Pohangina Gravel Resource Study

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REGIONAL COUNCIL

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(Pohangina at 12.5-mile mark)

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EXECUTIVE SUMMARY

This study examines the gravel resources of the Pohangina River, to identify any trends of aggradation or degradation and assess the sustainability of extraction volumes.

Cross-sectional surveys conducted in 2018 and in 2023 as well as reported gravel extraction volumes have been analysed to determine how the mean bed levels and gravel resources have changed through time.

The main methodology for calculating the mean bed levels and the change in gravel volumes used offsets covering only the wetted channel and gravel beaches, excluding the berm area.

The overall trend of the river analysed reported a loss of 519,000 m^3 of gravel from 2018 to 2023, which is 104,000 m^3/yr of degradation. This is a reverse of the overall aggradation trend of the 2020 gravel study. The same aggradation trend as the current 2025 study was observed below the 4-mile mark in the 2020 study. Similarly, both 2020 and 2025 studies resulted in degrading volumes at the 4- to 7-mile marks. However, between 7.5- to 12.5-mile marks, the present study found a degrading trend contrary to the 2020 study's aggrading results. It was also found in the present study that cross-sections 12- to 21-mile marks reported an overall degrading trend similar to the 2020 gravel study.

The results of the present study's mean bed level change showed that there has been no appreciable (i.e. greater than one metre change) aggradation or degradation in the river.

The One Plan allocable volume for the Pohangina River is 25,000 m^3/yr, and the recorded gravel extraction rate from 2018 to 2023 is 11,500 m^3/yr. This is well below the recommended 20,000 m^3/yr limit from the previous 2020 study.

Since the Pohangina reach is degrading at a rate more than the actual gravel taken, it is recommended that extractions should only occur if there is a river management need, targeting more on the aggrading beaches than the degrading ones. The overall recommended extraction volume for the Pohangina River is 10,000m^3/yr.

A resurvey in 2028 – 2029 is recommended for the Pohangina River including all the cross-sections surveyed in 2023. Additionally, it is recommended that a more recent LiDAR (Light Detection and Ranging) be flown to enable DoD (Difference of DEMs [Digital Elevation Model]) analysis.

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Pohangina River Gravel Study

1.0 Introduction

1.1 Background

The Pohangina River is a gravel bedded river situated on the south west of the North Island, and is a tributary of the Manawatū River. The headwaters of the Pohangina River are located in the Ruahine Ranges, and the river then flows generally south until it reaches the confluence with the Manawatū River near Ashhurst (Whale, 2020). The 2006 Scheme Review noted: "the material moves down in a complex pulsing way, with continual change of both bed and banks". The scheme review went on to say that "the cross-section surveys carried out over recent decades show little in the way of overall trends, with perhaps some slight degradation in the lower reaches" (Bell, 2013). The river has a length of approximately 73 kilometres, a catchment area of an estimated 550 square kilometres, and is recognised as a significant supplier of gravel to the Lower Manawatū River (Whale, 2020), as seen in Figure 1.1.

This study investigates the Pohangina River's gravel resource by analysing data from river cross-sections, gravel extraction records, and observations made while visiting the river's gravel beaches. This study examines the gravel resources in the Pohangina River from the 1-mile mark located at the confluence with the Manawatū River at Ashhurst up to the 21-mile mark, just above the confluence with the Makawakawa Stream. The locations of the cross-sectional surveys are shown on the aerial photograph in Figure 1.2. This study focuses on the 2018 to 2023 epoch, since the completion of the previous gravel resource study in 2020.

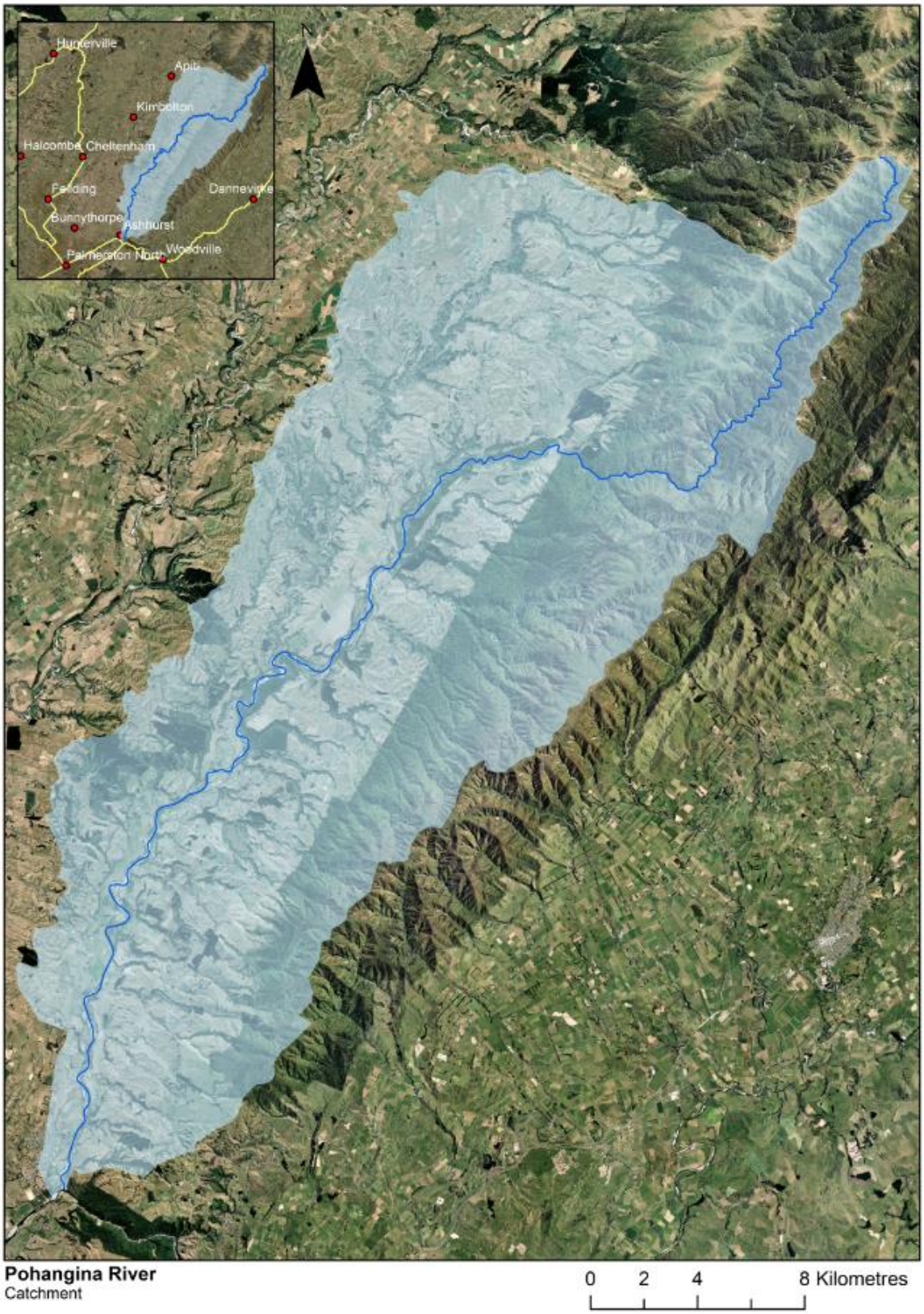


Figure 1.1 The Pohangina River catchment displaying the Pohangina River (Whale, 2020)

