BEFORE THE FRESHWATER HEARING PANEL

AT WELLINGTON / TE WHANGANUI-A-TARA

IN THE MATTER OF	the Resource Management Act 1991
AND	
IN THE MATTER	of submissions and further submissions on Proposed Change 1 to the Natural Resources Plan for the Wellington Region
AND	**The Royal Forest & Bird Protection Society Inc**

STATEMENT OF EVIDENCE OF THOMAS JAMES KAY ON BEHALF OF THE ROYAL FOREST AND BIRD PROTECTION SOCIETY INC

Hearing Stream 2

(Natural Form and Character)

14 March 2025

Royal Forest and Bird Protection Society of New Zealand Inc.
PO Box 631
Wellington
Solicitor acting: M Downing
Email: m.downing@forestandbird.org.nz
Phone: 022 048 1970

INTRODUCTION

1. My full name is Thomas James Kay.

2. I have been asked to provide evidence on natural form and character in my capacity as an ecologist.

QUALIFICATIONS AND EXPERIENCE

3. I am employed by the Royal Forest and Bird Protection Society of New Zealand Incorporated (Forest & Bird) as a Conservation Advocate for Freshwater. I have held this position since 28 February 2022.

4. In 2016 I graduated from Massey University with a Bachelor of Science in Environmental Science. In 2021 I graduated from Massey University with a Master of Science (MSc) in Ecology. My MSc thesis focused on how to best measure changes in the physical characteristics of river habitat through time, particularly through the further development and application of the Habitat Quality Index / Natural Character Index (HQI/NCI)[1] as a measure of change in the physical form of a river in response to activities such as flood protection engineering.

5. I worked at Forest & Bird in various roles from 2017-2021 and again from 2022-now. During this time I have participated in numerous Resource Management Act processes, including:

    a. Providing evidence on the protection of river habitat and natural character for the council-level hearing on Hawke's Bay Regional Council's (HBRC's) Proposed Plan Change 9 (TANK) in 2021[2];

    b. assisting with mapping the character of the Ngarururoro River for an NCI assessment used in preparation of evidence for the Ngarururoro Water Conservation Order (WCO) Environment Court case in 2020[3];

[1] The HQI/NCI identifies and quantifies change in the physical habitat or natural character of a river over time. It involves assessing a river's 'current' form against its form at some point in the past (a 'reference' condition). See Fuller et al. (2020).
[2] Submission/Evidence # 210 (1), https://www.hbrc.govt.nz/assets/Document-Library/TANK/TANK-evidence/Expert-Evidence-Received-from-Submitters/Evidence-Compiled-Part5.pdf
[3] ENV-2019-AKL-000270-309 Ngarururoro Water Conservation Order. See Kay, T. J., Fuller, I. C., Anderson, P. (2022). Maintaining River Morphology Through Policy: a Case Study from

c. providing lay evidence on willow pole planting within the Ngaruroro River for the WCO Environment Court case in 2020[4]; and

d. providing expert evidence on natural form and character before the Environment Court on Proposed Plan Change 7 to the Hawke's Bay Regional Resource Management Plan (Outstanding Water Bodies).

6. Through my current role I have gained an understanding of (particularly through producing imagery of and/or assessing) changes in the extent and character of rivers throughout Aotearoa over time. I have used this to communicate the (often human-induced) changes in river morphology to communities across Aotearoa, and as a result have become familiar with the changes imposed on many rivers across the country.

7. From 2021-2022 I worked at Kāhu Environmental as a Policy Advisor. During this time one of my projects involved using the HQI/NCI method to undertake a baseline assessment of river habitat in the Mangatainoka River prior to proposed gravel extraction activity.

8. I maintain professional development in river management and have attended several workshops in the last three years: the Massey University Innovative River Solutions 'Rivers Practitioners Workshop' (Sept 2022), the Te Uru Kahika Resilient River Communities 'River Management Practice Workshop' (Oct 2023), and the Te Uru Kahika Resilient River Communities 'Strategic Overview of Rivers & Catchments: Geomorphology & River Management Workshop' (Feb 2024). I also attended the NZ Rivers Group conferences in 2022 (including presenting a poster), 2023, and 2024 (including presenting a poster and a short talk).

