Hawke's Bay Regional Council

STREAM AND RIVER ASSESSMENTS FOR CYCLONE GABRIELLE RURAL RECOVERY

WHARERANGI STREAM – BROOKLANDS

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Hawke's Bay Regional Council

WSP
Palmerston North
49 Victoria Avenue
PO Box 1472
Palmerston North 4410, New Zealand
+64 6 350 2500
wsp.com/nz

REV	DATE	DETAILS
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	NAME	DATE
Prepared by:	Will Conley	16/04/2024
Reviewed by:	Niraj Tamang, Lisa Arnold	16/04/2024
Approved by:	Glenn Thomas	16/04/2024

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1 PROGRAMME BACKGROUND

1.1 CYCLONE GABRIELLE

Cyclone Gabrielle (CG) brought strong winds and heavy rain to New Zealand from 11 to 17 February 2023, causing extensive flooding and landsliding. It was only the sixth time in New Zealand's history that central government declared a State of Emergency (on 14 February). It was the most severe storm in New Zealand since Cyclone Bola in 1988. The Hawke's Bay Region was one of the hardest hit with at least eight fatalities and thousands of people displaced, thousands of homes flooded, loss of electrical and water supply, and widespread damage to infrastructure. State of Emergency declarations occurred for the Hawke's Bay Region as well as the Napier and Hastings district levels. The transport network and rural properties were widely and severely affected and continue to suffer ongoing disruption.

1.2 HBRC RURAL RECOVERY PROGRAMME

The Hawke's Bay Regional Council (HBRC) Rural Recovery Team (RRT) supports recovery of rural properties impacted by Cyclone Gabrielle. The voluntary program assists rural property owners with an initial high-level assessment related to land-use effects and consenting. High-level assessments for sites across Hawke's Bay are intended to identify:

1. Issues,
2. Options,
3. Expectations of action/inaction, and
4. Next steps related to both upland and river/stream related effects.

1.3 WSP ENGAGEMENT AND SCOPE

WSP supplements the RRT's in-house upland and land-use capacity by providing expertise associated with river and stream dynamics. A co-developed workflow facilitates escalation of an initial screening site visit by RRT for assessment by a Principal with specialty in fluvial geomorphology, rural infrastructure, and land-use. Such visits range are generally one-half day or less for observation of site-specific conditions and land-use intent, particularly related to sediment, erosion, large wood (a.k.a. debris), flood risk, and estimates of future channel changes (a.k.a. behaviour). A site is a contiguous, affected area for which concerns exist and a site visit is conducted. A site may occur on an individual property or collection of properties and/or there may be more than one site on a single property as suited to each situation and directed by RRT.

For each site, a report is prepared to:

1. Articulate observations related to high-level river dynamics,
2. Outline options/alternatives,
3. Outline expectations of action/inaction, and
4. Outline potential next steps.

Follow-on engagement by WSP (e.g., investigation, remedial works, design, or other next steps) for each site is beyond the scope of present work.

2 SITE AND BASIS OF UNDERSTANDING

2.1 SITE

The site under consideration is 1.5 kilometres of a subcatchment of Wharerangi Stream, hereafter referenced as the "site" (Figure 1, points *A* to *R*). The location is roughly 2 km northwest of the intersection of the Puketapu and Puketitiri roads, approximately 11 km west of Napier, Hawke's Bay. The primary access to the site was from Puketitiri Road. Queries of residents and maps did not yield a specific name for this subcatchment, so this report references it as the West Fork ("WF"). The primary land-use within the immediate site area are life-style blocks, cropping, and sheep-and-beef grazing.