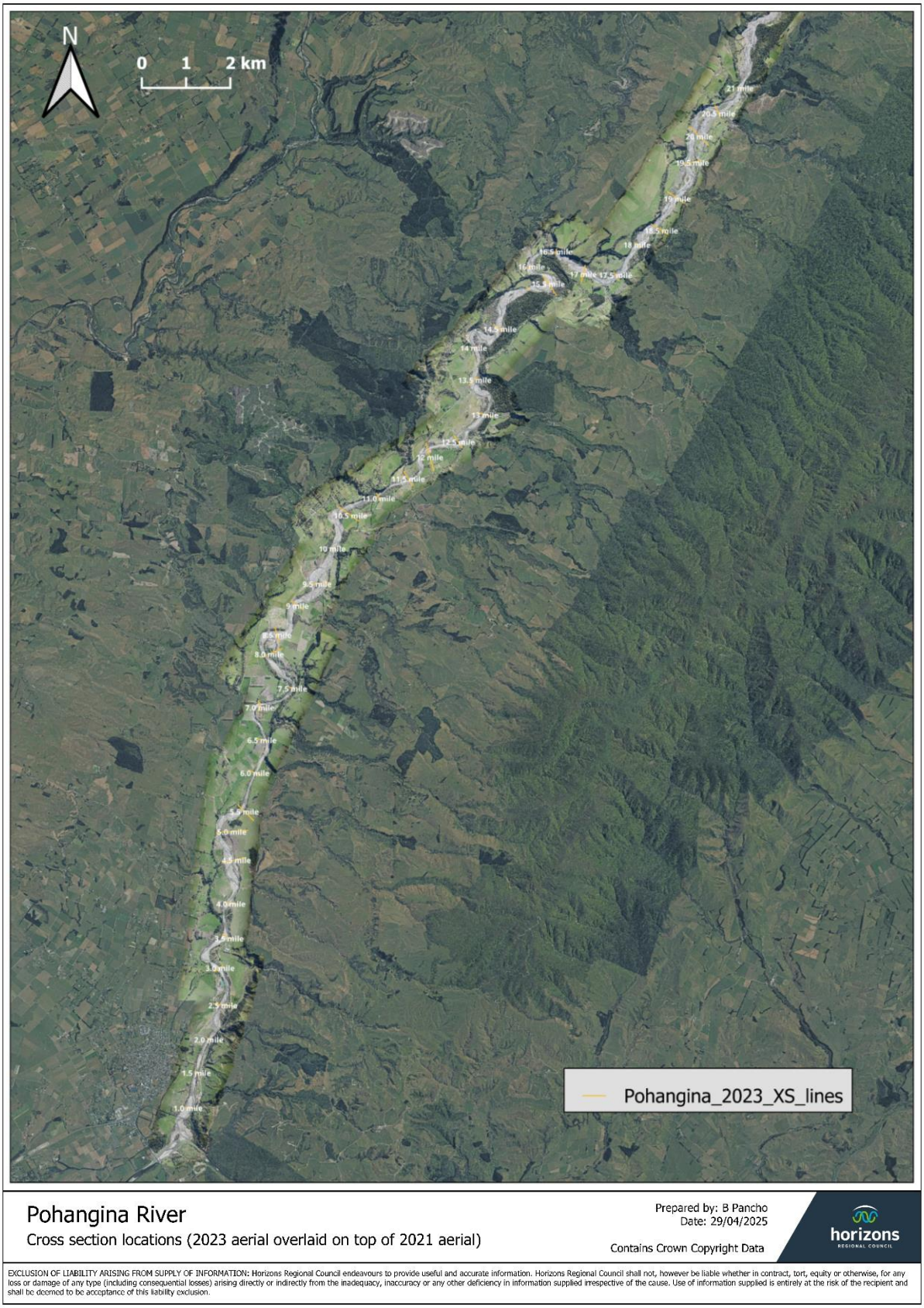


Figure 1.2 Cross-section locations of the Pohangina River

1.2 2013 Pohangina Gravel Resource Study

The 2013 gravel resource study concluded the following:

- Below the 4-mile mark, the gravel resource was degrading. This degradation was noted over the longer term between 1970 and 2012 as well as in the shorter term between 2000 and 2012.
- In the reach between the 4-mile mark and the confluence with the Manawatū River it was recommended that gravel extraction should be stopped. It was necessary to introduce this policy as the gravel resource in this reach of the river was severely degraded.
- The degradation in the lower part of the reach was evident by the exposed piles beneath the abutments of the Rail Bridge.
- Significant aggradation of the gravel resource had occurred in the upper half of the reach, between the 12- and 21-mile marks, a trend which was observed in the longer term from 1970 to 2012 as well as the shorter term from 2000 to 2012.
- In the reach between the 4- and 9-mile marks approximately 12,000m^3 of gravel had been extracted annually since 2000. Whilst there had been an overall aggradation in this reach, it was proposed to limit the extraction to 10,000 m^3/yr. If this gravel was extracted from the more immobile, well-armoured beaches, it would help with the overall river management whilst leaving the more mobile gravel to migrate downstream into the degrading reach.
- In the upper reach, between the 9- and 21-mile marks, gravel had been extracted at a rate of approximately 3,500 m^3/yr over the last 12 years. Due to the lack of cumulative change in the gravel volume it was proposed to continue the gravel extraction in this reach at the same rate.

1.3 2020 Pohangina Gravel Resource Study

The main findings to emerge from the 2020 gravel resource study of the Pohangina River were:

- Overall, between 2012 and 2018 the gravel volume was estimated to have aggraded by 147,100 m^3 across the whole river, which equates to around 24,500 m^3/yr.
- There was no distinct mean bed level trend of dominant increase or decrease. There was a trend of rising and falling across the gravel reach.
- 95,641 m^3 of gravel had been extracted from the river channel from 2012 to 2018.
- Gravel extraction could occur at a higher rate of up to 20,000 m^3/yr, but careful targeting of aggradation areas would have to be considered.
- Since the 2013 study, the degrading reach below the 4-mile mark was starting to replenish its gravel resource. It was also observed that the previously aggrading reach from the 12-mile mark to the 21-mile mark had seen overall degradation occur.
- The degradation in the lower part of the river observed in the 2013 study due to the exposed piles beneath the Rail Bridge abutments was starting to reverse as aggradation occurred and the piles became less exposed.
- Further analysis of the 2013 recommendations suggested that gravel extraction should continue to be limited downstream of the 4-mile mark with the limit of 10,000 m^3/yr to continue between the 4- and 9- mile marks. The reach from the 9- to 21- mile marks should not be confined to the limit of 3,500 m^3/yr, however increased extraction should only occur if there is an increased need for river management purposes, and not within significant areas of degradation.
- Due to the dynamic nature of the river, it was realised that while some reaches have recommended limits, these won't always be able to be adhered to due to the changing river reach and the adverse impacts that might be caused. However, the overall amount should not exceed what is outlined in the One Plan.

2.0 Analysis of Cross-section Survey Data

After the 2020 gravel study, the Pohangina River was surveyed in 2023. This current study utilises the 2018 and 2023 survey data for the analysis, using vertical datum NZVD2016. As the Pohangina River has been undergoing channel changes since the last gravel study, a new set of offsets has been determined by using recent fluvial surveys and recent aerial imagery. This gravel study defines the extents of the active channel as the wetted channel and gravel beaches, which were used to obtain the area under the section. The mean bed level was assessed in this study, which considers the same boundaries as the active channel. Figure 2.1 illustrates the channel cross-section areas of analysis for a gravel section.

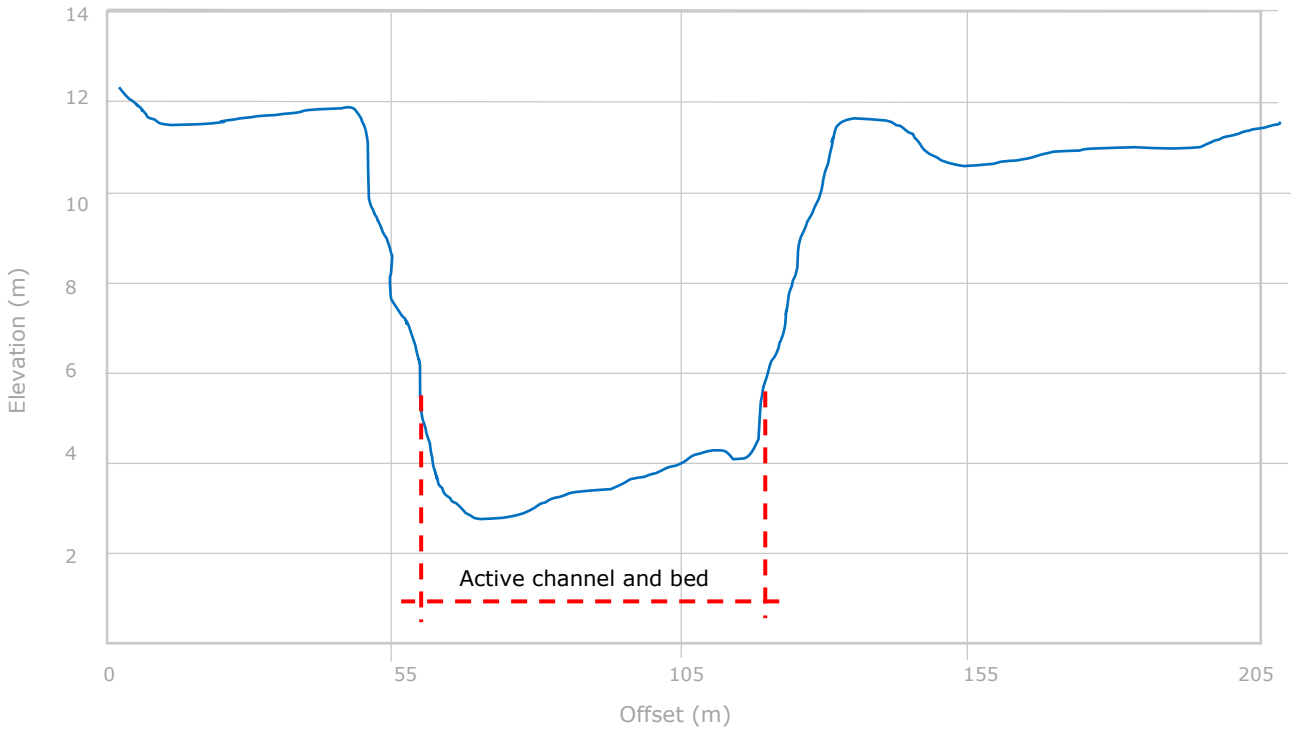


Figure 2.1: Conceptual channel cross-section for a gravel section

Cross-sections from 2018 and 2023 were over-plotted and analysed in Hilltop Manager (see Appendix C) to determine the extents of the active channel at each cross-section location. In cases where visual inspection was not feasible, aerial images were examined to determine cross-section extents. Hilltop Hydro - REACH was used to obtain the area under the section and the mean bed level. The defined offsets and datum used can be found in Appendix A.

2.1 Disconnected and incomplete cross-sections

The 2023 surveys in the Pohangina River were done intermittently. Due to high river levels in June 2023, the left and right banks of the river were surveyed separately, as well as the wetted channel. Cross-sections 1.0- to 3.5- mile mark were then resurveyed in October 2023 because water levels were low at that time. In order for Hilltop to calculate the sections properly, the aforementioned cross-sections were combined into one. Figure 2.2 shows an example of cross-section 2.0-mile mark, before and after the incomplete sections were combined.