9. In November 2024 I was awarded the Engineering NZ River's Group Early Career Award, recognising a young/early career person who has already made a significant contribution towards sustainable management of New Zealand Rivers

---

the Ngaruroro Water Conservation Order.
https://www.forestandbird.org.nz/sites/default/files/2023-03/Conference%20Poster%20-%20Maintaining%20River%20Morphology%20Through%20Policy%20A1.pdf

[4] See 'Reply Evidence of Thomas James Kay on Behalf of Royal Forest and Bird Protection Society of New Zealand Incorporated', appendix to submission/Evidence # 210 (4), p. 264 https://www.hbrc.govt.nz/assets/Document-Library/TANK/TANK-evidence/Expert-Evidence-Received-from-Submitters/Evidence-Compiled-Part5.pdf

10. I am an experienced whitewater kayaker and have kayaked and rafted for recreation, competition, and work on rivers in almost every region of Aotearoa, including Te Awakairangi / the Hutt River, the Mangaroa River, and the Waiwhetu Stream, which are in the PC1 area. In 2013 I received a Short Award in Raft Guiding from Tai Poutini Polytechnic and then completed a National Certificate in Outdoor Recreation (River Guide) as a Grade III Raft Guide through Skills Active NZ.

11. I am a member of the New Zealand Freshwater Sciences Society, the Engineering New Zealand Rivers Group (of which I am a committee member), and Whitewater NZ.

CODE OF CONDUCT

12. I confirm that I have read the Code of Conduct for Expert Witnesses as contained in the Environment Court's Practice Note 2023. I have complied with it when preparing my written statement of evidence and will do so when I give oral evidence. Unless I state otherwise, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

13. I understand the obligations on me as an expert witness and that this is separate to my role as an advocate with Forest & Bird. This evidence is based on, and limited to, my knowledge as an expert in the ecology, habitat, geomorphology, and the natural form and character of rivers.

MATERIAL CONSIDERED

14. The key documents that I have referred to in preparing my evidence include:

    a. The Proposed Plan Change 1 to the Natural Resources Plan for the Wellington Region (PC1)
    b. The National Policy Statement for Freshwater Management (2020) ("NPSFM")
    c. The Section 42A Report and related appendices

15. Additional documents I have relied on and referenced are noted throughout my evidence.

SCOPE OF EVIDENCE

16. This evidence relates to Hearing Stream 2 "Objectives and ecosystem health" and focuses on recommended s42A amendments to the plan relating to 'natural form and character' and 'riffles, runs, and pools'. It:

    a. Describes the connections between natural form and character and ecosystem health.

    b. Explains the importance of natural form and character to ecosystem health.

    c. Comments on the use of the term 'riffles, runs, and pools' in instead of 'riffles'.

EXECUTIVE SUMMARY

17. Natural form and character and ecosystem health are inherently connected.

18. Improvements to ecosystem health directed by PC1 will contribute to improvements in natural form and character.

19. Natural form and character is important in providing for ecosystem health, particularly in relation to the physical habitat needed for native species such as fish.

20. Recognition of natural form and character in the PC1 framework is scientifically justified.

21. 'Riffles, runs, and pools' is a more suitable term for use in than plan than 'ripples', presuming the intention is to capture this in the context of natural form and character and habitat.

