



Problem definition and Asset Condition Review Report (Task 3-2, FVA)

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Horizons Regional Council

Horizons Flood Vulnerability Study

Task 3-2 - Problem Definition Report + Asset Condition Review

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Horizons Flood Vulnerability Study
Task 3-2 Problem Definition Report + Asset Condition Review

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This report ('Report') has been prepared by WSP exclusively for Horizons Regional Council ('Client') in relation to the Horizons Flood Vulnerability Study ('Purpose') and in accordance with the Horizons Flood Vulnerability Study Contract with the Client dated 16 July 2024. The findings in this Report are based on and are subject to the assumptions specified in the Report and Horizons Flood Vulnerability Study Contract with the Client dated 16 July 2024. 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.



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EXECUTIVE SUMMARY

Flood protection assets are a vital component of managing flood risk across the Horizons region. These assets play a crucial role in safeguarding communities, infrastructure, and productive land from the impacts of flooding. However, Horizons Regional Council (Horizons) faces a range of challenges in effectively managing these assets, as outlined in their Infrastructure Strategy and Long-term plan.

Historically, Horizons' asset management approach has been largely reactive, addressing issues as they arise. The current approach to condition assessment and defect prioritisation has a reliance on prioritising visual condition inspections based on asset type and criticality. While this provides a useful starting point, it could be improved to provide a more comprehensive basis for prioritisation.

This report outlines a series of recommendations aimed at strengthening Horizons' flood protection asset management to improve risk-based decision making. Key recommendations include:

- Expanding the use of asset criticality by incorporating additional consequence and likelihood factors to better reflect service importance, performance reduction, and downtime across the asset portfolio.
- Use the updated asset service level information and results of the regional flood modelling, in conjunction with the results of the Flood Vulnerability Assessment, as a basis for targeting in-depth studies of asset level of service.
- Refining the risk framework to integrate asset criticality and outputs from the Flood Vulnerability Assessment, enabling more targeted decision-making.
- Broadening inspection methodologies to include drone and remote imagery, technical inspections, and remote monitoring; improving the accuracy and depth of condition assessments.
- Implementing geospatial data collection and dashboards to streamline inspection workflows, automate risk scoring, and support real-time decision-making and reporting.

These strategies are flexible and can be adopted individually or in combination, allowing Horizons to adapt and scale their approach as more data becomes available. By adopting these recommendations, Horizons can transition to a more proactive, risk-informed asset management model. This will not only improve the efficiency and effectiveness of maintenance, repair, and renewal activities but also strengthen the long-term resilience of flood protection infrastructure—ultimately enhancing the safety and well-being of the communities they serve.

To support implementation, the report also outlines how these recommendations align with Horizons' existing asset management improvement initiatives, including risk register development, data cleansing, and repair programme planning. It further recommends the development of key performance indicators (KPIs) and a dedicated risk management improvement plan to monitor progress and ensure continuous improvement.

1 INTRODUCTION

1.1 PURPOSE OF REPORT

Flooding poses a significant risk to communities, infrastructure, and the environment, necessitating effective flood risk management strategies. With the increasing frequency and intensity of flood events due to climate change and ongoing urbanisation in flood-prone areas (IPCC, 2021), it is crucial to adopt pragmatic, comprehensive and multi-faceted approaches to mitigate risks and enhance resilience.

Horizons Regional Council (Horizons) are completing a ten-year flood hazard mapping programme. Horizons recently completed a new Infrastructure Strategy for the management of approximately \$1 billion in river management and flood protection assets.

Horizons' Infrastructure Strategy and Long-term plan identified challenges surrounding managing the current infrastructure and demand for additional infrastructure. Issues were also highlighted around the levels of service for existing assets. Assets have been constructed over a period of time since the 1940's and been designed to provide a level of service (LoS), e.g. a 1 in 50-year flood protection. Due to changes in the catchments, climate change, and new hydrological information, this level of service has likely changed over time. Managing flood protection assets such as stopbanks, floodgates and weirs is critical to managing flood vulnerability. To support this, Horizons has increased its focus on asset management and asset condition inspection. Horizons has also implemented a planned maintenance-based programme moving away from a reactive based approach.

This report combines the problem definition review and flood protection asset condition review, along with additional tasks that have been identified during the drafting phase. Firstly, some of the drivers and objectives for flood protection assets will be outlined, followed by our understanding of Horizons' asset management process drawing on asset condition, level of service, criticality, and the risk assessment process. The report then presents an enhanced risk management framework that incorporates asset criticality and service prioritisation. This report is a step towards a more comprehensive understanding of asset condition and associated risks, to support more informed decision-making.

2 BACKGROUND INFORMATION

2.1 HORIZONS' FLOOD PROTECTION ASSETS

The general purpose of river protection schemes is to protect people, property, and infrastructure from flooding, while also allowing productive land to be utilised; while the drainage schemes allow for productive potential of large low-lying land to be fully utilised (Horizons Regional Council, 2023). The specific purpose of each individual scheme varies and is defined within the Horizons Regional Council River Management and Drainage Infrastructure Asset Management Plan 2025. Scheme focus is not always centred on the protection of human life, with many schemes focusing on protecting land, development and agricultural activity. Further detail about each scheme's purpose can be found within Table 1 and Table 2 of Horizons' Asset Management Plan (2025).

The complexity of these schemes varies with some schemes having no assets and focus on channel capacity, while others are complex to operate and maintain and have a diverse range of assets within them. Horizons manages a total of 34 schemes (Figure 1) comprising of 23 river and 11 drainage schemes (Horizons Regional Council, 2025; Horizons Regional Council, 2024). As of June 2024, there are 3,794 assets across 28 schemes (Figure 2), with the flood protection assets valued at approximately \$1.2 billion.

Operationally, Horizons focuses on maintaining and repairing their flood protection assets, while also establishing new assets in areas where it is required, for example where river erosion has occurred and protection is required (Horizons Regional Council, 2023). Horizons' capital program also aims to increase service levels to build resilience (Horizons Regional Council, 2023).

2.1.1 ASSET INFORMATION PROVIDED

As summarised in The Current State Analysis Report (WSP, 2025), the following datasets have been provided for this project:

- Shapefiles including points, lines and polygons of flood protection assets
- Excel table with asset quantities
- Excel table with asset condition ratings
- Shapefile of the asset scheme boundaries/extents

To support the asset condition review, the following reports were also provided:

- River Management and Drainage Infrastructure Asset Management Plan – 2025
- Part A – Infrastructural Asset Management Plan – 2018 (superseded)
- Infrastructural Asset Management Plans for each scheme – 2021 (superseded)
- Flood Protection Assets Performance Assessment Code of Practice – Rivers Managers Forum – 2015
- Horizons Flood Protection Asset Inspection Guide – 2025
- Horizons Long-term plan – 2024-2034 (including the Infrastructure Strategy)

2.1.2 SUMMARY OF HORIZONS FLOOD PROTECTION ASSETS

Flood protection assets within Horizons' schemes are categorised in Table 1 and displayed in Figure 2.

Table 1: River management and drainage assets by asset type as at June 2023 (Horizons Regional Council, 2023).

ASSET TYPE	ASSET SUB-CATEGORY	NUMBER OF ASSET	PERCENTAGE BY NUMBER OF ASSETS
Bank Protection	Erosion protection reserve	1697	44.7%
	Gabions		
	Groynes		
	Lining		
	Planting		
	Mesh units		
	Retaining walls		
	Rip rap		
	Stock gates		
	Tree work		
Control Structure	Bed armouring	57	1.5%
	Drop		
	Grades		
	Weirs		
Flood Protection	Detention embankment	1093	28.8%
	Inlets and outlets		
	Floodgates and structures		
	Flood walls		
	Flow diversion structures		
	Guidebanks		
	Portable flood barriers		
	Property mitigation bunds		
	Spillways		
	Stopbanks		
	Toe drains		
Site	Land use drainage pump station		1.2%
	Pump station land/access		
Vegetation Management	Drainage control	770	20.3%
Equipment		118	3.1%
Enhancement		15	0.4%
Total		3794	100%

All River and Drainage Scheme Boundaries

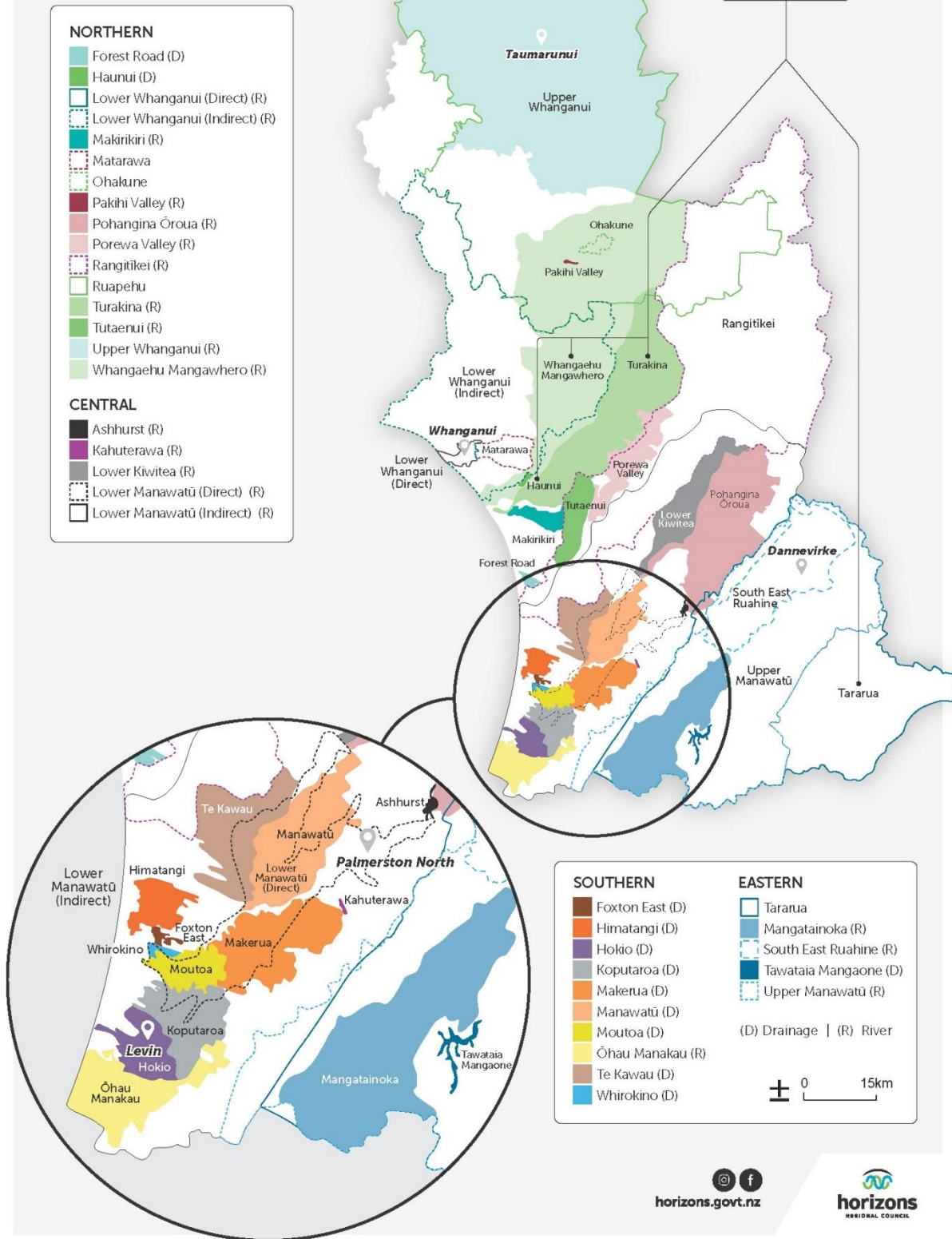


Figure 1: Horizons River and Drainage Scheme boundaries (Horizons Regional Council, 2025).

