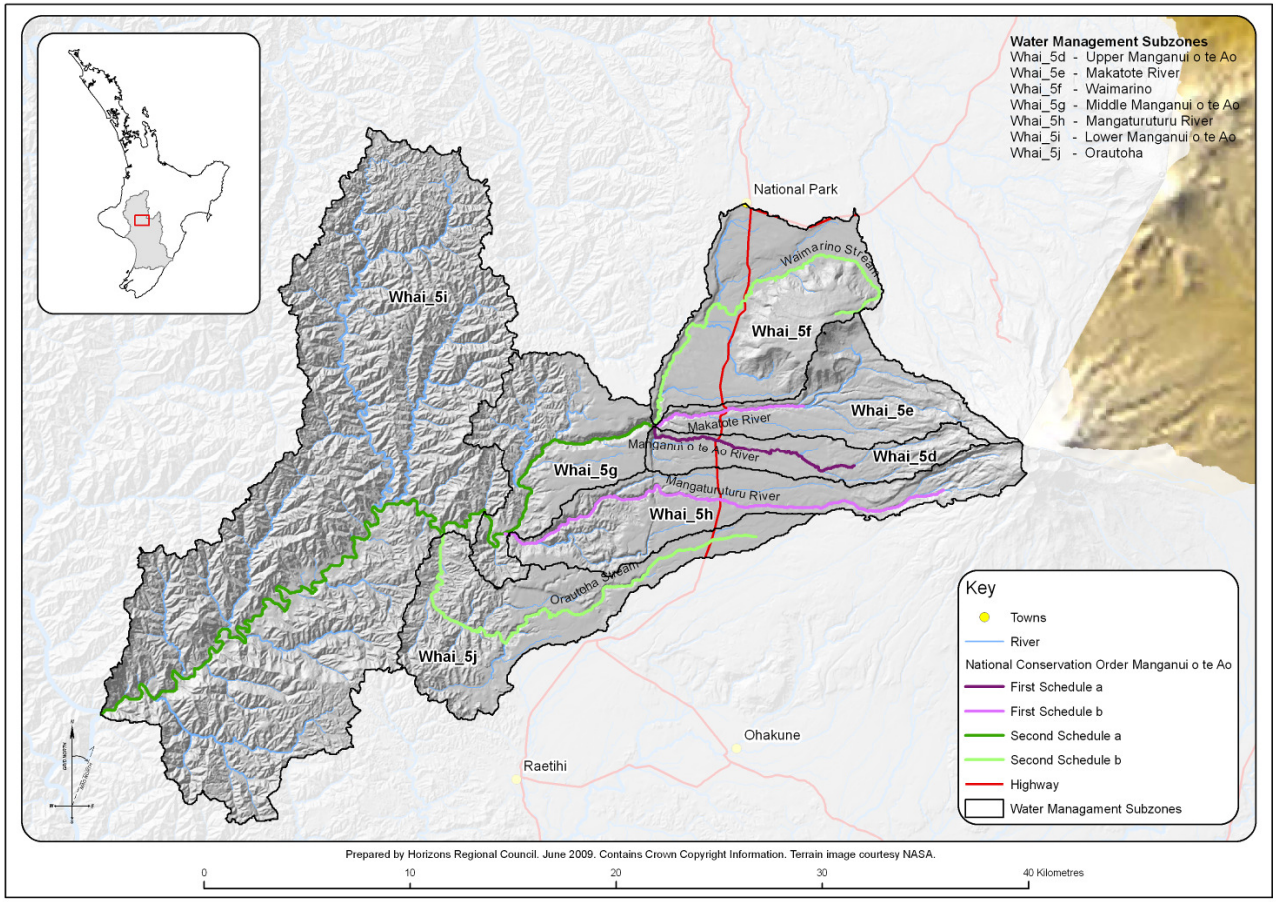
83. It is proposed that the Upper and Lower Manganui o te Ao are further divided into seven Sub-zones in total. This change has been made to better reflect the areas identified in the National Water Conservation Order (NWCO) and to allow the Water Allocation Framework to better align with the intentions of the NWCO. For more information on the effect this change has on the Water Allocation Framework see the evidence of Ms Hurndell and Dr Roygard. In terms of water body Values, it is intended that the values and standards for these Zones will remain the same as those identified in the POP. Changes in terms of the Schedule D tables to reflect the changes to these sub-zones are outlined in Table 12 and Table 13 of my evidence.

84. Map 15 and Table 6 show the new WMSzs proposed for the Manganui o te Ao catchment. The naming convention is the same as that outlined in Paragraphs 58-59.

Table 6. Proposed Sub-zones for the Manganui o te Ao

Management Zone	Sub-zone	Sub-zone Description*
Pipiriki (Whai_5)	Upper Manganui o te Ao (Whai_5d)	Manganui o te Ao River - source to Makatote confluence (S20:129-120)
	Makatote (Whai_5e)	Makatote River from the confluence with the Manganui o Te Ao River (S20:129-120) to source
	Waimarino (Whai_5f)	Waimarino Stream from the confluence with the Makatote River (S20:129-120) to source
	Middle Manganui o te Ao (Whai_5g)	Manganui o te Ao River - Makatote confluence (S20:129-120) to Hoihenga Road (S20:047-077)
	Mangaturuturu (Whai_5h)	Mangaturuturu River from the confluence with the Manganui o te Ao River (S20:057-067) to source
	Lower Manganui o te Ao (Whai_5~~e~~i)	Manganui o te Ao - Hoihenga Road to Whanganui confluence (R20:861-979)
	Orautoha (Whai_5j)	Orautoha Stream from the confluence with the Manganui o te Ao River (S20:026-067) to source

* Includes all inflowing tributaries and surrounding catchment area unless otherwise specified.



Map 15. Manganui o te Ao Water Management Sub-zones. The dark purple line indicates the First Schedule of the National Water Conservation Order part a, the light purple shows the First Schedule of the NWCO part (b), the dark green shows the Second Schedule of the NWCO part (a), the bright green shows the second schedule of the NWCO part (b), the black lines indicate Sub-zone boundaries, the blue lines indicate other water bodies, and the red line indicates the state highway.

85. It is proposed that the Makara Stream, a tributary of the Makotuku River, be sub-zoned below the NZ Energy weir for water allocation purposes (see the S42A Report of Ms Hurndell and Dr Roygard). The new locality description is provided in Table Ba10 in the Track Changes version of the POP document.

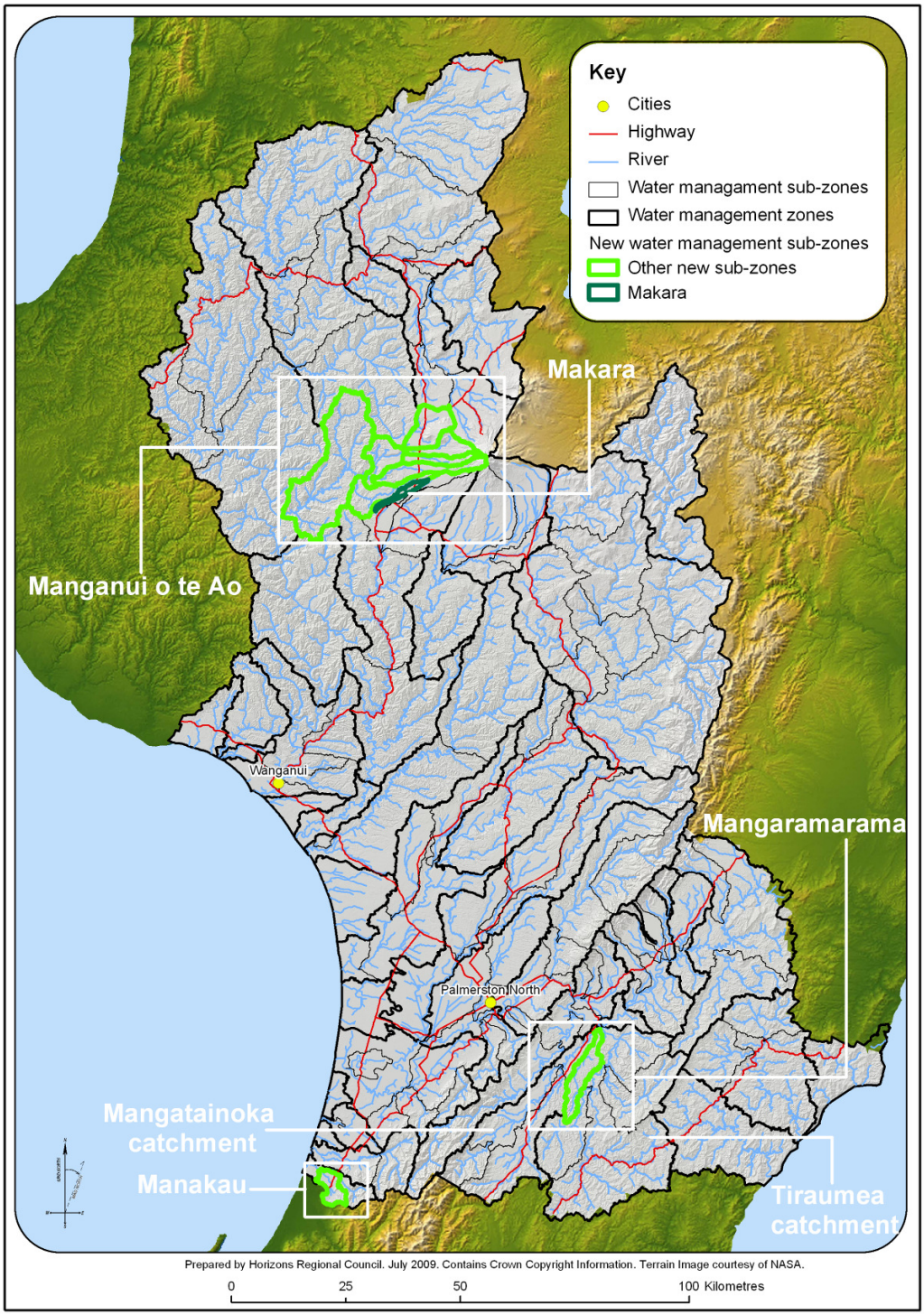
86. It is proposed that a sub-zone be created in the Waikawa (West_9) WMZ. This Sub-zone will encompass the Manukau Stream and its tributaries from the confluence with the Waikawa Stream to source. This Sub-zone has been cut from the confluence with the Waikawa Stream to enable a separate management of minimum flows in the Water Allocation Framework (see the S42A Report of Ms Hurndell and Dr Roygard).