CONNECTIONS BETWEEN, AND IMPORTANCE OF, NATURAL FORM AND CHARACTER AND ECOSYSTEM HEALTH

22. The s42A Hearing Report recommends the addition of reference to natural form and character in four PC1 objectives (WH.O2, WH.O9, P.O2, P.O6) on the basis that

> 92. … natural form and character is a relevant value for the waterbodies covered by PC1 and this value is expected to be improved to some extent by the regulatory and non-regulatory provisions. Accordingly, 'natural form and character' should be referenced in the narrative environmental outcome objectives (e.g. WH.O2 and

> P.O2) as the existing TAS included in PC1 will improve aspects of natural form and character …
>
> 314. …amendment sought to the chapeaus of [WH.O9 and P.O6] is appropriate in that I have recommended similar text be added into the first two objectives of each chapter to better relate environmental outcomes to the applicable values, i.e. the water quality and ecosystem improvements to be achieved by PC1 will also contribute to the overall natural form and character of rivers…

23. I consider this perspective to be correct—the natural form and character of rivers in the PC1 area will be improved by making progress towards the environmental outcomes in PC1, including those for water quality and ecosystem health as raised by the s42A. This is because there is a connection between natural form and character and the five components of ecosystem health. Many of the variables that influence the natural form and character of a river also influence components of ecosystem health, such as water quality and habitat.

24. In short, from a geomorphological perspective, the natural form and character of a river is largely determined by large-scale catchment variables that differ by catchment, such as rainfall and runoff (flow regimes), geology, land cover (vegetation), gradient, erosion rates (sediment supply), and valley-floor confinement (Fuller et al., 2018; Brierley & Fryirs, 2005; Gordon et al., 2004).

25. These variables combine with human interventions in a catchment (such as land clearance, flood protection works, etc) to determine a river's form and character (Fuller et al., 2020; Fuller, Macklin, & Richardson, 2015; Fuller, Reid, & Brierley, 2013). Figure 1 illustrates some different river forms from this perspective. For example, one river might be relatively straight while another is meandering, and one may have a wide floodplain while another is confined by a gorge.

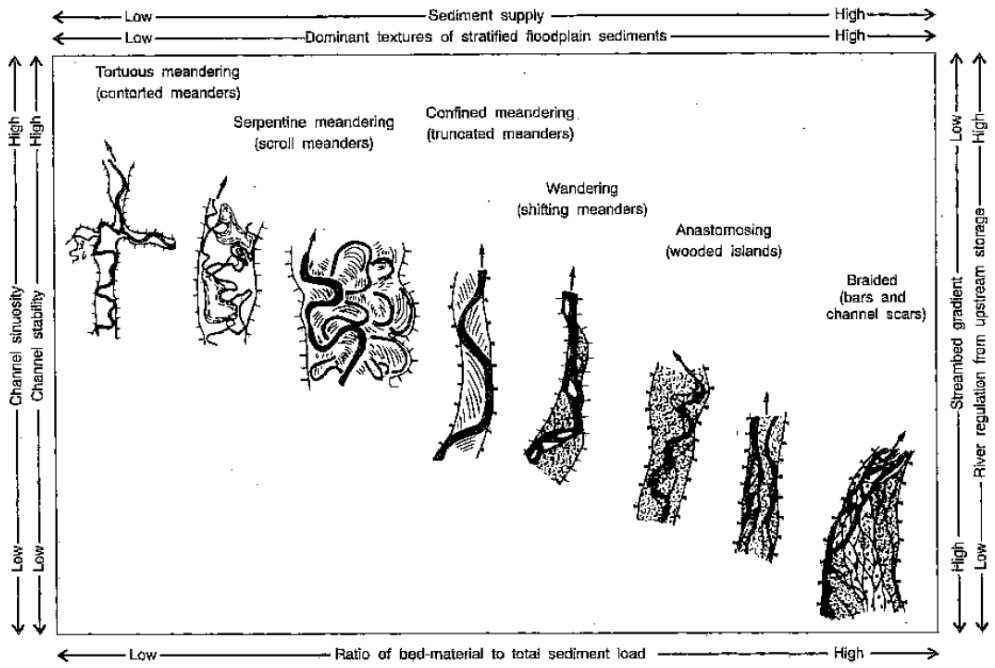

Figure 1: The continuum of alluvial river channel types (Fig 16.1, from Mosley, 1992, cited in Fuller, 2020).

