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Findings of a grower survey on the impacts of Cyclone Gabrielle on pipfruit orchards

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March 2025

Confidential report for:

New Zealand Apples & Pears Incorporated

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Executive summary

Findings of a grower survey on the impacts of Cyclone Gabrielle on pipfruit orchards

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On 13 and 14 February 2023, Cyclone Gabrielle caused widespread flooding that affected approximately 4000 of the 7000 ha of orchards on the Heretaunga Plains. Many orchards were covered by a layer of sediment ("silt") of varying depth, and some had areas that were underwater for extended periods. There was little information available about how growers should respond in these circumstances. Two to four weeks after the cyclone, soil profile assessments were conducted on 28 apple orchards. These were selected from locations across the Heretaunga Plains where it was uncertain whether the trees would survive, to help understand the effect of sediment deposition and waterlogging in the soil profile. In May 2023, the managers of these same orchards were surveyed to understand the impact of the sediment deposits and the duration of waterlogging. Both the initial and current grower observations about their crop, and the management options taken, were recorded. A priority for this survey was to determine the technical needs and information sources that might be of greatest help to East Coast apple growers whose orchards were seriously affected by the cyclone and flooding that followed. This will be used to develop technical workshops and resources for our recovery phase. It will also help to build up a knowledge-base to help decide which actions should be recommended in future flood events.

Of the 26 growers who answered the survey

- Orchards in the Fernhill, Tutaekuri and Pakowhai areas received an average of approximately 23–35 cm of sediment, whereas in the Twyford area the sediment depth averaged 6 cm. Growers reported none in the Crystall Rd area, which was mostly damaged by waterlogging.
- 38% of orchards (RPINs¹) had very few tree losses as a consequence of the cyclone ($\leq 1\%$ of trees lost).
- Of the 62% of orchards with significant tree losses, an average of 34% of the orchard was unrecoverable (range 15–98%).
- On average, growers harvested one-third of their crop. One-third of growers reported harvesting none, or almost none, of their fruit.

¹ Registered property identification numbers.

Of the growers surveyed, almost all planned to restore their orchards, with approximately 10% considering cropping their land for an indeterminate period of time.

When asked “What business support would be most helpful to you for orchard recovery?”, 81% responded that financial support would be most important. Some growers (12%) mentioned the need for clear guidance around waste disposal from Council, or greater flexibility to allow burning.

The most important topics mentioned for technical support were advice on tree health and management, and soil management. The main tree health concerns were (in order): waterlogging, soil and root health; plant diseases; as well as budbreak and fruit set for the coming spring. Resources listed as important for orchard recovery were machinery, money, advice and labour.

When asked if there were any other key learnings from the cyclone, many growers answered, and their responses covered a range of subjects. Thirty percent of the responses were messages or concerns relating to authorities, such as the Regional Council, Government or Civil Defence, with the most common being requests to upgrade the stopbanks.

Key learnings in relation to post-cyclone orchard management could be summarised as follows:

- After the cyclone, act early. Immediately start to develop a plan, this is good for your mental health and gives focus.
- Don't rush to spend lots of money, there is time, the trees are hardier than previously thought. Network with others and gather information from others who have experienced flooding. At the same time, don't be too slow to remove the silt, tree health will decline after some weeks of flooding.
- Removing the silt from around the trunk buys time.
- When prioritising, note that young trees (1-year-old) are more susceptible to suffocation than mature trees. [This note came from earlier in the survey, not this section].
- Not all the silt may need to be removed. Some growers left 10–20 cm depth of silt behind (as long as this was below the graft union) and cultivated this into the existing soil, which saved money.
- Have a plan, and chip away at it.

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1 Introduction

Twenty-eight apple orchards (RPINs) were surveyed for sediment or waterlogging damage in March, after Cyclone Gabrielle struck on 13 and 14 February 2023. The managers of these RPINs were again approached to complete a survey about the impacts of the cyclone on their RPIN. The reason why the survey was conducted is outlined below in the section entitled “Background”, which accompanied the survey that was given to growers, and was signed by Danielle Adsett from NZAPI.

“Background

Cyclone Gabrielle has caused widespread damage to horticultural properties. Some of this damage was immediate, due to wind or the force of flowing water. Additional damage may have occurred due to an extended period of waterlogging in imperfectly drained orchards. The effects may be numerous, including greatly increased fungal root and aerial infections, premature leaf drop and reduced photosynthesis, which impacts carbohydrate storage for next season. These effects are slower-acting and are likely to persist into next season and possibly beyond. There is limited knowledge on the extent of these effects, how severe are they likely to be, and what management options do growers have to mitigate the effects of waterlogging and when should these options be implemented.

The purpose of this work is to:

- Understand the nature of the waterlogging following Cyclone Gabrielle
- Collect management data about what growers did in response
- Record growers’ observations and learnings about what happened to the performance of their trees or vines.

To date, 34 pipfruit, summerfruit and kiwifruit orchards have been visited, and a preliminary assessment made of a range of soil characteristics, including depth to the water table and depth of silt deposit. This questionnaire is intended only for the orchards and blocks visited in the February/March silt/waterlogging survey completed by PFR, AgFirst and Fruition Horticulture.

Purpose

The purpose of this survey is to understand the impact of the sediment deposits and the duration of waterlogging, both the initial and current grower observations about their crop, and to record management options taken. A priority for this survey is determine the technical needs and information sources that might be of greatest help to East Coast apple growers whose orchards have been seriously affected by the cyclone and flooding that followed. This will be used to develop technical workshops and resources for our recovery phase. It will also help to build up a knowledge-base to help decide which actions should be recommended in future flood events.

**The NZAPI Flood Response Team
Facilitator – Danielle Adsett”**

Survey respondents and locations

Twenty-six pipfruit RPIN managers agreed to take part in the survey. This same survey was also conducted with three summerfruit growers, but their results have not been included in this report.

The RPINs were located on the Heretaunga Plains and can be grouped into five main areas (Figure 1). Nine properties were located along both sides of the Tutaekuri River, from above Apley Road to lower Omarunui Road, five were north and east of Fernhill (from midway along Swamp Road to midway along Korokipo Rd), four in Pakowhai, six sites in Twyford, and three in the area between Longlands and Crystall Roads. They were all in areas initially zoned as “uncertain” as to whether the orchards would recover after Cyclone Gabrielle. Areas where orchards were written off, such as the Esk Valley, were not included in the initial surveys or this questionnaire. Areas that were unaffected by the cyclone were also excluded.



Figure 1. The five areas where the 26 apple orchards surveyed were located on the Heretaunga Plains.

2 Methodology

Growers were approached by staff from AgFirst and Fruition and taken through the survey in person, although one grower completed the survey on-line. The surveys were conducted during the month of May 2023, 3 ½ months after Cyclone Gabrielle. Of the 28 RPIN managers approached, 26 completed the survey. All of these have agreed that their answers could be anonymously published in a report. The results are provided below, with numbers to identify the question number from the original survey. The original survey is provided in the Appendix.

Note that the word “silt” is used in the colloquial sense throughout this report, i.e. meaning sediment deposited by the flood. The word “silt” is not used in the technical sense, where it refers to the size of soil particle between sand and clay. Note that the authors have occasionally added in words to clarify grower comments: These have been enclosed in square brackets [].

3 Results

3.1 General impacts of the cyclone on the orchard

1. What proportion of this RPIN was flood or silt affected?

Most of the RPINs were 100% affected (Table 1) since the floodwater was typically 1–3 m deep and most of the orchards are relatively flat.

Table 1. Percentage of the RPIN affected by the flood or silt. Number of RPINS surveyed =26.