87. Map 16 shows the location of all of the WMSzs that are recommended for changes or additions in paragraphs 82-87. The addition of new WMSzs has increased the number of Sub-zones from 117 to 124; however, the number of Water Management Zones has not increased.

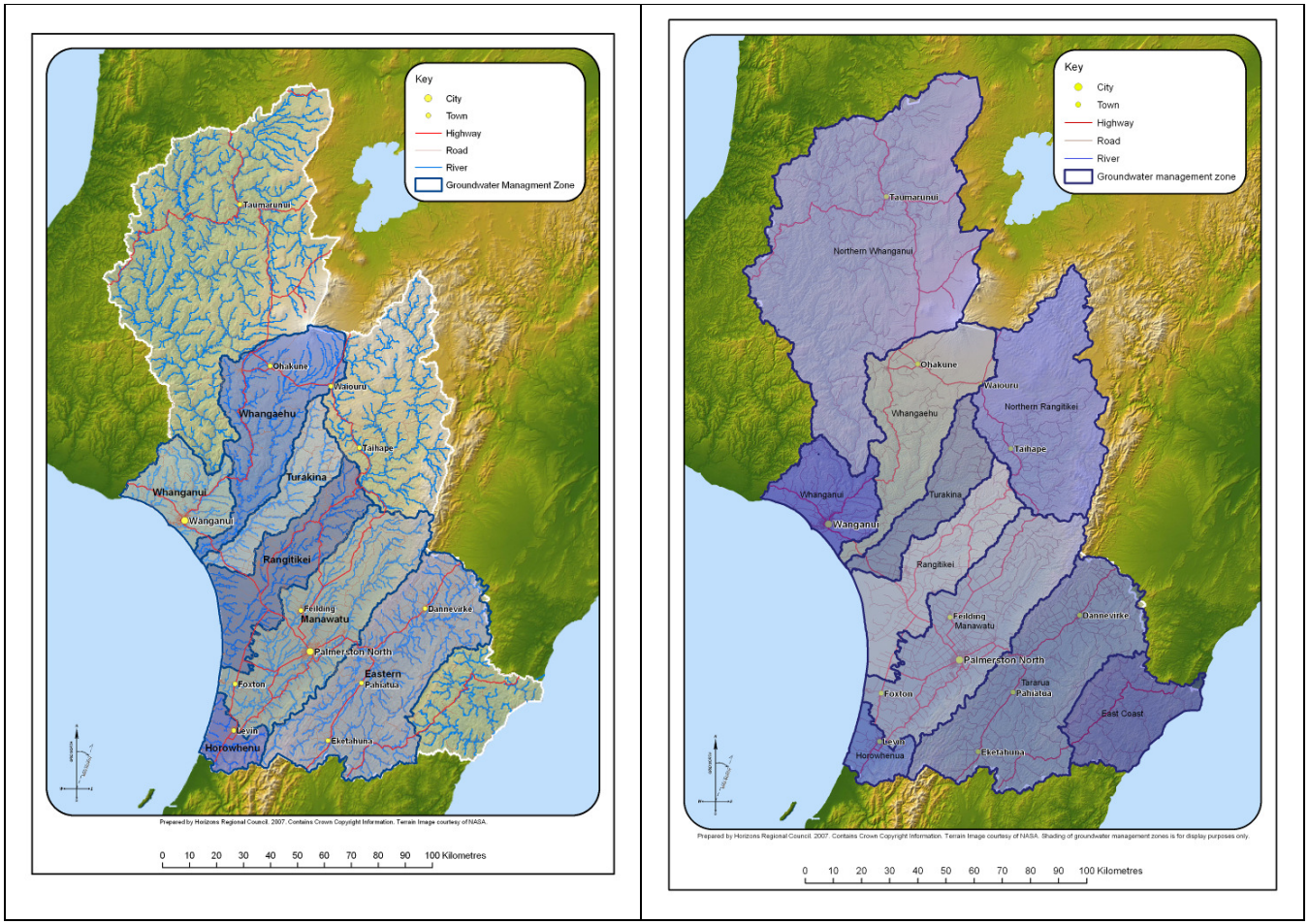
88. Additional GWMZs in the Upper Whanganui, Upper Rangitikei and East Coast are proposed for inclusion in the GWMZ framework. It is proposed that the existing Eastern GWMZ be renamed to Tararua GWMZ. These changes are shown in Map 17 and the surface WMZs that form the larger GWMZs are shown in Table 7.

Table 7. Proposed additional Groundwater Management Zones and their constituent Surface Water Management Zones

Ground Water Management Zone	Surface Water Management Zones within GWMZ
East Coast	Akitio (Akit_1)
	Owahanga (Owha_1)
	East Coast (East_1)
Northern Rangitikei	Upper Rangitikei (Rang_1)
	Middle Rangitikei (Rang_2)
Northern Whanganui	Upper Whanganui (Whai_1)
	Cherry Grove (Whai_2
	Te Maire (Whai_3)
	Middle Whanganui (Whai_4)
	Pipiriki (Whai_5)
	Paetawa (Whai_6)



Map 16. Location of the additional/changed Water Management Sub-zones.



Map 17. Groundwater Management Zones. The map on the left is the original map from the POP, and the map on the right shows the new and existing Groundwater Managment Zones recommended for inclusion in the One Plan.

89. Horizons' staff submission on the POP recognises that the use of the terms WMZs and WMSzs is inconsistent. It is therefore recommended to change the relevant references from WMZ to WMSz throughout the Plan.

Spatially representing Water Body Values in the Proposed One Plan

90. Water Body Values are the second spatial tier of the Water Management Framework in the POP. The following sections provide information about how the Values were spatially represented. It is outside the scope of this evidence to present information on why and where the Values were selected, and this is covered in the S42A Report of Ms McArthur.

Reach and Zone-Specific values

91. Throughout the Values framework there are two sets of values:
    i. Those that apply at a reach specific level.
    ii. Those that are applicable to all water bodies in a specified WMSz.

92. The values that apply zone-wide apply to all natural water bodies within the WMSzs identified for that Value. Table 8 presents the values in Schedule D of the POP and indicates whether they apply at a reach-specific or zone-specific level.

Table 8. Summary of the proposed list of Values associated with the water bodies in Horizons' Region and their status as zone-specific or reach-specific values.

Value	Zone Specific	Reach Specific
Natural State		✓
Life Supporting Capacity	✓	
Sites of Significance for Aquatic Biodiversity		✓
Sites of Significance Riparian		✓
Inanga Spawning[10]		✓
Contact Recreation	✓	
Amenity		✓
Whitebait Migration[11]		✓
Mauri	✓	
Shellfish Gathering[12]		✓
Sites of Significance Cultural		
Trout Fishery		✓[13]
Trout Spawning		✓
Aesthetics		✓[13]
Water Supply	✓	
Industrial Abstraction	✓	
Irrigation Abstraction	✓	
Stockwater	✓	
Capacity to Assimilate Pollution	✓	
Flood Control		✓
Drainage		✓
Existing Infrastructure	✓	

93. There are some differences between Table 8 and Table D-2 of the POP with regard to the classification of zone-specific and reach-specific values. The reasons for these changes are presented in Table 12 of my evidence.

94. As presented in Paragraphs 36-42, the REC was selected as the best tool to spatially represent the water body values described in Ausseil and Clark (2007a); Section 2.2.

[10] Note that this value has a proposed Name change from Native fish spawning to Inanga Spawning. Further detail on this can be found in the evidence of Ms McArthur

[11] Note that this value has a proposed Name change from Native Fishery to Whitebait Migration. Further detail on this can be found in the evidence of Ms McArthur

[12] Note that this value is to be removed and placed in Schedule H of the Proposed Plan (Table 12).

[13] It is noted that some Zones are specified entirely as Trout Fishery or Aesthetic due to conservation orders and notices.

Life Supporting Capacity Value Definition

95. Including a Life Supporting Capacity (LSC) Value recognises that not every water body in the Region has the ability to support the same ecosystem, and that differences between water bodies occur as a result of underlying factors geological or topographic. For a more detailed description of the LSC Value see the Section 42A Report of Ms McArthur, Ausseil and Clark (2007a); Chapter 2.2.1, and (Ausseil and Clark (2007b).

96. To represent the different LSC classes across Management Sub-zones, the Geology and Source of Flow categories were used from the River Environment Classification (REC). However, as the REC from NIWA is a nationwide dataset, it was not entirely applicable for Horizons' use at the regional scale. Therefore, the Geology and Source of Flow categories in the original REC (Table 2) were re-classified to create a Horizons-applicable REC (Ausseil and Clark, 2007a; Chapters 2.2.1 and 2.2.2). These modifications are outlined in the following paragraphs and the final dataset resulting from the modifications is referred to as the Horizons' Modified REC.

97. The Source of Flow category in the original REC was modified to provide a better regional fit (Ausseil and Clark, 2007a; Chapter 2.2.2.1). This was required because elevation definitions between Lowland and Hill country were considered to be inconsistent with the stream and river characteristics seen in the Region. For example, the majority of streams in the Upper Manawatu catchment were classified in the original REC as Lowland streams whereas they are upper catchment streams and therefore should be classified as sourced in Hill catchments.