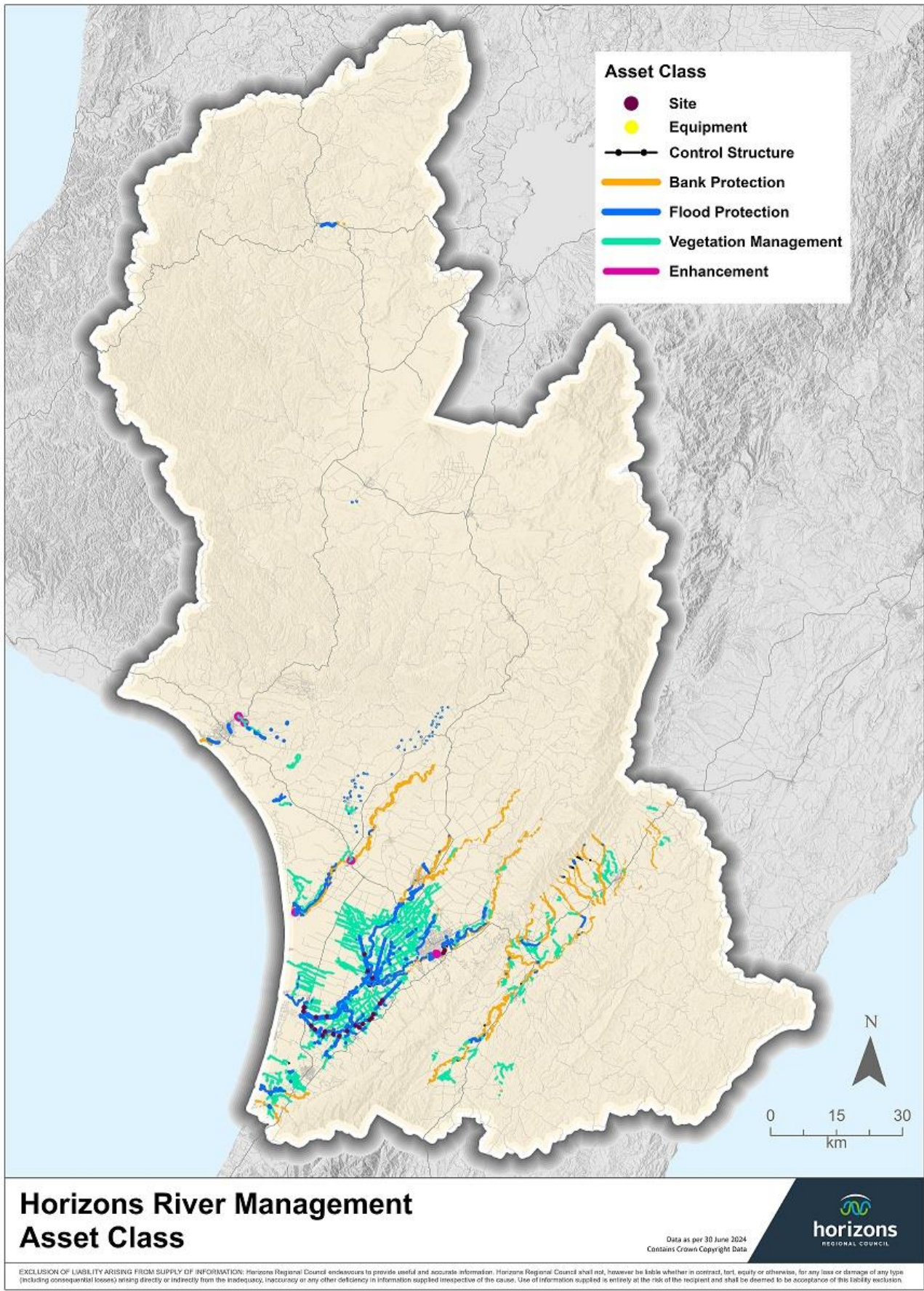


Figure 2: Map of Horizons’ river management assets by asset type as at 30 June 2024 (Horizons Regional Council, 2025).

3 HORIZONS' FLOOD PROTECTION ASSET MANAGEMENT

3.1 LEGISLATIVE SETTING

Flood protection asset management within New Zealand is governed by a range of legislation which provide the frameworks for Councils to manage flood risk and for the provision and maintenance of flood protection infrastructure. The existing primary pieces of legislation include:

3.1.1 LOCAL GOVERNMENT ACT 2002 (LGA)

The Local Government Act 2002 (LGA) establishes the framework for local and regional government, outlining the powers, purpose and responsibilities of authorities.

Under the LGA local authorities are required to prepare and adopt an infrastructure as part of their long-term plans. Section 101B (Infrastructure Strategy) requires councils to prepare and adopt an infrastructure strategy for at least 30 years. The strategy identifies significant infrastructure issues throughout the period covered by the strategy, and the principle options to manage those issues. Infrastructure assets covered by this strategy include flood protection and control works. The infrastructure strategy must also outline the financial provisions for managing these risks, including indicative estimates of capital and operating expenditures.

Schedule 10 of the LGA requires councils to produce a Long-term plan which is a strategic planning document, covering functions from financial planning, social service provisions, and also relates to flood protection and control works. A Long-term plan must cover at least 10 consecutive financial years and be updated every 3 years.

3.1.2 SOIL CONSERVATION AND RIVERS CONTROL ACT 1941

The Soil Conservation and Rivers Control Act 1941 is a foundational piece of New Zealand legislation aimed at managing and mitigating the effects of soil erosion and river-related hazards. The purpose of the Act was to promote soil conservation and prevent damage from floods and erosion. It empowers authorities to undertake works that protect land and infrastructure from the adverse effects of water and soil movement by granting powers to Regional Councils to carry out river control and soil conservation works. These include constructing stopbanks, planting vegetation, and managing river channels. It allows for the creation of schemes funded by both central and local government, often with contributions from landowners who benefit from the works. While many of its functions have since been absorbed into newer legislation like the Resource Management Act 1991, the 1941 Act laid the groundwork for integrated catchment management and remains relevant in the administration of older flood protection schemes.

3.1.3 HORIZONS' LONG-TERM PLAN

As part of their requirements under the Local Government Act 2002 (LGA), Horizons must produce a Long-term plan (LTP) that provides a work programme for the next 10 years. Responsibilities for Horizons within the LTP include the management, design and operational activities associated with the river and drainage schemes in the region.

The LTP defines the activities Horizons intend to carry out for the coming 10 years, and the level of service required for each activity. One community outcome is that the region's communities are resilient to the impacts of natural hazards and climate change, which helps to promote social, economic, environmental and cultural well-being of the community (Horizons Regional Council, 2023). The levels of service are defined

within the Asset Management Plan (AMP) for river and drainage schemes and contribute to this outcome and towards achieving natural hazard resilience and a robust economy.

3.1.4 HORIZONS' INFRASTRUCTURE STRATEGY

Amendments made to the LGA in 2014 require Horizons to prepare an infrastructure strategy for an at least 30-year period, which is to be incorporated into long-term plans. Horizons' infrastructure strategy outlines the Councils approach to managing and maintaining the flood protection and land drainage assets throughout a 30-year period. Horizons Infrastructure Strategy was reviewed and updated in 2024 in line with the 2024-34 Long-term plan (Horizons Regional Council, 2023). The Infrastructure Strategy focuses on river management, flood protection and drainage scheme assets. These contribute to building the resilience of the Horizons communities to climate change and natural hazards, while also supporting a thriving economy (Horizons Regional Council, 2023). The Infrastructure Strategy outlines the key issues from the period of 2024-2054, while linking in how the issues may impact the goals of the Long-term plan.

3.2 HORIZONS' CURRENT APPROACH TO ASSET CRITICALITY AND RISK

Horizons' current approach to risk and asset criticality for River Management and Drainage Infrastructure is outlined in the River Management and Drainage Infrastructure Asset Management Plan (March 2025) (Horizons Regional Council, 2025). The Asset Management Plan (AMP) is reviewed every three years and updated annually. The current AMP, AMP (2025), will be reviewed in 2028 and outlines the levels of services for the schemes and assets, describes the life cycle management regime, sets out the condition inspections, maintenance and repair regimes that are required to maintain levels of service and quantifies the risks associated with the management of assets. Within the AMP, Horizons aim to continually improve the assets for their community to ensure resilience to flood hazards.

Prior to 2024, Horizons used a scheme-based asset management approach, with 27 AMPs developed for 34 schemes (Horizons Regional Council). This has since been updated to a regional asset management approach, where the 27 scheme based AMPs have been collated into one AMP that covers all schemes to provide a consistent approach.

3.2.1 LEVEL OF SERVICE (LOS)

The AMP sets flood protection service levels for each scheme based on risk, aiming to maintain them over time. These vary by scheme and range from 0.2% to 50% annual exceedance probability (AEP). Further details on the service levels for each scheme are detailed in the LTP. Erosion protection schemes do not have defined service levels.

3.2.2 ASSET CRITICALITY

The Asset Management Plan (AMP) Section 3.7 categorises assets into two categories – high or low criticality, which is based on asset type. High criticality assets are essential for maintaining a scheme's service level and include dams, pump stations, stopbanks, floodgates, and weirs. Figure 3 presents a regional level spatial overview of the high and low criticality assets while Table 2 presents an overview of the number of high and low criticality assets. Asset criticality is used to distinguish the frequency of condition inspections where high criticality assets are inspected annually, and low criticality assets are inspected 5-yearly (Horizons Regional Council, 2025). Horizons have a target of inspecting 20% of the low criticality assets annually. Servicing of assets occurs at the time as inspections, and therefore is also dictated by asset criticality.

Table 2: Summary of assets by criticality rating as of June 2024 (Horizons Regional Council, 2025).

CRITICALITY	NUMBER OF ASSETS	VALUE OF ASSETS
High	1312	\$701,048,002
Low	2532	\$496,841,970

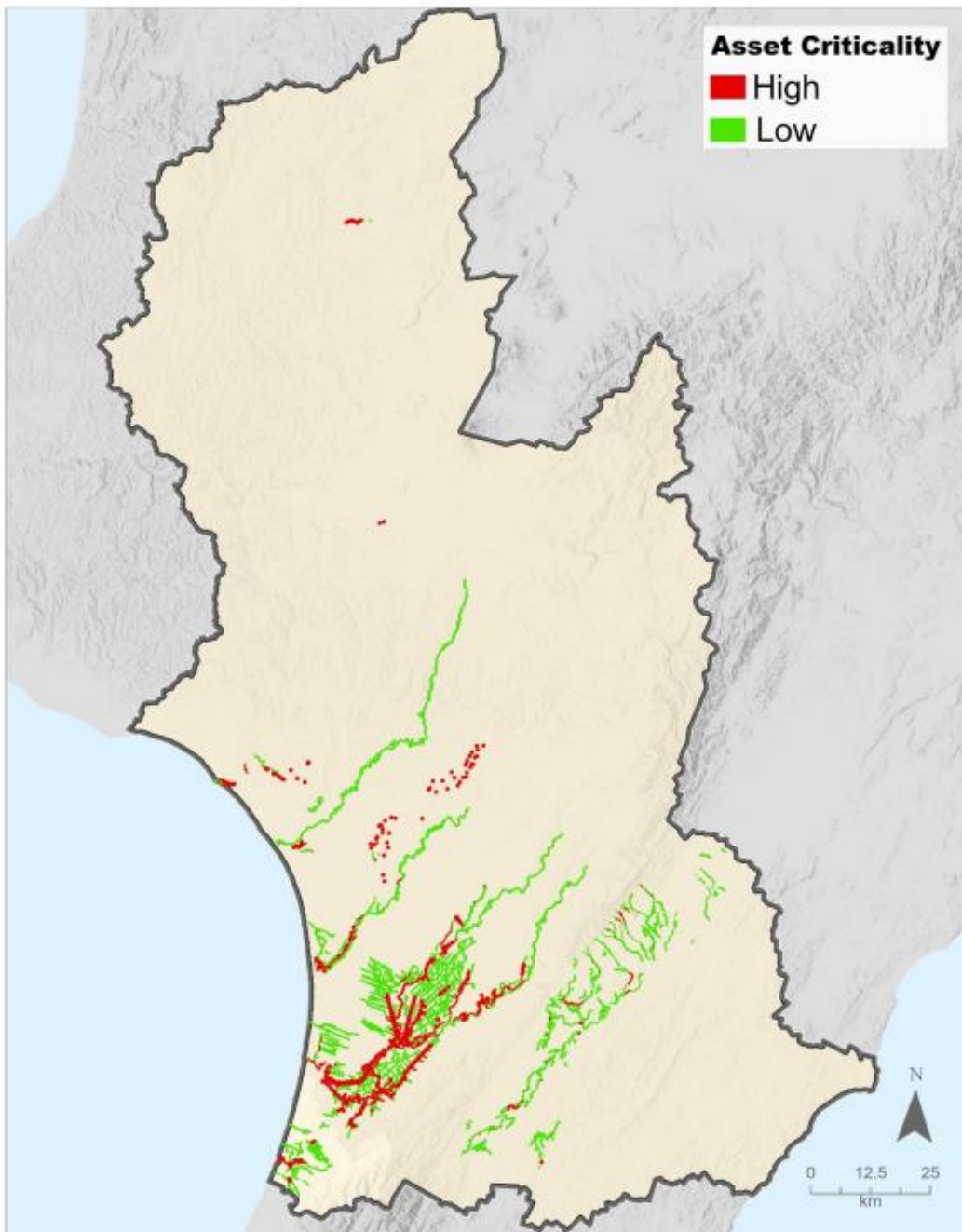


Figure 3: Distribution of assets based on criticality (Horizons Regional Council, 2025).