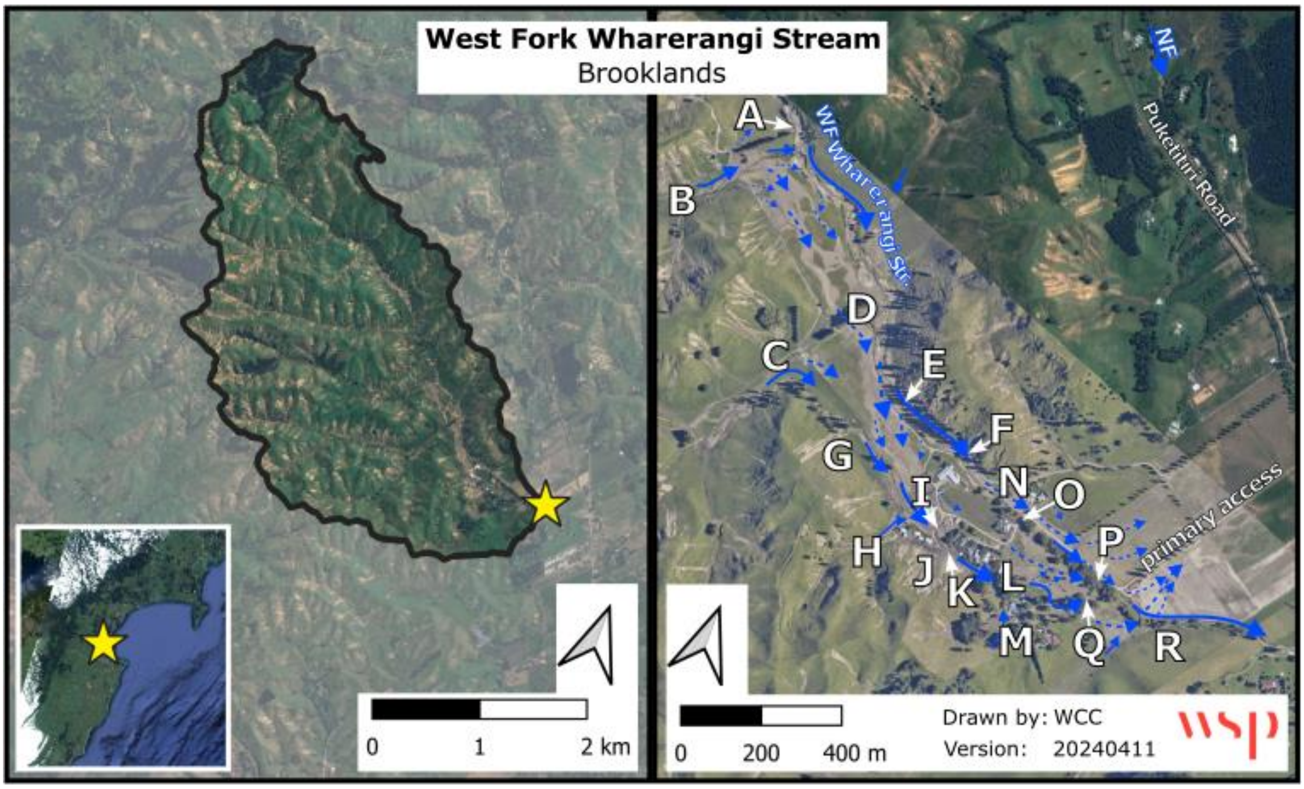

Figure 1. *Left*: The contributing catchment (9.0 km^2) drains southeasterly toward the site where it is initially stopbanked (approximately point *D*) then channelised into a constructed channel (approximately point *O*). *Right*: Post-Cyclone Gabrielle (CG) imagery reflects very active floodplain engagement and sediment-rich conditions including a very strong response from subcatchment *B*. The Area of Concern (AoC) is the area of residences within the *N-H-M-P* polygon inclusive of the *access* road. Hashed arrows represent overbank flow paths and are indicative, not definitive. Lettered points are referenced in the text and mark the same locations as in Figure 3.

2.2 UNDERSTANDING

RRT's *screening* visit was conducted on 6 November 2023 by Carl Nicholson (Rural Recovery Advisor, RRT) and provided background information on use and site concerns. More information was gained from viewing the site and discussion with Carl Nicholson and approximately 10 residents, during the *assessment* visit conducted by Will Conley on the afternoon and evening of 20 November 2023. The site was visited with residents in the early afternoon, then the main channel was walked downstream from point *A* to point *P*, and concluding up the south channel from *P-Q-L-K*. The weather was mostly rainy with streamflow beginning low and tea-coloured to rising and more turbid, but still safely wadable.

2.3 AREA OF CONCERN

The Area of Concern (AoC) is approximately 400 m of valley (Figure 1, bounded by points *N-H-M-P* inclusive of *access*), particularly where most of the highly flood affected residences are concentrated along the southern valley margin (point *I* to point *L*).

Figure 2. *Top Left*: Downstream view of the south channel looking toward point *L*, where the hillside and buildings converge to constrict flow and a fenceline with stock panels crosses the creek (cover, lower-right). *Bottom-left*: Looking upstream toward point *I*, mid-valley stockyards, fences, and buildings concentrate flow into the low portion of the valley along the hill toe. *Right*: CG flood sediment (sands and silts) within an abandoned residence near point *K*; the high-water line (dark, horizontal streak between hammer and window) is 0.72 m while sediment depth ranged between 0.09-0.12 m above the floor.

3 ISSUES AND ASSESSMENT

3.1 GEOMORPHIC AND CATCHMENT SETTING

The downstream end of the site is approximately 40 m above sea level with a contributing catchment area of 9.0 km^2 of mostly hilly terrain. The maximum catchment elevation is 255 m and longest flow path of approximately 5.9 km. The higher elevations are along the north and western hydrographic divide with the Mangaone River. A high-level review of aerial photos[1], digital elevation models (DEMs)[2], and geologic maps[3] indicates that sedimentary lithology (mostly sandstones, limestones, and conglomerates) dominates surface parent materials with some mudstones and a minor component of lacustrine (lake) and fluvial sediments.