98. The Source of Flow category in the original REC used the following cut-offs: 400 m and 1,000 m to separate the Lowland/Hill/Mountain categories. While 1,000 m was considered an appropriate threshold between Mountain and Hill categories, 400 m was considered too high to appropriately differentiate the Lowland streams from the Hill country streams in the Region. Therefore, instead of a 400 m cut-off for differentiating between Lowland and Hill country streams, I used a 200 m cut-off (see Ausseil and Clark, 2007a; Chapter 2.2.2.1 for further information on the appropriateness of the thresholds used). This adjusted cut-off was applied to the modified REC and reflected in the lowland vs. hill LSC Classes.

99. The Geology categories in the original REC classified 32.2% of reaches in the Region as 'Miscellaneous'. The Miscellaneous category includes infrequent soil types such as peat and urban soils (Snelder *et al.,* 2004). To provide more certainty of the Geology

classification of these reaches I undertook a comparison across the Region with the original REC and the Land Resource Inventory (LRI). The LRI is a New Zealand-wide GIS shapefile that contains information about land, such as Land Use Capability, geology, and soil information. From this comparison it was determined that the reaches classified for Miscellaneous geology corresponded with Sandstone toprock in the LRI.

100. In order to modify the original REC geology information to correct the 'Miscellaneous' classification, the raw data that fed into the original REC was obtained from Ton Snelder at NIWA. I then made changes to the Miscellaneous category in the raw data and re-calculated the percentage of each geology class, as was carried out in the original REC classification (Table 1.9 page 35 Snelder *et al.,* 2004) with the exception that Miscellaneous was fed into the Soft Sedimentary category. This new data was fed into the modified REC.

101. I was then provided with a first cut of which geology category applied to which reaches. However, when applying this to the Management Sub-zones in order to define a LSC class I noticed that the streams in the South East Ruahines were classifying as soft sedimentary, although the dominant geology of the Ruahine Ranges is greywacke.

102. Further analysis of which geology class each of the reaches was dominated by was carried out by calculating a percentage area of each geology class for each reach. Where a given geology class covered more than 10% of that reach, it was mapped and compared to where the geology was recognised in the New Zealand Land Resource Inventory (LRI). This comparison found that a number of rock types in the original REC were misclassified (Figure 7). This was rectified in the creation of the modified REC.

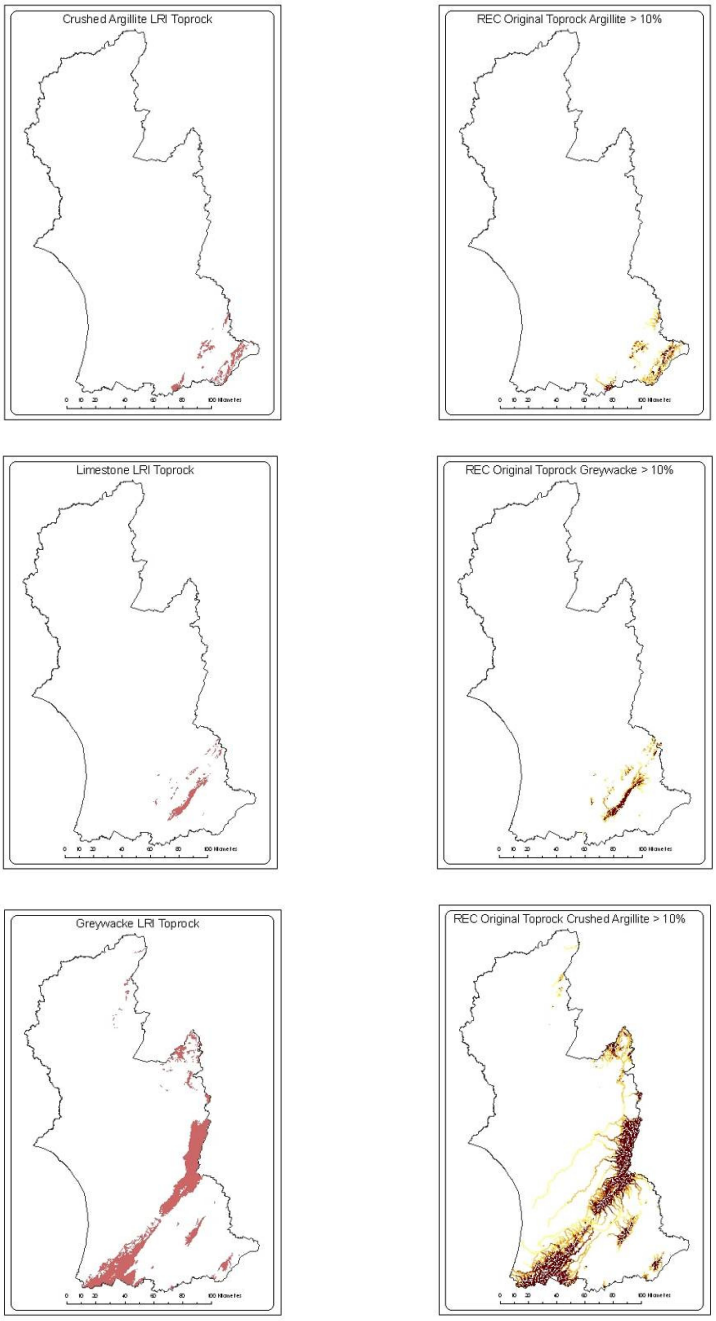


Figure 7. Examples of comparison between the REC geology layer's[2] raw data and the Land Resource Inventory (LRI) toprock information. These maps show the LRI toprock on the left and the Geology classification in the original REC data on the right. Source: Ausseil and Clark (2007a); p 8. Note the geology class for each of the separate maps is written at the top (eg. Crushed Argillite from the LRI was classified as Argillite in the original REC).

103. In order to rectify the errors in the Geology classification found in the original REC, I changed the geology category labels on each of the classes in the raw data in order to better align with the LRI rock types (Paragraph 102) and then undertook the analysis of the data. The analysis involved classifying each Geology category from the raw data into the simplified categories in Table 9. Once this was completed, I calculated the percentage of each Geology category upstream of the reach.

Table 9. Modified geology classification (Abbreviations as per LRI. Source: Ausseil and Clark 2007c).

Category	LRI Category
Alluvium	• Alluvium • Gravel
Hard Sedimentary	• Greywacke
Limestone	• Limestone
Loess	• Loess
Peat	• Peat
Soft Sedimentary	• Unconsolidated sands and gravels • Mudstone or fine siltstone - Massive • Mudstone or fine siltstone - Banded • Mudstone or fine sandstone - jointed • Mudstone - bentoitic • Sandstone or coarse siltstone - massive • Sandstone or coarse siltstone - banded • Conglomerate and breccia • Argillite • Crushed Argillite • Miscellaneous (as classified in the original REC)
Volcanic Acidic	• Ngaruhoe ash • Ashes older than Taupo Ash • Taupo and Kaharoa breccia and volcanic Alluvium • Tawawera ash and laipilli • Lavas ignimbrite and other 'hard' volcanic rocks • Kaharoa and Taupo ashes
Wind Blown	• Wind Blown

104. The original REC classified the Geology by dominant toprock category, with the exception of Soft Sedimentary geology, which was classified if the reach had greater than 25% Soft Sedimentary. However in Horizons' Region a number of reaches have more than 25% Soft Sedimentary. Therefore, the original REC classification was not a good fit for the Region. To overcome this, I undertook the analysis using the dominant simplified Geology category and a 40% threshold for Soft Sedimentary geology, as the

40% threshold better discriminated between streams moderately and heavily influenced by Soft Sedimentary Geology.

105. A combination of the modified REC Geology classification and the Source of Flow category was used to create the eight LSC classes as outlined in Chapter 3 of Ausseil and Clark (2007a).

106. In order to represent these LSC classes spatially within the WMSz Framework, I added a field[7] to the WMSz attribute table[8] and filled in the LSC class code (Ausseil and Clark, 2007b; Appendix 1).

Determining Reach-specific Values in GIS

107. River Environment Classification (REC) was also used to provide a spatial dataset for the reach-specific values described in the Section 42A Report of Ms McArthur. Although this dataset has limitations (Paragraphs 51-55 and 139-140), it is the best dataset available for the purposes of reach-specific spatial values identification.

108. The Horizons Modified REC was expanded to allow for the identification of reach-specific values by adding a field[7] to the attribute table[8] for each of the Values.

109. The reaches outlined below were selected and assigned a '1' for presence of the Value in the attribute table[8] of the modified REC, and a '0' if the Value is absent from the reach. This process provides a numerical tag for the identified Values, and allows only those reaches where that Value applies to be selected (by choosing only those reaches that have been assigned a '1'). Once selected, those reaches can be mapped.

Table 10. A subset of the Horizons Modified REC showing the presence/absence identification of values. NB: this does not show all columns in the Horizons Modified REC.

ORDER_	NZREACH	Sub-zone	LSC	SOSA	Aesthetic
2	7000340	Upper Ongarue	UVA	1	0
1	7000338	Upper Ongarue	UVA	1	0
3	7007984	Upper Whanganui	UVA	0	1
1	7007924	Middle Whanganui	UVM	0	0

110. Where map references were used to locate a Value they then had to be converted into coordinates for display in GIS[6]. This is because the GIS[6] system is set up in a co-

ordinate system in metres, and therefore needs to know how many metres the spatial location is from a known point. The conversion from map references to coordinates results in a possible 100 m error in each direction. This error sometimes manifested itself in an inaccuracy of positioning of points. To fix these errors, I went back to the original data to see which water body was to be recognised for that value and manually moved the point to that water body.