3.2.3 ASSET CONDITION ASSESSMENTS

Understanding asset condition is crucial in ensuring an asset is performing at its intended LoS. This allows defects to be identified and prioritisation of future remedial and renewal work. Asset condition is currently based on a visual inspection with assessments recorded in a geospatial form and graded on a 1 to 5 scale; with 5 equating to damage that significantly reduces the agreed service level. Conditions 1 and 2 reflect the maintenance status, while conditions 3 to 5 identify defects which may trigger replacement or repair actions Table 3 . Shown in Figure 4, based on the condition status results within the LTP Infrastructure Strategy, most assets have been assessed with a criticality rating of ‘1’ or ‘2’ (Horizons Regional Council, 2023).

Table 3: Asset condition descriptions (Horizons Regional Council, 2025).

CONDITION RATING	CLASSIFICATION	DESCRIPTION
1	Fully Effective	Operating at agreed level of service. No operation action Required.
2	Functional	Maintenance program. Requires maintenance to maintain agreed level of service.
3	Minor damage	Minor damage. Requires minor repairs to return to agreed level of service.
4	Major damage	Damage reduces agreed level of service. Requires major repair to return to agreed level of service.
5	Significant loss	Damage reduces agreed level of service significantly. Requires replacement or new capital work to return to agreed level of service.

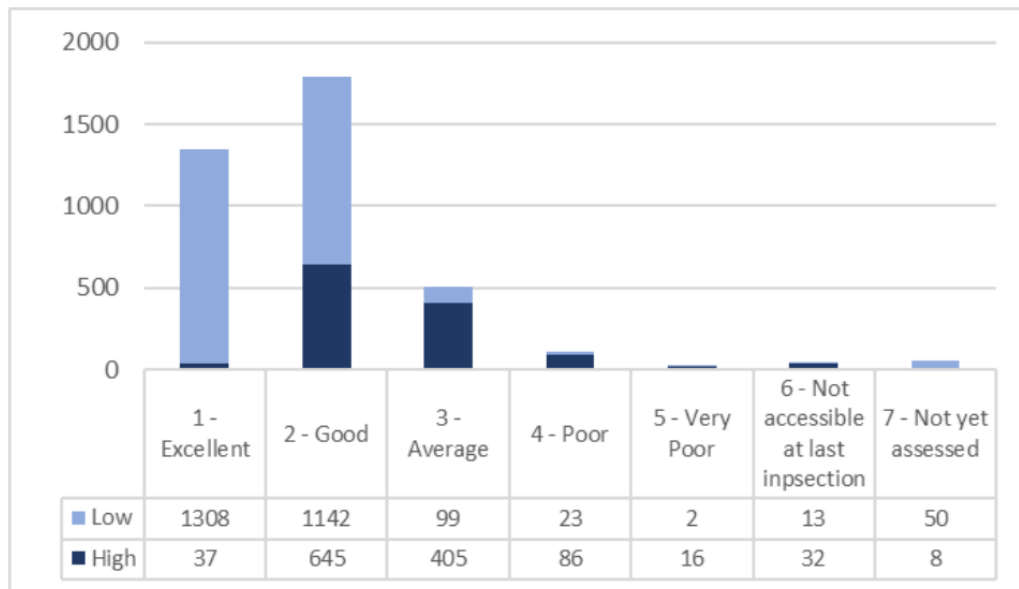


Figure 4: Summary of asset condition ratings as of November 2023 (Horizons Regional Council, 2023).

3.2.4 RISK ASSESSMENT

Following condition inspections, a risk assessment is undertaken to assist Horizons in prioritising repairs based on the defects identified, the likelihood of the defect impairing asset performance occurring and the consequence of failure. The matrix assesses the consequence of the defect not the asset itself. Where there

are multiple defects, the compounding effect is considered. Where available, flood modelling (including present and future climate scenarios) and banks down scenarios can be used to consider the consequences of defect.

The prioritisation framework for defect repairs is calculated as risk = consequence x likelihood, as shown in Table 4. Likelihood is inferred from the condition score that is determined from the asset inspection, while consequence represents the impact if the defect occurs. This approach has been informed by the Rivers Mangers Forum 2015 Flood Protection Asset Performance Assessment Code of Practice. As stated within the River Managers Forum (2015), the consequence of failure is usually structured in a way to consider the full range of impact that may occur from a failure, including specific items which may include:

- The value of land being protected.
- Land use.
- Loss of production on inundated land.
- Lost wages of employees unable to attend work.
- Damage to flood protection assets.
- Damage to other critical infrastructure.

While this list is not exhaustive, it primarily reflects economic impacts. Broader societal consequences are not explicitly addressed, though may be addressed through proxies such as building count.

Table 4: Horizons' risk metric used to prioritise the repair of defects within flood protection assets (guided by River Managers Forum 2015).

Risk = likelihood x consequence			Likelihood of defect impairing asset performance, inferred using asset condition score				
			Excellent	Good	Average	Poor	Very Poor
Consequence of a flood occurring before defect is repaired	Paddock scale or single property, no buildings.	1			Low	Low	Low
	Multiple properties, no buildings.	2			Low	Medium	Medium
	Infrastructure, or up to 9 buildings impacted.	3			Medium	High	High
	Between 10 and 49 buildings impacted.	4			Medium	High	Very High
	Greater than 50 buildings impacted.	5			High	Very High	Very High

Source: Guided by River Managers Forum, 2015. *Flood Protection Assets Performance Assessment Code of Practice*.

"The consequence of failure is usually structured in such a way as to consider the full range of impact that a failure may have including specific items for flood bank failures such as: 1) Value of the land being protected; 2) Land use; Loss of production on inundated land; Lost wages of employees unable to attend work; Damage to the flood protection assets; Damage to other critical infrastructure (e.g. transport, telecommunications, power)"; and the criteria within <https://www.horizons.govt.nz/HRC/media/Media/Grant-and-Sponsorship/20230130-Environmental-Grant-Eligibility-for-River-works.pdf>

Note: assets will each have an intrinsic strength and capacity towards delivering the Level of Service of the scheme. However, for this purpose we are not assessing the asset, we are assessing the indicative consequence of the defect which is impairing the asset. Where there are multiple defects impairing the asset, consider the compounding effect of those defects. For the purposes of considering consequence, flood plain modelling and banks down scenarios may be used where available. Over time, this approach for assessing consequences can be improved to using available research such as modelled flood vulnerability.

3.2.5 ENHANCEMENTS TO EXISTING ASSET MANAGEMENT PROCESS

Following a review of Horizons' current asset management process, the following areas for enhancement have been identified:

- 1 The existing asset risk assessment is primarily consequence-based, focusing on land use, economic value, productivity, wage loss and damage to flood protection and critical infrastructure (Horizons Regional Council, 2025). While direct references to human life safety are not explicitly included, the number of buildings is used as a proxy for human presence, indirectly reflecting potential impacts on people. This approach may not fully capture the societal risk associated with asset failure – particularly in a densely populated or vulnerable community. Expanding the assessment to more explicitly consider these dimensions would support a more comprehensive understanding of risk and enable more targeted flood risk management decisions contributing towards improved natural hazard resilience and a more robust economy.
- 2 Criticality of assets has been defined by whether an asset is likely to experience changes between and during flood events, and whether they are essential for a scheme meeting its LoS. This definition does not include reference to the vulnerability or exposure. As a result, assets that may be structurally weak or located in high-risk flood zones could be under-prioritised, potentially overlooking key risk factors that influence overall system resilience.
- 3 Horizons currently rely on visual inspections to assess the condition of their flood protection assets. While this identifies surface-level issues, such as vegetation, animal burrowing, or erosion, visual inspections limit the ability to detect any structural, geotechnical or hydraulic deficiencies that may lead to failure during flood events.
- 4 Asset conditions are assessed based on the agreed level of service. Erosion protection assets, which comprise 44.7% of Horizons' network, do not have a defined level of service. An absence of benchmarks or standards makes it difficult to evaluate the performance of these assets. Establishing a clear level of service for these assets would enhance the accuracy and consistency of their condition assessments.
- 5 Condition ratings for linear assets are currently aggregated across their entire length, meaning each asset is evaluated as a single, continuous unit. This holistic approach can lead to inaccuracies, as it may either overstate or understate the actual risk. Segmenting these assets into smaller sections and assigning condition ratings at that level could provide a more precise assessment of their condition and associated risks.
- 6 Historically, the approach to asset inspections, maintenance, and renewals has been predominantly reactive, with actions taken in response to visible issues or failures. While this approach has addressed immediate concerns, it can result in inefficiencies, higher lifecycle costs, and increased exposure to risk—particularly in areas vulnerable to natural hazards. Horizons is now working to shift toward a more proactive, risk-informed asset management strategy. A key opportunity for improvement lies in the integration of natural hazard data and asset vulnerability assessments into planning and prioritisation processes. This would enable more targeted inspections and maintenance in high-risk areas, reduce the likelihood of asset failure during hazard events, and support more resilient and cost-effective infrastructure management over the long-term.

4 ASSET LEVEL OF SERVICE

4.1 INTRODUCTION

As explained in Section 3.2.1, flood protection assets are typically designed to meet specific Levels of Service (LOS), which define their expected performance under various flood conditions. Within the Asset Management Plan (2025) these are generalised to a scheme level.

To better understand how existing assets perform under a range of flood scenarios, a high-level assessment was undertaken using updated flood modelling data provided by NIWA as part of this Flood Vulnerability Study. This modelling includes flood events with return periods of 20, 50, 100, and 200 years, with the 200-year scenario incorporating projections for climate change and sea level rise (NIWA, 2025).

The purpose of this assessment is to provide an initial indication of how well current assets align with these flood scenarios, helping to identify potential vulnerabilities and inform future planning and investment decisions.

4.2 METHODOLOGY

Due to the absence of detailed as-built documentation specifying freeboard allowances or defined Levels of Service (LOS) for individual flood protection assets, a generalised geospatial approach was adopted to assess asset performance against modelled flood scenarios. This approach was designed to provide a consistent and scalable method for evaluating a large number of assets using available spatial and elevation data.

The first step involved converting the flood protection assets - originally provided by Horizons as shapefiles representing linear (e.g., stopbanks) and polygonal (e.g., detention basins) features - into representative point features using geospatial midpoint feature functionality. This conversion was necessary to enable spatial overlay analysis and to simplify the comparison between asset elevations and modelled flood levels.

Once the assets were converted into points, a single representative point was extracted for each asset. This point served as a proxy for the asset's location and elevation. For example, a point representing a stopbank is intended as a proxy for the stopbank crest elevation, rather than representing a surveyed or as-built crest level. While this method does not capture the full spatial variability of each asset, it provides a practical means of conducting a broad-scale assessment for more than 3,800 assets.

At the location of these points, high-resolution terrain data was used to extract the ground elevation at each asset point. This elevation represents the surface level of the asset at the selected location and forms the baseline for performance comparison. Ground elevation values were provided for both with and without stopbanks. The 'with stopbank' values are derived from the digital elevation model (DEM), while the 'without stopbank' are sampled from a separate DEM where stopbank geometry has been removed and interpolated.

For each of the modelled flood scenarios the water surface elevation was extracted at the same asset point. This was completed for all flood scenarios, including those with and without stopbanks, with the inclusion of climate change and sea level rise.

The ground elevation of each asset point was then compared with the corresponding flood water elevation. If the modelled flood level exceeded the ground elevation, the asset was considered at risk of overtopping or failure under that scenario. Within the results, if no elevation is provided, the asset level has not exceeded the modelled flood levels, indicating that it has not failed. This binary pass/fail approach provides a high-level indication of whether each asset would meet its LOS under the given flood conditions.

4.3 RESULTS

The results of this analysis were delivered to Horizons in two formats. First, geospatial datasets (including point, line, and polygon layers) were provided, containing asset IDs, associated schemes, and performance outcomes. Second, tabulated results were delivered in Excel format, summarising asset performance by ID and scheme, to support further analysis and integration into asset management systems. The tabulated results represent where modelled flood levels exceed the ground elevation.

The spreadsheet enables a pass/fail interpretation of results through consideration of modelled flood levels and ground elevation. The results can serve as a proxy for performance and provide Horizons an initial evidence base to validate the LOS of assets against the as-built data and associated ARI's. Integrating these results with asset criticality data would further support prioritisation of inspections, maintenance, or renewal activities.