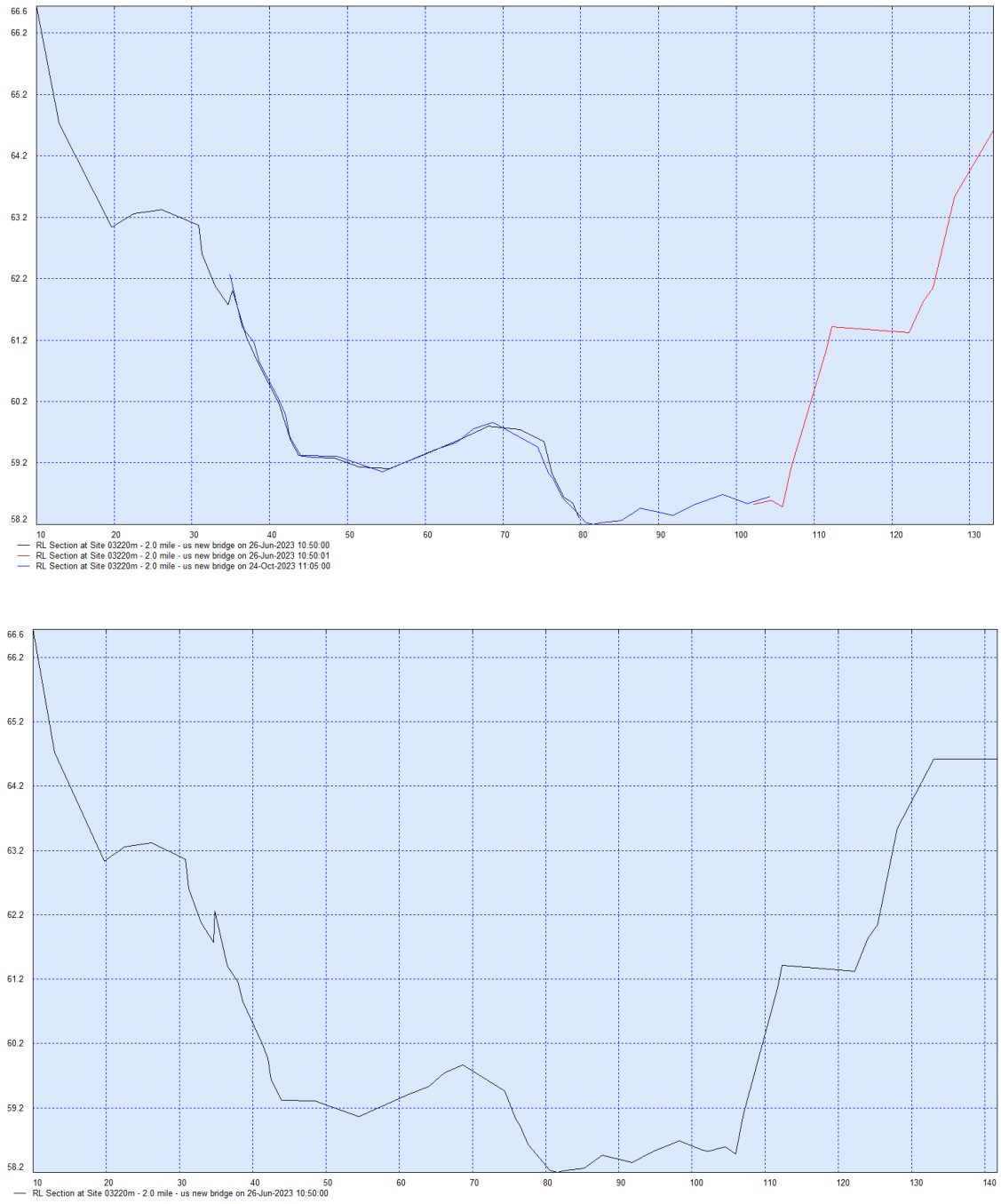


Figure 2.2: Before (top) and after (bottom) cross-sections were combined
Note: The after-combination data was saved under 26-Jun-2023 10:50:00 for simplicity

In the case of cross-sections 9.5-mile and 13.5-mile marks, the 2018 cross-section surveys were incomplete due to the migration of the channel. To fill in the gap, the cut off 2018 is extended using the 2005 DEM derived from LiDAR. The 2005 DEM was in the Wellington 1953 vertical datum and in NZMG projection. Thus, to have comparable data with the 2018 and 2023 survey data, the DEM was converted to NZVD2016 and NZTM. Figure 2.3 shows the before and after extension of the 2018 survey for cross section 9.5 mile.

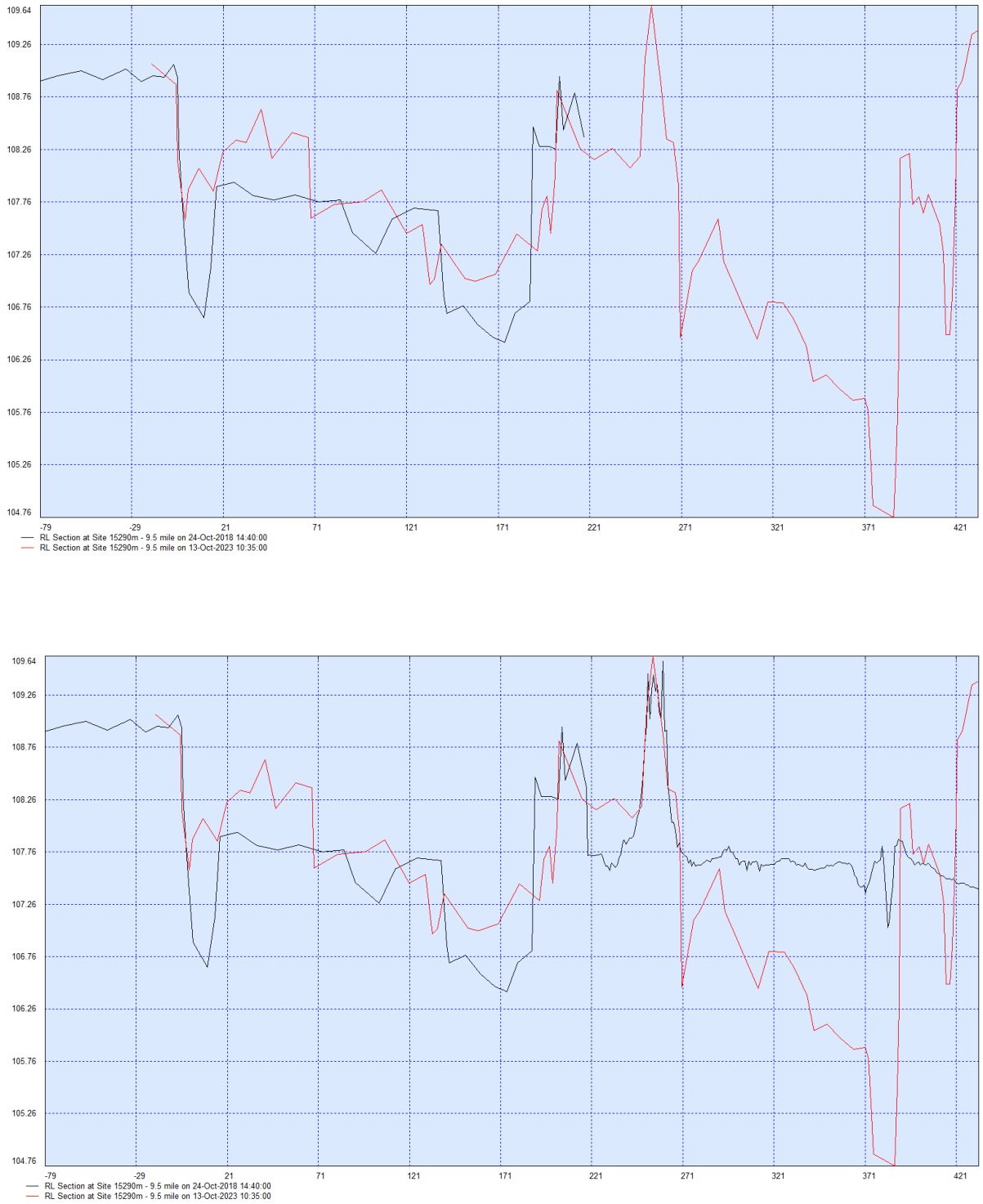


Figure 2.3: Before (top) and after (bottom) cross-sections were combined

2.2 Analysis of Gravel Resources under the Active Channel

Each period of the individual cross-sections was analysed using Hilltop. The survey years 2018 and 2023 were plotted using the over plot function on Hilltop Manager. The offsets were determined using visual inspection on the over plotted cross-sections. The extents of these offsets for the area calculation cover the active channel or the wetted channel plus the gravel beaches. This excludes the berm area. In cases where visual inspection is unclear, aerial images were used for confirmation. The left and right offsets can be found in Appendix A. The datum was set as 0. The area under the section of each year was obtained using the "Section over Time" in Hilltop Hydro - REACH.

The volume was then calculated using the following end-over-area MBL (mean bed level) equation:

$$V_x = (D_2 - D_1) \times (\sqrt{}(A_1 \times A_2) + A_1 + A_2)/3$$

Where:

V_x = gravel volume in m^3

$A_x = L_x \times W_x$ OR can be obtained using the Area under the section from Hilltop

D_x = river distance of cross-section x

A_x = end area of cross-section x

L_x = surveyed mean bed level at cross-section x

W_x = fairway width at cross-section x

This formula was the same formula used by Environment Canterbury and by Tonkin & Taylor Ltd in their gravel analyses (Tonkin & Taylor Ltd, 2024).

2.2.1 Results of Gravel Volume Change

The results of the change in gravel volume of the Pohangina River are shown in Figure 2.4. Using the method and formula above, there is an overall loss of 519,235 m^3 of gravel from 2018 to 2023, which is 103,847 m^3/yr of degradation. The 14-mile mark cross-section showed the largest change in gravel volume, with a gravel loss of 72,516 m^3.

A comparison of the previous gravel studies' results was made on gravel volume change and the results are shown in Figure 2.5; a summary of which is outlined in Table 2.1. The results show that the degradation trend observed in the 2000-2012 period below 4.0-mile mark has reversed and shows aggradation from 2012 to 2023. Between 4.0-mile and 9.0-mile marks, the trend shows aggradation from 2000-2012, however it has degraded over the two periods after that. Aggradation was continuously observed from all three periods at 14.5-mile to 21-mile marks. The overall change of gravel volume in the Pohangina River has fluctuated from degradation in the 2013 study to aggradation in the 2020 study to degradation again in the current 2025 study.