111. Trout Fishery, Trout Spawning, Inanga Spawning, Whitebait Fishery and Aesthetic Values have been identified in the Land and Water Regional Plan and the Beds of Rivers and Lakes Regional Plan. Where these values were identified I converted Map References to Coordinates and plotted the start and end points for each of the sites in ArcGIS. I then selected the reaches from the Horizons Modified REC that were between each of the sets of points in order to identify where the value was located.

112. Draft maps of Native Fish Spawning, Trout Fishery and Trout Spawning Values were provided to Massey University Ecology Department (Native Fish Spawning), Department of Conservation Wanganui and Wellington Conservancies (Inanga Spawning and Whitebait Migration) Fish and Game Councils for Wellington, Taranaki and Waikato, (Trout Fishery and Trout Spawning) for feedback, and minor changes were made to the maps upon recommendation to Horizons.

113. All of the reach-specific values were incorporated into the Horizons Modified REC by imputing value-specific information into the attribute table and/or creating a join to the values information in the Horizons Modified REC.

114. The following sections of this report present the data of origin for each of the reach-specific values.

Natural State

115. To define the water bodies identified for their Natural State Value I added the Department of Conservation (DOC) layer[2] to ArcGIS and I intersected[14] the reaches in the Horizons modified REC with the DOC land polygons[5]. This created a new layer[2]showing the river reaches within Public Conservation Land in the Region.

[14] The overlay of two layers to join source records where they exist in the same geographic location to create a new layer that is a combination of both sets of information.

116. Using this newly created layer[2], I labelled the river reaches that had their source in the Public Conservation Land and all the reaches downstream of the source until the edge of the Public Conservation Land boundary with a '1' in the attribute table[8] (see Paragraph 109). All other reaches that may have intersected Public Conservation Land but did not have their source in that land were manually removed from the layer[2].

117. Reaches from the Mangahao River and Tokomaru River and the Mangaore Stream identified by this process as being rivers affected by damming and/or diversion, and therefore not in Natural State, were manually removed from the layer.

118. The completed Natural State layer[2] was then joined back into the Modified REC. The new layer and the Horizons Modified REC both have a unique identifier field[7] for each reach, ie. the 'NZReach'. I used this field[7] to create the join and the Natural State field was populated.

Sites of Significance – Aquatic (SOS-A)

119. Distribution records from the New Zealand National Freshwater Fish Database (NZFFDB) between 1991 and 2006 were used to identify sites where one or more of the species identified in Ausseil and Clark (2007b) and described in Ms McArthur's Section 42A report were known to occur.

120. Each of the records in the NZFFDB is recorded as a geographical point identified by a NZMS 260 map reference, and for use in ArcView these were converted to coordinates (paragraph 109).

121. In order to provide a buffer zone of suitable habitat around each site of significance, I extended the reach from the NZFFDB point to whichever was the shortest of (Ausseil and Clark, 2007b):

- 2 km upstream and downstream of the recorded site; or
- downstream to the nearest major confluence; or
- to the source of the water body if the reach ended at a 'Natural State' boundary;

122. Small extensions to the 2 km buffer zone have also been made to link ecologically relevant habitats together to a reach of river classified as Natural State, or to the sea. This is because the species identified for classification into SOS-A are migratory, and where sites containing SOS-A species were found to be near, or within short distances to, the sea these reaches were linked together to provide for the migratory pathways.

Or where several sites were located in close proximity within a river these sites were linked together because instream habitat was likely to be contiguous (i.e. the Waikawa Stream).

123. If there was no modified REC water body that intersected the data point obtained from the NZFFDB (eg. because it occurred within a Wetland) it was displayed as a point in Schedule D of the POP.

124. For further information on the definition of SOS-A please refer to Ms McArthurs' S42A Report, Ausseil and Clark (2007b), and McArthur *et al.* (2007b)

Sites of Significance - Riparian (SOS-R)

125. Three datasets were used to create this layer[2] and James Lambie will be presenting evidence on the delineation of the Sites of Significance - Riparian for the POP in his Section 42A Report.

Amenity

126. This data comprises the location of popular swimming spots and reaches selected from the modified REC.

127. As well as the swimming spot points, I determined reaches that were important for amenity by using NZMS 260 topographic map and the modified REC to identify all reaches of river that were within the major cities and towns to the boundaries as outlined on the Topographic Map.

Trout Fishery

128. In addition to the data from previous plans (Paragraph 109), National Water Conservation Orders and Local Water Conservation Notice Rivers that related to trout fisheries were added to the Trout Fishery Value. This was done by selecting the reaches of rivers that are classified as having either a National Water Conservation Order or Local Water Conservation Notice and assigning a '1' in the Trout Fishery field[7] of the attribute table[8].

129. Coordinates provided by the Wellington and Taranaki Fish and Game Councils were used in the identification of where the Trout Fishery Value should apply and I plotted the

start and end points for each of the sites in ArcGIS. I then selected the reaches from the Horizons Modified REC that were between each of the sets of points, in order to identify where the value was located.

130. I then added in trout fishery data from the Trout Fishery Value locations identified in the Upper Manawatu Water Resource Assessment (Roygard *et al.,* 2006) and the Rangitikei River Water Resource Assessment (Roygard and Carlyon, 2004), and a consultative (Paragraph 112) map was created.

131. Following consultation, the Trout Fishery Value was further classified into three tiers (Table 11). For more information about the classification of the Trout Fishery Value, see the Section 42A Report of Ms McArthur. In order to incorporate the classification into the Horizons Modified REC I created a new attribute field[7] called 'TFClass' and added the classification wording to the table.

Table 11. Trout Fishery classification

Classification	Reason
I	The Trout Fishery was of national significance
II	The Trout Fishery was of regional significance
III	The Trout Fishery was of local significance

Trout Spawning

132. Coordinates were provided by the Wellington and Taranaki Fish and Game Councils and where the Trout Spawning Value should apply, I plotted the start and end points for each of the sites in ArcGIS. I then selected the reaches from the Horizons Modified REC that were between each of the sets of points, in order to identify where the value was located.

133. In addition to the Fish and Game Council data, Trout Spawning sites identified in previous plans (Paragraph 109) and those identified in the Upper Manawatu Water Resource Assessment (Roygard *et al.,* 2006) and the Rangitikei River Water Resource Assessment (Roygard and Carlyon, 2004) were included to create a consultative map (Paragraph 112).

Aesthetic

134. I created the Aesthetic layer[2] using river reaches identified for their Aesthetic Value, including the National Water Conservation Order and Local Water Conservation Notice Rivers by selecting the reaches from the Horizons Modified REC and assigning a '1' in the Aesthetic field[7] of the attribute table[8] (Paragraph 109).

Flood Control/ Drainage

135. James Lambie will be presenting evidence on the delineation of the Flood Control/ Drainage Value in his Section 42A Report.

Consumptive Uses

136. I created the Consumptive Uses layers[2] by extracting information from Horizons' consents database R2D2 for all current consents or those operating under existing use rights for water supply, irrigation and industrial abstraction.

137. The data from the R2D2 database is in the form of NZMS 260 map grid coordinates and was plotted in ArcMap to create the layer[2] for each of the Consumptive Use Values.

138. For the selection of water bodies upstream of a water supply I took a similar approach to that used for the selection of polygons[5] to create WMZs and WMSzs, ie. a flag was placed on the point of abstraction, the Trace Upstream tool was used and each of the river reaches within that selection was given a '1' in the attribute table[8] for being upstream of a water supply take.

Issues with using the REC to spatially define values

139. There are some inherent problems with the use of the REC to spatially represent river lines. This is because river lines in the REC do not entirely match the New Zealand Map Series 260 topographic maps (Figure 8).

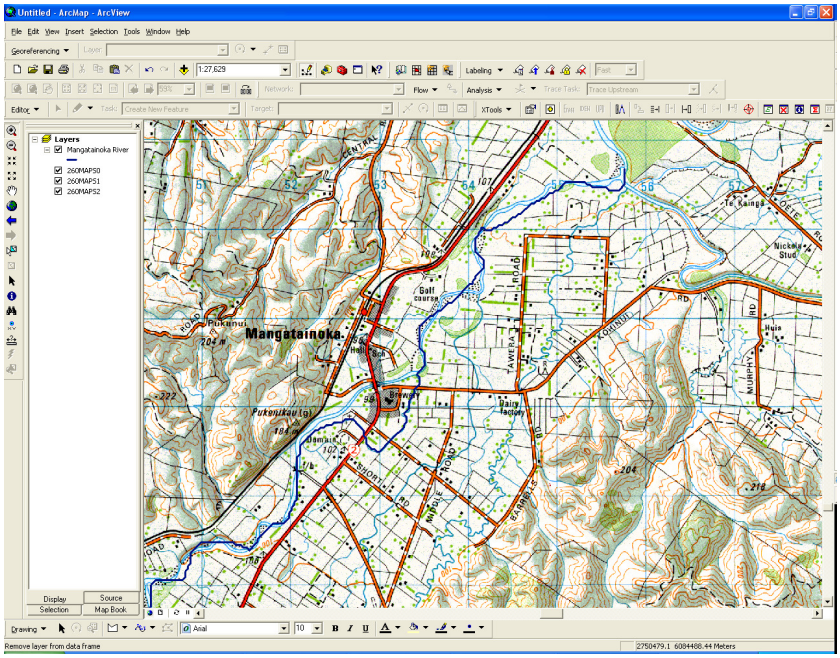


Figure 8. Mangatainoka River from the River Environment Classification (indicated by the dark blue line) in comparison to the river as shown on the New Zealand Map Series 260 Topographic Map (indicated by the light blue line).

140. This issue is relatively minor in terms of value definition for the Region and the Horizons Modified REC was not adjusted to match the NZMS260 river lines. This is because all spatial data has a degree of error depending on the co-ordinate system used to create it, and the viewing scale for the data. This error means that no one dataset will be 100% accurate with the situation in the real world.