26. At a smaller scale, the physical form and character of a river determines the quality and quantity of habitat available to biological communities (Harding et al., 2009). The physical features in a river that provide (or limit) habitat, such as riffles, runs, and pools (e.g. Figure 2); woody debris; and substrate and fine sediment (among other things) are determined in part by those larger-scale river form and catchment characteristics. For example, if the sinuosity of a river is significantly constrained (i.e., the river is straightened), the gradient will decrease, and the river may lose its ability to develop the pools (habitat) that would otherwise occur on the outside of its bends. Likewise, if there is wide-scale clearance of vegetation in a catchment, or clearance of riparian vegetation, erosion may increase, changing the substrate composition or increasing the cover of fine sediment, thereby limiting habitat. Physical form and character thereby determine physical habitat and, in turn, influence ecosystem health.

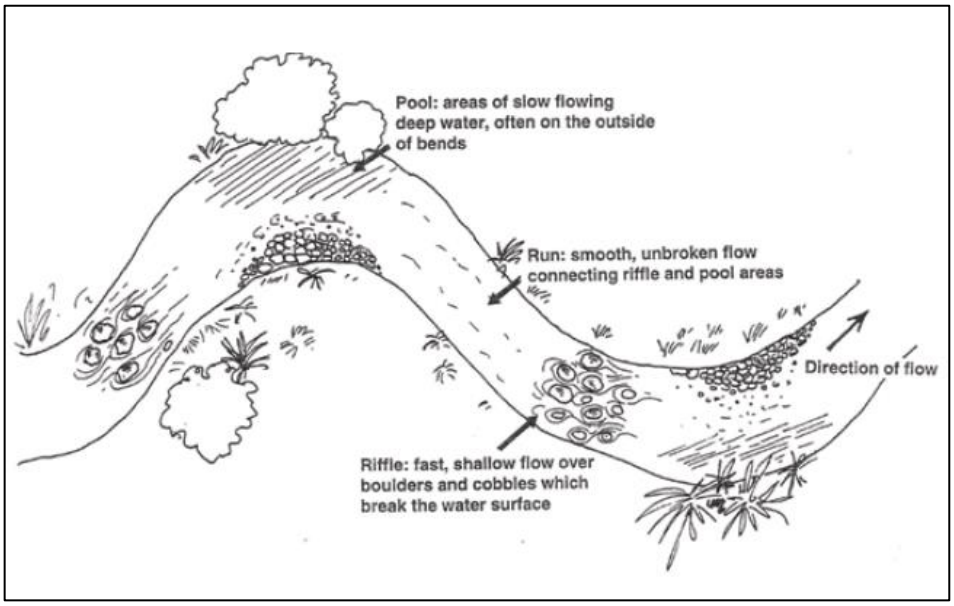

Figure 2: Riffle, run, and pool features in a river (from Biggs et al., 2002, reproduced in Clapcott et al, 2011).

27. Generally, where the condition of natural form and character and habitat is higher, ecosystem health is likely to be higher. Where natural form and character and habitat condition is lower, ecosystem health is likely to be lower. This is because many aspects of natural form and character and habitat directly provide for native species. Table 1 provides a summary of important characteristics of habitat for ten native fish species in New Zealand, while Figure 3 provides an example of a high vs low character/habitat river reach in the Wellington region.

Table 1: Habitat variables known to be important for each of ten native species of fish (based on Petrove and McEwan, 2024).

	Longfin eel	Torrentfish	Giant kōkopu	Kōaro	Dwarf galaxias	Inanga	Shortjaw kōkopu	Lamprey	Bluegill bully	Redfin bully
Substrate										
Percent Deposited fines (100 – %x)	x	x		x	x	x	x	x	x	x
Particle compaction	x			x	x		x		x	x
Inorganic substrate diversity	x	x	x	x	x	x	x	x	x	x
D_{50} (mm)	x	x	x	x	x	x	x	x	x	x
Instream cover										
Total area of Instream cover	x		x		x	x	x	x		x
Undercut banks	x		x				x			
Instream wood	x		x		x		x	x		x
Macrophytes	x				x	x				
Flow types										
Deep pools	x		x				x			
Backwaters	x		x			x	x			
Side braids				x		x	x			
Riffles	x	x	x	x	x				x	x
Runs		x	x	x	x	x		x		
Riverbank										
Riparian vegetation			x		x	x	x	x		x
Overhanging vegetation	x		x				x			
Stream bank height			x			x	x			
Inanga spawning habitat						x				
Floodplain width	x					x	x			
Sinuosity	x					x			x	