Mean	Minimum	Maximum	No. of RPINs 100% affected
93%	33%	100%	21

2. How deep was the silt across the affected RPIN?

The sediment deposited in the Tutaekuri and Fernhill areas (see Figure 1) was generally deep, although there were a few properties with a low average silt depth (Table 2). Growers in these two areas tended to have a large range in the depth of silt deposited across their RPIN. Growers in Pakowhai reported silt deposits that averaged 18 cm deep, with much less variation in the thickness of the deposits on their RPIN than growers in the Tutaekuri or Fernhill areas. Deposits in Twyford were generally shallow, and none of the three RPINs in the Crystall Rd area reported receiving a significant depth of silt. The damage in the Crystall Rd area was mostly from waterlogging.

Two-thirds of the managers surveyed reported that the maximum depth of silt was greater than 15 cm in their orchard, meaning that there is a risk that some of their RPIN will have had sediment covering the graft union². It is also difficult to mix silt with the original soil when it is greater than 15 cm deep. This means at least two-thirds of growers are likely to be considering removing all or some of the silt from their property, particularly in the Tutaekuri, Fernhill and Pakowhai areas, which is what is reported in later questions.

Table 2. Area means, and highest and lowest average values for RPINs in each area values for the question "How deep was the silt across the affected RPIN?" Note that the minimum (min) and maximum (max) depths reported are for the RPINs in that area that have the lowest and highest average silt depth, respectively.

Area	Tutaekuri	Fernhill	Pakowhai	Twyford	Crystall Rd	All RPINs
Mean silt depth (cm)	37	35	18	6	0	24
Min silt depth (cm)	18	8	4	3	0	0
Max silt depth (cm)	85	100	30	8	0	100
Range in silt depth within RPIN (Max – Min)	61	71	27	14	0	41
% of RPINs with max sediment >15 cm	90%	80%	100%	20%	0%	65%
No. of RPINs	9	5	4	5	3	26

² Note that the height of the graft union may vary significantly between and within orchards. Fifteen cm is a conservative value, many graft unions will be higher.

3. What percent of your RPIN is recoverable?

There was ambiguity with the way this question was worded, with two possible interpretations:

1. Some growers interpreted this as 'the RPIN is recoverable once they have replanted', so they have stated that their RPIN is 100% recoverable. In later answers some of these same growers mentioned having to replant a considerable proportion of their RPIN.
2. Other growers interpreted this question as asking whether the trees will recover after the cyclone. These growers made statements such as "99.9% recoverable", implying that 99.9% of trees will survive, rather than they could no longer use 0.1% of their RPIN because of the cyclone.

For the sake of a consistent interpretation, it has been assumed that this question relates to the proportion of trees that will recover after the cyclone, so where replanting or tree loss rates mentioned in other parts of the survey indicate that a grower has used the first interpretation of this question, the percentage given in question 3 has been adjusted accordingly.

Of the twenty-four responses to this question the average percentage of RPIN recoverable was 75% (Table 3). This includes nine RPINs that were 99–100% recoverable (i.e. the trees were 'unaffected' by the cyclone). The remaining fifteen RPINs were <99% recoverable, and the reasons why are discussed in question 4 below. The average percentage affected of these partly non-recoverable RPINs was 66% (Table 3).

Table 3. Pooled data from the question "What percent of your RPIN is recoverable?"

% of RPIN recoverable (Average of all RPINs)	Percentage of orchards ≥99% recoverable	Average % of RPIN recoverable (Average of affected RPINs)
Average 78% (Range 15–99.9%)	38%	66%

4. Give a brief description of your non-recoverable blocks (cultivars and ha) and reasons they won't be salvageable (e.g. life decision, economics, tree age, cultivar, rootstock etc): Be sure to note whether the block assessed last visit was non-recoverable and reasons.

Of the seventeen RPINs where >1% was not recoverable because of cyclone damage, all growers mentioned tree damage as being one of the reasons why these portions of the orchard would not recover (Table 4). The damage most mentioned was trees being ripped out of the ground or smashed by water and water-borne debris. Another reason for tree damage was tree death due to suffocation. A few growers mentioned that tree age was a factor that influenced tree death, with one grower noting that younger trees with smaller root systems were more susceptible to being ripped out of the ground, and other growers observing greater tree losses in one-year-old trees. Economics was mentioned or implied as a reason by six growers as to why some portion was not recoverable. Of these, five cited unprofitable cultivars as the reason why it was not economic. Soil issues also impact the economics: silt depth, or difficulty in scooping up the silt due to its consistency, difficulties with the heavy textured silt, was mentioned in three cases. The large amount of debris deposited in the orchard was given as a reason in three cases.

Reasons mentioned by less than three growers were listed under "Other" in Table 4. These reasons included:

- Infrastructure damage – to posts, wire, irrigation system, pump and machinery
- Block location – the block was in an area that was difficult to access
- Life stage – the block would not become economic again until after the grower had retired.

Table 4. Percentage of growers mentioning different reasons why parts of their RPIN would not be salvageable. Note that one RPIN may be included under several topics.

%	Topic	Details
100	Tree damage	The damage mentioned most was trees being ripped out of the ground or smashed by water and water-borne debris. Another reason for tree damage was tree death due to suffocation. A few growers mentioned that tree age was a factor that influenced tree death, with young trees being more susceptible than older trees.
38	Economics	Unprofitable cultivars made up the majority of this reason, with depth of silt and its cost of removal being the other reason given.
31	Unprofitable cultivars	There were a number of cultivars that were deemed unprofitable prior to the cyclone and therefore not worth 'saving'.
19	Sediment issues	Silt depth, or difficulty in scooping up the silt due to its consistency.
19	Slash/debris	A large amount of debris. One grower mentioned the debris piles being "head high".
31	Other	Infrastructure damage – to posts, wire, irrigation system, pump, and machinery Block location – the block was in an area that was difficult to access Life stage – the block would not become economic again until after the grower had retired.

5. Can you give us a brief summary of future plans for your cyclone-affected RPIN?

Twenty-four answers were considered for this question. Of these 24 RPINs, just over half had replanting to do. Forty-two percent indicated that they still need to finish clearing out their orchard, which in 8 of the 10 instances involved silt removal (Table 5). A range of other issues were mentioned in less than 20% of responses. Some growers reported new springs appearing, or drainage issues arising that would need addressing. The tree health issues mentioned were nutrition and disease management or monitoring. Some growers were still weighing up the economics of different options for all or parts of their RPIN. A small number of growers were considering annual cropping cycles for a year or more as an option. Only 17% of the RPINs reported business as usual, i.e. no extra work as a result of the cyclone.

Table 5. Approximate percentage of answers mentioning different topics in response to the question "Can you give us a brief summary of future plans for your cyclone-affected RPIN?", and main details of the topics. Note that one RPIN may be included under several topics, except for business as usual, as this category indicates that the cyclone has not significantly altered growers plans for their RPIN.

%	Topic	Details
54	Replanting and possibly changing varieties	Changing to more profitable cultivars.
42	Removal of silt, dead trees, and damaged infrastructure	Of the 42% that indicated that they still need to finish clearing out their orchard, almost all still had silt to remove.
17	Tree Health issues related to cyclone	Tree nutrition and disease management/monitoring
17	Infrastructure repairs and maintenance	This includes fixing irrigation systems, pumps, ruts and drains
17	Financial considerations	Deciding whether to restore a block, replant (including what varieties to plant), to lease the land out or crop (i.e. change the land use).
17	Business as usual	No further extra work as a result of the cyclone.
13	Addressing new or exacerbated drainage issues	Putting in new drains to address new springs or other wet areas highlighted by the cyclone
8	Cropping	May crop or lease out land for cropping for one to several years, depending on economics

6. What business support would be most helpful to you for orchard recovery?

Almost all (88%) of respondents stated that they still needed some kind of business support at the time of the survey – May 2023 (Table 6). The kind of assistance needed was mostly financial. Some growers (15%) mentioned the need for information, particularly clear guidance from Council regarding the rules for clean-up, including waste disposal.

Table 6. Approximate percentage of answers mentioning different topics in response to the question "What business support would be most helpful to you for orchard recovery?", and main details of the topics.