Review of post-CG satellite imagery suggests high densities of mostly small, generally shallow landslides occurred throughout the catchment, with many coalescing and some likely translating into debris flows. Higher density landsliding seems crudely associated with steeper (> ~0.40 m/m) slopes, especially in subcatchments south and west of the main channel. Forested areas account for a small component of the catchment but, where present, appear to have far fewer landslides than non-forested ground covers on comparable slopes. A high percentage of landslides appear connected to the channel network and are likely the main supply of sediment.

3.2 OBSERVATIONS

This section notes key observations and inferences based on field evidence, discussions with residents, and review of pre- and post-CG aerial photos and digital elevation models (DEMs):

1) The valley:
   a) The valley bottom form appears to be at least moderately tectonically-controlled:
      i) Uplift at the down-valley end (point *R* vicinity of Figure 1) deflects over-bank flow toward the left side of the valley, and
      ii) The southern portion of the valley (roughly point *G* to *K*) is at or below the bed of the main WF channel;
         (1) This portion of the valley has ample accommodation space (i.e., available space to store water and sediment),
         (2) The elevation difference may result from subsidence or differentially slower uplift (e.g., side-tilt) along the southern valley margin and/or higher sedimentation rate adjacent to the main stream channel (northern valley margin),
         (3) This portion of the valley naturally attracts out-of-bank flow from the main WF.
   b) Has high areas immediately adjacent to the main WF channel from point *E* to point *O* and point *P* to point *R*,

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[1] Source: https://data.linz.govt.nz Hawke's Bay 0.10m Cyclone Gabrielle Aerial Photos (2023); Hawke's Bay 0.3m Rural Aerial Photos (2021-2022); Hawke's Bay 0.3m Rural Aerial Photos (2019-2020)

[2] Source: https://data.linz.govt.nz Gisborne and Hawke's Bay - Cyclone Gabrielle River Flood LiDAR 1m DEM (2023); Hawke's Bay LiDAR 1m DEM (2020-2021)

[3] Source: https://data.gns.cri.nz/geology/ 1:1M Geology

c) Has soils that appear poorly to imperfectly drained with very tight cohesive units below half a metre of depth (based on bank stratigraphy along main channel).

2) Stream channels:

a) The West Fork of Wharerangi Stream (*WF*):

i) Is predominantly a single-thread throughout the site,

ii) Has been highly modified historically, including:

(1) Realignment into a linear constructed channel downstream of point *N*,

(2) Possible changes to cross-sectional forms ("two-stage" channel) between points *E* and *O*.

iii) Becomes progressively incised (i.e., banks increase in height) downstream of point *F*:

(1) A long sequence of many knickpoints downstream of point *N* indicates historic (over many decades) and ongoing degradation,

(2) CG flood gravels have not made it this far downstream (most likely).

iv) Has bed composition that:

(1) From points *A* to *F* is gravelly and mostly mobile-bed (particles up to 4-6 mm were observed in transport near *A* with ~60 mm water depth),

(2) Downstream of *N* composition shifts to consolidated, cohesive fines (geologic materials) with extensive root reinforcement.

v) Has banks that:

(1) Are largely composed of native, highly consolidate, cohesive sedimentary materials, (only some of which appear to be alluvial),

(2) Contain alluvial gravel lenses very infrequently, even upstream in the vicinity of point *A*,

(3) Have areas of active bank erosion upstream of point *F* are generally small (less than a channel width), localised, and hydraulically-forced (i.e., sediment deposition increases water energy directed onto the bank) and in many cases appear to pre-date CG,

vi) Has a bund that runs along the right-bank from point *D* to almost *P* to contain flows arriving from upstream,

vii) Transitions from being connected to a small floodplain between the stopbank and hillside (~two-stage channel from points *D* to *F*) to being highly incised and generally disconnected downstream of point *O*,

viii) The slope adjacent to the south channel (vicinity of point *J*) has had multiple small failures over the years that have partly obstructed and/or displaced the south channel.

b) The tributary that enters the valley at point *B* appears:

i) To have had one of the most intense flow and sediment responses to CG,

ii) Has likely flowed across the valley directly to the West Fork at some points in time, but currently discharges to the south channel.