The results provided to HRC do not contain direct LOS values from as-built documentation of assets and instead provides a proxy of asset performance by comparing the modelled flood heights to asset elevation. This enables Horizons to infer whether an asset meets its intended level of service under specific flood scenarios. The binary pass/fail outcome offers a scalable method for identifying underperforming assets and forms a foundation to support future investment and renewal decisions.

This regional-level approach provides an indication of where assets within the flood protection schemes may not perform to their intended Levels of Service (LOS). The binary pass/fail outcome offers a scalable method for identifying underperforming assets and can support future investment or renewal decisions. It also highlights where higher-resolution modelling may be required to better understand individual asset performance, or where comparisons with as-built LOS documentation may be necessary to update asset-specific service levels.

4.4 RECOMMENDATIONS

We recommend that Horizons convert the modelled water levels into Annual Exceedance Probability (AEP) values and incorporate these into the asset performance analysis. This approach would enable a more meaningful comparison between observed performance and the expected Levels of Service (LOS). It would also allow assets to be assessed against the LOS defined at the time of their construction (as per as-built documentation) and support the definition of updated LOS where appropriate.

To strengthen the assessment, Horizons should also integrate LOS criteria at the scheme level, or where available, at the individual asset level. This information was not included in the original geospatial dataset provided for analysis. For this reason all assets have been modelled against all flood scenarios regardless of the ideal LOS the scheme was originally designed to provide.

By incorporating AEP values, LOS benchmarks, and criticality into the analysis, Horizons can move toward a more risk-based approach to asset management and decision-making, ensuring resources are directed where they are most needed.

These high-level results combining the asset service level against the results of the regional flood modelling could be viewed in conjunction with the results of the Flood Vulnerability Assessment (FVA). Where the FVA identifies a community as highly exposed to flooding, this could be used to identify where more detailed flood modelling is required to understand asset performance.

4.5 LIMITATIONS

This assessment draws on outputs from the Flood Vulnerability Assessment (FVA) to inform high-level understanding of where flood protection assets influence exposure. However, the FVA is based on Level A regional-scale modelling, which is designed for comparative regional analysis rather than asset-specific performance evaluation. Its results cannot be used to quantify asset performance, levels of service, or expected flood behaviour at the scheme or asset scale, rather the FVA can inform asset criticality at a broad,

indicative level. Any conclusions regarding actual asset performance, design standards, or levels of service require higher-resolution hydraulic modelling (Level C/D) or detailed site-specific investigations.

A key simplification in the methodology is the use of a single representative point for each asset. For linear features such as stopbanks or polygonal features like bed armouring, this point may not reflect the full range of elevations across the asset. As a result, localised vulnerabilities - such as low points that are more susceptible to overtopping - may not be captured in the analysis. Additionally, the assessment does not segment assets into smaller components. Segmenting linear and polygonal features could reveal variations in performance along their length or area, helping to identify specific sections that may be underperforming. The absence of segmentation limits the granularity of the results and may obscure critical details.

The original geospatial data provided to WSP does not include any information of scheme level of service. While this information has been provided within the Asset Management Plan (Horizons Regional Council, 2025) the levels of services have not been carried over into the geospatial datasets of the assets.

This assessment was conducted at a broad scale and used point data that served as proxies for each asset's location and elevation. The elevation data assigned to the asset points have been extracted from two different DEM surfaces (for stopbanks up and stopbanks down), have not been calculated by adding a stopbank height to underlying ground levels and therefore are not expected to match perfectly. Discrepancies may arise because asset points may not align exactly with the stopbank crestline, or the asset shapefiles may have been digitised at a resolution that does not perfectly align with the DEM. Further variation may also result from the resolution and smoothing from the DEM itself.

An additional limitation is the interpretation of flood heights in relation to Annual Exceedance Probabilities (AEP). The modelled flood elevations do not directly correspond to specific AEP values. This means that it is not possible to conclusively state, for example, that an asset is performing to a 50% AEP event when it is expected to meet a 20% AEP standard. This restricts the ability to benchmark asset performance against design expectations and LOS criteria with precision. To conclusively reassess individual asset LOS, higher resolution modelling and/or as built LOS comparisons would be required.

5 ENHANCED RISK MANAGEMENT APPROACH

While condition assessments and inspections are essential components of asset management, they represent only one dimension of a comprehensive risk management strategy. Risk management within asset management should be viewed through a broader lens—one that considers not only the physical condition of assets but also their criticality, function, and the potential consequences of failure. By integrating risk-based thinking into asset planning and decision-making, Horizons can prioritise resources more effectively, focusing attention on assets that are most vital to service delivery, safety, and operational continuity. This approach is in line with Horizon’s 2025 Asset Management Plan which has a shift from reactive maintenance to proactive risk mitigation, ensuring that high-criticality assets receive the scrutiny and investment they warrant, while still maintaining oversight of the broader asset base. While our scope focuses on asset management regarding inspections, this section highlights how criticality and the risk assessment framework could be adapted.

5.1 RISK MANAGEMENT PRINCIPLES

Application of risk within the asset management context needs to consider a hierarchical approach to managing risk. The risk hierarchy comprises various levels of risk within an organisation, representing the organisational delivery chain and the differing risk management contexts that exist. The diagram in Figure 5 demonstrates the various levels of risk within an organisation and how these can influence the asset management approach. For the Asset Condition Review, the principal focus is to develop an approach for managing risk at the ‘Asset Risk’ tier. Asset Risk can be used to identify the highest risk assets, which can be elevated to Service Risk level influencing the wider asset management planning approach.

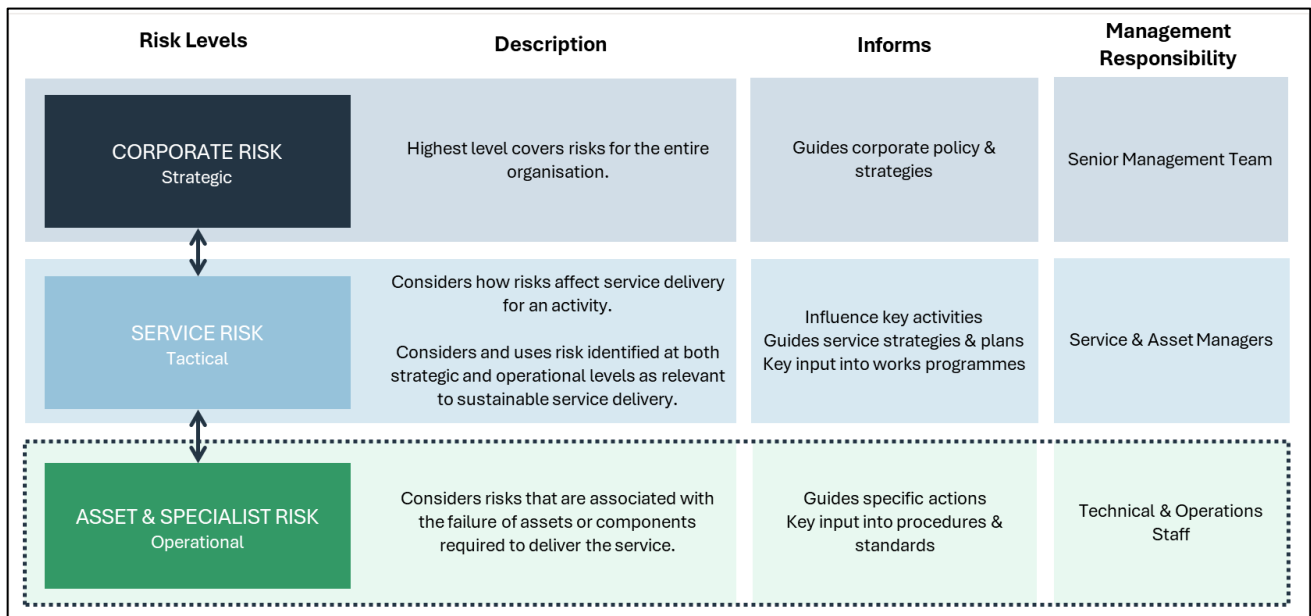


Figure 5: Hierarchy of risk within an organisation and how this influences asset management (aligns with the principles of ISO 31000 and ISO 55001).

Asset risk is the product of the likelihood of failure and the consequence of the failure, arising from a predetermined hazard of a certain magnitude Figure 6. Often, risk and criticality are incorrectly interchanged and used to define risk.



Figure 6: Equation for asset risk (References: ISO 31000 and IAM Risk Assessment and Management, Version 1.1 October 2016).

5.2 ASSET CRITICALITY

Asset Criticality is a key tool for informing Horizon's asset management strategy, planning, decision making tools and processes.

Asset Criticality is the consequence arising from the sudden and total loss of an asset (or one of its components). Criticality is a reflection of the extreme consequential impact created by the sudden loss of a system, asset or asset component.

Horizons' most critical assets are those which have a high consequence to service delivery if they fail (Horizons Regional Council, 2025). By refining the way Horizons identifies critical assets, asset managers can target and refine investigative activities, maintenance plans and capital expenditure at critical areas, and can prioritise studies such as more detailed risk assessments and inspections. For this project, asset criticality is a key factor that impacts on the Asset Condition Review. Figure 7 shows key elements that can be considered when determining Consequence and Likelihood.

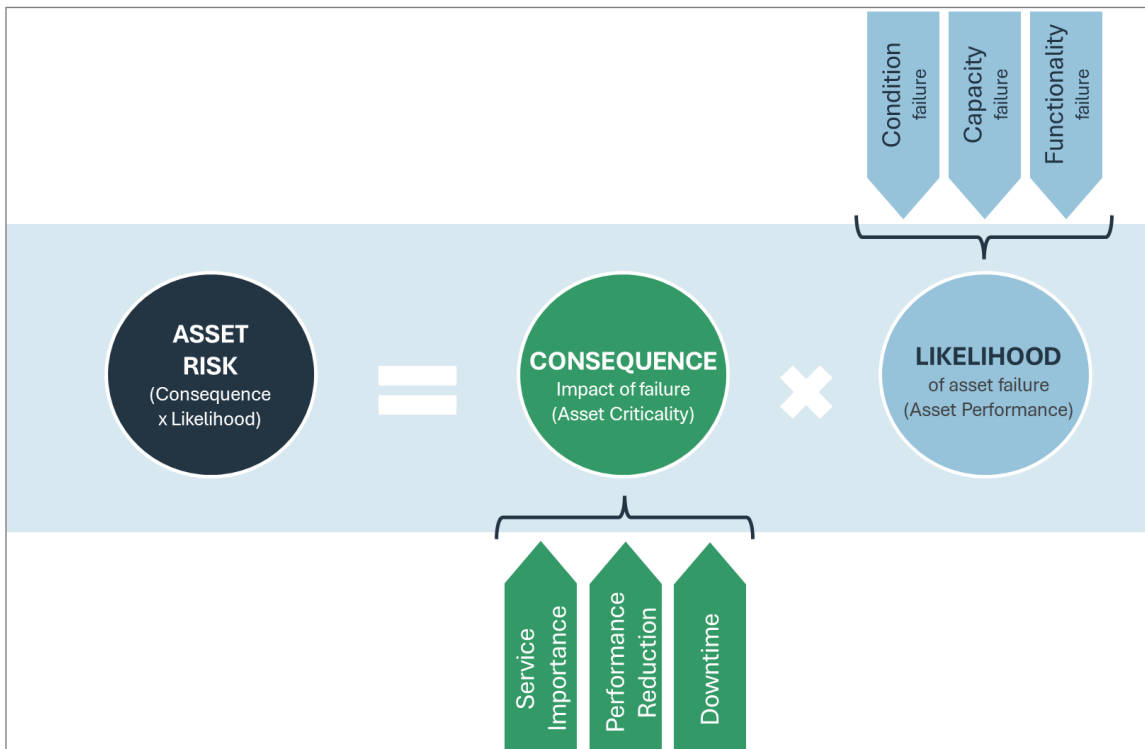


Figure 7: Elements to consider for determining consequence and likelihood when considering asset risk (Reference: IAM Risk Assessment and Management, Version 1.1 October 2016).

For the purposes of this Asset Condition Review, Likelihood will still be driven by Condition, however the work completed on the vulnerability assessment mapping can be used as key inputs to quantify consequence and likelihood factors.