Figure 3: A comparison of a reach of river with low natural form and character, and habitat, values (Waiwhetu Stream, top) and a reach with high natural form and character, and habitat, values (Kaiwharawhara Stream, bottom).

28. It is also well-established that many of the large-scale catchment variables that influence natural form and character and habitat also have a significant influence on other components of ecosystem health, such as water quality. For example, changing land uses can increase nutrient levels from fertiliser use and stock effluent, and increase sediment loads as a result of vegetation removal, cultivation, and livestock access to waterbodies (which can destabilise river banks); loss of riparian vegetation can increase light and temperature as a result of lost shading; and loss of vegetation and increased coverage of impermeable surfaces can cause changes to catchment hydrology (Allan, 2004; Matthaei et al., 2006; Townsend, Uhlmann, & Matthaei, 2008).

29. Changes in large-scale catchment variables, such as through land use management, can therefore influence (and degrade or improve) natural form and character, and ecosystem health and its components (habitat, water quality, water quantity, ecological processes, and aquatic life) at the scale of a river or reach of river.

30. Reach-scale human interventions can also degrade or improve natural form and character and ecosystem health in tandem. For example, the clearance of riparian vegetation could degrade physical habitat (e.g., through loss of spawning habitat) and water quality (by increasing sediment from bank erosion), and influence form and character through erosion processes at that reach, as well as potentially having consequences on form and character upstream and downstream as a result of the geomorphic processes that operate at a larger (but connected) scale.

31. This connection between the variables influencing ecosystem health and those influencing natural form and character is well established. These influences are inherently connected and, in my view, somewhat inseparable. Many of the methods used around the world for assessing overall river health from geomorphological and ecological perspectives measure components of natural form and character and ecosystem health in some combination (see Table 1 of Kay, 2020). Methods of wholistic river assessment developed for New Zealand, such as the Stream Ecological Valuation (SEV) (Storey et al., 2011), Rapid Habitat Assessment Protocols (Clapcott et al., 2015), and Stream Habitat Assessment Protocols (Harding et al., 2009), also include measures that relate to both natural form and character and ecosystem health. This illustrates the significant connection between natural form and character and ecosystem health, and how improvements in one area often connect to improvements in another.

32. Improvements in natural form and character (and associated improvement in ecosystem health) also contribute, in turn, to improvements in other values such as the protection of threatened species, swimming and recreational use, drinking water, and mahinga kai. Riparian setbacks and vegetation, for example, can improve a range of river values (Fenemor & Samarasinghe, 2020)—they help prevent pollution in surface runoff (sediment, phosphorus, pathogens) entering rivers, which improves water quality; they provide shading, keeping water temperatures down to levels which can support native fish species; and they

provide a source of leaf and wood litter for macroinvertebrates, as well as a source of insects to feed fish, which in turn supports mahinga kai.

33. These connections are such that managing land use impacts to improve ecosystem health, such as I understand is the intent of PC1, will improve the condition of natural form and character and other associated values. Similarly, I note that managing land use in a way that degrades ecosystem health will decrease the condition of natural form and character and other associated values.

34. Based on the above reasoning, I consider it is scientifically justifiable to include express recognition of natural form and character in PC1. Improvements to matters of ecosystem health, particularly the components related to habitat and water quality, will improve natural form and character. I note that the Council's 42A Report recommends different wording to that sought by Forest & Bird in its submission, and this is addressed is Ms Dowse's planning evidence for Forest & Bird.