3) CG flow was valley-wide with complex flow paths:
   a) Whose general tendency was to flow toward low ground (e.g., points *G* to *L*),
   b) That are strongly influenced by human modifications;
      i) Including buildings, fences, hedgerows/shelterbelts, bridges / culverts, embankments/bunds, and past channel modifications (e.g., diversions, reshaping, and straightening),
      ii) These human modifications (i) caused or contributed to altering flow paths by:
         (1) Local backwatering (increased flow depths and sedimentation),
         (2) Direct obstruction (e.g., buildings),
         (3) Altered flow resistance:
            (a) Deflecting flow where debris fouling/trapping by stock yards, hedgerows/shelterbelts, etc.,
            (b) Attracting flow where channels have been dug and/or vegetation has been removed.
   c) Which directly engaged at least six residences within the immediate AoC.
4) Post-CG low-flow stream channels:
   a) Appear mostly within pre-CG horizontal alignments,
   b) Variable channel responses within the site:
      i) Partly filled with CG sediments, especially:
         (1) The main channel upstream of point *F*,
         (2) The south channel between points *G* and *L* (including through the AoC),
         (3) The tributaries *B* and *H*.
      ii) Coarse CG sediments either not affecting or haven't yet arrived):
         (1) The mainstem channel downstream of point *O,*
         (2) The lowest portion of tributary *G* (i.e. where it enters the main valley),
         (3) The south channel downstream of *Q*.
   c) Has CG-delivered sediments which are:
      i) *Overbank and south channel:* mostly sands,
      ii) *In-channel*:
         (1) Main channel from *A* to *F*: a mix of sands to large gravels,
         (2) Tributary *B*: a mix of gravels, cobbles, and sands.
5) The flow peak contributing to effects at the AoC was:
   a) The result of very intense, high-volume rain,
   b) Almost certainly increased by:
      i) Mostly single-layer herbaceous ground covers within the catchment that rapidly yield more water to channels (e.g., vs. partly forested conditions),

ii) Straightened, steepened, "cleaned", and/or stop-banked channels upstream delivered water to the AoC faster than in a pre-managed state.

c) Residents made several mentions of a farm dam that failed in one of the upstream tributary catchments. Depending on the nature of the breach and timing relative to the flood peak, then an outburst/surge of water could have supplemented flood flows. .