Rather than basing asset criticality on asset type alone, it is recommended to assess the criticality of an asset based on service importance, performance reduction and downtime (Figure 8):

- **Service Importance:** The importance of the schemes (which the asset forms a part of) to provide the service to the community. This essentially considers the effect on the community of losing service provision. Key factors that could be considered:
 - Economic – loss of productivity, damage to commercial property, disruption to transport or utilities
 - Social – effect on community wellbeing and access to essential services
 - Cultural – damage to culturally significant sites, marae or heritage landscapes
 - Environmental – erosion, sedimentation or degradation of natural habitats
- **Performance Reduction:** Reflects how important the asset is to scheme performance based on the impact on the service provided by the scheme if the asset fails.
- **Downtime:** The time to return the asset to full capacity (full service restored), relating to the time for the service to be fully restored. This may include the physical time to repair the asset, and also the time to secure funding, resources and approvals. If an asset continues to operate below its intended service level, this increases the likelihood of failure and may influence the impacts. The duration an asset takes to return to service may lead to higher repair costs and reduced community resilience.

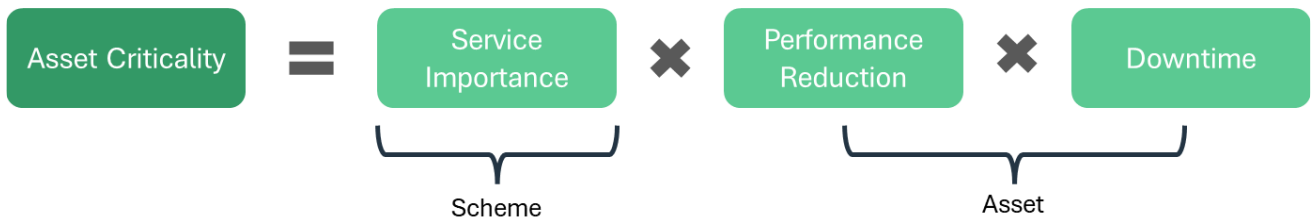


Figure 8: Asset criticality based on the scheme and the asset.

5.3 ASSET PERFORMANCE

To determine the likelihood of failure there are different factors to be considered that affect asset performance. While asset condition grade is a key consideration, there are several other factors that contribute to the overall asset performance as shown in the example in Table 5 (US EPA, 2016).

Table 5: Asset Performance Indicators Example.

ASSET PERFORMANCE INDICATOR	DESCRIPTION	SERVICE STATEMENT	ASSET PERFORMANCE MEASURES	DESCRIPTION	STOPBANK (EXAMPLE)	LIKELIHOOD CONTRIBUTION (EXAMPLE)
Condition	Ensures that the asset is capable of performing	Assets are in working order, not damaged or in need of replacement	Condition Grade	Condition may be assessed in different ways, but related back to consistent grading	Grade 2 (Good) – minor surface erosion, no structural issues	Low
			Age	Time since asset was created	Constructed in 1985 (40 years old)	Moderate
			Remaining life	Based on deterioration modelling and condition	Estimated 30+ years with current maintenance	Low
			Obsolescence	Asset may be in good condition, but becoming obsolete	Design still meets current standards	Low
			Maintenance & Operational Requirements	Historic repairs & programmed defects	Annual inspections, minor repairs after storm events	Moderate
Capacity	Ensures the asset is right sized for the intended use	Assets have capacity to meet service requirements	Current capacity	Asset is 'right size' for current demand	Designed for 1-in-100-year flood; recent events approaching design threshold	Moderate
			Future capacity	Asset is 'right size' for future demand	May be exceeded under climate change projections (1-in-200-year events)	High
Functionality	Ensures that the asset operates as intended	Assets are where they are needed	Location	Asset is where it needs to be to provide service	Strategically aligned along riverbank protecting urban fringe	Low

ASSET PERFORMANCE INDICATOR	DESCRIPTION	SERVICE STATEMENT	ASSET PERFORMANCE MEASURES	DESCRIPTION	STOPBANK (EXAMPLE)	LIKELIHOOD CONTRIBUTION (EXAMPLE)
		Assets are reliable and resilient	Availability	Asset operates when called upon	Always in place; passive protection	Low
			Vulnerability	Assets can withstand predictable events and hazards	Prone to overtopping in extreme events; seepage risk in some sections	High
			Durability	Asset is tolerant to 'wear and tear'	Well-compacted earthworks; some vegetation encroachment	Moderate
		Assets work efficiently and effectively	Design performance	Assets perform as designed	Meets original design intent; no major redesigns needed	Low
			Cost of operating	Value delivered	Low operational cost; periodic maintenance only	Low

The Flood Vulnerability Assessment provides information that can feed into a number of these asset performance measures. Horizons can use the table above and the Flood Vulnerability Assessment as a starting point to further develop their asset risk assessment approach.

Table 5 provides a worked example of how to apply these performance indicators. For this stopbank example, the stopbank currently exhibits good condition and functionality, with low operational costs and minimal structural concerns. However, the likelihood of failure is increasing under future climate scenarios due to capacity limitations and vulnerability to overtopping and seepage.

5.4 RECOMMENDATIONS

Using this suggested risk framework, the key areas of focus in the short-term should be on:

- Confirming and refining the approach for assessing asset criticality, with consideration of additional rankings for asset criticality and then applying it to determine asset criticality across the asset portfolio, and integration of results of the Flood Vulnerability Assessment.
- Using asset criticality as a key input in developing the initial management strategies. This will provide more insight into the consequence of asset failures and can help improve management strategies. These management strategies will in turn help refine the Condition 'likelihood' factor in a risk framework.
- Any analysis on the prioritisation of investment in flood protection assets is completed periodically and in line with council's LTP requirements.

This approach allows Horizons to get some 'quick wins' by building on their current risk management approach, while still allowing for future enhancement to better support investment planning using a risk-based approach.

The principles presented in this section, highlighting the importance of asset criticality, are carried throughout the following sections, where asset criticality can be used to inform decisions on inspections and management strategies.

6 INSPECTIONS & MONITORING OPTIONS

This section presents an overview of inspection and monitoring methods that Horizons could utilise to assess the condition of flood protection assets. Regular condition assessments are fundamental to effective flood risk management, and provide critical data on asset performance, deterioration and vulnerabilities (Bay of Plenty Regional Council, 2024). Condition assessments help to identify deterioration early, enabling informed decision-making for maintenance, reducing repair cost and extending an asset life, before the asset fails (UK Environmental Agency, 2025; CIRIA, Ministry of Ecology, USACE, 2013; Waikato Regional Council, 2021; Bay of Plenty Regional Council, 2024).

Condition assessments also play a strategic role in highlighting systemic vulnerabilities across the network. This supports the prioritisation of upgrades, informs investment planning, and can be used to support decision-making (Waikato Regional Council, 2021). This contributes to a proactive, risk-informed approach to flood protection.

Inspections are conducted on a regular and recurring basis, or in response to events that may impact asset performance (CIRIA, Ministry of Ecology, USACE, 2013). Each method outlined below can be used individually or in combination to enhance understanding of asset conditions. By integrating these approaches, Horizons can achieve a more detailed and accurate assessment, supporting strategic investment and maintenance planning. A comparison of the indicative costs associated with each method is provided at the end.

6.1 MONITORING OPTIONS FRAMEWORK

6.1.1 VISUAL INSPECTIONS

Visual inspections are systematic onsite assessments, where inspectors evaluate the condition of flood protection assets using direct observations (UK Environmental Agency, 2025). They can be completed by typically by walkovers or 'drive-bys, whereby inspections look for visible signs of deterioration or damage, and identify obvious or emerging issues (Waikato Regional Council, 2021). Horizons currently employ visual inspections as their primary inspection methods (Horizons Regional Council, 2025).

Visual inspections can occur routinely or can be detailed inspections, integrating specialised equipment. As explained in Section 3.2.3, Horizons complete annual routine inspections for all high criticality assets and have targets of completing annual inspections for 20% of low criticality assets (Horizons Regional Council, 2025).

Visual inspections are often supported by geospatial tools such as ESRI's Survey123 or Field Maps, allowing structured, geotagged inspection forms to be completed in the field (Waikato Regional Council, 2021). Horizons uses a geospatial-enabled field data collection app, along with these ESRI tools, to streamline inspection processes. Geospatial workflows can be automated to incorporate risk assessments, with results integrated into other GIS tools such as dashboards to support decision making. Visual inspection can also be supplemented by drone inspections by suitably qualified operators capturing typically video content for harder to reach areas or for rapid deployment pre/post event.

6.1.2 TECHNICAL INSPECTIONS

Technical inspections are detailed inspections that are conducted to investigate specific concerns that are not identified or assessed through visual inspections. They may be triggered after a visual inspection identifies an issue that needs further inspection (UK Environmental Agency, 2025). Within New Zealand, some councils, such as Bay of Plenty Regional Council, incorporate technical inspections into long-term asset condition and

performance programmes, focusing on visual inspection and drones for operational and post-event inspections (2024). Technical inspections may focus on structural integrity, geotechnical stability, hydraulic performance or the functionality of assets (Bay of Plenty Regional Council, 2024). Technical inspections seek to identify issues that may be hidden or developing that would impact the performance of the asset or may be triggered as part of post-event inspections after events like floods or earthquakes. This can include internal erosion, seepage, settlement or structural issues.

Technical inspections may utilise or investigate the following (UK Environmental Agency, 2025):

- **Geotechnical inspections** – with potential follow-up actions such as investigation excavations, installation of investigation and deformation /groundwater monitoring boreholes, surface deformation monitoring instrumentation and geophysical surveys
- **Structural inspections** – material testing, crack monitoring
- **Hydraulic performance evaluations** – flow measurements, pump testing, and stopbank capacity
- **Instrumentation data review** – piezometers, inclinometers

Technical inspections support evidence-based decision making for asset management and investment, while also can be used to verify that the asset meets design specifications and performance standards. They are typically completed less frequently than routine visual inspections (Bay of Plenty Regional Council, 2024), and may be conducted after events such as floods or earthquakes.

6.1.3 DIGITAL AND REMOTE MONITORING & INSPECTIONS

Digital and remote inspections utilise technologies to collect data to allow assessment of the condition and performance of assets. They do not require physical access onto the site making remote monitoring and inspections useful for sites with challenging access. These methods utilise sensors and remote sensing technologies and can enhance other inspection methods (such as technical or visual) by providing site-wide data collection. Building a robust collection of digital asset data, including point clouds, DEM's, DSM's and imagery, can contribute to the development of a digital twin of Horizons' assets in the long-term and assist in supporting future decision making. There are several different tools and technologies that can be used. Consideration of the environment, monitoring precision, and project scale is important to determine the most appropriate tool for a task. Key tools and technologies include:

- **Drone imagery** – capture high resolution imagery and videos of assets. These are ideal for targeted inspection work and provide means of inspection for assets that are in areas that are difficult or unsafe to access, (UK Environmental Agency, 2025; Knott, Stewart, Fallas, & Delpont, 2019). For larger scale or regional surveys helicopter/fixed wing aircraft should be prioritised over drones for efficiency. Drone inspections can be conducted at regular intervals (e.g. annually) and/or after significant events. If captured correctly the imagery can be processed readily using photogrammetric software into accurate 3D survey models of the site, that can be useful for detecting subtle changes in elevation, deformation or erosion. This is cost effective and useful in open environments (e.g. monitoring change in gravel be rivers). Photogrammetry is less effective than LiDAR in highly bushed environments or where more vertical accuracy is required. Drone imagery can also be supplemented with Google or Satellite Imagery to allow for change detection (Environment Canterbury, 2023). We are aware that Horizons has their own survey team/survey capabilities.

Drone or helicopter / aeroplane LiDAR scanning – create high resolution 3D models of the terrain and structures. These models offer precise measurements and detailed mapping and can be useful for detecting subtle changes in elevation, deformation or erosion. LiDAR is better for surveying ground surface levels in bushed areas than surveys processed from drone imagery. LiDAR data collected in conjunction with aerial photography allows true photo colours to be added to the LiDAR data, which is more useful for visualisation and the identification of surface features than monochrome LiDAR outputs. Both drone and LiDAR methods

can also support hydraulic modelling where the information captured can be used to model water levels to understand stopbank capacity (Environment Canterbury, 2023).

- **Satellite imagery** – provides a broad repeatable view of the flood protection assets and supports long-term monitoring for land use changes and flood extents or identification (UK Environmental Agency, 2025). Satellite imagery can also supplement aerial and drone surveys to fill any gaps. Satellite radar (inSAR) allows precise survey positioning of ‘reflective’ features in the landscape and can be utilised for identification of more subtle surface movement detection. Satellite imagery is particularly useful for assets that are spread over broad areas (UK Environmental Agency, 2025).
- **Topography assessment and change detection** - while assessment of survey models from photogrammetry or LiDAR allows assessment of the topography of the site, comparison of repeat survey models from photogrammetry, LiDAR and inSAR allows changes in the topography to be highlighted, be they natural (ground deformation e.g. slumping or erosion) or manmade (recent earthworks or structures). Assessment of the unclassified (ground and above ground features) survey data allows changes in vegetation heights to be assessed. The use of more than one technique allows more reliable interpretation of the change (‘anomaly’). For more subtle ground surface movement, such as stop bank settlement, repeat InSAR surveys are optimal.