COMMENTS ON OVERLAP BETWEEN NATURAL FORM AND CHARACTER AND ECOSYSTEM HEALTH IN NPSFM

35. I note there is considerable overlap between the five components of the ecosystem health value (water quality, water quantity, habitat, aquatic life, and ecological processes) and the natural form and character value as they are articulated in the NPSFM.

36. Matters contributing to natural form and character of an FMU are described in the NPSFM as

> …biological, visual and physical characteristics that are valued by the community, including:
>
> a) Its biophysical, ecological, geological, geomorphological and morphological aspects
> b) the natural movement of water and sediment including hydrological and fluvial processes
> c) the natural location of a water body and course of a river
> d) the relative dominance of indigenous flora and fauna
> e) the presence of culturally significant species

f) the colour of the water

g) the clarity of the water

37. As above, I agree with the s42A officer that improvements to many aspects of ecosystem health directed under PC1 will also improve aspects of the 'natural form and character' value as articulated in the NPSFM. For example, targets in Tables 8.4 and 9.2 of PC1 address some "biophysical, ecological… and geomorphological" aspects of natural form and character, as well as "the colour of the water" and "the clarity of the water"; provisions related to erosion, sediment, and stormwater runoff address "natural movement of water and sediment"; and MCI and Fish IBI targets address "the relative dominance of indigenous flora and fauna" and (perhaps to some degree) "the presence of culturally significant species". Improvements in these aspects will contribute to an improvement in the natural form and character of rivers.

38. Improvements to aspects of the habitat component of ecosystem health will make a particular contribution to improvements to natural form and character. This is because of the geomorphological links and overlap—described above—between physical habitat and the physical components of natural form and character.

39. Habitat (as one of the five components of ecosystem health) is described in Appendix 1A of the NPSFM as:

> the physical form, structure, and extent of the water body, its bed, banks and margins; its riparian vegetation; and its connections to the floodplain and to groundwater

40. Matters described in the 'habitat' component of ecosystem health overlap significantly with natural form and character from a scientific perspective. For example, "the physical form, structure, and extent of the water body, its bed, banks and margins" noted under habitat are can also be captured in the "geological, geomorphological and morphological aspects" of natural form and character. "Riparian vegetation" in habitat overlaps with several matters of natural form and character, such as "the relative dominance of indigenous flora and fauna". And "connections to the floodplain and to groundwater" in habitat overlaps with "the natural movement of water and sediment including hydrological and fluvial processes" under natural form and character.

41. Table 1 above (summarising important habitat variables for native fish) includes aspects covered by both the descriptions of habitat in NPSFM Appendix 1A and natural form and character in NPSFM Appendix 1B. This illustrates the significant overlap and connection between these physical aspects of river health. As noted above, when overall river condition is assessed from geomorphological and ecological perspectives, it often also includes other components of ecosystem health such as water quality and biological communities.

42. While PC1 does not include provisions to explicitly address all matters of habitat as per Appendix 1A of the NPSFM, it does include matters to address some aspects. It includes, for example, targets for deposited fine sediment, which contributes to the "the physical form [and] structure… of the… bed". PC1 also includes a number of provisions and controls related to bank stability, river margins, and riparian vegetation, which are also aspects of habitat under the NPSFM.

43. Improving riparian vegetation, controlling bank erosion (such as through stock exclusion, riparian vegetation, and management of earthworks), and reducing deposited fine sediment will therefore contribute to an improvement in the habitat component of ecosystem health. This will, in turn, contribute to an improvement in natural form and character because of the overlapping and related aspects of natural form and character and habitat described above.