%	Topic	Details
88	Need business support	Need some kind of ongoing business support
81	Financial assistance/funding	Need for financial support or funding to aid in orchard recovery.
15	Information	Information on various options, including clear guidelines and rules regarding clean-up activities.
12	Waste disposal support	Assistance with waste disposal and providing designated locations for debris and silt. More flexibility around burning.
8	Other	Need for skilled labour, such as machinery operators, builders, and tradesmen. Access to government.

7. What technical support would be most useful for orchard recovery?

Most growers wanted advice from technical experts, or from people who had been through flooding before. Others mentioned that the sharing of ideas was important, with someone saying that "There are no stupid ideas". The two main topics where advice was requested were on tree health and soils (Table 7). For tree health the main concerns were around tree nutrition and disease. There was also a related question on how to manage trees post-cyclone, e.g. how to prune, how to manage bud break, what crop load should they carry? The soils topic centred around a desire for soil testing, with other questions including "Is the silt suitable to replant into?", "How to manage soil structure – particularly with regard to compaction during silt removal?", "Can you predict soil aeration and how does this relate to root health?", and information on soil biology. Some growers stated that access to a silt map would be helpful. Other comments included the need for better machines to remove silt, better access to machinery, and what to replant.

Table 7. Approximate percentage of answers mentioning different topics in response to the question "What technical support would be most useful for orchard recovery?", and main details of the topics.

%	Topic	Details
46	Advice on tree health and management	Tree nutrition, leaf tests, root health, what crop load to carry, pruning and budbreak management.
38	Soils advice	Soil testing. How to manage soil structure? Can we predict aeration and how does that relate to root health? Can we replant into the silt? Soil biology.
8	Silt mapping	Maps of the different types of silt and their composition.
8	Other	Better machinery. More economic ways to remove silt. What to replant?

8. What other resources would best assist orchard recovery?

Machinery, money, advice, and labour were the resources most commonly mentioned by growers, with each topic mentioned by approximately one-third of growers (Table 8).

Table 8. The percentage of growers that mentioned various topics in response to the question "What other resources would best assist orchard recovery?"

%	Topic	Details
40	Machinery	Bobcats and other specialised machinery for removing silt – with drivers.
35	Money	Some growers just mentioned money. One mentioned government support for fruit loss. They did have insurance*, but the excess was significant.
35	Advice	A number specified a need for financial advice, including managing cashflow and for long-term planning. Advice about being fully insured.
30	Labour	A lot of labour-intensive tasks to do. Need easier access to labour. More RSE workers.
10	Hawke's Bay Infrastructure	Fixing bridges and roading, confidence in flood protection infrastructure in future
5	Time	

*Note that this insurance most likely only covered property, buildings and machinery, not posts and wires, and very few growers (if any) had crop insurance.

3.2 General post-cyclone orchard tree health questions

9. Can you estimate the overall percentage of current crop that was harvested for commercial purposes?

There was a wide range of losses experienced by the growers who were surveyed (Table 9). On average, growers harvested one-third of their crop. One-third of growers reported harvesting none, or almost none, of their fruit. For some growers, the only fruit harvested was from their early varieties, which were picked prior to the cyclone. No growers picked fruit that had been underwater. The commercial pick was lowest in the Pakowhai and Tutaekuri areas, and highest in the Crystall Rd – Te Aute Rd area (Table 9).

Table 9. Mean, minimum and maximum percentages reported by growers in response to the question "Can you estimate the overall percentage of current crop was harvested for commercial purposes?"

	Mean	Minimum	Maximum
Tutaekuri	18	0	50
Fernhill	38	0	51
Pakowhai	17	0	66
Twyford	35	0	70
Crystall Rd	92	85	99
Total	31	0	99

10. How did you remove any non-harvestable fruit (and what worked well e.g. Ethrel, physical, shaking)?

Ethrel® was the most common method growers used to remove non-harvestable fruit (Table 10). Ethrel was often difficult to apply 'conventionally' in silt-covered orchards, so some growers had opted for aerial spraying, whereas others were unable to get machinery down the rows, so utilised Task Force Green³ to shake and whack the trees with sticks. One grower mentioned that shaking served two purposes, it removed silt and debris from the trees as well as removing non-harvested fruit.

Table 10. Percentage of answers in each category in response to the question "How did you remove any non-harvestable fruit?" Note that a grower response may be included in more than one category.

%	Category	Details
38	Ethrel	Most growers simply mentioned Ethrel. Some mentioned that a high rate was used, or two applications.
33	Did nothing	Over half of the growers who did nothing mentioned that the fruit was dropping naturally.
14	Shaking	Including whacking with a stick.
14	Picking	Generally done in orchards where ≥90% of the fruit had been harvested.
10	Undecided	Grower hasn't taken any action yet

11. What is your primary tree health concern on the orchard?

Growers had two or three main concerns, depending how answers were grouped. There was a lot of overlap with growers who mentioned waterlogging and also mentioned root diseases (Table 11). Approximately two-thirds of growers mentioned waterlogging, soil and root health or diseases. Approximately half of the surveyed growers mentioned disease, with *Phytophthora* or root diseases being most commonly mentioned, although some growers mentioned fireblight due to stress flowering, or disease [such as canker] as a consequence of broken branches. Budbreak and fruit set this coming spring was also mentioned by approximately half of the growers, with budbreak or bud quality being mentioned much more frequently than fruit set or fruitfulness. One grower mentioned that scion rooting was a concern, although another grower mentioned that fresh aerial roots were easily addressed by rubbing the trunk. Another grower mentioned that tree structure was a concern because he'd had no time for business-as-usual jobs such as pruning.

Table 11. Percentage of grower responses in each category in response to the question "What is your primary tree health concern on the orchard?". Note that a grower response may be included in more than one category.

%	Category	Details
66	Waterlogging, soil and root health	Root diseases have been included in this category
48	Disease	If specific diseases were mentioned, it was often <i>Phytophthora</i> or root diseases. One grower mentioned fireblight.
48	Bud break, fruit set this coming spring	Category included bud health
13	Other	Scion rooting, silt removal and reseeding grass, tree structure – because no time for pruning.
4	No concerns	This grower had been affected by waterlogging only, not silt

³ Enhanced Task Force Green was an initiative funded by the Ministry of Social Development that employed jobseekers to help with the clean-up after Cyclone Gabrielle.

12. How widely have you applied phosphorous acid, or do you still plan to apply it?

Almost all growers (88%) surveyed used phosphorous acid over a portion of their block, with two-thirds using it over their entire block. One grower who did not use phosphorous acid said they noticed the trees were dying early on, so saw it as a waste of money, and in hindsight is happy with the decision.

- a. **Approximately when was phosphorous acid applied?**
Answers ranged from post cyclone until early May.
- b. **If so, how many applications?**
Of those who applied phosphorous acid, 52% applied one spray, 39% applied two sprays, and 9% applied three sprays.

13. Have they, or will they apply any fertiliser?

Answers to this question are summarised in Table 12.

Table 12. Percentage of growers giving certain answers to the question "Have they, or will they apply any fertiliser?"

Yes	No	Depends on soil test result	Not yet
57	30	9	4

- a. **What type?**
A range of fertilisers were used, including foliar and solid. Over 60% of the fertilisers used provided nitrogen. Four growers mentioned using Bud Builder™.
- b. **Rate?**
Modest rates of nitrogen fertiliser were used – up to 46 kg N/ha.
- c. **How many applications?**
All growers using fertiliser mentioned only one application.

14. Anything else you are planning to do above and beyond usual to improve tree health?

Answers to this question are summarised in Table 13.

Table 13. Percentage of respondents, and categories of answers in response to the question "Anything else you are planning to do above and beyond usual to improve tree health?"

%	Category	Details
35	No. Not at this stage	
22	Apply additional fertiliser	
17	Lighter crop load or harder pruning	This included carrying a lighter crop load or getting the crop load down early to reduce tree stress or pruning harder [over winter] to even up the [shoot:root ratio due to] potential loss of root mass due to flooding and asphyxiation.
13	Depends on soil test	
13	Watching trees closely	
17	Other	Use biostimulants. Fix ruts. One grower decided to stump/pole young trees.