6.1.4 INSTRUMENTATION MONITORING

Monitoring instrumentation includes devices to measure changes in asset condition or performance when positioned in strategic locations and can be useful for understanding long-term trends and performance. Examples of instrumentation monitoring options for stopbanks may include devices to measure changes in pore pressure (piezometers), deformation (settlement or slope movement) and flow rates from seepages or toe drains. Web camera and computer vision technology development has accelerated and offers considerable opportunities for asset monitoring.

Additional instrumentation may include rain gauges or soil moisture level monitoring. Devices, such as pressure sensors, can be located in drilled boreholes or at, or near, surface. Conventional flow gauges and water level instrumentation data can also be captured and used to support hydraulic surveys.

While instrumentation methods were previously required to be manually read, they can now be accessed remotely to provide real-time continuous, reducing the requirement for frequent on-site visits (UK Environmental Agency, 2025).

6.1.5 RECOMMENDATIONS

These recommendations are designed to improve the quality, consistency, and utility of spatial information across the Horizons region. They emphasise collaboration with key stakeholders, alignment with risk and asset criticality, and the preservation of data for long-term value. Together, they form the foundation for a resilient and adaptive asset management and flood risk assessment program.

Regional Aerial Photography Programme

- 1 Maintain a coordinated 5-yearly regional aerial photography capture program to:
 - Provide consistent baseline datasets across the region,
 - Track land cover and infrastructure changes,
 - Support spatial analysis, planning, and public-facing mapping platforms.
- 2 Promote coordination to align national aerial photography acquisition with local initiatives:
 - Engage with Territorial Authorities (TAs), Waka Kotahi NZTA, utility providers (e.g., Line Companies), and KiwiRail to avoid duplication and maximise the value of regional coverage.

Targeted Annual Monitoring for Dynamic Catchments

- 1 Implement annual aerial photogrammetry surveys over highly dynamic gravel-bed rivers where morphological changes (e.g., channel migration, gravel bar movement) are frequent. These datasets should be used to:
 - Update hydraulic and sediment transport models,
 - Inform asset condition and risk assessments,
 - Support adaptive management of river corridors.

Cross-Cutting Recommendations

To enhance the effectiveness and integration of aerial and topographic data collection:

- 1 Integrate multiple data sources (LiDAR, photogrammetry, satellite imagery, ground surveys) for comprehensive change detection and terrain analysis.
- 2 Use drones selectively to support and supplement larger-scale programs, not as a replacement for regional data collection.
- 3 Develop a multi-year survey plan that aligns data collection methods, spatial scales, and repeat frequencies with asset criticality, environmental dynamics, and risk exposure.
- 4 Preserve all original records in their native formats to ensure future reusability and traceability.

6.2 MONITORING COMPARISON

Table 6 outlines the estimated costs associated with each inspection method. Given the diversity and complexity of the asset types within Horizons' portfolio, the costs presented should be viewed as general guidance rather than definitive pricing. To support efficient planning, we have made several key assumptions:

- **Proximity-Based Efficiencies:** For non-linear assets, such as pump stations, floodgates, or weirs, it is assumed that where assets are located in close proximity, multiple inspections can be conducted within a single site visit or inspection journey. This approach allows for cost efficiencies by reducing travel and mobilisation time.
- **Linear Assets:** For linear assets such as stopbanks or floodwalls, inspection costs are presented on a per-kilometre basis. These assets typically require more continuous coverage, and the cost structure reflects the extended nature of the inspection.
- **Aerial Data Capture Considerations:** The cost of aerial inspections through drone or LiDAR survey can vary significantly depending on terrain and vegetation. Isolated linear assets, especially those in areas with dense bush or tree cover, may incur higher costs—particularly if ground-based surveys are also required. In contrast, where multiple assets are clustered within an area, aerial data collection can be more efficient, potentially reducing the cost per kilometre.
- **Instrumentation Costs:** For assets requiring instrumentation, the costs will vary depending on the complexity of the equipment and the availability of data connectivity. Our costings exclude of any borehole drilling, which may be needed for subsurface monitoring installations, and should be scoped separately.
- **Data Collection:** Unless otherwise stated, the cost estimates provided for each inspection method are based solely on the data collection, supply, and basic metadata reporting. They do not include cloud storage or network integration costs.
- **GST:** high level costs exclude GST.

We would recommend that visual inspections remain to be conducted across all assets as this ensures broad coverage and can identify surface level issues. These inspections are quick and cost-effective and provide insights into the general condition of the assets. We recommend that the more advanced methods, such as digital and remote monitoring and inspections, technical inspections, and instrumentation monitoring, should be strategically focused on assets that are identified as high criticality or where visual inspections have identified potential defects. This targeted approach would ensure that resources are allocated efficiently and that detailed assessments are prioritised where the risk of failure is highest.

Table 6 provides a comparative analysis of the above inspection methods, including benefits, limitations and approximate costs for each.

Table 6: Comparative analysis of inspection methods.

INSPECTION TYPE	DESCRIPTION	BENEFITS	LIMITATIONS	INDICATIVE COST (ROUGH ORDER)
Visual inspection	Direct observations to assess condition. Typically conducted regularly	Generally low cost Quick to deploy Requires minimal equipment	Subjective and dependent on inspector training, experience, and judgement. However, can standardise using guidelines Limited to visible surface conditions so may miss subsurface or structural issues	
Technical inspection	In-depth targeted inspections led by geotechnical, structural or hydrological specialists	In-depth and provide high-confidence in assessments Can identify structural or surface issues	Higher cost and require specialist personnel Can be time consuming	\$2,000 per 1 km (including inspection completing by 1 person and brief inspection report)
Remote inspection/ survey	Aerial imagery through use of drone or manned aircraft	Enables repeatable and comparable data capture Useful for targeted inspections such as an erosion site Capture high-resolution imagery that can be used for change detection or rapid post-event assessment LiDAR and photogrammetry can be combined in the same flight	Higher costs upfront Lower accuracy than LiDAR Horizons' drone is suitable for small areas only due to cost and battery life Accuracy dependent on weather and visibility, sensor resolution and interpretation Requires technical expertise and equipment	Drone ¹ : \$5,000 to \$15,000 per 5 km Manned aircraft ² : \$15,000 per 10 km
	Satellite Imagery and Radar (includes InSAR, Google Earth)	Can cover a wide area efficiently Enables repeatable and comparable data capture Can be used to detect trends Sources like Google Earth are free, while others can be targeted for image capture post-event	Higher costs upfront Accuracy dependent on weather and visibility, sensor resolution and interpretation	InSAR ³ : Historical data (where available): \$9,700 - \$20,000 Ongoing data access: \$7,760 - \$15,520 per year Automatic reports: \$800 Custom report: \$6,000 - \$8,000

INSPECTION TYPE	DESCRIPTION	BENEFITS	LIMITATIONS	INDICATIVE COST (ROUGH ORDER)
				Note that the availability of imagery may vary depending on the location of the asset, which will influence the cost. Bulk purchase of imagery can also influence and decrease cost.
	LiDAR – includes bathymetric LiDAR and terrestrial LiDAR – captured by drone or manned aircraft	<p>Can cover a wide area efficiently</p> <p>Enables repeatable and comparable data capture</p> <p>Can be captured by drones or manned aircraft</p> <p>LiDAR and photogrammetry can be combined in the same flight</p>	<p>Higher costs upfront</p> <p>Accuracy dependent on weather and visibility, sensor resolution and interpretation</p> <p>Requires technical expertise and equipment</p> <p>LiDAR is not always comparable due to variation in calibration, point density, changes in vegetation, and flight path</p> <p>Bathymetric LiDAR is often ineffective in sediment-laden rivers which are common in the region</p>	<p>Drone¹: \$5,000 to \$15,000 per 5 km²</p> <p>Manned aircraft²: \$15,000 per 10 km²</p>
Instrumentation monitoring	Instrumentation installed at specific critical locations and maintained to provide data feed to (typically) online data portal to allow continuous or periodic monitoring to track changes in asset behaviour	<p>Provide continuous data for long-term trends</p> <p>Enables remote monitoring</p>	<p>Higher cost</p> <p>Require ongoing calibration and maintenance</p> <p>Accuracy dependent on calibration, maintenance and sensor type</p>	Cost dependent on number, type and location of sensors. For 10 surface sensors, approximately \$30,000 for installation and \$6,000 per annum maintenance ⁴

1. Cost of drone inspection is based on what some consultants charge for similar drone inspection work and includes cost of producing any outputs (imagery and survey models).
2. Manned aircraft LiDAR cost is indicative only based on our understanding of rates over the past 5-10 years. Horizons may have different rates based on previous LiDAR commissioned work.
3. InSAR costs are from SatSense 2024.
4. Instrumentation costs are from WSP Research May 2025. These may decrease with time due to the rise of infrastructure in this space. WSP are also aware that Horizons have a private Long Range communication network, which will help to reduce telecommunication overheads.

7 MANAGEMENT STRATEGIES

Horizons have requested options for management strategies that they can use to enhance the asset management process. In particular these strategies focus on the inspection and monitoring processes for asset condition assessments and improving the prioritisation of inspections and maintenance works. The recommended options include the development of a risk identification framework that utilises the Flood Vulnerability Assessment (FVA) results, inspection methodologies, and data collection methods. Each of these options can be implemented individually or in combination, offering flexible and dynamic solutions that can be updated as more information becomes available. For example, if changes are made to the way criticality is assessed to incorporate additional levels or ranking of criticality, this could be incorporated into the inspections or the risk prioritisation framework. The ideas presented are high-level, based on the current information, and can be fine-tuned with practical insights specific to the region and the client's assets. By integrating these recommendations, Horizons can make informed, risk-based decisions and strategically invest in their infrastructure. This approach ensures the long-term resilience and reliability of their assets.

The cost estimates provided for the three management strategies are indicative only. They are based on preliminary assumptions and available information at the time of reporting. Actual costs may vary depending on site-specific conditions, asset complexity and implementation methods.

7.1 RISK MANAGEMENT FRAMEWORK

Developing a robust risk management framework for flood infrastructure assets is essential for ensuring the resilience and safety of these assets to create community resilience to natural hazards and climate change. This approach supports Horizons in achieving its Long-term plan goals and enables more effective and strategic resource allocation. We recommend Horizons look to develop a risk-based approach to identify and prioritise the renewals and repair of flood protection assets such as stopbanks, floodwalls, floodgates, groynes, weirs, pump stations and rock revetments. This process is designed to pinpoint the assets that carry the highest risk, particularly where the consequences of failure pose significant reputational and operational impacts. Other regional councils across New Zealand are already implementing similar risk-based prioritisation frameworks to align asset management with long-term strategic goals and community resilience objectives. For example, Waikato Regional Council developed and employed a risk-based process that followed the principles of ISO31000:2009 to identify and prioritise stopbanks based on their risk of overtopping (Basheer, 2017), while other councils utilise the Asset Performance Tool which assesses the performance of assets against service levels to identify critical assets and prioritise remedial actions (Bowman, 2019). By identifying the most critical assets and the most vulnerable locations, this approach can effectively guide strategic investment decisions through incorporation of engineering risk, and the values and needs of the communities the flood assets are designed to protect.

Building on the Enhanced Risk Management Approach outlined in Section 5, we have provided an outline of key considerations for further developing Horizons' risk management framework as shown in Figure 9. This also highlights where key outcomes from the FVA can feed into the framework.