Study period / Mile Mark	2013 study (2000-2012)	2020 study (2012-2018)	2025 study (2018-2023)
1.0-mile to 4-mile	Degradation	Aggradation	Aggradation
4-mile to 7-mile	Aggradation	Degradation	Degradation
7.5-mile to 14-mile	Degradation	Aggradation	Degradation
12-mile to 21-mile	Aggradation	Degradation	Degradation
14.5-mile to 21-mile	Aggradation	Aggradation	Aggradation
Overall change	Degradation	Aggradation	Degradation

Table 2.1: Comparison summary of gravel study results

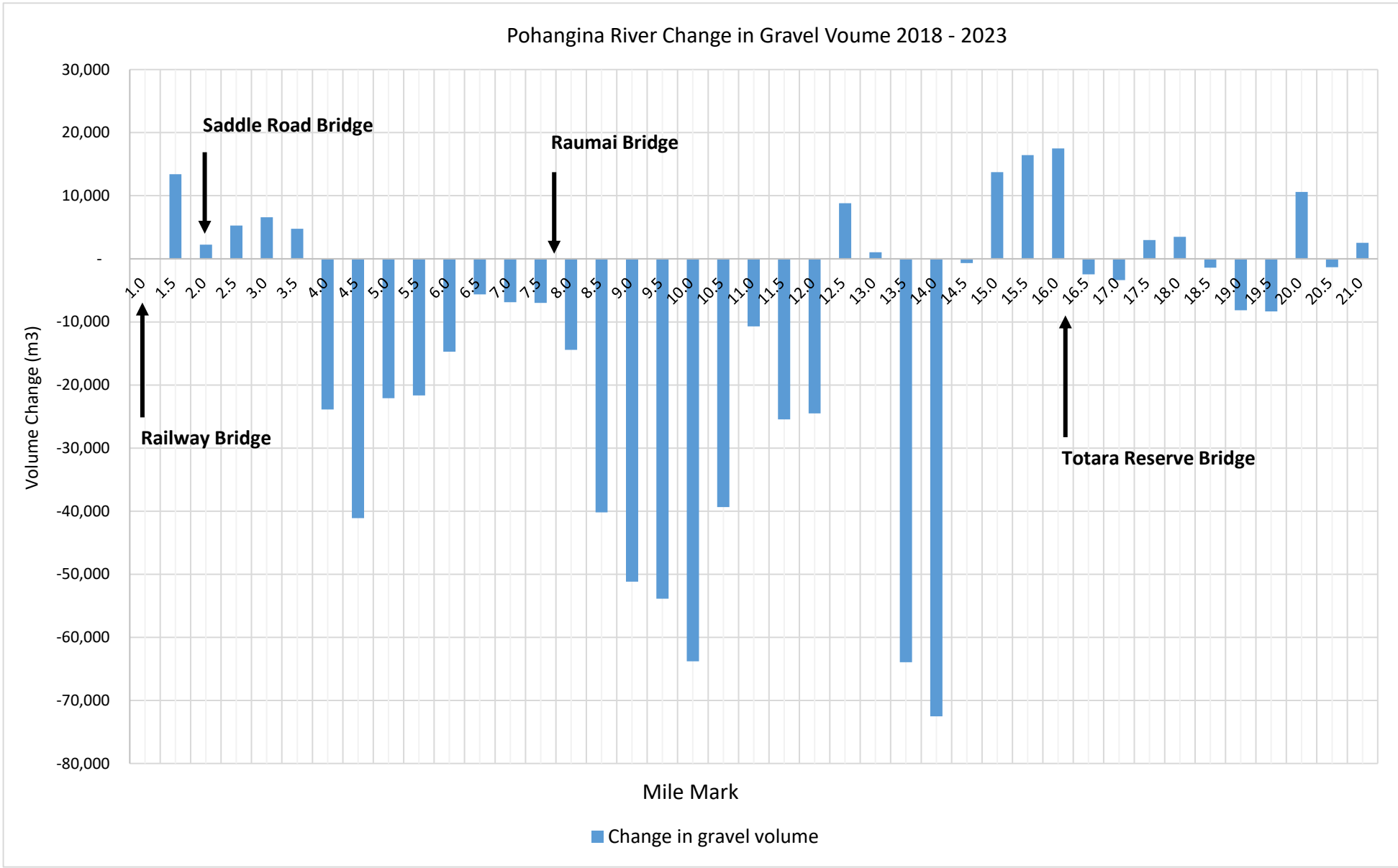


Figure 2.4 Change in Gravel Volume 2018-2023

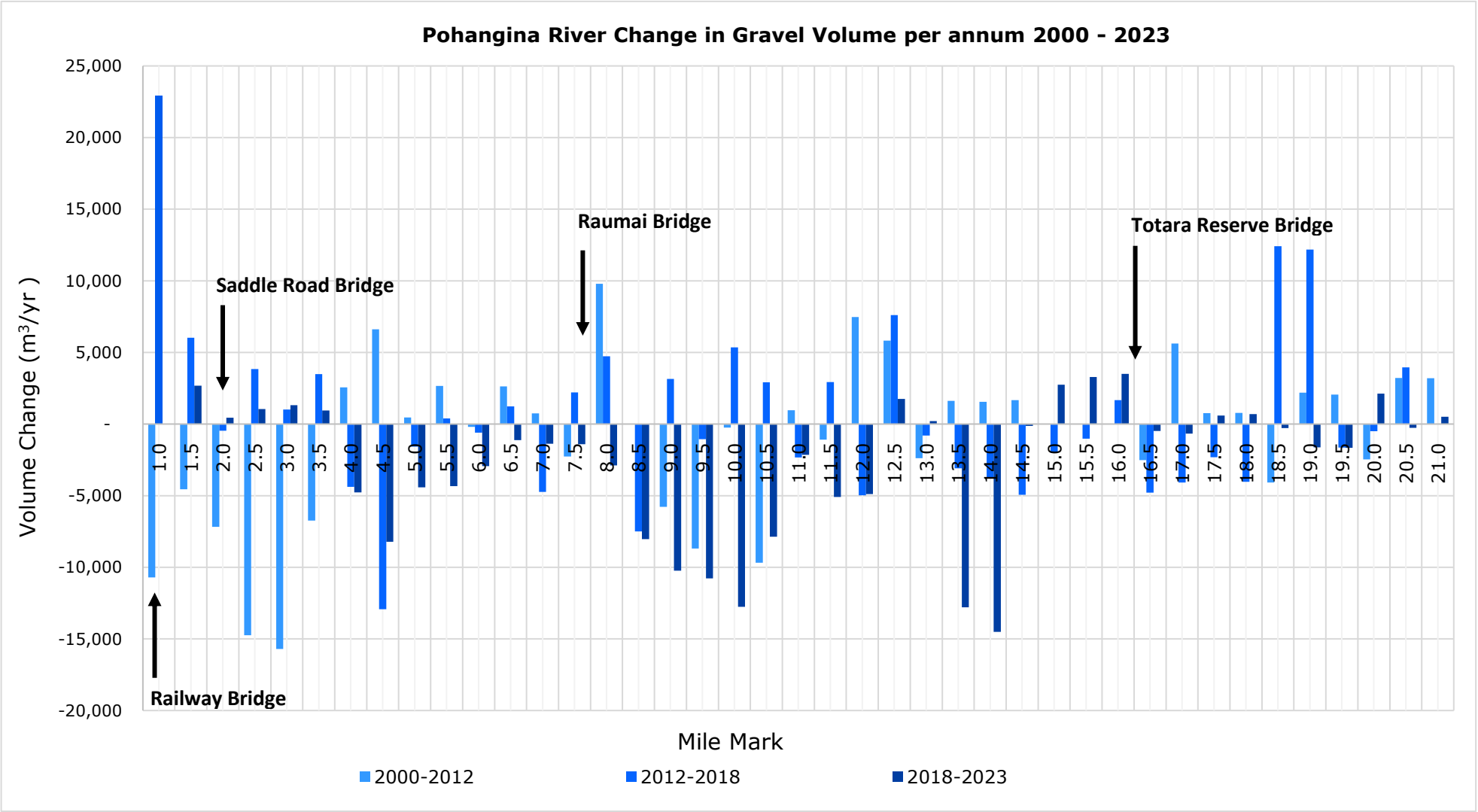


Figure 2.5 Change in Gravel Volume 2000-2023

2.3 Analysis of the Mean Bed Level

Hilltop was used to analyse each period of the individual cross-sections, over-plotting the years of interest. The extent of the offsets for the mean bed level covers the same extents as the area under the section– that is to say, it covers both the wetted channel and the gravel beaches. Inputting the left and right offsets found in Appendix A, the mean bed levels of each year were obtained using the "Section over Time" feature found under the Reach tab of Hilltop Hydro.

2.3.1 Results of the Mean Bed Level Change

Figure 2.6 shows the results of the change in mean bed level from 2018 to 2023, and Figures 2.7.1 to 2.7.5 shows the long section. There has been no appreciable (i.e. greater than one metre change) aggradation or degradation in the river. Monitoring can be done if the change has been greater than 0.3m while potential intervention can be done for cross sections with greater than 0.5m change.

Cross sections with more than 0.5m negative change include 4.0-mile, 10.0-mile, 11.5-mile, and 13.5-mile marks. Cross sections with more than 0.3m negative change include 8.0-mile, 8.5-mile, 9.0-mile, and 14.0-mile marks. The maximum bed level change of negative 0.714m was observed at cross-section 13.5-mile mark. An aggrading trend was seen in the lower reaches while a degrading trend is seen in the middle reaches. In the upper reaches, an alternate rising and falling of mean bed level was observed. The results of the mean bed level changes roughly match the results of the change in gravel volume, meaning that if the gravel volume increased, the mean bed level change also increased; conversely, if the gravel volume decreased, the mean bed level change also decreased.