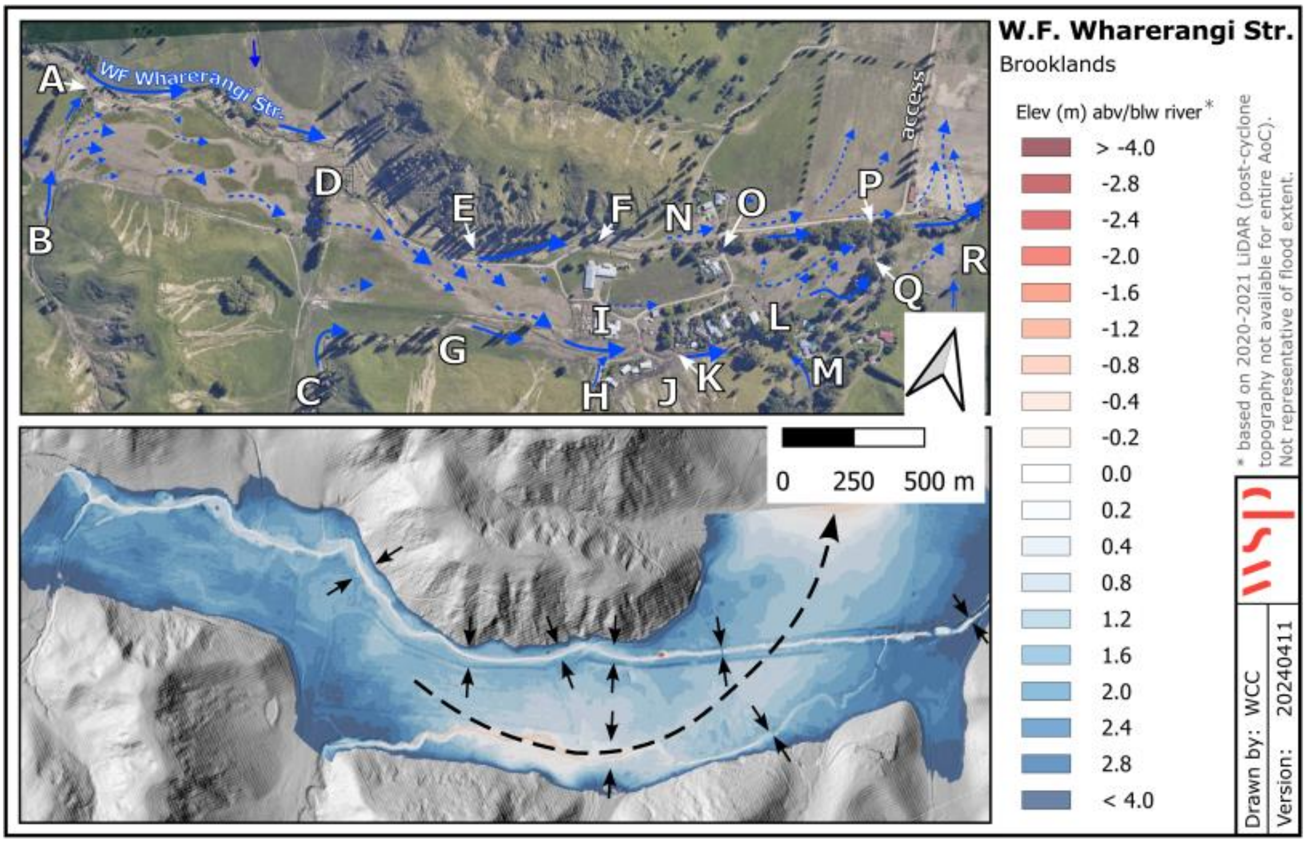

Figure 3. *Top*: Post-CG imagery view of the site, inclusive of the AoC (points bounded by *N-H-M-P* inclusive of *access*). Annotation notes same locations as Figure 1 and is discussed in the text. The image is post-CG and generally representative, but not specifically accurate of channel and bar locations at the time of the 20 November 2023 visit. *Bottom*: Ground elevation relative to the stream channel shows the right/south side of the valley is up to 0.5 m lower than the pre-CG stream bed along ~850 m of the valley. Pairs of black arrows mark channel locations where channel confinement increases (limiting flow and promoting back-watering). The black hashed arrow generalises water flow along the lowest portion of the valley. The red dot near *N* results from erroneous source data. Source elevation data are pre-CG as only a small portion of the site was covered by post-CG LiDAR.

3.3 KEY CONCLUSIONS

Flood effects can generally be attributed to one or more of A) the quantity and intensity of water and sediments delivered from upstream, B) on-site conditions, and/or C) downstream controls. In the case of CG, all three played a role within the AoC.

1) The site's flood adversity results from a mix of on- and off-site controls but fundamentally is one of concentration in space and time;
    a) The south side of the valley between *G* and *H/I* is lower than the main channel and attracts overbank flows,
    b) Buildings and cross-valley fences and shelterbelts concentrate flow into a smaller amount of space and direct flow toward some of the houses,
    c) Channel obstructions (e.g. fouling of fences and stock barriers) likely increased backwater effects.
2) The site occupies a naturally sensitive geomorphic setting that:
    a) Is low relief and will naturally tend to distribute water across the valley floor,
    b) Has side-tilt that directs out-of-channel flow toward the southern edge of the valley where most of the houses sit,
    c) In the absence of human maintenance, the trend will most likely be for the West Fork to avulse (shift course) toward points *G-I-K*.
3) The complex and energetic flow patterns that occurred during CG could be reduced by coordinating property (and sub-property) management in a manner that considers combined effects during flood conditions.
4) Human modifications to the channel morphology, network geometry, and floodplain connectivity are super-imposed on the geomorphic setting:
    a) These include buildings, fences, hedgerows/shelterbelts, road crossings, channel realignments, and bunds,
    b) Channel locations and forms generally concentrate more frequent flows in a manner contrary to what would occur in the absence of human intervention,
    c) Road and farm track crossings change local hydraulics that alter patterns of sediment and water transfer,
    d) These modifications can be expected to deliver water more rapidly to the Puketitiri Road vicinity.
5) The reach between points *F* and *O* is a critical location for understanding change in stream processes (e.g. from being horizontally oriented to vertically oriented).
    a) Upstream of *F*, the stream system:
        i) Appears in-balance or somewhat limited by sediment transport capacity (amount),
        ii) Will tend toward horizontal water and sediment transfer (and channel movement).
    b) Downstream of *O*, the channel:
        i) Appears limited by sediment supply,

ii) Will tend to cut downward,

iii) Is held together by cohesion of basal (geologic) materials and vegetation,

iv) Is still vertically adjusting downward to pre-CG channelisation.

6) Water volume following longer, shallower flow paths across the floodplain during the flood may have positively contributed to reducing the downstream flood peak along Puketitiri Road and in the Tutaekuri Valley (i.e., possibly prevented worse flooding to downstream floodplain residents and producers).

7) Post-CG stream channels mostly follow pre-CG horizontal alignments but have partly filled with sediment (except downstream of *N*) and likely have somewhat reduced flow capacity.

8) Probable channel relocation/construction (e.g., downstream of point *N* and, potentially, between *E* and *N*):

   a) Routes the channel through higher portions of the floodplain,

   b) Thus, out-of-channel flow will seek flow paths that are not adjacent to the channel.

9) As of the November 2023 visit, the streams are still in a period of adjustment with a mix of erosion, deposition, and downstream sediment movement actively occurring in proximity of the AoC.

10) Portions of the channel upstream of point *D* that appeared “retired” (e.g., livestock exclusion with riparian plantings) generally appeared to have responded well (e.g. very modest bank erosion) to the elevated water and sediment since CG (inclusive).

4 EXPECTATIONS AND NEXT STEPS

Post-CG, the Wharerangi Stream catchment is in a sediment-enriched state. Compared to the quantity of sediments delivered to the upstream channel network and available for downstream transport, relatively little sediment has arrived at the AoC. As packets of coarse sediment (gravels and larger) arrives, more dynamic channel behaviours can be expected beyond those expected pre-CG. Such behaviours may include increased presence and size of bars, increased bank erosion frequency and intensity, transient bed rise and fall, multi-thread channel formation, and/or increased rates of erosion and overbank flow. Flooding along the south channel has been frequent over the past 17 years, with six of the nine most impactful floods since 2006 occurring in 2022 and 2023 according to residents.