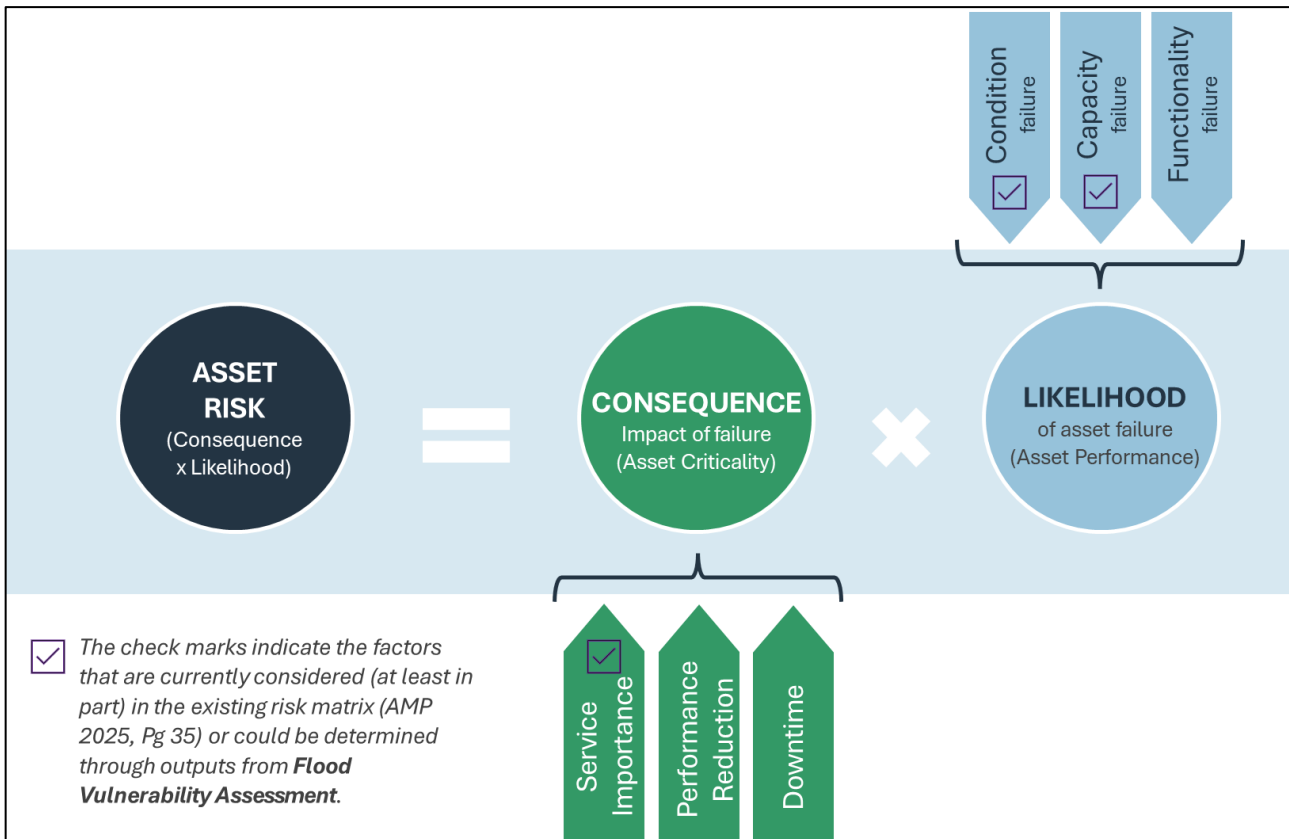


Figure 9: Potential risk management framework for Horizons' river management and drainage assets.

7.1.1 CONSEQUENCE FACTORS

As outlined in Section 5, asset criticality would need to consider the following components (refer to Figure 8):

- **Service importance** - from the scheme.
- **Performance reduction** - from the individual asset.
- **Downtime** - from the individual asset.

Whereby Horizons' current risk prioritisation framework primarily focuses on economic consequences and uses proxies such as building counts to indirectly represent human activity, we recommend enhancing the framework by explicitly incorporating outputs of the 2025 Horizons Flood Vulnerability Assessment (FVA) into the impacts. Key factors in the **Service Importance** component of the consequence could be included as shown in the example in Figure 10. These factors could be informed from the results of the FVA, and could be improved over time as additional information is included within the FVA, such as productive agricultural land, and non-residential buildings such as Marae or other community buildings.

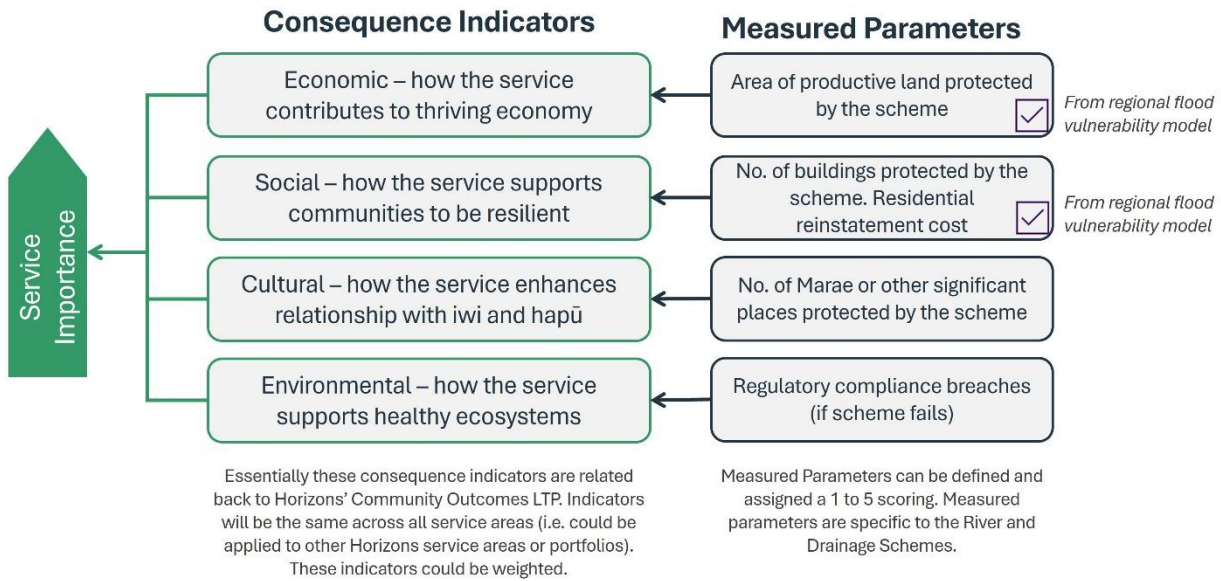


Figure 10: Example Service Importance factors Horizons could use to assess asset criticality.

Once the individual importance factor ratings have been assessed, they can be summed together to get an overall Service Importance score. This can then be related back to the 5-point rating system for Service Importance shown below in Table 7.

Table 7: Service Importance Rating point system.

Service Importance Rating	Importance Description
5	Extremely important
4	Highly important
3	Important
2	Moderately important
1	Low Importance

The other components of the consequence rating can be determined as follows.

Performance Reduction (P) – if the asset fails how much will it affect the scheme performance, arising from the event (Table 8).

Table 8: Performance Reduction Rating point system.

Performance Reduction Rating	Performance Reduction Description
5	Total loss of service if the asset fails.
4	The scheme performance is severely impaired if the asset fails, some very limited service is provided.
3	The scheme is moderately impaired if the asset fails, limited service(s) provided.
2	The scheme is slightly impaired if the asset fails, a significant proportion of service(s) provided.
1	No impact or very minor impact on service performance if the asset fails.

Downtime (D) – if the asset fails what is the disruption time until service is fully restored, arising from the event (Table 9).

Table 9: Downtime Rating point system.

Downtime Rating	Downtime until Service is Fully Restored
5	Years (12 months or more)
4	Months (6 months or more)
3	Weeks (1 - 2 months)
2	Days
1	Hours

The overall Asset Criticality score can be seen in Figure 8 and is:

$$\text{Service Importance Rating} \times \text{Performance Reduction Rating} \times \text{Downtime Rating}$$

The result of the multiplication is then used, based on the bands in the table below to get the overall Asset Criticality rating Table 10.

Table 10: Asset Criticality Rating system.

Asset Criticality Rating	Asset Criticality Description	Score Bands
5	Extremely critical	Score \geq 100
4	Highly critical	Score \geq 75 and $<$ 100
3	Critical	Score \geq 50 and $<$ 75
2	Moderately critical	Score \geq 22 and $<$ 50
1	Low criticality	Score $<$ 22

7.1.2 LIKELIHOOD FACTORS

Horizons' current risk prioritisation framework primarily focuses on asset condition score as a proxy for likelihood. Other key factors in the **Condition** component of the likelihood could be included as shown in the example in Figure 11. Condition grade would be informed by the results of the condition assessment inspections. Further to these factors shown within, we also recommend widening the likelihood considerations to include other factors such as:

- **Capacity/Hydrology:** based on flood event, using hydraulic modelling inputs and the level of service the asset has been designed to protect against. This may also include any freeboard information and could be informed from the results of the Asset Level of Service information (refer to Section 4).
- **Durability:** ability of the asset to withstand stress without failure. Based on construction methods, materials, and design of asset and likelihood of failure. This would be informed from technical inspections, or digital and remote inspections.

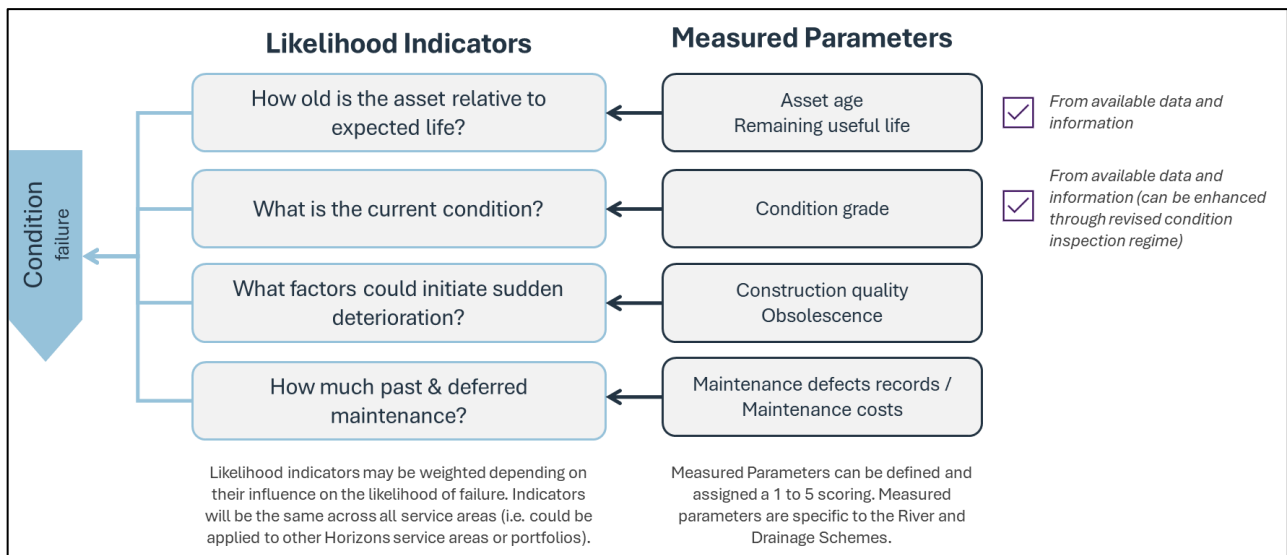


Figure 11: Example Condition factors Horizons could use to assess likelihood.

These factors could be a starting point that Horizons can build on as they develop more information about assets or improve inspections.

7.1.3 ASSET RISK OUTCOMES

The Asset Risk calculation can be implemented geospatially or through tools such as a Feature Manipulation Engine (FME), where each parameter is assigned a value. As condition assessments are completed, the associated risk levels are automatically updated, with results visualised spatially. This process can be applied both before and after flood events to assess changes in asset vulnerability. The outputs can be integrated into an interactive dashboard similar to the one described in Section 7.3 - providing key metrics to help users interpret the results effectively. Displaying risk data geospatially enabling Horizons to quickly identify the most at-risk assets, supporting more efficient inspection scheduling, prioritisation of repairs, upgrades, and targeted post-flood assessments.

The risk management framework presented is intended as a draft or example model to illustrate how Horizons could incorporate different factors into the assessment and prioritisation of flood protection assets. It is not a final or prescriptive tool but rather a starting point that Horizons can build upon as more detailed asset information becomes available and inspection and monitoring practices evolve. The proposed framework includes a set of core risk factors that are commonly used in infrastructure risk assessments and provide a basis for evaluating the consequence and likelihood of asset failure. The framework should remain flexible to be adapted as asset data quality is improved and/or enhanced through new methods of inspections or monitoring, or as additional factors are identified that can be integrated into the framework.

7.1.4 RECOMMENDATIONS

The review, refinement, and implementation of a risk assessment framework would involve collaborative workshops and technical development to ensure the framework is both practical and aligns with Horizons' operational needs.