A comparison of the previous gravel studies' results on mean bed level change was made, and the results are shown in Figure 2.8. During the period 2000-2012, it was observed that the negative changes in mean bed level below 4.0-mile mark have reversed in the succeeding periods of 2012-2018 and 2018-2023. Above 4.0-mile mark, the magnitude of the negative changes observed in the period 2000-2012 were seen to have reduced in the period of 2012 to 2018. From 4.0-mile to 14.0-mile marks, a general lowering of the bed has been observed from 2012-2023. Similarly, from 17.0-mile to 21.0-mile marks, the mean bed levels were observed to have generally lowered from 2012 to 2023.

According to Whale (2020), when analysing the mean bed level changes of a gravel bedded river, such as the Pohangina River, it would be expected to see fluctuations in the mean bed level due to the natural movement of gravel through the river system. However, some significant fluctuations could also be due to the dynamic nature of the river or could have been influenced by gravel extraction.

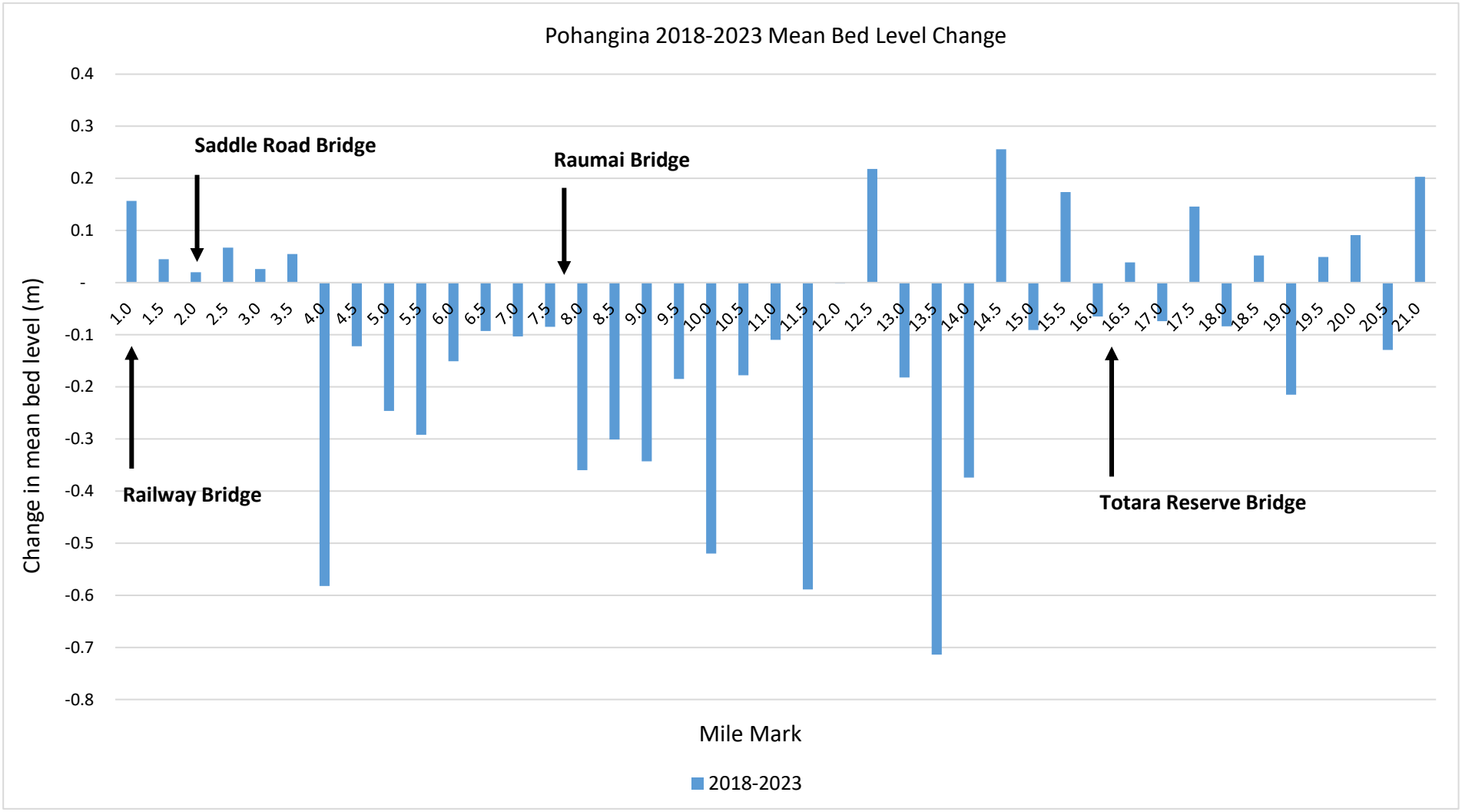


Figure 2.6: Mean Bed Level Change (2018-2023)

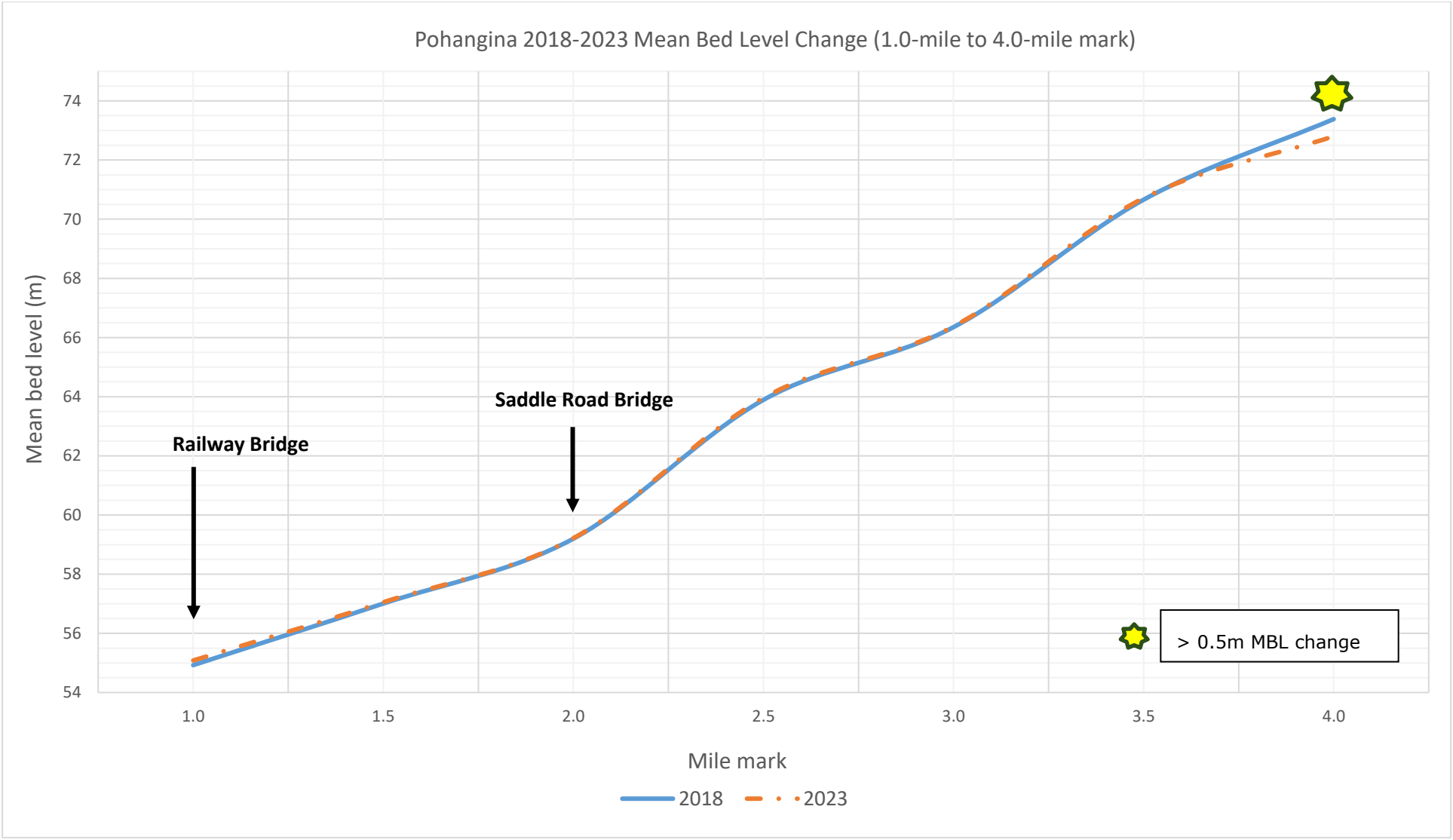


Figure 2.7.1: 2018-2023 Mean Bed Level Long Section (1.0-mile to 4.0-mile mark)