3.3 Changes or abnormalities in your trees since the cyclone

15. Any dead trees in the RPIN since the cyclone?

Growers interpreted this question in one of two ways, as outlined below.

1. Trees flattened during the cyclone died some time later, so were considered to have died since the cyclone, so were included in the percentages given.
2. Trees flattened during the cyclone were considered to have died during the cyclone, so these tree deaths are excluded from the answers and only percentages of subsequent tree deaths were provided.

The way this question was interpreted makes a big difference to the answer, since some growers had whole blocks of trees flattened during the cyclone, with one grower reporting that only 15% of his orchard would be recoverable because of trees being flattened during the flood. An indication of tree losses because of the force of the water flattening trees or suffocation is given in question 3, where growers report what proportion of their RPIN is recoverable. Therefore, the answers reported in Table 14 are an attempt to obtain data for the percentage of trees that died since the cyclone from slow asphyxiation or from root diseases. Where it was clear that the grower had provided an answer based on the first interpretation of this question, an attempt was made to estimate tree losses excluding flattened trees. This estimate of losses since the cyclone has been based on comments from the grower, answers to question 3 and, in one case, the author's estimate after visiting the affected RPIN. If an estimate of losses was not possible, the data were omitted from the data set in Table 14. As a result, the data in Table 14 are considered less accurate because of the ambiguity of this question, and because some answers are estimates.

Tree losses post-cyclone averaged 5% (Table 14), being higher in the Tutaekuri, Fernhill and Pakowhai areas where the silt was deeper than in the Twyford or Crystall Rd- Te Aute Rd areas (Table 2). The highest post cyclone losses were recorded in Pakowhai (Table 14) where the sediment deposited had a heavier texture than in other areas (Trollove et al., 2025). These percentages are similar to those observed at the same time in transects on the same RPINS in the survey by Plant & Food Research reported by Trollove et al. (2025), although post-cyclone tree deaths by May averaged 3% and losses in Pakowhai were 9% in the study of Trollove et al. (2025). The difference may be due to data in the current study being confounded with trees that were lost during the cyclone. Note that Trollove et al. (2025) also identified continuing tree losses in these orchards after May 2023 when this grower survey was conducted. Tree losses post cyclone were likely to be caused by root diseases and slow suffocation due to ongoing waterlogging.

Table 14. Percentage of trees that died since the cyclone. Note that some data may include trees flattened by the cyclone, although in obvious cases these answers were excluded. These data are considered less accurate.

	Mean	Minimum	Maximum
Tutaekuri	4	0	18
Fernhill	5	1	11
Pakowhai	15	1	40
Twyford	1	0	2
Crystall Rd	1	0	2
Total	5	0	40

16. Any trees with branch/leaf damage?

An average of 14% of trees showed branch or leaf damage following the cyclone, with percentages being higher in the Tutaekuri and Fernhill areas (Table 15) where the water flow was generally deeper or faster than in the other areas.

Table 15. Percentage of trees with branch or leaf damage following the cyclone. Data grouped by area. Note that data were not provided for all properties, so there may be some inaccuracies.

	Mean	Minimum	Maximum
Tutaekuri	20	0	85
Fernhill	21	0	88
Pakowhai	5	0	10
Twyford	8	0	20
Crystall Rd	0	0	0
Total	14	0	88

What symptoms? (e.g. leaf browning, flagging leaves)

Symptoms mentioned included snapped trees, broken branches, flagging leaves, silt on leaves, leaf browning or discolouration and early leaf fall. One grower mentioned that the silt set like concrete on the leaves. Another mentioned that leaf browning was evident particularly on young trees where the roots weren't properly established. In one case the leaf discolouration was attributed to an Ethrel application [used to aid in dropping the crop post flooding], rather than the cyclone itself.

17. General leaf colour (e.g. yellowing, chlorosis, reddening etc)

Seventy-eight percent of growers reported that leaves looked normal after the cyclone (Table 16). The remaining 22% reported a colour change, with leaves either changing to a yellow, red or bronze colour. In addition to reporting on a colour change, some growers reported trees losing leaves earlier or holding leaves for longer. In one instance where early senescence was noted, the grower stated that this occurred in trees that had fallen and had been stood up again, whereas early leaf fall was not observed in trees that had not fallen. In the two RPINs where the leaves held for longer, the grower wondered whether this was a result of their Ethrel application or a stress response. Early leaf loss is discussed in more detail in Question 19.

Table 16. Percentage of RPINs in different categories in response to the question about effects of the cyclone on general leaf colour.

%	Category	Details
78	Normal	
22	Colour change	Yellow, red or bronze
13	Early senescence	
8	Held leaves longer	

18. Any tree wilt, dieback? (Approx. % of trees)

Of the 25 growers with trees on their RPIN at the time of the cyclone, the average percentage of wilt or dieback mentioned was 4% (Table 17). Most growers indicated no wilt or dieback, with only one-third mentioning observing some symptoms. Of that third, the percentage of the RPIN with symptoms was generally low, averaging 12% of the RPIN. Answers ranged from 0 – 40%. Trends in the prevalence of dieback on affected RPINs among the different areas followed those observed for tree losses since the cyclone (Table 14), with a greater prevalence of dieback in Pakowhai, Tutaekuri and Fernhill than at Twyford or the Crystall–Te Aute roads area.

Table 17. Answers (in %) to the question "Have they observed and tree wilt or dieback?"

	% of RPIN with wilt (average of all RPINs)	% of RPINs with some wilt or dieback	% of wilt in affected RPINs	Range of %s given (Min – Max)
Tutaekuri	4	29	15	0 – 20
Fernhill	4	40	9	0 – 10
Pakowhai	11	50	23	0 – 40
Twyford	0	20	1	0 – 1
Crystall Rd	0	33	1	0 – 1
Total	4	32	12	0 – 40

19. Premature leaf drop? (Approximate date of leaf fall)

Half of the growers (52%) indicated early leaf fall in at least some of their block. Some growers mentioned that this was just in their young trees, and others mentioned only in one cultivar. Another grower mentioned that early leaf fall was not to do with the cyclone per se, but because the trees had "wet feet".

20. Fruit fall or shrivel? Below what height? *Phytophthora*?

Of the growers that had fruit on their trees at the time of the cyclone, 29% reported fruit drop (Table 18), with most mentioning that this occurred in fruit below the floodwater line. Even a grower who had no silt deposited – only floodwater, reported that any fruit that came into contact with the floodwater rotted quickly. In contrast, other growers that had fruit underwater reported no fruit drop. Fruit fall was greatest in Pakowhai, and lowest in Twyford and the Crystall Rd –Te Aute Rd areas (Table 18). *Phytophthora* was reported in all areas except for the Crystall Rd – Te Aute Rd area. Fruit shrivel was not mentioned by any growers. There did not appear to be any relationship between observations of fruit fall and *Phytophthora*.

Table 18. Percentage of RPINs reporting fruit fall or *Phytophthora*.

	% of RPINs with fruit fall	% of RPINs with <i>Phytophthora</i>
Tutaekuri	38	38
Fernhill	25	40
Pakowhai	75	25
Twyford	0	40
Crystal Rd	0	0
Total	29	33

21. Any effect on fruit size? (Normal or smaller)

Most growers reported that the cyclone had no effect on fruit size (Figure 2). Seventeen percent mentioned that the fruit were smaller, with some growers stating that the fruit stopped increasing in size after the cyclone. One grower mentioned that ‘Envy’ stopped increasing in size, whereas ‘Jazz’ didn’t. Two growers (9%) reported larger fruit than normal. One grower suggested that because the cyclone caused the fruit to be left on rather than picked, it may have kept getting larger. Another grower particularly noted that particularly the “Royals” had increased in size.