What is Schedule D?

141. Schedule D of the POP identifies Water Body Values and proposed Water Quality Standards in order to give protection to those values, It is outside the scope of this evidence to describe standards and values, and this is covered in the Section 42A Report of Ms McArthur.

142. The WMZs and Sub-zones are the underpinning management units for the values and standards outlined in Schedule D. They provide a spatial description of:

a. The location of values; and

b. Where Water Quality Standards apply.

143. When Horizons staff began to use Schedule D it became apparent that it was difficult to negotiate and to understand the connection between Schedule D and other sections of

the POP. Bettina Anderson (Pukeko Blue) was contracted to help revise Schedule D in order to make it easier to use. Her key recommendations were to:

- Create a simple user (how-to) guide at the front of the Schedule.
- Make moving about the Schedule easier by breaking it into the key steps or content themes that link back to the how-to guide, using sub tabs (tabs on top will distinguish from side tabs),
- Provide useful additional interpretive material for users (ie. a pictorial key of aquatic fish species).
- The use of a foldout key to aid interpretation of the tables and abbreviations throughout the schedule. This key would fold out from A4 to A3 to provide context to the reader when viewing tables throughout the Schedule.
- A larger A3 master WMZ map with each of the master catchments presented in D2-D8. This map should include spatial locators such as towns and roads to aid in identification of the WMZ or WMSz where a proposed activity will take place.
- An interactive digital schedule would solve most problems related to the location of a proposed activity within a WMZ or Sub-zone, and identification of the reach-specific values that apply to the activity (see Paragraphs 158-160 for more explanation).
- Orienting all tables to landscape to make the tables easier to read with the foldout key.
- Label maps clearly as a visual guide only, to encourage the use of the tables to identify if a reach-specific value is present in the water body where the activity is proposed to be undertaken.
- Provide simple, short introductory/context statements for each data table/map.
- Ensure table names are copied onto the top of each page to help the user identify which value they are looking at the whole way through the Schedule.

144. I then undertook a revision of Schedule D to accommodate these recommendations. I also included the recommendations from the Section 42A Report of Ms McArthur and applied them throughout the Schedule. The revised Schedule D is provided in the Track Changes version of changes to the POP.

Proposed Revisions to Schedule D and C

145. Because WMZs, Sub-zones and values are the underpinning framework for water management in the POP, it is proposed that the Surface and GWMZs and Surface Water Values are removed from Schedule C and Schedule D and placed in a Schedule in front of Schedule B. This altered Schedule is presented as 'Schedule Ba' in the Track

Changes version of the POP. WMZ, values and standards information presented below will refer to the table numbers in the Track Changes Version of the POP.

146. Therefore, Schedule D will then only contain Water Quality Standards, and Schedule C will only contain allocation limits for groundwater as identified in the Section 42A Report of Mr Zarour.

Proposed Schedule Ba

147. The Proposed Schedule Ba will contain the WMZs, WMSzs, GWMZs and the values information from Schedule C and Schedule D. Schedule Ba will be sectioned into:

a. Part Ba1 – Management Zones and Sub-zones

b. Part Ba2 - Values

General Changes to Schedule Ba

148. I have developed a user guide that can be used alongside the plan that:

a. Provides an explanation of the importance of the WMZ, WMSz and the Values Framework in interpreting the provisions of the POP; and

b. Guide readers of the POP on how to identify:

i. In which WMZ, Sub-zone or Ground WMZ the proposed activity will take place.

ii. For activities taking place within the surface water provisions of the POP, which Water Management Values apply to the zone in which the activity will take place.

c. Provides 'real-life' worked examples for common activities where the Schedule would be used.

d. Provides trouble-shooting options for non-specialist users as to how to access some of the critical tools needed for interpretation. For example, "Call the Horizons Regional Council Customer services Freephone 0508 800 800 and ask for a staff member to help identify your WMSz".

149. A Table of Contents is provided at the front of Schedule Ba to help guide users through the framework.

150. To provide clarity, a summary of the context of the changes associated with Schedule Ba are presented in Table 12. It is recommended that the reader has a copy of Schedule D of the POP and the proposed Schedule Ba from the Track Changes version of the POP to make following the changes outlined in the table easier.

Table 12. Suggested changes to information previously in Schedule D and now presented in Schedule Ba

General		
Change	**Explanation**	**Further Evidence**
Ba1.2 heading	Clarity of content	
All of the Values tables have had Sub-zone code added under the Sub-zone name	Clarity	
Map reference in all table headers in the POP Schedule D denoting where a value applies has been changed to locality description in Schedule Ba	Clarity	
The Life Supporting Capacity table has been removed	This table is already incorporated into Table Ba10 and does not provide any additional information, so is superfluous	
Native Fish Spawning has been changed to Inanga Spawning throughout the Schedule	The sites identified as Native Fish Spawning only reflect the location of Inanga Spawning. Therefore Inanga Spawning is a more accurate label	Horizons Regional Council staff submission. Kate McArthur S42A
Native Fishery is changed to Whitebait Migration throughout the Schedule	The sites identified currently only apply to the whitebait fishery. The word fishery has been replaced with migration as the harvest of these species is not under statutory management of the Regional Council	Kate McArthur S42A
All Values maps have been replaced with modified maps	Unless otherwise specified, this is to allow for the proposed changes to WMZs and Sub-zones	Paragraphs 82-87 Raelene Hurndell S42A Dr Jon Roygard S42A
Captions for all tables have been moved to the top row and repeated on each page	This is to allow the user to know what table is being looked at when a table crosses many pages.	
General spelling and grammatical changes throughout the schedule	Clarity and consistency	
Tables and Maps Ba1 - 8		
Change	**Explanation**	**Further Evidence**
Addition of Table Ba1	To help the user identify their WMZ by parent catchment and Zone Code, by referring to Map Ba1	
Addition of Tables Ba2 – Ba8	To help the user identify their WMSz by WMZ name or Code	
Map Ba1 only shows WMZs, as opposed to previously showing both WMZs and WMSz's	To help the user identify the WMZ in which the activity will take place and refer the user to Maps Ba2 – Ba8 for the Sub-zone detail	

Map Ba1 has a change in boundary line between Mangatainoka and Tiraumea WMZs	This is to reflect the move of the Mangaramarama from the Mangatainoka to the Tiraumea Sub-zone	Paragraph 82 Raelene Hurndell S42A Dr Jon Roygard S42A
More localities are identified and labelled in maps Ba1 – Ba8 and these maps are A3 foldouts	This is to provide easier navigation around the map and identification of which WMZ an activity will take place in	
Map Ba2 the Management Zone boundary line between Mangatainoka and Tiraumea WMZs has changed.	This is to reflect the move of the Mangaramarama from the Mangatainoka to the Tiraumea Sub-zone	Paragraph 82 Raelene Hurndell S42A Dr Jon Roygard S42A
Map Ba4 has more Sub-zones in the Pipiriki WMZ	This is to reflect the alignment of the Manganui o te Ao Sub-zones with the National Water Conservation Order.	Paragraphs 83 & 84 Raelene Hurndell S42A Dr Jon Roygard S42A
Map Ba5 has the addition of the Makara Sub-zone to the Lower Whangaehu	This is to better align with water allocation	Paragraph 85 Raelene Hurndell S42A Dr Jon Roygard S42A
Map Ba8 has had a) the Lake Horowhenua Sub-zone added, and b) the new Manukau Sub-zone added to the Waikawa WMZ	a) Unintended exclusion of the Horowhenua WMZ in the map for the POP and; b) To reflect additional WMSzs recommended in other officers' reports	b) Paragraph 86
All maps and tables for consumptive uses have been removed from Schedule Ba	Consumptive uses are zone-wide values that apply everywhere, except where there is no allocation. The maps and tables in the POP Schedule D only reflect where there were abstractions at the time of notification of the POP, and not where the value applied. Therefore, maps were not informative.	Kate McArthur S42A
Southern Whanganui Lakes has had the letter 'h' added into Wanganui	Consistency	
Map and Table Ba 9		
Change	**Explanation**	**Further Evidence**
Addition of the GWMZs Map (Ba9)	To bring the entire WMZ Framework under one Schedule	

In Map Ba9 and Table Ba9 the addition of the East Coast, Northern Rangitikei and Northern Whanganui GWMZs.	To incorporate changes to GWMZs	Hisham Zarour S42A Paragraph 88 and Map 17
In Map Ba9 the Eastern GWMZ has been renamed as Tararua GWMZ and the spelling of Horowhenua in the map has been corrected	Following recommendations from other officers reports	Hisham Zarour S42A Paragraph 88 and Map 17
Table Ba10		
Change	**Explanation**	**Further Evidence**
Table Ba10 has had a user guide note included to: guide uses to look for the values key	Clarity and ease of use of the Schedule.	
Table Ba10 Sub-zone description the sub-zone description column has had the following changes: a) changes to the descriptions to make them from the most downstream point of the WMSz to the most upstream b) The addition of the words from approx NZMS 206	Consistency throughout the schedule	
Shellfish gathering is removed from Recreational and Cultural Values in the Values Key and also removed from Table Ba10	To reflect removal of the values within the CMA from Schedule Ba and into Schedule H	Kate McArthur S42A
The CMA Management Zone Area has been removed from Table Ba10	To reflect movement of the CMA into Schedule H of the POP	Kate McArthur S42A
In Table Ba10, the Mangaramarama WMSz has been moved out of the Mangatainoka WMZ and into the Tiraumea WMZ	To reflect the move of the Mangaramarama Sub-zone from the Mangatainoka to the Tiraumea WMZ	Paragraph 82 Raelene Hurndell S42A Dr Jon Roygard S42A
In Table Ba10, the Upper and Lower Tiraumea Sub-zone descriptions have been corrected from the Ngaturi Confluence to the Makuri Confluence	To correct a typing error. The Ngaturi is the flow recorder related to the WMZ, and not a confluence, whereas the Makuri Confluence is the boundary between the upper and lower Tiraumea WMZs	