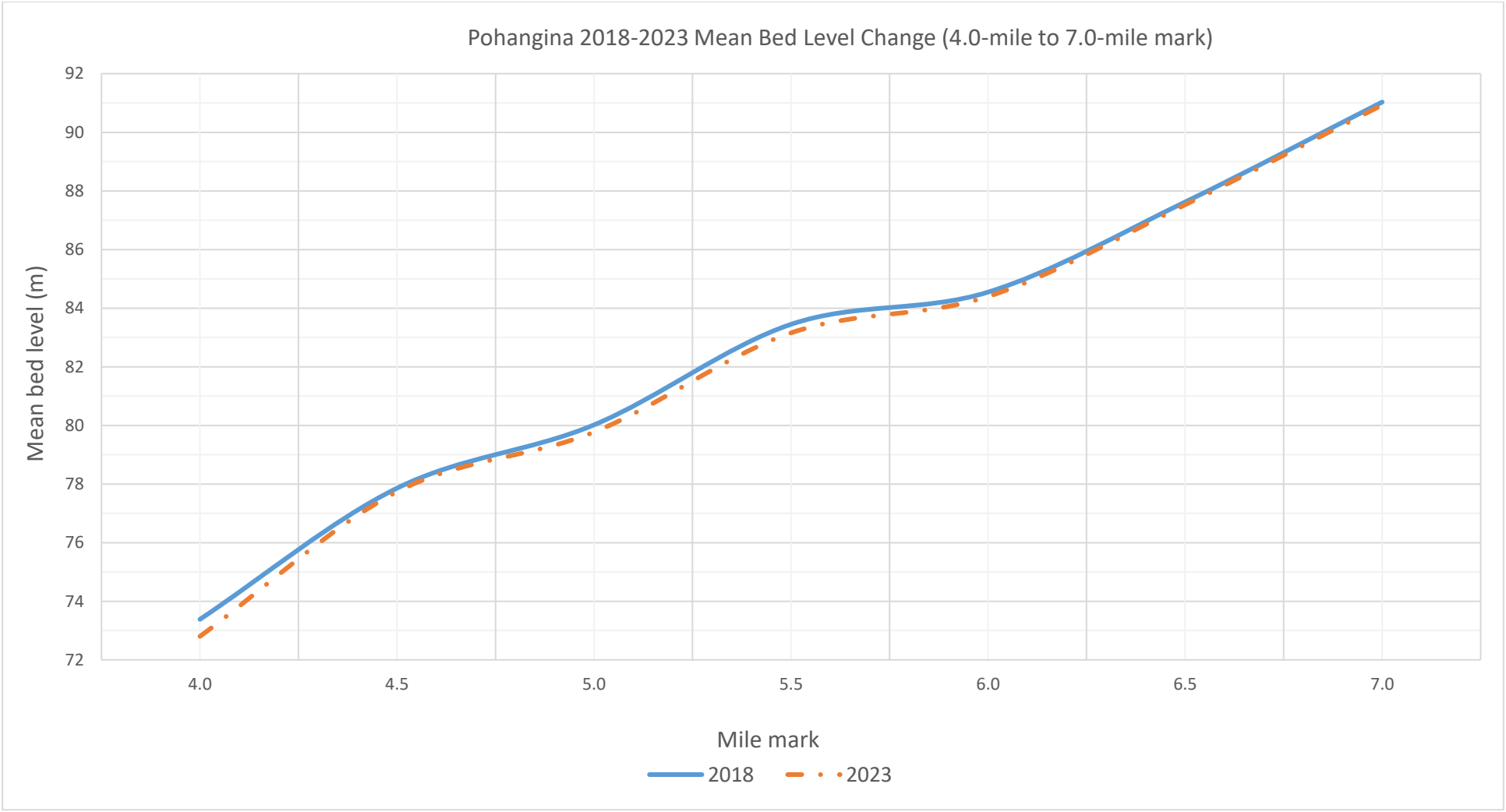


Figure 2.7.2: 2018-2023 Mean Bed Level Long Section (4.0-mile to 7.0-mile mark)

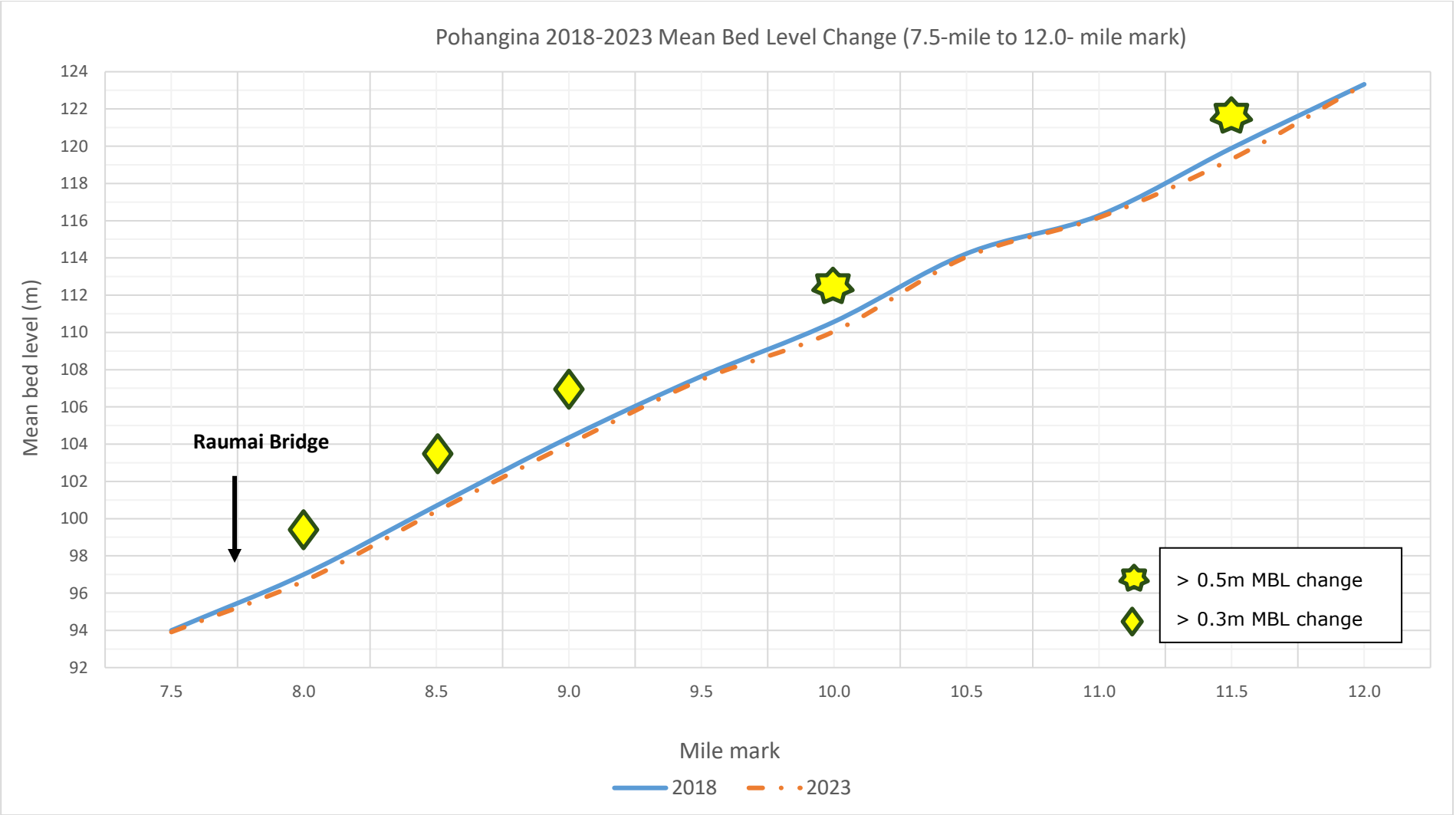


Figure 2.7.3: 2018-2023 Mean Bed Level Long Section (7.5-mile to 12.0- mile mark)

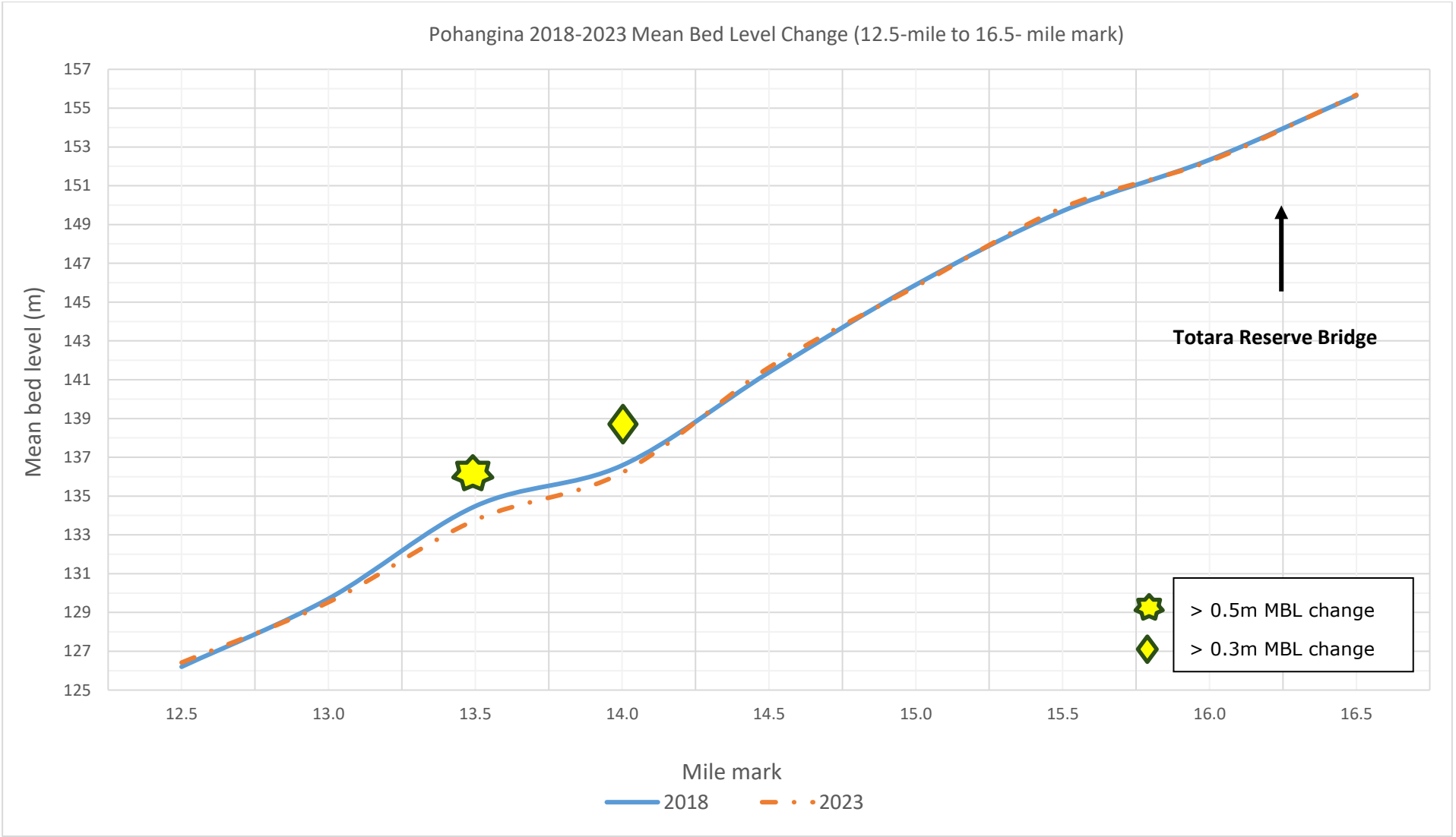


Figure 2.7.4: 2018-2023 Mean Bed Level Long Section (12.5-mile to 16.5- mile mark)