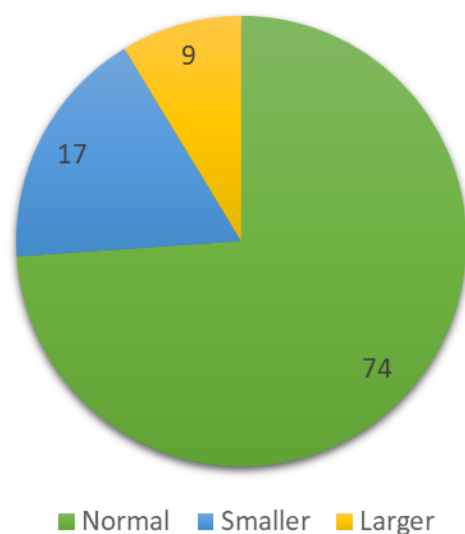


Figure 2. Percentage of RPINs who said that their fruit size either was larger, smaller or normal as a consequence of the cyclone. If some (but not all) varieties in the RPIN had a change in fruit size, then this has been entered as smaller or larger, rather than normal. Number of respondents =23.

22. Tree vigour (post-cyclone vegetative growth)

No growers mentioned strong growth after the cyclone (Figure 3). There was generally low or no vegetative growth after the cyclone (Figure 3).

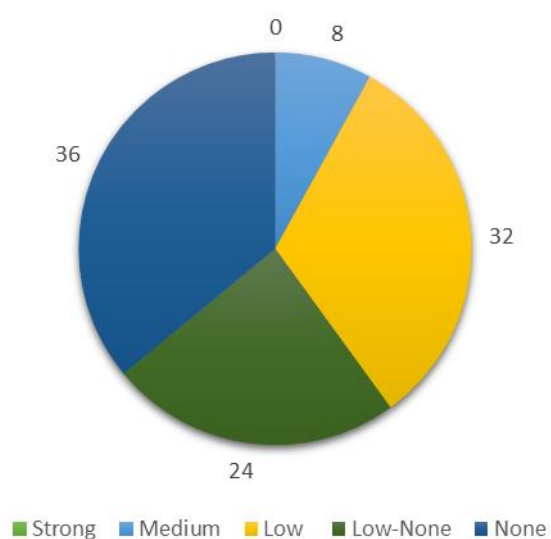


Figure 3. Percentages of RPINs in categories describing the vigour of their trees post-cyclone. Number of respondents = 25.

23. Were there any cultivars or rootstocks in their orchard that seemed more susceptible to waterlogging?

It is difficult to arrive at strong conclusions from this question, since it is not always clear when a grower mentions a rootstock is susceptible, which other rootstocks and cultivars the grower was comparing it to, and whether all rootstocks and cultivars experienced the same degree of waterlogging. The cyclone affected areas of land rather than specific rootstocks or cultivars, which is important to keep in mind when comparing susceptibility. However, the grower feedback is still useful, particularly where the same rootstocks or cultivars are mentioned by several RPIN managers.

The clearest result from this question was that rootstock ‘M9’ was mentioned as being susceptible to waterlogging by half of the twenty-two RPIN managers who answered this question (Table 19). Three growers mentioned ‘M116’ was susceptible. One grower mentioned ‘M793’ was susceptible whereas there were hardly any deaths on ‘MM106’. Another grower observed no difference in tolerance between ‘M793’ and ‘MM106’, which another grower described as tolerant. So it is unclear from these survey data whether ‘M793’ is susceptible or not.

Amongst the cultivars, ‘Jazz’ and ‘Posy’ were mentioned more than once as being susceptible (Table 19). The cultivars, ‘Pacific Queen’, ‘Envy’, ‘Kanzi’ and ‘Fuji Supreme’ all got one mention as being susceptible to waterlogging, although for ‘Fuji Supreme’ the grower mentioned this cultivar was planted in the area with the thickest silt where it was still wet three months on, so this may have been a location effect, rather than a cultivar effect. ‘Granny Smith’ and ‘Galaxy’ were mentioned by surveyed growers as being tolerant cultivars.

Table 19. Rootstocks and cultivars mentioned by RPIN managers as being susceptible or tolerant to waterlogging.

Rootstock				Cultivar			
Susceptible	No. of mentions	Tolerant	No. of mentions	Susceptible	No. of mentions	Tolerant	No. of mentions
‘M9’	11	‘MM106’	1	‘Jazz’	4	‘Galaxy’	1
‘M116’	3	Another grower mentions ‘MM106’, ‘M26’ and ‘M793’ were all responding the same.		‘Posy’	3	‘Granny Smith’	1
‘M793’	1			‘Pacific Queen’	1		
				‘Envy’	1		
				‘Kanzi’	1		
				‘Fuji Supreme’ (Possibly a location effect)	1		
				Young trees			

24. Estimated rootstock deaths by rootstock type

There were very few rootstock comparisons listed by growers, so relevant information provided in this question has been incorporated into question 22.

3.4 Crop/tree protection programme post cyclone

25. Number of captan applications applied on your orchard since 14 February

Most growers applied captan post cyclone, with the number of applications listed in Table 20. One grower wanted to apply captan, but decided not to because they were worried that it might “prevent” [reduce] the drop and decomposition of unpicked fruit.

Table 20. Numbers and percentages of RPINs where captan was applied post cyclone.

No. of applications	0	1	2	3	4	Hydrated lime
Number of RPINs	4	6	5	4	2	1
% of RPINs	18	27	23	18	9	5

26. Any other fungicides or crop protection products applied?

A small number of other crop protection products were used on some RPINs (Table 21). Some growers included phosphorous acid in their answer to this question, which has already been covered in Question 12. It was difficult to apply crop protection products post cyclone. Some growers mentioned applying crop protection products along with phosphorous acid by helicopter. Another grower who responded “No” to this question mentioned trying to apply Mycorrcin™ but could only get the sprayer over half a block.

Table 21. Crop protection products (besides phosphorous acid and captan) applied to RPINs.

Product	Number of RPINs
Copper	1
Ethrel	2
Carbendazim	2
Sinergon 2000	1
Proclaim® opti (insecticide).	1

27. Which is your worst block for canker on the orchard – and cultivar?

- What is your best estimate of the percentage of trees with canker on that block?
On average, growers estimated approximately 1% of trees had canker on their worst affected block, with responses ranging from 0 – 6% (Table 22). There did not appear to be differences among areas in the percentage of trees infected on a grower’s worst canker block, particularly given the small number of RPINs surveyed in some areas.

Table 22. Average, minimum and maximum percentages provided by growers in response to the question "What is your best estimate of the percentage of trees that had canker on your worst affected block?"

	Mean	Minimum	Maximum
Tutaekuri	1.3	0.0	5.5
Fernhill	1.4	0.0	5.0
Pakowhai	0.4	0.0	1.0
Twyford	3.4	0.5	6.0
Crystall Rd	0.7	0.0	2.0
Total	1.4	0.0	6.0

- b. What are your canker management practices?
Only one grower stated that they rely on sprays only (captan). All other respondents mentioned that they do walks and remove infected wood. Some growers relied solely on preventative sprays for blocks with low levels of infection, only walking the worst affected blocks.
- c. Describe your canker removal programme?
Growers described their canker removal programme in a range of ways. Some used the words "aggressive" or "regular". Others specified the number of walks per season, which ranged from one to four, with some stressing the importance of walking early in the season. Most growers specified that they burnt it immediately or removed it from the orchard. Some growers mentioned paying employees a bounty if they positively identify canker.
- d. How many captan sprays would you normally apply per season for canker?
There was a wide spread in the number of captan applications normally applied per season (Table 23).

Table 23. RPINs categorised based on the number of captan sprays normally applied per season.

Number of applications	% of RPINs
0	5
1-3	32
4-7	23
7-10	23
>10	18

What are your post-cyclone canker (also any other disease) concerns on the orchard?