Up-catchment coarse CG sediments are already working their way to and through many parts of the site. Present and future channel fills may cause smaller magnitude storms to manifest as floods covering wider areas. This should be expected for at least the next five to 10 years, though the adjustment period for some East Cape streams was over 20 years following Cyclone Bola. Ultimately, response timelines will depend on processes specific to the catchment and subsequent weather that occurs. It is important to be aware that different processes will occur on different, but overlapping, time and spatial scales and will have different time-lags behind CG. For example, erosion at a particular bank may be concentrated in space and occur within short windows of time. However, once within the active channel, the eroded sediment may take longer periods of time and larger patches of space to find a home.

4.1 APPROACHES

The site's flood adversity results from a mix of on- and off-site controls but is fundamentally one of concentration in space and time. The collective effect of actions causing less flow in some spaces means the same amount of flow gets concentrated into a smaller amount of space. Catchment conditions that both increase total runoff and the rate of runoff combined with more intense storms concentrates flow in time. Concentration in space and time will generally intensify effects. Actions and/or approaches that diffuse flow in space and/or time will generally diminish flood adversity.

Generally, there are two high-level ways to approach:

- <u>Passive approaches</u> allow natural river and catchment processes to take their course. Aside from a "no action" approach, these could include monitoring.
- <u>Active approaches</u> usually involve heavy equipment and occur on a spectrum that may enhance or counter natural processes:
  - *Process-based* approaches address types, rates, and magnitudes of physical, chemical, and biological processes that drive and resist geomorphic change.
    - Process-based actions usually seek functional transformation such that the system will perform less intensively during disturbance events (e.g. floods).
    - Some tolerance of increased flood frequency and/or extent may be necessary.
    - Typically focus on questions like "how" and "how fast" energy and materials move from one place to another:

        - Often this means accommodating and/or enhancing natural processes, particularly those that diffuse energy.
        - For example:
            - Re-meandering bends into previously straightened channels reduces the amount of stream energy at a point and lengthens downstream flow time.
            - Riparian planting in and of itself is not necessarily nature-based when stabilising a section of stream that would not otherwise be stable and, thus, very unnatural.
            - By contrast, riparian plantings that increase vegetation density and promote out-of-channel flow (i.e., diffusion) and may compliment natural processes.
        - Process-based approaches may include "nature-based" approaches that:
            - May be implemented within a short block of time, with or without heavy equipment.
            - Almost always produce more ecologically favourable outcomes,
            - Done properly, become more self-maintaining than form-based approaches,
            - Are not necessarily less costly to design and construct but can be less expensive over their life cycle as with less costly damages.
    - *Form-based* approaches are the standard means of adding or removing materials to create forms, dimensions, and/or resistance. Usually, this means directing a watercourse somewhere it might not otherwise go. Such approaches:
        - Usually provide the most rapid results for short-term human benefits (e.g. cropping, grazing, etc),
        - Require robust maintenance commitments,
        - Include:
            - Adding/enlarging features like bunds, stopbanks, and levees or rock armour,
            - Indiscriminate removal of floodplain and in-channel wood/trees.
        - Energy balance tends toward extremes, for example:
            - Stopbanks and straightening tend to greatly increase stream energy,
            - Reservoirs radically lower stream energy.

Successful implementation of process-based approaches requires understanding of geomorphic processes above all else. As sites become more complex, the need for proper contextual understanding and multi-disciplinary expertise increases. Human development within and surrounding the AoC makes purely passive (e.g. do nothing) approaches impractical and likely to result in distress.

The Business-As-Usual (BAU) approach in this case would continue the current regime of reactive, form-based response on a point-by-point basis without consideration of cumulative effects. For example, construction of bunds, walls or other features that do not transmit flow may protect a single building but might increase water surface elevation and/or velocity in an adverse manner to other buildings or valued resources.

"Catchment-based" approaches address the issue of scale by giving consideration of drivers and effects beyond an individual site. However, implementation may fall into form-based (typical) and/or process-based approaches. Form-based approaches are often favoured due to familiarity, tangibility, and/or perception of immediate effect. The power of catchment-based thinking however is to consider the complexity and interactions of processes. This can often raise awareness of the limitations, consequences, and failure points of form-based approaches that often go unscrutinised. Implementing many, geographically distributed projects associated with catchment-based approaches is also more challenging than one or two big capital projects but may be more achievable given smaller costs of any single action. From a resiliency perspective, the consequences of a "failure" point in distributed scenario are probably lower than where all the eggs are placed into a structural, form-based project. There is always a super-design event lurking somewhere in the future.