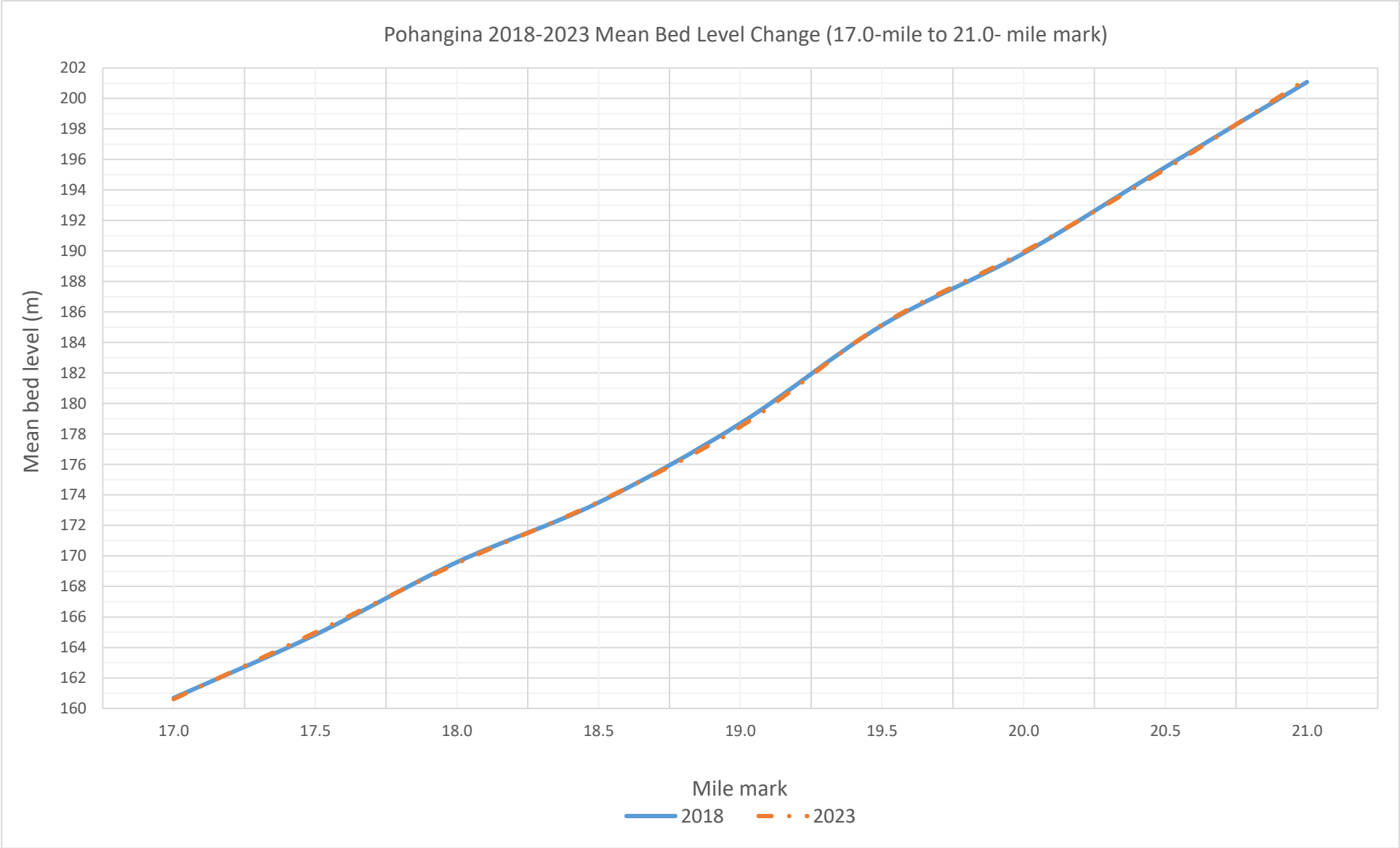


Figure 2.7.5: 2018-2023 Mean Bed Level Long Section (17.0-mile to 21.0- mile mark)

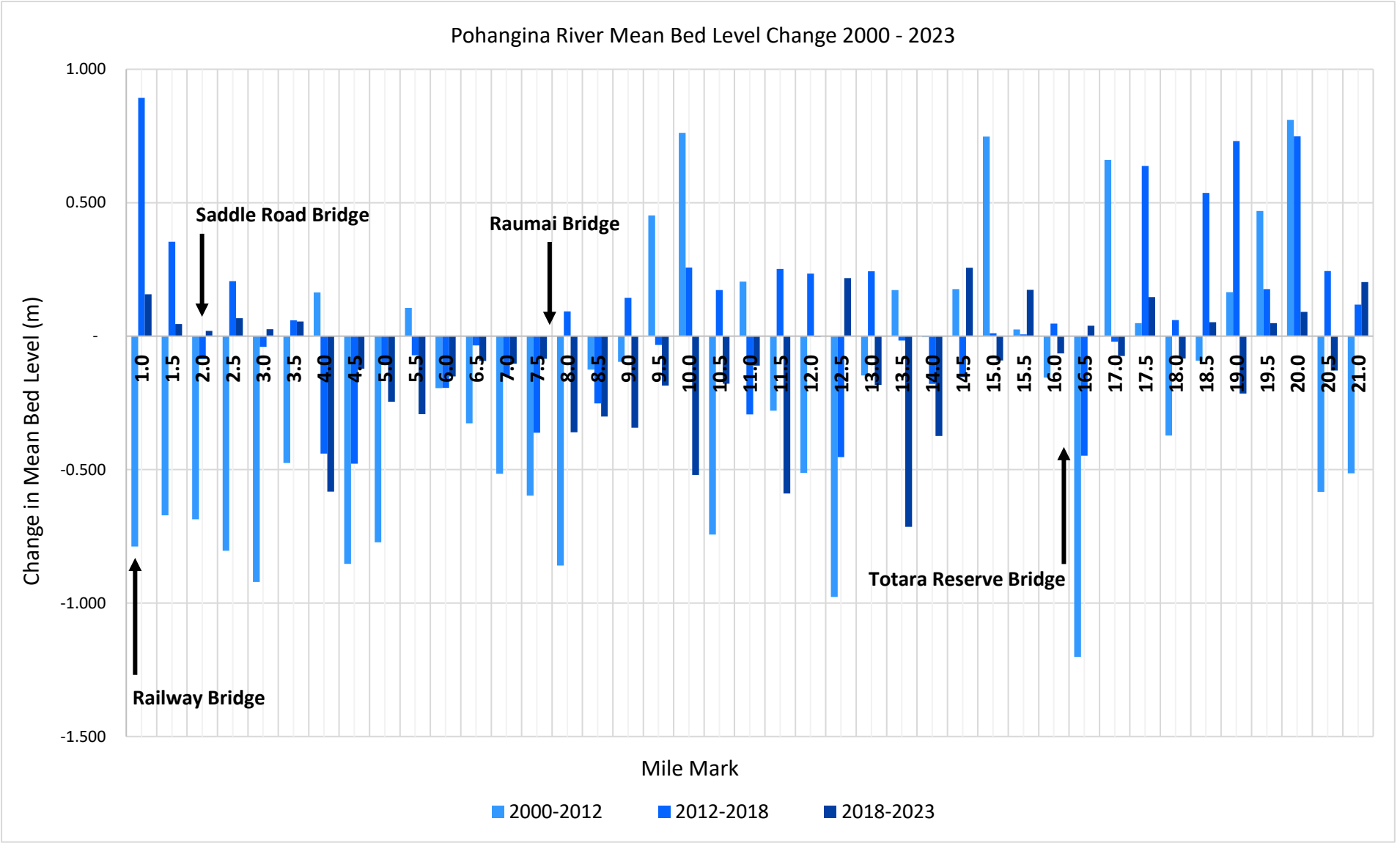


Figure 2.8: Mean Bed Level Long Section (2000-2023)

2.4 Discussion of Outliers

From Figure 2.3, it is observed that the majority of gravel volume fluctuations fall within the range of less than 40,000m^3, but the following cross-sections showed volume changes close to or greater than 40,000 m^3: 4.5-mile, 8.5-mile, 9.0-mile, 9.5-mile, 10.0-mile, 10.5-mile, 13.5-mile, and 14.0-mile marks.

4.5-mile

About 41,000m^3 of gravel degradation was observed from Figure 2.3. The comparison of 2021 and 2023 aerial imagery in Figure 2.9 shows the difference between pre and post Cyclone Gabrielle. The channel has eroded and moved towards the true left bank of the river as evidenced in the cross-section at 4.5-mile mark. This could be one reason for the degrading result. Cross-section shows signs of degradation caused by the shift.

8.5-mile

At the 8.5-mile mark, an estimated loss of about 40,000 m^3 was observed from Figure 2.3. The aerial imagery comparison in Figure 2.10 shows that the channel has eroded into the true left bank of the river, which can be observed in the cross-section as well.