The disease concerns mentioned by the growers are listed in Table 24. Canker was the most commonly mentioned disease, being reported by approximately one-quarter of surveyed RPIN managers. It is not clear whether this result was influenced by the fact that canker was the only disease named in the question. *Phytophthora* and fireblight were the next most commonly mentioned. Some other diseases mentioned were black spot and mildew. Some growers mentioned tree health related concerns that will influence their susceptibility to disease.

Other concerns mentioned were two wet seasons in a row and the increased risk of disease from bins and debris from other orchards that were carried onto their property by the cyclone. Some growers

mentioned insect pests in response to this question, which were woolly apple aphid and apple leaf curling midge. Approximately a quarter of growers said they had no specific disease concerns.

Table 24. Percentage of RPINs where a disease (or other concern) was mentioned. The number of respondents was 22.

Concern	% of RPINs
Canker	27
<i>Phytophthora</i>	14
Fireblight	9
Other fungal	18
Insects	14
Weak trees/tree health	14
Tree wounds	9
Root stress	9
Other	9
None	27

3.5 Cyclone support feedback

28. What do you consider has been the most helpful source for cyclone support information?

Almost half of the growers surveyed found Ross Wilson's WhatsApp group the most helpful source of cyclone support information (Table 25). One third found that NZAPI was the most helpful. Other sources of information identified as most helpful were consultants, spray reps, the Hawke's Bay Fruitgrowers Association (HBFA) Newsletter. Two growers said that they really received no helpful information.

Table 25. Percent of surveyed growers mentioning various sources as the most helpful cyclone support information. Number of respondents =23.

Ross Wilson's WhatsApp group	NZAPI	Consultants	Spray rep.	Within company	HBFA	No helpful info.
43	35	17	9	9	4	9

29. Can you identify information that you have received that has been extremely helpful to your situation?

There was a wide range of responses to this question (Table 26). Half of the growers mentioned other sources of information that had been helpful to them, besides those they had mentioned as "most helpful" in Question 30. These sources included Ross Wilson's WhatsApp Group, NZAPI information, the HBFA Newsletter, other growers, contractors, and growers who had experienced flooding before. Advice on how to manage the silt was mentioned by 15% of growers. Emotional support was mentioned by 12% of growers – a positive attitude, comments from the owner to the manager, saying "It's not your fault" was incredibly helpful, and even a big hug. A number of growers said that being provided with comprehensive, understandable information as soon as possible was key. Little specific advice was mentioned. The most common advice, mentioned by only 8% of growers, was about the

need to remove the silt to avoid scion rooting, or how to remove the silt, what machinery to use. Other advice mentioned included cultivating in shallow silt into the existing soil, drone mapping, the “Silt Update on tree health (rots)”, and advice around access to funds and contractors for silt removal. Twenty three percent of growers answered “No” or Not applicable”.

Table 26. Percentage of answers in different categories in response to the question “Can you identify information that you have received that has been extremely helpful to your situation?”

Info. from other sources	How to manage the silt	Emotional support	Info. on funding	Info. that was fast, comprehensive and understandable	Other	No or not applicable
50	15	12	8	8	15	23

30. How do you rate information received through the ‘WhatsApp’ Flood Response link?

There were no negative comments regarding the WhatsApp Group. Two thirds of the RPin managers indicated they had used it at some stage, although some said the information was not relevant to their particular orchard. The other third had not used the App. Of those that had used it, most were highly complimentary, with growers mentioned finding it really supportive, and it was helpful to see what others were doing.

31. Can you list in order of priority the information that would be most helpful to your orchard operations over the remainder of this year?

The most important topic mentioned by growers was tree health, followed by funding (Table 27).

Table 27. Grower responses to the question “Can you list in order of priority the information that would be most helpful to your orchard operations over the remainder of this year?”. Growers were asked to rank information from 1 (top priority) down to 4. information listed as highest priority was given the highest score (4), information with priority 2 was given a score of 3, down to the fourth level of priority was given the lowest score (1). The scores for all surveys were summed, and the information with the highest score was ranked as most important. The number of surveys that mention an issue is also given. Number of respondents = 22.

Score	No. of mentions	Category	Details
39	9	Tree health	Tree health, nutrition, bud health, how to identify root health
29	10	Funding	Information on government funding
20	5	Technical information	General technical information from a consultant
16	5	Diseases	<i>Phytophthora</i> , canker. Any tweaks to the spray programme required?
14	5	Council information	Silt and waste disposal. How good are the stopbank repairs, likelihood of future flooding? Housing zoning.
13	4	Crop loading	How much crop can my trees carry this year, given the stress the trees are under? Are chemical thinners more or less effective on stressed trees?
12	5	Pruning	Cheap ways to prune, given the financial constraints. Do I need to prune differently in light of cyclone effects on bud health? Structural pruning.
10	3	Budgeting	How to budget in light of uncertainties around funding support
28	10	Other	Information on tree selection and availability for replanting, Gov’t information on how zoning affects RSE accommodation, how to modify sprayers to avoid bellying, a database of info. about cyclone effects on orchards, leaving flood-affected fruit, soil issues, the future of the apple industry, more accurate weather forecasting.

3.6 Specific questions relating to the survey by Plant & Food

32. Cultivar and rootstock

The blocks surveyed in the silt/waterlogging assessments carried out in the month following the cyclone covered a range of cultivars and rootstocks.. The cultivars included in the surveyed RPINS were: 'Envy' (26% of survey responses), 'Royal Gala' (including a range of early, and standard cultivars, 24% of survey responses,) and other cultivars such as 'Pacific Queen', 'Breeze', 'Dazzle', 'Jazz', 'Rockit', 'Fuji', 'Pink Lady', 'Aurora', and 'NZ Prince'. Almost half of the rootstocks in the blocks surveyed were 'M9', with other rootstocks being 'M16', 'BA29', 'M793', 'CG202', 'M106', and 'Marc'.

33. Was this block affected by silt? Waterlogging?

Eighty-one percent of the blocks were affected by "silt" (sediment), with the remaining 19% being predominantly affected by waterlogging in the blocks surveyed.

34. What proportion of this block was harvested?

On average, 24% of the fruit on the surveyed blocks were harvested. This is similar to the answer of 31% for the amount of fruit commercially harvested for the RPIN (Question 9), so provides some indication that the surveyed blocks were representative of the RPINs. The range in answers was 0–95%, which is similar to the answer of 0–99% given in Question 9.

35. What have you done about the silt in this block and how soon after the cyclone did you respond? e.g. Ripping, cultivation, removal, moving it away from tree/vine trunks?

Grower responses to this question are categorised in Table 28 below. Many growers did not provide a specific timeframe as to when the silt was removed from the surveyed block, as the focus was generally on the first part of the question "What have you done?" In hindsight this should have been split into two questions.

Of the six growers that provided a timeframe in response to this question, five said they started removing the silt within 6 weeks of the cyclone, with the remaining grower starting slightly later in mid-April. An additional four growers said that they dug around the trees to remove silt, which was generally done within a few weeks of the cyclone.

Table 28. Grower responses to the question "What have you done about the silt in this block?"

% of respondents	Action	Details
32	Initially moved silt away from trunks	Usually this was done by hand [with shovels], but one grower mentioned grading and doing by hand
41	Complete removal	
23	Selective removal	This may involve just removal from headlands and high spots, or removal down to some depth below the graft union (e.g. 10–20 cm), then cultivating the remaining silt into the original soil.
18	Cultivated it in	This was generally done where silt was shallow or had been removed to a shallow depth.
18	Nothing yet	Reasons for doing nothing (yet) included: the silt was shallow (7 cm), the block will be replanted, or currently have other priorities, e.g. harvesting.
9	Ripped	One grower who had shallow silt (≤ 6 cm) did ripping only. The other grower ripped multiple times prior to cultivating in the silt.
18	Other	Clearing drains and getting in pumps to get the water away, Morley's agripher, reseeding alleyways.