The temptation in these cases is almost always to rush to action (a.k.a. a bias toward action), however, a vision should exist beforehand that facilitates evaluating potential actions in terms of:

- In service to what?
- With what consequences?

For example, it would be surprising if discussions did not include sediment removal from the channel and/or floodplain. However, it's important to recognise that floodplains (i.e., the surface on which the buildings sit within the AoC) are built by processes such as deposition during out-of-bank flows. If (when) the channel re-cuts to a lower elevation, floodplain deposition may well make a future flow of similar magnitude less damaging. Floodplain sediment removal would effectively increase flood risk and is not recommended without formal consideration of future risk to the proposed and surrounding properties.

It is similarly expected that removal of wood and/or "debris" from the channel and/or floodplain may be advocated by some. Large wood (i.e., downed trees and/or large portions thereof) was generally not observed during the walk. However, some accumulations were observed that effectively trapped sediment and reduced erosion potential. Removal of such instances would increase the amount of sediment being delivered downstream and is not recommended without due consideration. Not all wood is unstable. Where benefits are possible, but stability is a concern, it could be stabilised in-place such as interplanting with live-stakes or poles. Engaging a professional with specialty in-stream wood experience can help increase understanding and manage fears.

While relocating buildings out of flood-prone areas is almost always a "no brainer" action, it is not always feasible or acceptable. Elevating buildings on piles is a good option but can be compromised if BAU results in a neighbour constructing bunds that direct higher velocity flow and/or deeper water toward the elevated structure. Upstream floodwater dispersal is another no-brainer in the sense of shallow water over fields to prevent deeper water around houses. It is also worth considering orientation of fences and hedgerows/shelterbelts relative to flow and include relief points.

Stakeholders are strongly encouraged to seek process-based over form-based approaches, but there are grey areas. Multicriteria, multi-stakeholder assessment is suggested for all cases.

The following action hierarchy is recommended for consideration:

1) Do not make the problem worse:
    a) Do not place further resources of value (e.g., buildings) in harm's way.
    b) Do not constrict flowpaths further.
2) Step changes (with fairly immediate results):
    a) Reduce/reconfigure floodplain flow obstructions, especially:
        i) Fences and stockyards between points *F* and *H,*
        ii) Fences in the vicinity of *L,*
    b) Move the right bank stopbank to the south (i.e. away from the stream channel) to accommodate more flow (and sediment),
    c) Modify existing buildings:
        i) Relocate,
        ii) Elevate (e.g. piles),
        iii) Strengthen/seal in-place.
3) Incremental changes:
    a) Retire and increase ground covers to reduce slope instability (highest priority should be the slope in vicinity of *J*),
    b) Up-catchment management:
        i) Increase management that reduces sediment production, and/or
        ii) Increase management that reduces sediment connectivity to the channel network, and/or
        iii) Increase management that slows runoff.

In summary:

- The approaches and actions noted in the report mitigate, but do not remove flood hazards. The one action that eliminates the hazard is to move residences (and other buildings) to locations that do not flood.
- Passive and/or BAU approaches are not recommended as these are likely to increase complexity with good potential for amplified damage under flood conditions. Catchment-based approaches are favoured as these address the broader issues at scale.
- Before rushing to take action, consider the vision of what is trying to be achieved, the consequences of potential actions, and connectivity of processes necessary to achieve the vision through space and time.

- Actions such as floodplain sediment and wood removal are likely to be favoured but require careful consideration and will require indefinite maintenance through time likely to become an increasingly costly obligation. Actions such as floodplain sediment and wood removal are likely to be advocated for, but require careful consideration and will require indefinite maintenance through time and likely to become an increasingly costly obligation.
- Actions such as earthworks and elevating buildings should consider effects on flow paths and potential to affect and be affected by others in the wider area.
- Other important considerations include upstream floodwater and orientation of infrastructure such as fences and shelterbelts influencing flow.
- In most cases, process-based approaches are encouraged over form-based approaches.

4.2 POTENTIAL NEXT STEPS

1. Establish a vision for the site and identify measurable criteria for success (including life expectancy and maintenance requirements).
2. Begin data collection:
    a. At a minimum, photo-documentation.
    b. Bed and bank topography would be ideal.
    c. A fluvial geomorphic investigation that conducts a spatial (e.g. “reach”) analysis that:
        d. Characterises and maps processes operating at different locations along the stream (and valley),
        e. Discusses process drivers and limitations (including patterns and rates of sediment transfer),
        f. Links the above to stream behaviour through space and time (including climate-adjusted hydrology).
3. Decide on a community-based approach. Concurrently:
    a. Select an approach or combination of approaches. Note: some approaches may not be compatible (e.g., nature-based, etc.).
    b. Begin discussions with appropriate authorities to determine consenting requirements.
4. Estimate costs.
5. Acquire funding.
6. Engage a design team, select, and initiate a design process.
7. Apply for and acquire consents.
8. Identify and acquire materials.
9. Engage a construction contractor.
10. Construct project.
11. Monitor project.
12. Maintain as necessary.