USE OF 'RIFFLES, RUNS, AND POOLS' IN P.O1 INSTEAD OF 'RIPPLES'

44. The s42A report suggests amending part of P.O1 to use the term "riffles, runs, and pools" rather than "ripples"

> 168. … I agree that the correct terminology for describing 'ripples' is the term 'riffles' which are those parts of a river where a faster current breaks the water surface in sections of shallow water. Whereas a 'ripple' is akin to a stone being thrown into a pool and small waves forming in circles on the surface of the water. I agree the objective would be clearer if it used the scientifically clear terminology for what I understand are the important flow features of riffles, runs[96] and pools as suggested in [Forest & Bird's] submission. …

[Footnote] [96] My understanding is runs are areas of fast water with little or no turbulence

45. The s42A report recommends the wording

> "Rivers flow naturally, with ~~ripples~~ riffles, runs and pools, and the river beds are stony

46. I agree with the author that the "correct" or "scientifically clear" terminology to describe a river's flow features is "riffles, runs, and pools". While there are other flow type terms used in ecological assessments and literature (e.g., backwaters, cascades/waterfalls, side braids)[5] these are arguably sub-categories of flow types and the use of "riffles, runs, and pools" is sufficient to capture the idea that diversity in flow types is important for ecosystem health and natural form and character.

47. Features such as riffles, runs, and pools provide valuable habitat for native species, including invertebrates, fish, and birds throughout different parts of their life cycle (Harding, 2009). Any loss or significant change to the mosaic of these features will change the form and character of the river and could degrade ecosystem health, particularly through impacts on its habitat component.

48. "Riffles, runs, and pools" is a more accurate and meaningful term from an ecological and geomorphological perspective than the term "riffles".

CONCLUSION

49. Natural form and character, habitat, and ecosystem health are inherently connected.

50. Improvements to ecosystem health directed by PC1, particularly to the water quality and habitat components of ecosystem health, will contribute to improvements in natural form and character.

[5] E.g., the Rapid Habitat Assessment protocol (Clapcott, 2015) refers to "pool, riffle, fast run, slow run, rapid, cascade/waterfall, turbulance, backwater"; the Stream Habitat Assessment Protocols (Harding et al., 2009) refer to "riffles, rapids, runs (or glides), pools, backwaters, and cascades."; and the Stream Ecological Valuation (Storey et al., 2011) refers to "pool, riffle, run, chute, waterfalls; variety of pool sizes and depths".

51. Natural form and character is an important value in providing for ecosystem health, particularly in relation to the physical habitat needed for native species such as fish.

52. Recognition of natural form and character in PC1 is scientifically justified.

53. 'Riffles, runs, and pools' is a more suitable term for use in than plan than 'ripples', presuming the intention is to capture this in the context of natural form and character and habitat values.

Dated 14 March 2025

Thomas Kay

REFERENCES

Allan, J. D. (2004). Landscapes and riverscapes: The influence of land use on stream ecosystems. *Annual Review of Ecology Evolution and Systematics, 35*, 257-284.

Brierley, G.J., Fryirs, K.A., 2005. Geomorphology and River Management: Applications of the River Styles Framework. Blackwell, Oxford. https://www.researchgate.net/profile/Gary-Brierley/publication/43941649_Geomorphology_and_River_Management/links/0fcfd50c686473cd26000000/Geomorphology-and-River-Management.pdf

Clapcott, J. E., Young, R. G., Harding, J., Matthaei, C. D., Quinn, J., Death, R. (2011). Sediment Assessment Methods: Protocols and Guidelines for Assessing the Effects of Deposited Fine Sediment on In-Stream Values. https://www.researchgate.net/publication/240311233_Sediment_Assessment_Methods_Protocols_and_Guidelines_for_Assessing_the_Effects_of_Deposited_Fine_Sediment_on_In-Stream_Values

Clapcott, J. E. (2015). *National rapid habitat assessment protocol development for streams and rivers* (Cawthron Report No. 2649). https://www.cawthron.org.nz/media_new/publications/pdf/2015_03/CR2649_NATIONAL_RAPID_HABITAT_ASSESSMENT_PROTOCOL_DEVELOPMENT_FOR_STREAMS_AND_RIVERS.pdf