36. Is silt removal completed or incomplete?

Twenty-seven percent of growers surveyed had completed silt removal on their block by the time the survey was conducted (Figure 4). Forty-two percent still had silt to remove. For most of the growers the silt would be removed within another two to four weeks, although one grower mentioned they would not be finished for another five months.

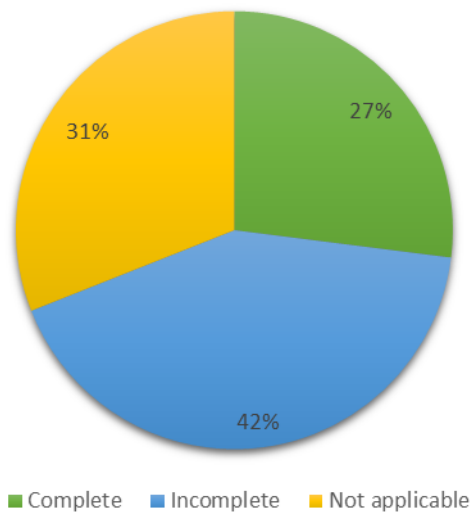


Figure 4. Percentage of RPINs where silt removal was complete or incomplete at the time of the survey. The surveys were conducted in May 2023.

37. If silt was removed, why? [e.g. Flood subsidy, block highly profitable, avoid scion rooting, even work surface, to improve trafficability?]

Table 29. Percentage of respondents who removed silt for various reasons. The number of respondents who removed silt =16.

% of respondents	Reason	Details
44	Profitable	It was more profitable to remove the silt and keep producing apples, rather than leave the silt and lose the orchard.
38	Tree health	
31	Avoid scion rooting	
25	Improve trafficability	To improve trafficability and to allow access
19	The silt was deep	The deep silt was likely to affect tree health. One grower stated that the silt was not removed from blocks where deposits were shallower.
13	Other	

38. If the silt has not been removed, why?

Three reasons given for why the silt had not been removed from the block surveyed in March:

- It wasn't very deep (The average silt depth was ≤ 7 cm in blocks where this answer was given).
- Redevelopment was planned for the block
- Timing. The silt had not been removed yet because had only recently decided the block will stay, so now they can proceed with silt removal. They also had a lack of labour for silt removal.

39. – 40. How many days was water ponded on this block, how deep was it ponded, and how long was the block probably waterlogged for?

Grower estimates for the number of days of waterlogging, water ponding and depth of ponding are shown in Table 30 below. Data is not presented by area because some areas had few responses and there was quite a lot of variation within each area, particularly in days of waterlogging, which make the data difficult to interpret. The average number of days of water ponding after the cyclone was 12 (Table 30), ranging from 8 days in Fernhill to 16 days in Tutaekuri. There was a wide range in depths of water ponding, with average depths ranging from 0 to 2 m, and maximum depth up to 3 m on one RPIN. Days of waterlogging also varied widely, depending on soil type and drainage system, with two growers stating that their properties had been waterlogged the entire season.

Table 30. Number of days water was ponded on the surveyed block, how deep was it ponded (and the average of the maximum values given for each block), and how long do you estimate it was waterlogged for? Number of respondents =19.

Days of ponding		Depth of ponding (cm)		Days of waterlogging	
Average	Maximum	Average	Average maximum	Average	Maximum
12	42	44	86	48	243*

*Whole season.

41. Any evidence of extended period of water ponding, surface sealing, ongoing soil issues?

One point to note, that was only mentioned by one grower [but occurred across all RPINs with sediment], is that the sediment cracked once it dried. [The cracking occurred within <2 to a number of weeks, taking longer where the sediment was deeper. This allowed some aeration and water penetration.]

Table 31. Percentage of answers in response to the question "Any evidence of extended period of water ponding, surface sealing, ongoing soil issues?" Number of respondents = 19.

Answer	%	Evidence observed
Yes	58%	• Puddles • Surface sealed, until cultivated. • Early leaf fall • Grass death • Springs appeared
No	42%	• Sandy soil • Abundance of worms • Water rushed through, rather than ponded

3.7 Key Learnings

42. Are there any other key learnings from the cyclone not covered in this survey that should be recorded to help growers in the future?

There was a wide range of responses to this question (Table 32). The largest percentage of responses (30%) were directed towards the Council, Government and Civil Defence, with two-thirds of these requests being that the stopbanks be upgraded.

Table 32. Responses to the question "Are there any other key learnings from the cyclone not covered in this survey that should be recorded to help growers in the future?". Number of respondents=20.

% of respondents	Learning	Details
30	Messages for Council, Gov't, Civil Defence	- Two-thirds of these respondents requested upgrades to (or expressed concerns about) the stopbanks. Other points included: - Upgrading drainage systems. - Response times from Civil Defence and the Army were too slow. Army offered no help with the clean-up. - Alert systems were poor. Hukanui Farm recorded 750 mm before the banks broke, the warning systems did not work. - Communications during the event were non-existent. - Shingle takes of the rivers need to be reinstated. - Riparian plantings on flood rivers should stop as they impede flood flows. - Bridge structures need to be open span. - Council need to find areas to flood so save land that has high value - Infrastructure e.g. Fearnly farms. - Make decisions and stick to them. Deliver with clear messaging. - Take advice from the trenches. Don't have unaffected people making the decisions. Growers are getting no say in what happens. - Give the funding to the right places. Mental health and technical advice is not where the funding should be going. Growers know how to stretch a dollar. Growers give money back to the community. They should be the ones getting the funding to clean up.
25	Act early	Get some oxygen into the soil early. The prime time is the first few weeks. Acting early provides a vision and focus.
20	Trees survive longer than first thought*	
15	Don't rush to spend money	People shouldn't rush in and spend money when there's cheaper and more efficient options – we have more time than initially thought.*
15	Use Extenday® alternatives	Extenday acted "like a wall" in the flood [and exacerbated damage]. Consider alternatives such as silver paper, leaf plucking and blowing, or different pruning techniques to let in more light in flood-prone areas.
15	Consider planting row direction	[Presumably this refers to the orchards being less damaged if the rows were orientated with, rather than across, the flow of floodwater]
10	Make a plan	Having a plan in place focussed and energised them [the orchard owners, managers and team].
10	Improve electricity and pump set-up	Use irrigation pump to pump out field tile sumps. Use more pumps. Put the generator higher up [off the ground in case of future floods].

% of respondents	Learning	Details
50	Other	• Use of strong shelter-belt trees such as sheoak, they slow the velocity of the river and remove debris. • Don't plant an orchard near a river. • Document the flood response. • Ask anyone and everyone what they think. • Drone application was fantastic – use the technology available. • Chip away at it [in reference to progressing with clean-up]. • People have been really supportive and rallied together. There's a lot of empathy. • Mental health is a biggie. The people that are positive are the ones that will get through. Everyone's responded differently to the cyclone. The longer clean up goes on, the people that are feeling down are getting worse. Noticing neighbours staying positive is key – the ones that are feeling negative seem to find it harder to stay motivated. Adrenaline lasted for 2 months and when it wore off – noticed the moods dropping.

*[This may allude to a widely circulated message that trees would start to die within 3 days of being underwater.]

3.7.1 Draft sediment action plan assembled from growers' comments

Answers that growers gave to this question, and elsewhere in the survey, have been assembled to develop a plan to help future growers who face sediment inundation in their orchards. The authors have tried to avoid inserting their own ideas into this plan.

- After the cyclone, act early. Immediately start to develop a plan, this is good for your mental health and gives focus.
- Network with others and gather information from others who have experienced flooding.
- Don't rush to spend lots of money; there is time, the trees are hardier than previously thought. At the same time, don't be too slow to remove the silt, tree health is far better where they managed to clear the silt.
- Removing the silt from around the trunk buys time [to clear the bulk of the debris].
- When prioritising, note that young trees (1-year-old) are more susceptible to suffocation than mature trees.
- Not all the silt may need to be removed. Some growers have left 10–20 cm depth of silt behind (as long as this was below the graft union) and cultivated this into the existing soil, which saves money.
- Chip away at your plan.