In Table Ba10, the Sub-zone descriptions for all WMSzs that previously contained a River with a defined CMA boundary in Schedule H of the POP have been changed to make the CMA boundary the cut-off for that Sub-zone	To reflect the removal of the CMA from Schedule Ba to Schedule H and the inclusion of the Estuary WMZs in Schedule H	Paragraphs 17 and 72-79 Kate McArthur S42A
In Table Ba10, the addition of the WMSzs that have been changed or added in the Manganui o te Ao, Waikawa and Lower Whangaehu into the table	To reflect the changes proposed to the WMSzs.	Paragraph 17 and 83-86 Raelene Hurndell S42A Dr Jon Roygard S42A
In Table Ba10, Water Supply, Irrigation and Industrial Abstraction Values have been moved from reach-specific to Zone- wide values. Ticks have been added to reflect where these values are now recognised and removed from Zero Allocation Zones	To better reflect the water allocation policy whereby all water bodies are valued for Allocation, with the exception of those identified for zero allocation	Kate McArthur S42A Raelene Hurndell S42A
In Table Ba10, Trout Fishery and Amenity Values have been moved to become reach-specific values	To reflect recommendations in officers' reports	Kate McArthur S42A
In Table Ba10, existing infrastructure has been added as a Zone-wide value and ticks added to all WMZs	This was mistakenly left off of the initial table in the POP Schedule D.	Kate McArthur S42A
In Table Ba10, Drainage /Flood Capacity Values have been added as reach-specific and Ticks have been added to the Flood Control/Drainage column where the value applies	To reflect the definition of the Value	James Lambie S42A
In Table Ba10, Aesthetic has had a) the tick removed from the Mangaramarama; b) a tick added to the Middle Manawatu sub-zone and; c) ticks added to Makatote, Waimarino, Middle Manganui o te Ao, Mangatururu and Orautoha Sub-zones	a) & c) To reflect changes to the WMZ framework and allow for inclusion of this value in these Sub-zones where is applied already. NB: this is not the addition of new reaches for the Aesthetic Value but reflects changes to the WMSz's that this value now applies within) b) To reflect recommendations in officers' reports and better align with Table D.12 of the POP	a) and c) Paragraphs 17 and 83-86 b)Kate McArthur S42A

In Table Ba10, Stockwater, Mauri and Contact Recreation, have had ticks added. Ticks have been added to a number of WMSzs.	a) To reflect changes to the WMZ framework; and b) To allow for inclusion of this value in all sub-zones where the value applies. NB: this is not the addition of new reaches for the specified values but the reflection of changes to the WMSz's that this value now applies within	Kate McArthur S42A
In Table Ba10, the existing infrastructure water supply, irrigation abstraction and industrial abstraction have had ticks added.	a) To reflect the zone-wide nature of these values; b) To align with the Water Allocation Framework for water supply, irrigation abstraction and industrial abstraction; and c) To reflect changes to the WMZ framework.	Raelene Hurndell S42A
In Table Ba10 Trout Fishery has had a trout fishery class 'I' placed in the Makatote, Waimarino, Middle Manganui o te Ao, Mangaturuturu and Orautoha Sub-zones	To reflect changes to the WMZ frame work and allow for inclusion of this value in these sub-zones where is applied already. NB this is not the addition of new reaches for the Trout Fishery value but the reflection of changes to the WMSz's that this value now applies within	Paragraphs 17 and 83-86
In Table Ba10, Trout Spawning has had ticks placed in the Makatote, Middle Manganui o te Ao and Orautoha Sub-zones	To reflect changes to the WMZ framework and allow for inclusion of the Trout Spawning Value in those Sub-zones where is applied already. NB: this is not the addition of new reaches for the Trout Spawning Value but the reflection of changes to the WMSz's that this value now applies within	Paragraphs 17 and 83-86
In Table Ba10, Natural State has had ticks placed in the Middle Manganui o te Ao, Mangaturuturu, Waimarino, Makatote, and Makara Sub-zones, and has had the tick removed from the Upper Makotuku Sub-zone.	To reflect changes to the WMZ framework and allow for inclusion of this value in those Sub-zones where is applied already. NB: this is not the addition of new reaches for the Natural State Value but the reflection of changes to the WMSzs that this value now applies within	Paragraphs 17 and 83-86
In Table Ba10 Natural State has had ticks placed in the Upper Ohau, Waikawa and Manukau Sub-zones	To reflect the intention of this value an error in processing has meant that the streams with their source in the Tararua Forest Park in these Sub-zones were not originally selected and should have been.	
In Table Ba10 Water Supply ticks have been removed from the Upper Rangitikei, Upper Moawhango and Middle Moawhango Water Management Sub-zones	To reflect the Water Allocation Framework as these are zero Allocation Sub-zones.	Raelene Hurndell S42A
The description of the Whai_4a Sub-zone has been changed to remove Wades Landing/Whakahoro Reference	To reduce confusion	
Map Ba 11		

Change	Explanation	Further Evidence
The Natural State Map Ba11 has been changed to include all Order One streams	This is for clarity as there is not table describing reach by reach where this value applies	
The Natural State Map Ba11 has had the reaches within the Upper Ohau, Waikawa and Manukau Sub-zones that have their source in and flow within the Tararua Forest Park included	Accidental omission from POP Schedule D	
Map and Table Ba 12		
Change	**Explanation**	**Further Evidence**
Table Ba12 has had the Waimarino Stream Site of Significance -Aquatic added	Unintended exclusion in the notified table but was in Map D11	
Table Ba12 has had c) whio SOS-A sites added to the Upper Whanganui, Upper and Lower Whakapapa and Waimarino WMSZs; and d) corrections to co-ordinates in the Mangatepopo Stream, Whanganui River and Whakapapa/Whakapapiti Stream rows	Additional information provided after notification of the POP	Appendix 4 of the staff submissJ ames Lambie S42A
Map Ba12 has had the following changes: a) The key has Brown Mudfish site as a point, this has been changed to Site of Significance - Aquatic. b) The data presented in the map has been changed to remove the CMA	a)To reflect recommendations in the other officers' reports: and b) To remove sections of water bodies that contain the SOS-A Value within the CMA, as this information is now in proposed Schedule H	Kate McArthur S42A
Species names in the Sites of Significance - Aquatic Table (Ba12) have had capitals removed and 'dwarf galaxid' has been changed to 'dwarf galaxias'	To reflect the correct scientific naming convention	Kate McArthur S42A
In Table Ba12, the Mangawhararikiri River in the Pukeokahu-Mangaweka WMSz has had the species changed.	To correct an error in the manual transcription of the table in the POP.	
In Table Ba12, the coastal Rangitikei (Rang_4b) row has been moved from below the Tutaenui to above it	To remedy an error in this table with regard to the location of the WMZ and align with the naming convention.	

In Table Ba12, the locality description of the Mowhanau and Waikawa Streams has been changed	To reflect the removal of the CMA section of the river from Schedule Ba to Schedule H for the Waikawa, and to align the Mowhanau Stream with the location where that the value applies.	Paragraphs 17 and 72-79 Kate McArthur S42A
In Table Ba12, the addition of the new WMSzs has resulted in changes in the table. This is not the addition of new data but just showing where the data is located now that the newly proposed Sub-zones have been added	To reflect that the Upper and Lower Manganui o te Ao have been further divided and place each of the streams that the values identified apply into the right WMSz. NB this is not new data.	Paragraphs 17 and 83-84 Raelene Hurndell S42A Dr Jon Roygard S42A
Map and Table Ba 13		
Change	**Explanation**	**Further Evidence**
Map Ba13 has had changes to the data presented and changes to the table where there have been defined CMA boundaries in Schedule H of the POP. NB: the tidal Rangitikei SOS - R has been removed completely from this Schedule and placed in Schedule H as a result	This is to reflect the removal of values occurring within the CMA and placement of these values in Schedule H	Paragraphs 17 and 72-79 Kate McArthur S42A
In Table Ba13, the naming of the Manawatu Weber-Tamaki and Tamaki-Hopelands Sub-zones has been changed	To reflect the correct naming convention for those Sub-zones	
Map and Table Ba 14		
Change	**Explanation**	**Further Evidence**
In Map Ba14 and Table Ba14 e) the Mangaramarama Creek Aesthetic value has been removed.	To reflect changes recommended in other officers' reports	Kate McArthur S42A
Table Ba14 has been changed to reflect the addition of more WMSzs in the Manganui o te Ao	To reflect that the Upper and Lower Manganui o te Ao have been further divided and place each of the streams that the values identified apply into the right WMSz. NB: this is not new data.	Paragraphs 17 and 83-86 Raelene Hurndell S42A
Map and Table Ba 15		
Change	**Explanation**	**Further Evidence**

Map Ba15 and Table Ba15 have been changed to a) remove the water bodies valued for Inanga Spawning occurring within rivers that have a CMA description in the POP Schedule H. NB: the Coastal Whanganui Inanga Spawning site has been removed completely from this schedule and placed in Schedule H; and b) to reflect naming changes to the value.	To reflect changes recommended in other officers' reports and relocation of CMA values from Schedule Ba into Schedule H	Kate McArthur S42A
The description of the Lake Papaitonga reaches has changed	To better reflect the map	
Map and Table Ba 16		
Change	**Explanation**	**Further Evidence**
All Amenity sites within the CMA have been removed from Map Ba16 and Table Ba16.	To reflect changes recommended in other officers' reports and relocation of CMA values from Schedule Ba into Schedule H	Kate McArthur S42A
Map and Table Ba 17		
Change	**Explanation**	**Further Evidence**
Map Ba17 and Table Ba17 have been changed to remove the water bodies valued for Whitebait Migration occurring within rivers that have a CMA description in the POP Schedule H, and to reflect naming changes to the value. NB: the Lower Turakina Whitebait Migration site has been removed completely from this schedule and placed in Schedule H	To reflect changes recommended in other officers' reports and relocation of CMA values from Schedule Ba into Schedule H	Kate McArthur S42A
In Table Ba17 the spelling of Lake Papaitonga has been corrected	Grammatical error	
The description of the Lake Papaitonga reaches has changed	To better reflect the map	
Map and Table Ba 18		
Change	**Explanation**	**Further Evidence**
In Table Ba18, the Management Zones in the first row, Hopelands-Tiraumea, have been changed	To reflect the proper name of the WMZ	