Fenemor, A., & Samarasinghe, O. (2020). Riparian setback distances from water bodies for high-risk land uses and activities. Manaaki Whenua/ Landcare Research. Prepared for: Tasman District Council. https://www.tet.org.nz/wp-content/uploads/2020/12/2057-tsdc167-riparian-setback-distances-from-water-bodies-for-high-risk-land-uses-and-activities.pdf

Fuller, I.C., Death, R.G., Garcia, J.H., Trenc, N., Pratt, R., Pitiot, C., Matos, B., Ollero, A., Neverman, A., Death, A. (2020). An index to assess the extent and success of river and floodplain restoration: recognising dynamic response trajectories and applying a process-based approach to managing river recovery. *River Research & Applications*, https://doi.org/10.1002/rra.3672

Fuller, I. C., Gilvear, D. J., Thoms,. M. C., Death, R. G. (2018). Framing resilience for river geomorphology: Reinventing the wheel? *River Research & Applications 2019, 35*, 91–106. https://doi.org/10.1002/rra.3384

Fuller I.C., Reid H.E., and Brierley G.J. Methods in Geomorphology: Investigating River Channel Form. In: John F. Shroder (Editor-in-chief), Switzer, A.D., and Kennedy, D.M. (Volume Editors). Treatise on Geomorphology, Vol 14, Methods in Geomorphology, San Diego: Academic Press; 2013. p. 73-91.

Fuller, I. C., Macklin, M. G., & Richardson, J. M. (2015). The Geography of the Anthropocene in New Zealand: Differential River Catchment Response to

Human Impact. *Geographical Research, 53*(3), 255–269 255 https://doi: 10.1111/1745-5871.12121

Fuller, I. C. (2020). Ngaruroro Water Conservation Order case. Expert Rebuttal Evidence of Ian Fuller on behalf of Royal Forest & Bird Protection Society, dated 27 November 2020.

Gordon N.D., McMahon T.A., Finlayson B.L., Gippel C.J. and Nathan R.J. 2004. Stream hydrology an introduction for ecologists. John Wiley & Sons, Chichester, UK.

Harding, J., Clapcott, J., Quinn, J., Hayes, J., Joy, M., Storey, R., Greig, H., Hay, J., James, T., Beech, M., Ozane, R., Meredith, A., & Boothroyd, I. (2009). *Stream Habitat Assessment Protocols for wadeable rivers and streams of New Zealand*. Christchurch, New Zealand: University of Canterbury. https://www.envirolink.govt.nz/assets/Envirolink/Stream20Habitat20Assessment20Protocols.pdf

Kay, T. (2020), A methodology to assess river habitat quality: a thesis presented in partial fulfilment of the requirements for the degree of a Masters in Science in Ecology at Massey University, Manawatū, Aotearoa New Zealand. https://mro.massey.ac.nz/items/efa12e8a-ceee-41c1-8fa3-c52a73f89b52

Matthaei, C. D., Weller, F., Kelly, D. W., & Townsend, C. R. (2006). Impacts of fine sediment addition to tussock, pasture, dairy and deer farming streams in New Zealand. *Freshwater Biology, 51*, 2154-2172.

Petrove & McEwan (2024). Habitat requirements of native freshwater fish in Aotearoa New Zealand. Department of Conservation. https://www.doc.govt.nz/globalassets/documents/conservation/land-and-freshwater/freshwater/native-fish-habitat-requirements-report.pdf

Storey, R.G., Neale, M.W., Rowe, D.K., Collier, K.J., Hatton, C., Joy, M.K., Maxted, J. R., Moore, S., Parkyn, S. M., Phillips, M. J., Quinn, J.M. (2011). *Stream Ecological Valuation (SEV): a method for assessing the ecological function of Auckland streams* (Auckland Council Technical Report 2011/009). Retrieved from https://knowledgeauckland.org.nz/media/1397/tr2011-009-stream-ecological-valuation.pdf

Townsend, C. R., Uhlmann, S. S., & Matthaei, C. D. (2008). Individual and combined responses of stream ecosystems to multiple stressors. *Journal of applied ecology, 45*, 1810-1819.