The first phase would focus on agreeing upon a detailed process for risk calculation, followed by the additional effort required to perform the calculations and generate the corresponding risk maps. To ensure the framework is practical and effective, it is recommended that a pilot study be undertaken. This could focus on a specific scheme or a defined section of flood protection assets, allowing for targeted testing and refinement before broader implementation. The pilot study could also trial the segmentation of linear assets, allowing the review, refinement, and implementation of a risk assessment framework to evaluate the benefits of segment-

level condition and risk assessments, which will improve prioritisation and decision making, while enhancing the spatial resolution of risk mapping. The criteria for segmentation could be based on design or level of service, known construction standard or methodology, the age of the asset, or changes in river or channel type (River Managers Forum, 2015). The River Managers Forum also suggest appropriate segmentation lengths dependent on the environment (e.g. 0.5 to 1 km lengths in urban settings, or 1 to 5 km in rural settings (River Managers Forum, 2015).

7.2 INSPECTION METHODOLOGY OPTIONS

Based on the overview of inspection methodologies presented in Section 6, we recommend Horizons continue to undertake regular visual inspections of their flood protection assets and to keep this as a core component of their asset management plan. Visual inspections are cost-effective method of understanding asset condition and are generally easy to implement as they can be conducted by trained staff without the need for specialised equipment or extensive training (UK Environmental Agency, 2025). Visual inspections offer a good baseline assessment of asset conditions, and when completed regularly can identify issues early. We recommend that visual inspections are continued to be conducted regularly particular for high criticality assets.

To improve the reliability and depth of understanding of asset conditions, Horizons could complement the visual inspections with drone-based technology, LiDAR scanning and instrumentation. This is suggested for either high criticality assets that have been identified to have defects following visual inspections. Focusing on these compromised high criticality assets ensures that the most significant risks are monitored, helping Horizons to ensure that resources are used effectively, enabling preventive maintenance and early issue detection.

Drones and LiDAR offer advantages in terms of coverage and the richness of data. Drones can be utilised in remote areas where assets may be difficult or unsafe to access on foot. They can capture high-resolution imagery allowing for detailed condition analysis or detection of changes over time. LiDAR can be used to capture precise 3D elevation data, which can highlight subtle deformations, settlement or erosion.

We also recommend the installation of instrumentation for condition monitoring on assets that are critical or have been assessed as at risk of failure. This may include instruments such as piezometers, inclinometers, soil moisture sensors and water level sensors. These instruments provide real time data on conditions that may not be visible during visual inspections and will enable early detection of changes to issues such as erosion or seepage.

Indicative costings for implementation of these condition monitoring options can be viewed in Section 6.2. These costs are estimates only and would need to be updated on a site-by-site basis.

7.3 INSPECTION DATA COLLECTION

Horizons could enhance its asset management practices by adopting an expanded use of geospatial data collection tools that deliver measurable efficiency and quality improvements. Horizons is already using geospatial applications for inspections, and there is an opportunity to build on this foundation through integration of more advanced features and workflows.

Mobile geospatial applications such as ESRI's Survey123 and Field Maps enable inspectors to complete structured, location-based questionnaires directly in the field. These tools have been effectively used in various contexts to assess hazard ratings and asset corridors within transport corridors, including rail and road network, and for the assessment of geotechnical assets, and streamline data entry while also improving data accuracy.

Inspectors can use geospatially enabled digital forms to evaluate asset conditions on-site. Once submitted, data can be processed within the apps or via FME - a platform that automates data transformation and

integration workflows. This automation reduces manual processing time, ensures consistent risk scoring, and enables faster decision-making. Processed data can then be visualised in real-time dashboards, allowing asset managers to track condition trends, prioritise inspections and plan mitigation strategies more effectively. These dashboards enhance communication and transparency, while supporting informed risk decision-making.

Figure 12 presents an example ArcGIS Online (AGOL) dashboard developed for New Zealand Transport Agency Waka Kotahi (NZTA Waka Kotahi), which presents metrics for geotechnical structures along the Kaikoura coastline and inland road transport corridors that was developed for the New Zealand Transport Agency Waka Kotahi (NZTA Waka Kotahi). This dashboard allows users to view detailed information on the schedule of future inspections and the priority of defects identified from inspections (Kreft, Easton, & Topham, 2021). This integrated approach not only streamlines data collection and analysis but also supports a more proactive and data-driven asset management strategy.

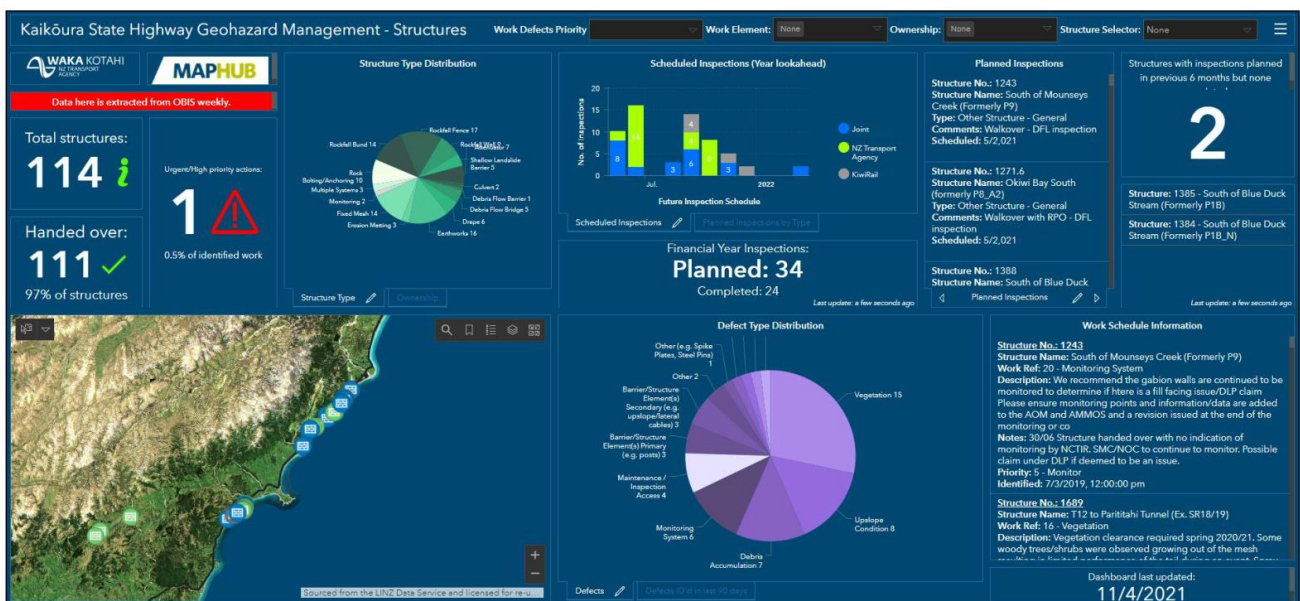


Figure 12: Example of an ArcGIS Online Dashboard developed by WSP for NZTA Waka Kotahi following the Kaikoura Earthquake to provide metrics for geotechnical structures along the coastline and road transport corridors (Kreft, Easton, & Topham, 2021).

Horizons could adopt a similar approach, utilising Survey123 or Field Maps to complete asset condition assessments in the field. Once inspections are completed, risk scores can be processed automatically in real-time, with data uploaded to reporting dashboards. If an asset is identified as underperforming, automated alerts can be configured to notify relevant personnel that an assets condition has changed prompting timely follow-up.

Initially, a standardised risk calculation method could be applied uniformly across all schemes to establish a consistent baseline. However, as the system matures and more data becomes available, there is potential to enhance this approach by incorporating scheme-specific parameters. This would allow for more tailored risk assessments that reflect the unique characteristics, priorities, and operational contexts of each scheme. Developing this capability over time would support more nuanced decision-making and improve the overall effectiveness of risk management strategies.

The resulting data can be visualised in interactive reporting dashboards, which can also incorporate additional contextual information such as flood hazard maps, summaries of risk levels by asset type and criticality, real-time weather alerts, and outputs from monitoring instrumentation. These dashboards significantly improve efficiency by consolidating diverse datasets into a single, accessible platform, reducing the need for manual collation and interpretation. Widgets can be configured to display graphs showing key metrics such as the number of assets requiring inspection, summaries by scheme or asset type, inspection findings, and trends in condition ratings over time.

This level of configurability allows users to quickly identify priorities and track progress across multiple schemes. Dashboards can be easily shared with asset managers, operational teams, and others within council, ensuring that all stakeholders have access to the same up-to-date information. The visual format and intuitive layout make complex data easy to interpret, supporting more transparent communication, faster decision-making, and more strategic investment planning.

For the development of a geospatial data collection app and reporting dashboard, we would estimate approximately \$50,000 for fees. This includes:

- Conversion/edits to Horizons' existing condition assessment forms to link to assets geospatially
- Automation of condition-based alerts and risk calculations
- Development of reporting dashboard
- Initial basic onboarding and training for staff (excludes any maintenance).

8 CONCLUSIONS

Flood protection assets form a critical part of managing flood risk within the Horizons region. These schemes are integral to protecting people, property, and infrastructure from flooding, while enabling productive land to be utilised. However, Horizons Regional Council faces many challenges around the management of their flood protection assets, which are highlighted within their Infrastructure Strategy and Long-term plan.

Historically, Horizons' approach to asset maintenance and renewals has been largely reactive, relying on visual inspections and responding to issues as they arise. While this has addressed immediate concerns, there is a need to address greater vulnerability of critical infrastructure, particularly in areas exposed to natural hazards. Currently, asset criticality is used to guide the frequency of visual condition inspections, but this alone does not provide a comprehensive basis for prioritisation.

This report presents a review of Horizons' current asset condition and management practices and outlines a suite of enhancements to transition towards a more proactive, risk-informed model. Key recommendations include:

- **Focus on asset criticality:** Horizons' current asset management process could be enhanced through expanding the criticality component to consider additional factors to allow for multiple rankings, which can be used across the asset portfolio to support decision making.
- **Enhance asset service levels:** Use the updated asset service level information and results of the regional flood modelling, in conjunction with the results of the Flood Vulnerability Assessment, as a basis for targeting in-depth studies of asset level of service.
- **Refine the risk framework:** update the risk framework to have a focus on asset criticality, incorporating service importance and the results of the vulnerability study. This can be used to develop a risk management framework that will enable targeted risk based decision making.
- **Expand inspection methodologies:** current inspections are predominately visual inspections, but could be supported by digital and remote imagery and remote monitoring. These methods will enhance the current methods and support improving the depth of condition assessments.
- **Implement geospatial data collection and dashboards:** use of geospatial tools could be expanded to streamline inspection workflows, automate risk scoring and support real-time decision-making, while providing an alternate method for reporting on risk.

These strategies focus on the inspection and monitoring processes for asset condition assessments and improving the prioritisation of inspections and maintenance works. Each of these options can be implemented individually or in combination, offering flexible and dynamic solutions that can be updated as more information becomes available. By integrating these recommendations, Horizons can make informed, risk-based decisions and strategically invest in their infrastructure. This approach ensures the long-term resilience and reliability of their assets, ultimately enhancing the safety and well-being of the communities they serve, while directly supporting one of the council's community outcomes from the Long-term plan, of building resilience to and lessening the impacts of climate change to contribute to community well-being.

8.1 MEASURING IMPROVEMENT

These recommendations should be incorporated into Horizons' overarching asset management improvement planning approach. This will allow Horizons to measure and monitor the improvement being achieved. Horizons' Asset Management Plan (March 2025) outlines the current improvements and focuses on Data Reliability and Asset Management Maturity. At present there are three improvement items related to asset risk (refer Tables 32 and 33 of the 2025 AMP):

- **Managing Risk and Resilience:** Risk register for all asset portfolios to be developed
- **Data Cleanse:** Confirming dimensions for critical assets
- **Repair Programme:** Critical assets identified risk grade, through development of an asset risk identification process

The recommendations in this report will contribute to Horizons robustly addressing all three improvement items. However, this improvement approach could be further enhanced by further developing the following:

- Define key performance indicators (KPIs) to assess the success of improvement actions already identified (above) for risk management (e.g. Data Cleanse KPI: Number of value of assets with enhanced criticality assessment completed). Establish targets against these KPIs. This will allow Horizons to monitor improvement progress towards achieving their desired outcomes.
- Establish new KPIs to better assess improvement against the recommendations in this report and confirm targets for these (e.g. Number or value of high criticality assets meeting LOS targets; Ratio of reactive to proactive maintenance on high criticality assets).
- Confirm any new data requirements needed to monitor these KPIs.
- Development of a specific improvement plan for risk management incorporating recommendations from this report. This risk management improvement plan should include detailed actions, KPI targets, resources, timeline. It could form part of a wider Risk Management Strategy or sit within the existing AMP.

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