In Table Ba18, the reference to the Mangaramarama Creek in the River column has been removed	To reflect removal of the Mangaramarama from the Mangatainoka WMZ into the Tiraumea WMZ	Paragraph 82
Map Ba18 and Table Ba18 have been changed	To remove the water bodies valued for Trout Fishery occurring within rivers that have a CMA description in the POP Schedule H	Kate McArthur S42A
In Table Ba18, the addition of the new WMSzs has resulted in changes in the table. This is not the addition of new data but just showing where the data is located now that the newly proposed sub-zones have been added	To reflect that the Upper and Lower Manganui o te Ao have been further divided and place each of the streams that the values identified apply to the right WMSz, and the further Sub-zone in the Lower Whangaehu Catchment. NB: this is not new data	Paragraphs 17 and 83-86 Raelene Hurndell S42A
Map and Table Ba 19		
Change	**Explanation**	**Further Evidence**
In Table Ba19, the Upper and Middle Pohangina have been moved out of the Upper Gorge WMZ row and into the Middle Manawatu WMZ row	This was mistakenly placed in the wrong Management Zone row so has been moved to the correct one.	
In Table Ba19, the addition of the new WMSzs has resulted in changes in the table	To reflect that the Upper and Lower Manganui o te Ao have been further divided and place each of the streams that the values identified apply to into the right WMSz , and the further Sub-zone in the Lower Whangaehu Catchment. NB: this is not new data.	Paragraphs 17 and 83-86 Raelene Hurndell S42A
The words to source have been added to the Mangatwainui Sub-zone description	To better reflect the map	
The reference to the Mangaiora Stream in the Oroua WMZ has been changed to Mangahuia Stream	To reflect the correct name on the NZMS 260 topographic map	
Map and Table Ba 20		
Change	**Explanation**	**Further Evidence**
Table and Map Ba20 have been added to show where the Flood Control/Drainage Value applies	This was previously unmapped	James Lambie S42A
Values Key		
Change	**Explanation**	**Further Evidence**
Table D1 from the POP has been moved out of Schedule D and placed at the back of Schedule Ba as a Values Key	Clarity	

The Values Key has a column headed Location in Schedule Ba, including a page reference for each of the values in Schedule Ba.	Clarity and ease of movement throughout the Schedule	
The legend from Table D2 of the POP has been removed to a fold-out key at the back of the Schedule	Clarity and ease of recognition of what the heading row of the table represents, without having to turn back to the first page of Table Ba10 to look up what the value means	
The HSS LSC class has been added to the legend in the fold-out key	Unintended exclusion in POP	
WQS (Water Quality Standard) has been deleted from the legend in fold-out key	This column is not in the table in the POP or the revised Schedule Ba	
In the Values Key the definition of Existing Infrastructure has been changed	This is due to a copy and paste error not representing what the value is recognised for	Kate McArthur S42A

Revised Schedule D

151. Schedule D will only contain Water Quality Standards now that the Values and Management Zones have been moved to Schedule Ba.

General Changes

152. I have developed a user guide that can be used alongside the plan that:

a. Provides an introduction to water quality standards

b. Guide readers of the Plan on how to identify:

i. Which WMZ, Sub-zone or Ground WMZ the proposed activity will take place in by directing the user back to Schedule Ba; and

ii. Direct users who are planning to undertake an activity within the CMA to look at the standards in the revised Schedule H.

c. Provides 'real-life' worked examples for common activities where the Schedule would be used.

d. Provides trouble-shooting options for non-specialist users as to how to access some of the critical tools needed for interpretation (eg. "Call the Horizons Regional Council Customer services Freephone 0508 800 800)".

153. A Table of Contents is provided at the front of the schedule to help guide plan users through the framework.

154. To provide clarity, a summary of the context of the changes associated with Schedule D is presented in Table 13. It is recommended that the reader has a copy of Schedule D of the POP and the Track Changes version of Schedule D to make following the changes outlined in the table easier.

Table 13. Suggested changes to Water Quality Standards in Schedule D

General Changes		
Changes	**Reason**	**Reference**
Table D.19 and D.20 from the POP have been removed.	To reflect recommendations of the other officers' reports	Kate McArthur S42A Max Gibbs S42A
Table D.18 and reference to *"lowland"* lakes water quality standards has been removed	To reflect recommendations of the other officers' reports	Kate McArthur S42A
Water Quality Standards for the marine coastal water bodies have been removed	To reflect all aspects of water management relating to the CMA being placed in Schedule H	Kate McArthur S42
BOD_5 has now been changed to $sCBOD_5$ throughout the Schedule	Recommendations in other officers' reports	Dr John Quinn S42A Kate McArthur S42A
All units have been changed from mg/m^3 to g/m^3 throughout the Schedule	Recommendations in other officers' reports	Kate McArthur S42A
All headers where DO shows a 'less than' sign have been changed to a 'greater than' sign	Recommendations in other officers' reports	Kate McArthur S42A
All standards that had flow requirements in the POP Schedule D for three times median flow have been changed to apply at 20^{th} percentile flow	Recommendations in other officers' reports	Kate McArthur S42A Staff Submission Dr Barry Biggs S42A
Ammonia in the Schedule has been changed to refer to Ammoniacal Nitrogen	Recommendations in other officers' reports	Kate McArthur S42A Dr Bob Wilcock S42A
Turbidity Standards have been removed from Schedule D	Recommendations in other officers' reports	Kate McArthur S42A Dr Rob Davies-Colley S42A Max Gibbs S42A
Chla has been changed to Chl *a* throughout the schedule	To reflect the proper naming of the species	
The toxcicity < has been changed to % throughout the Schedule	Clarity	
<m in the column headers of all tables has been replaced with < 50^{th} %ile	Consistency	

Table D1a		
Changes	**Reason**	**Reference**
Table D1a Standards that apply to all natural Stream and River Waters	These are not new standards, just the additional water quality standards from page D-88 of the POP in tabular format for consistency.	
The exclusion of the Blue Green Algal toxin Standard from the table	Recommendations in other officers' reports	Kate McArthur S42A
A % cover standard shall be included of no more than 60% cover of diatoms/cyanobacteria more than 0.3cm thick	Recommendations in other officers' reports	Kate McArthur S42A Barry Biggs S42A
The Periphyton % Cover standard is moved from Table D.17 and into Table D1a	Because there is only one standard that applies to all water bodies	
A 20% change standard for QMCI has been added with a footnote explaining this standard is only applicable to point sourced discharges	Recommendations in other officers' reports	Kate McArthur S42A Dr John Quinn S42A
Table D2a (Table D17 from the POP)		
Changes	**Reason**	**Reference**
In Table D2a, the lower $sCBOD_5$ standard of 1 g/m^3 has been changed to 1.5g/m^3 and shall only apply at flows less than 20th percentile	Recommendations in other officers' reports	Kate McArthur S42A Dr John Quinn S42A
In Table D2a, the 165mg/m^3 for the Mangaore has been changed to 0.167g/m^3	To correct a typo and incorporate recommendations in other officers' reports	Kate McArthur S42A
The Temperature Change standard has had a footnote excluding stream restoration plantings	Recommendations in other officers' reports	Dr John Quinn S42A
The POM Standard will change to 5g/m^3 for all rivers in the Region and only apply when the flow in the river is equal to or less than median (50th percentile flow)	Recommendations in other officers' reports	Kate McArthur S42A Dr John Quinn S42A

The QMCI Standard has been changed to MC with the addition of a footnote outlining the methodology for soft bottomed streams: • a MCI score of 100 has replaced the QMCI Standard of 5; and • a MCI score of 120 has replaced the QMCI Standard of 6;	Recommendations in other officers' reports	Kate McArthur S42A Dr John Quinn S42A
Horizontal visibility (black disc) standards from Ausseil & Clark (2007c) Table 24 at flows less than median (50th percentile) have been inserted to Schedule D	Recommendations in other officers' reports	Kate McArthur S42A Dr Rob Davies-Colley S42A Ausseil and Clark (2007c)
The addition of the new WMSzs and adding of the standards that applied from the sub-zone the new zones were originally part of. For example the Waimarino Sub-zone standards are the same as the Upper Manganui o te Ao Standards from the POP with the exception of any changes recommended to standards	To reflect that the Upper and Lower Manganui o te Ao, Upper Makotuku and Waikawa have been further divided and place each of the streams. NB: this is not a new standard, just carry- over from the original Sub-zone.	Paragraphs 17 and 82-86 Raelene Hurndell S42A
Table D3a		
Changes	**Reason**	**Reference**
Table D3a Standards for trout Spawning has been added	These are not new standards, just the additional water quality standards from page D-92 of the POP in tabular format for consistency	
Table D4a		
Changes	**Reason**	**Reference**
Table D4a Standards For Natural Lakes And Lake Catchments have been added.	This incorporates the standards on pages D-88 to D-89 of the POP and includes recommendations from other officers' reports for changes to the numerical standards for lakes	Kate McArthur S42A Max Gibbs S42A
A definition of lakes where water quality standards apply has been added that is consistent with the provisional determination on Schedule E	Recommendations in other officers' reports	Kate McArthur S42A
The addition of a Deep and Shallow lake definition	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A