3.8 Miscellaneous

43. Does the grower agree to their results being published anonymously as part of pooled data?

Three growers initially answered “No” to this question. These responses were followed up later with a phone call, and each one gave consent for their responses to be anonymously published.

Is the grower willing to participate in an ongoing study on cyclone recovery including:

- 44. Economic factors**
- 45. Productivity**
- 46. Plant health**

Twenty-one growers responded “Yes” to these three questions, with three responding “No” and two responding that they weren’t the correct ‘tier’ within their business to give permission.

4 Authorship

Surveys were conducted by Angus Bews and Meg Becker, and the data analysed by Stephen Trolove.

5 Acknowledgements

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6 Reference

Trolove S, Husband E, Sorensen I, White M, van der Weyden J, Arnold N, Walker J, Horner M, Brookes J. 2025. The effects of Cyclone Gabrielle on pomefruit tree health in Hawke’s Bay. New Zealand Journal of Crop and Horticultural Science (Soon to be submitted).

Appendix. The survey form

Survey Questions for growers

(This a follow-up on assessments already done in early March on 24 silt-affected apple orchards and 6 waterlogged orchards)

Background

Cyclone Gabrielle has caused widespread damage to horticultural properties. Some of this damage was immediate, due to wind or the force of flowing water. Additional damage may have occurred due to an extended period of waterlogging in imperfectly drained orchards. The effects may be numerous, including greatly increased fungal root and aerial infections, premature leaf drop and reduced photosynthesis, which impacts carbohydrate storage for next season. These effects are slower-acting and are likely to persist into next season and possibly beyond. There is limited knowledge on the extent of these effects, how severe are they likely to be, and what management options do growers have to mitigate the effects of waterlogging and when should these options be implemented.

The purpose of this work is to understand the nature of the waterlogging following Cyclone Gabrielle, and to collect management data about what growers did in response, and to record their observations and learnings about what happened to the performance of their trees or vines.

To date, 34 apple, summerfruit and kiwifruit orchards have been visited, and a preliminary assessment made of a range of soil characteristics, including depth to the water table and depth of silt deposit. This questionnaire is intended only for the orchards and blocks visited in the February/March silt/waterlogging survey completed by PFR, AgFirst and Fruition Horticulture.

Purpose The purpose of this survey is to understand the impact of the sediment deposits and the duration of waterlogging, both the initial and current grower observations about their crop, and to record management options taken. A priority for this survey is determine the technical needs and information sources that might be of greatest help to East Coast apple growers whose orchards have been seriously affected by the cyclone and flooding that followed. This will be used to develop technical workshops and resources for our recovery phase. It will also help to build up a knowledge-base to help decide which actions should be recommended in future flood events.

The NZAPI Flood Response Team
Facilitator – Danielle Adsett

Questions for the grower interview

Grower name: _____ Date: _____

Contact phone: _____ Email: _____

Orchard RPIN and location: _____

Total orchard area at this location: _____ ha

General impacts of the cyclone on the orchard

1. What proportion of this RPIN was flood or silt affected? _____ % or _____ ha
2. How deep was the silt across the affected RPIN? Average _____ cm Min _____ cm Max _____ cm
3. What percent of your RPIN is recoverable? _____ %
4. Give a brief description of your non-recoverable blocks (*cultivars and ha*) and reasons they won't be salvageable (*e.g. life decision, economics, tree age, cultivar, rootstock etc*): Be sure to note whether the block assessed last visit was non-recoverable and reasons.

- a) _____
- b) _____
- c) _____
- d) _____
- e) _____
- f) _____

5. Can you give us a brief summary of future plans for your cyclone-affected RPIN:

6. What business support would be most helpful to you for orchard recovery?

7. What technical support would be most useful for orchard recovery?

8. What other resources would best assist orchard recovery?

General post-cyclone orchard tree health questions

9. Can you estimate the overall percentage of current crop that was harvested for commercial purposes? _____

10. How did you remove any non-harvestable fruit? (and what worked well e.g. ethrel, physical, shaking)

11. What is your primary tree health concern on the orchard? _____

12. How widely have you applied phosphorus acid, or do you still plan to apply it? _____ %
 c. Approximately when was phos acid applied? _____
 d. If so, how many applications? _____

13. Have they, or will they apply any fertiliser? _____
 d. What type? _____
 e. Rate? _____
 f. How many applications? _____

14. Anything else you are planning to do above and beyond usual to improve tree health?

Changes or abnormalities in your trees since the cyclone

15. Any dead trees in the RPIN since the cyclone? _____ %

16. Any trees with branch/leaf damage? _____ % What symptoms? (e.g. leaf browning, flagging leaves)

17. General leaf colour (e.g. yellowing, chlorosis, reddening etc)

18. Any tree wilt, dieback? (Approx. % of trees) _____ %

19. Premature leaf drop? (Approximate date of leaf fall) _____

20. Fruit fall or shrivel? **Y/N** Below what height _____ m. *Phytophthora*? **Y/N**

21. Any effect on fruit size? (Normal or smaller) _____

22. Tree vigour (post-cyclone vegetative growth?)
☐ Strong ☐ Medium ☐ Low ☐ None ☐

23. Were there any cultivars or rootstocks in their orchard that seemed more susceptible to waterlogging? _____

24. Estimated rootstock deaths by rootstock type (e.g. M9, CG202, MM106 or other)

Rootstock _____ Deaths _____ %

Rootstock _____ Deaths _____ %

Rootstock _____ Deaths _____ %

Rootstock _____ Deaths _____ %

Crop/tree protection programme post cyclone

25. Number of captan applications applied on your orchard since February 14th _____

26. Any other fungicides or crop protection products applied? _____

European canker management

a. Which is your worst block for canker on the orchard - and cultivar?
 Block _____ cultivar _____

b. What is your best estimate of % of trees with canker on that block? _____%

c. What are your canker management practices?

i. Describe your canker removal programme?

ii. How many captan sprays would you normally apply per season for canker?

d. What are your post-cyclone canker (also any other disease) concerns on the orchard?

Cyclone support feedback

28. What do you consider has been the most helpful source for cyclone support information?

29. Can you identify information that you have received that has been extremely helpful to your situation?

30. How do you rate information received through the 'WhatsApp' Flood Response link?

31. Can you list in order of priority the information that would be most helpful to your orchard operations over the remainder of this year.

32. **Specific questions relating to March block survey** (pre-fill questions 34-35 from silt/waterlogging survey):

Block description _____ **Row number** _____

Cultivar _____ **Rootstock** _____

33. Was this block affected by silt **Y/N** Waterlogging? **Y/N**

Orchard/vineyard management post the cyclone

34. What proportion of this block was harvested? _____%

[Ask these questions if their block was affected by silt]

35. What have you done about the silt in this block and how soon after the cyclone did you respond? e.g. Ripping, cultivation, removal, moving it away from tree/vine trunks?

36. Is silt removal completed or incomplete? _____ % complete. With time to complete?

37. If silt was removed, why? [e.g. Flood subsidy, block highly profitable, avoid scion rooting, even work surface, to improve trafficability?]

38. If the silt has not been removed, Why?

[Ask these questions if their block was affected by water ponding]

39. How many days was water ponded on this block? _____ days

40. How deep was it ponded? Average _____ cm. Maximum _____ cm

41. How long do you think the block was probably waterlogged for? _____ days

42. Any evidence of extended period of water ponding, surface sealing, ongoing soil issues? **Y/N**
If yes, describe _____

43. Are there any other key learnings from the cyclone not covered in this survey that should be recorded to help growers in the future?

44. Does the grower agree to their results being published anonymously as part of pooled data? **Y/N**

Is the grower willing to participate in an ongoing study on cyclone recovery including:

45. Economic factors (Y/N)

46. Productivity (Y/N)

47. Plant health (Y/N)

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