The following are also recommended at broad-scale:

- Adaptation planning that identifies land-uses, crops, infrastructure approaches, etc. that are more compatible with flooding and/or sedimentation. Whether buildings, roads, fences, hedges/shelterbelts, tanks, or other, infrastructure considerations should include siting (e.g. orientation to flow) and style (e.g., degree of flow obstruction or transmission). The potential to shift to land-uses and/or crops less vulnerable to flooding and/or sedimentation could reduce the need for more costly treatments and/or reduce the risk of crop failure and loss of income in a given year if protective treatments are unsuccessful.
- Catchment planning that evaluates past and future catchment changes (including climate and ground cover) and their role in delivering water, sediment, and other materials downstream. In particular, the following should be considered:
    - Controlled or slowing down travel time for rainwater flow in necessary portions of headwaters could reduce the peak amount of flow arriving at a point downstream. For example, increased canopy interception reduces the amount of rain that becomes streamflow at all.
    - Decreasing up-catchment mass-wasting (e.g., landslides) potential and connectivity to stream channels to reduce sediment recruitment into the stream network (including effects of roads and farm tracks).
    - Increasing up-catchment sediment storage (on-slope, within channels associated with large wood, and/or floodplains) will attenuate downstream delivery of recruited sediments.
    - Increasing travel time of flows delivered from upstream. For example, wetland restoration and re-meandering channels will reduce the size of flood peaks received by downstream areas.

The success of any assessment or implementation will require a strong foundation of understanding the system as it is functioning post-CG and provide guidance regarding probable future adjustments. Awareness of the river's history (and pre-history) is also important as a sense-checking exercise and to potentially understand how or why it got to where it is.

Reviews of archival records (e.g., aerial photographs, rainfall data, and streamflow data) are often helpful to understand the context of the preceding history of processes (i.e., combinations of high and low-flow hydrology, sediment supply, river management, etc.). Specific to aerial image interpretation, it is critical to understand where images sit within timelines and related processes including past earthquakes, outbursts of landslide dams, other flood histories (e.g., Cyclone Bola, 1938 Flood, et al.), land clearance and drainage, and introduction of exotic species. Without this understanding, there is grave risk the exercise could become akin to catalogue shopping where a visually pleasing historic channel form is selected as a design target despite resulting from different geomorphic processes than presently control the site. As a result, work could progress down a path that is unrealistic for contemporary and/or future conditions.

5 DISCLAIMER AND LIMITATIONS

Limitation Statement

This report ('Report') has been prepared by WSP exclusively for Hawke's Bay Regional Council ('Client') in relation to Stream and River Assessments for Cyclone Gabrielle Rural Recovery ('Purpose') and in accordance with the Work Brief HBRC-23-990 with the Client dated 26th September 2023. The findings in this Report are based on and are subject to the assumptions specified in the Report and our Offer of Services dated 22nd September 2023. WSP accepts no liability whatsoever for any reliance on or use of this Report, in whole or in part, for any use or purpose other than the Purpose or any use or reliance on the Report by any third party.

In preparing this Report, WSP has relied upon data, surveys, analyses, designs, plans and/or other information ('Client Data') provided by or on behalf of the Client. Except as otherwise stated in this Report, WSP has not verified the accuracy or completeness of the Client Data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in this Report are based in whole or part on the Client Data, those conclusions are contingent upon the accuracy and completeness of the Client Data. WSP will not be liable for any incorrect conclusions or findings in the Report should any Client Data be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to WSP.

Supplemental

- This work provides a high-level descriptive overview based on a short field visit and limited compilation and review of available data/information. Thorough review of prior works and/or data, quantitative analysis, and design guidance are beyond the scope of this work.
- Assessing alignment between management intent and likely channel responses requires a more quantitatively driven approach. This work has not quantitatively assessed the feasibility of channel, belt, or floodway conditions desired by owners. Modifications to slope, form, dimension, and/or levels of resistance of many managed sites often increases energy conditions that make channel response more dramatic to disturbance (e.g., storms).
- Approaches and alternatives are presented from technical and pragmatic perspectives. Compliance and regulatory considerations (e.g., consenting) are beyond the scope of this work.
- Elevation and imagery data presented in the maps is the most suitable available but does not reflect site conditions at the time of the field assessment with great accuracy. The elevation data pre-dates Cyclone Gabrielle. The colour satellite images are post-Gabrielle, but pre-date the field assessment by at least several months.
- Any and all discussions regarding potential actions or implementations, including those had in the field with the Client's representatives and/or third parties (e.g., landowners) shall be considered strictly hypothetical. Nothing in this report or in the course of discussions shall be construed as direction or design-level guidance on the part of WSP or its representatives.