The standards are now split out over the two lake categories ie. Deep And Shallow lakes	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
pH change standard is excluded from the table	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
Temperature change standard is excluded from the table	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
Dissolved Oxygen Standard is removed from this table	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
The $CBOD_5$ Standard is removed from this table	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
Average Algal biomass and Maximum Algal Biomass standards have been specified for each of the lake types	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
An annual average Total Phosphorus Standard has been applied for each of the lake Types	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
An annual average Total Nitrogen Standard has been applied for each of the lake types	Recommendations in other officers reports	Kate McArthur S42A Max Gibbs S42A
The Ammoniacal Nitrogen Standard only applies when lake pH exceeds 8.5	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
A Clarity Standard has been added for each of the lake types with a footnote defining the black disc equivalent measure	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A
The exclusion of the Blue Green Algae Standard from the table	Recommendations in other officers reports	Kate McArthur S42A
A Euphotic Depth Standard has been added	Recommendations in other officers reports	Kate McArthur S42A Max Gibbs S42A
Standards Key		
Changes	**Reason**	**Reference**

The Standards key contains the wording for each standard identified in Tables D1a-D4a. Original data from Table D17 has not been underlined but additional data from the Lake and other standards that has been included has been underlined	Clarity - this takes the original table D17 from the POP and adds the narratives for the other standards to it	
The flow at which the SIN and DRP Standards apply is changed to at or below 20th percentile flow	Recommendations in other officers' reports	Kate McArthur S42A Dr Barry Biggs S42
Standard spelt out in the heading has been changed to full wording of the standard	Clarity	
The column header in the key has been changed to abbreviations in Tables D1a–D4a	Clarity	
The word 'changed' has been replaced with 'reduction in the Clarity' % change explanation	Recommendations in other officers' reports	Kate McArthur S42A Dr Rob Davies-Colley S42A
$sCBOD_5$ has the words a) filtered soluble carbonaceous biochemical oxygen demand added (NB: biological has changed to biochemical) b) The addition of a flow category when the standard applies c) This standard is a monthly average.	Recommendations in other officers' reports	Kate McArthur S42A Dr John Quinn S42A
The Periphyton Standard rows have had river and lake standards spelt out separately		
The addition of a % change in QMCI Standard downstream narrative	Recommendations in other officers' reports	Kate McArthur S42A
The addition of the word Community to the MCI and QMCI standard wording	Clarity	
The addition of a statement for the SIN standard reading unless natural levels exceed the standard	Recommendations in other officers' reports	Kate McArthur S42A
The addition of a narrative for Lake Ammoniacal Nitrogen	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A

The narrative Turbidity Standards have been removed from this table	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A Dr Rob Davies-Colley S42A
The addition of a narrative for Clarity Standards for rivers and lakes	Recommendations in other officers' reports	Kate McArthur S42A Dr Rob Davies-Colley S42A Ausseil and Clark 2007c
The addition of a narrative for Euphotic Depth Standards	Recommendations in other officers' reports	Kate McArthur S42A Max Gibbs S42A Dr Rob Davies-Colley S42A

Issues of Scale with the Maps:

155. The current scale of the WMZ, WMSz and Values maps make it difficult to identify exactly which WMSz an activity is occurring in. There are two options for remedying the issue of scale for using the paper copy of the Plan:

i. Including in Schedule Ba a series of 20 1:150,000 scale maps covering the Region for each of the values and one A3 Map for each WMZ.

ii. Providing an electronic copy of Schedule Ba that includes all layers[2] in the Schedule, and identifying layers[2] such as roads, towns, cities and land parcels.

A series of 1:150,000 Maps for Schedule Ba

156. Creating a series of 20 maps for each of the values at 1:150,000 would add an extra 240 maps to the Plan as well as an extra 44 maps for the larger scale WMZ maps.

157. In my opinion it will not be any easier to find out where a value applies with larger scale paper maps, as it will be difficult to navigate through the maps to find the page required for each value.

An electronic Schedule Ba

158. An electronic copy of Schedule Ba with the Values and WMZs and Sub-zones pre loaded can be created. Users can only zoom into the visible extent of any layer[2]. Users will be able to zoom into any given location and switch on or off values to see if they apply to the proposed activity. This method of viewing the values will reflect the way Horizons carries out values assessments currently.

159. Users of an electronic schedule will be able to zoom into their specific area of interest and use an information tool to query what values apply to the area in which they wish to undertake an activity. This is a very user friendly technology that is easily implemented. User notes would be provided to assist those less familiar with mapping programmes.

160. In my opinion, the electronic version of the Schedule would be the best option to ensure non-specialists can use it successfully.

Using New Zealand Map Series 260 Map References in Preference to New Zealand Transverse Mercator

161. As of September 2009 all New Zealand Map Series (NZMS) 260 Topographic maps will replaced by a new Topo 50 Map series of in the New Zealand Transverse Mercator (NZTM) projection[15]. The new Topographic Maps, as well as having a different co-ordinate system, will be A1 portrait sheets instead of the landscape sheets of the NZMS 260 maps. Horizons will begin changing the organisational fundamental data layers[2] into the NZTM projection in September to align all internal electronic datasets with national systems. It will take longer for paper maps to be changed for all users.

162. As a result of this, the NZMS 260 Map references will over time become redundant and this may have implications for the map references used throughout the POP. However, due to the manual nature of changing the coordinates in Schedule Ba there has been no move yet to change the references from NZMS to NZTM, although it can be done if required. Internally Horizons has the ability to convert and work with both, however, non-specialists do not. It should be noted that the Land Information New Zealand website provides a coordinate conversion tool that can convert coordinates and map references between NZMS260 and NZTM. However, this is a manual process allowing five coordinates to be manually entered at a time to the website; they are then translated to a coordinate in NZTM and then need to be further calculated into a map reference.

163. Further, it is envisaged that most users of the plan will be familiar with, and likely have copies of, the NZMS 260 maps. Should a move to NZTM be instigated in the One Plan, it would be useful to retain the old NZMS 260 references also for this reason, although this would make the values tables more confusing. A changeover between the coordinate systems should not be immediate and a phase-in, phase-out period where the two systems overlap is appropriate.

Discharge Monitoring Programme

164. Horizons carries out water quality monitoring within its Region under two major monitoring programmes, run in conjunction with each other. These provide a cumulative picture of the state of freshwater quality and the impacts of sources of contaminants throughout the Region. The two programmes are known as the State of the Environment (SoE) Monitoring Programme and the Discharge Monitoring Programme.

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[15] A projected co-ordinate system is any system designed for a flat surface such as a printed map or a computer screen because the earth is spherical a projection is required to transform the spherical data to fit the purpose of the display.

165. The SoE programme measures water quality at 60 SoE monitoring sites throughout Horizons' Region on a monthly basis. The main underlying factors for determining site location were the presence of a continuous flow recorder and proximity to the bottom of a catchment under resource pressure. For more information on the SoE Monitoring Programme and results, see the S42A reports of Ms McArthur and Dr Roygard.

166. The Discharge Monitoring Programme was the result of attempts (Leiden *et al.*, 2007; McArthur and Clark, 2007; Roygard and McArthur, 2008) to quantify the impact that major point source discharges were having on water quality throughout the Region, and by inference determine the non-point sourced loads.

167. McArthur and Clark (2007) found it difficult to accurately quantify the contaminant contribution that point source discharges were having on downstream SoE monitoring sites, due to scarcity of samples from discharges collected on the same day as SoE samples. Each site was often only monitored once or twice a year for compliance purposes and self monitoring data from consent holders was generally unusable; additionally, there was little or no available flow data to calculate loadings of contaminants at many sites.

168. The current Discharge Monitoring Programme has been operating in the Manawatu, Owahanga and Whangaehu River catchments since July 2007, monitoring a total of 26 major discharges (20 of which occur in the Manawatu catchment) and was extended to include major discharges to the Rangitikei River catchment in July 2008, thus adding a further eight discharges to the programme. It was again extended to include the Whanganui catchment discharges (a further three discharges) in July 2009.

169. The coordinated sampling regime for these two water quality programmes means that discharges and rivers are monitored on the same day and under the same flow conditions, better quantifying the effect of discharges on the receiving environment. This results in the ability to determine relative contributions of point and non-point source contamination of surface waters in the Region.

170. The main aim of the two integrated monitoring programmes is to improve understanding of the impact of point source discharges on general water quality, then to take this a step further by determining cumulative effects and the contribution of each discharge to downstream water quality monitoring sites. This enables calculation of relative inputs from point source discharges and, by proxy, the ability to determine the non-point source

contributions of contaminants within a catchment area. The monitoring data is communicated to stakeholders in near real time on Horizons' WaterQuality Matters Website (for more information on the WaterQuality Matters Website see the S42A Report of Dr Roygard)

171. I have been involved in the analysis of data collected as a result of the combined Discharge and SoE monitoring programmes. The analysis I have undertaken of the results from the first two years of monitoring has led to further refinement of the monitoring programme, to ensure that the discharges are being monitored in the correct location so the results are meaningful and provide an increased understanding of the effects of the monitored discharges on the receiving environment. The data from this analysis has also contributed to identifying the Water Management Sub-zones that do not meet the proposed nutrient and *E. coli* standards within Schedule D of the Proposed One Plan, in Appendix 1 of the S42A Report of Ms McArthur. However, a shortcoming of this monitoring programme is the lack of availability of continually monitored discharge volumes at a number of sites.

172. Ideally, all of the discharges in the Region should have flow meters recording the discharge and transmitting the information back to Horizons' telemetry system, to enable calculation of known loads of contaminant attributable to the discharge (for more information see the S42A Report of Dr Roygard).

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