9.0, 9.5, and 10.0-mile

Figure 2.3 shows that an approximate loss of 51,000 m^3, 54,000 m^3, and 64,000 m^3 were observed at cross-sections 9.0-mile, 9.5-mile, and 10.0-mile marks, respectively. From Figure 2.11, it can be seen that between 2021 and 2023, sections 9.0-mile, 9.5-mile, and 10.0-mile marks have undergone dynamic changes. Migration of the dominant channel from the true left to the true right bank of the river was observed at 9.0-mile and 10.0-mile marks. Evidence for the migration of the main channel is supported by their corresponding cross-sections (Figure 2.12). At 9.5-mile mark, slight movement of the main channel can be seen, shifting from the true right to the true left bank of the river and a split in the river channel.

10.5-mile

At 10.5-mile mark, results show that a net degradation of 39,000m^3 was observed. A visual reduction in gravel beach was observed from the 2021 and 2023 aerials in Figure 2.13. This is supported by the cross-section at 10.5-mile mark where degradation has occurred.

13.5-mile and 14.0-mile

At 13.5-mile mark, an approximate degradation of 64,000m^3 was observed from Figure 2.3, while at 14.0-mile, an approximate 72,500m^3 of gravel was lost from 2018 to 2023. There has been migration of main channel from the true right to the true left of the river at 13.5-mile, and degradation is apparent in the cross-section in Figure 2.14. At 14.0-mile, the river channel split in two and there was a visible reduction in gravel from the cross-section in Figure 2.14.

Figure 2.9: Aerial images 2021 (top left), 2023 (top right), and cross-section 4.5-mile mark (bottom)

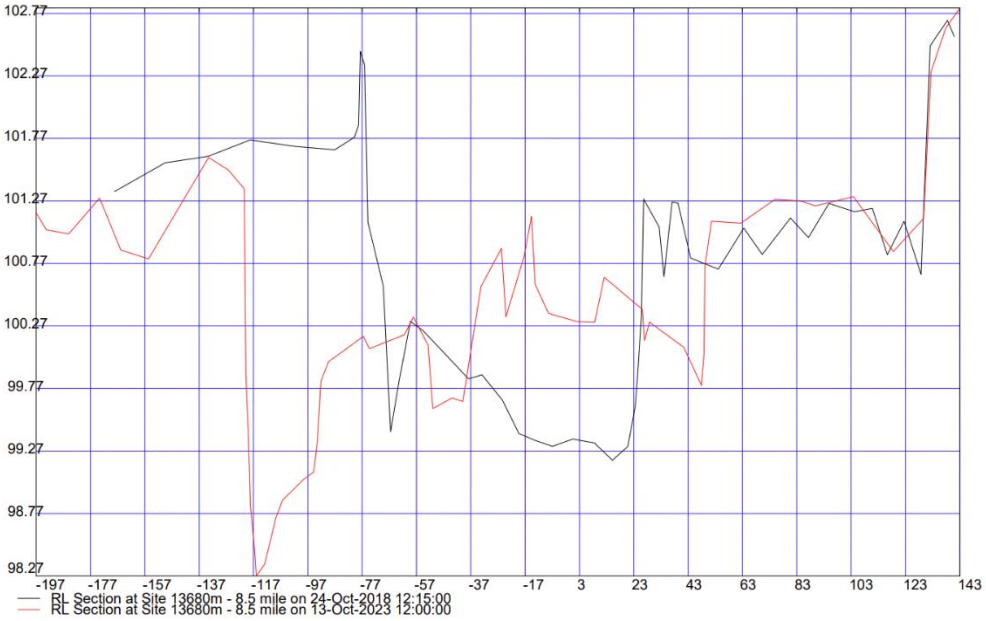


Figure 2.10: Aerial images 2021 (top left), 2023 (top right), and cross-section 8.5-mile mark (bottom)

Figure 2.11: Aerial images 2021 (left) and 2023 (right) showing cross-sections 9.0-mile, 9.5-mile, and 10.0-mile marks

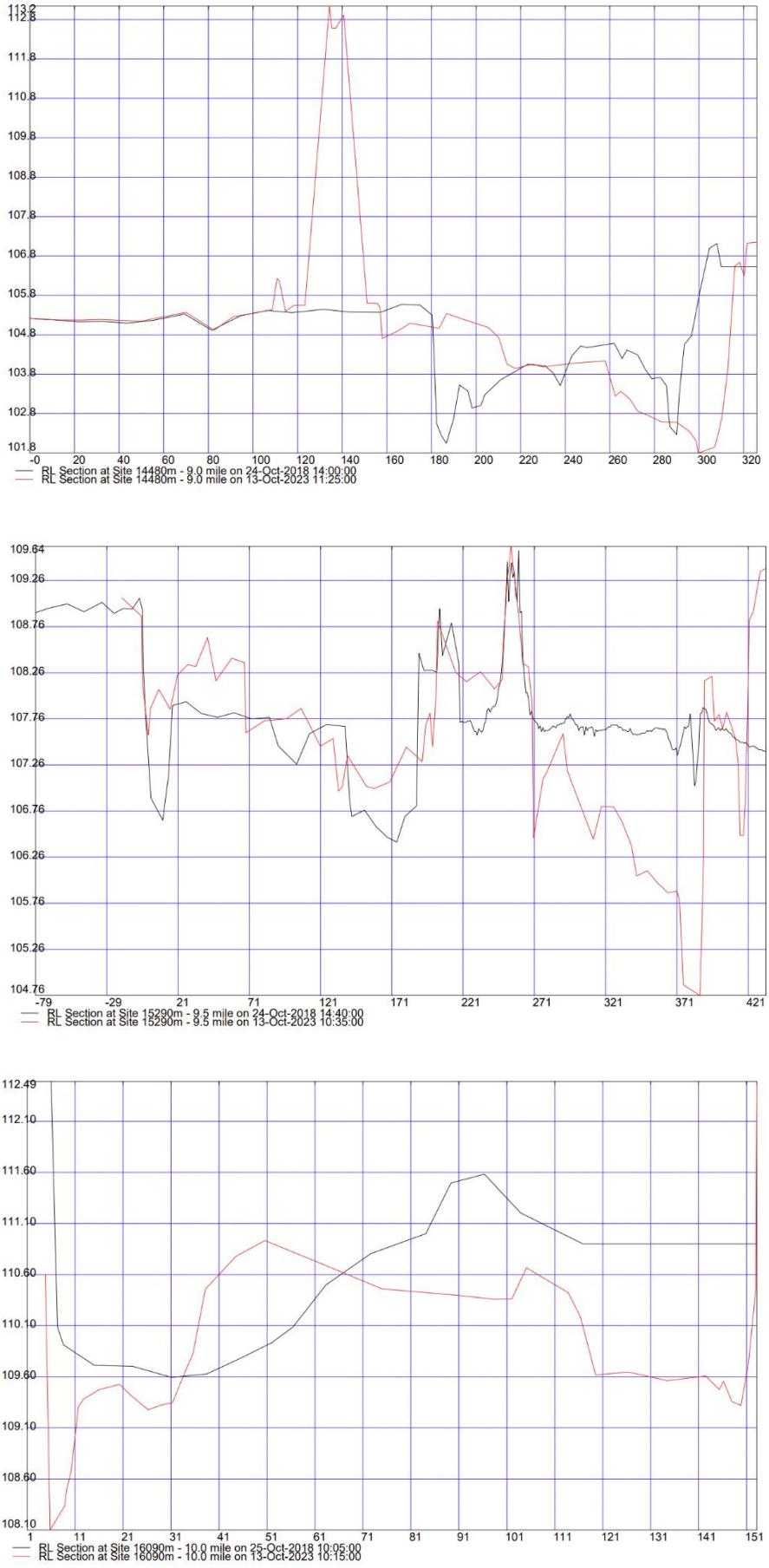
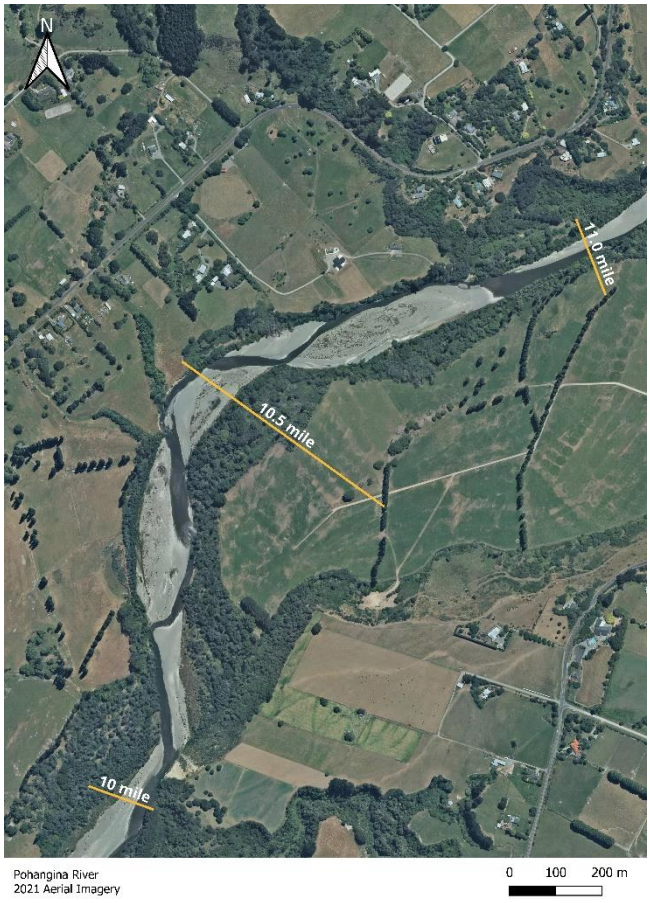


Figure 2.12: Cross-sections of 9.0-mile (top), 9.5-mile (middle), and 10.0-mile marks (bottom)



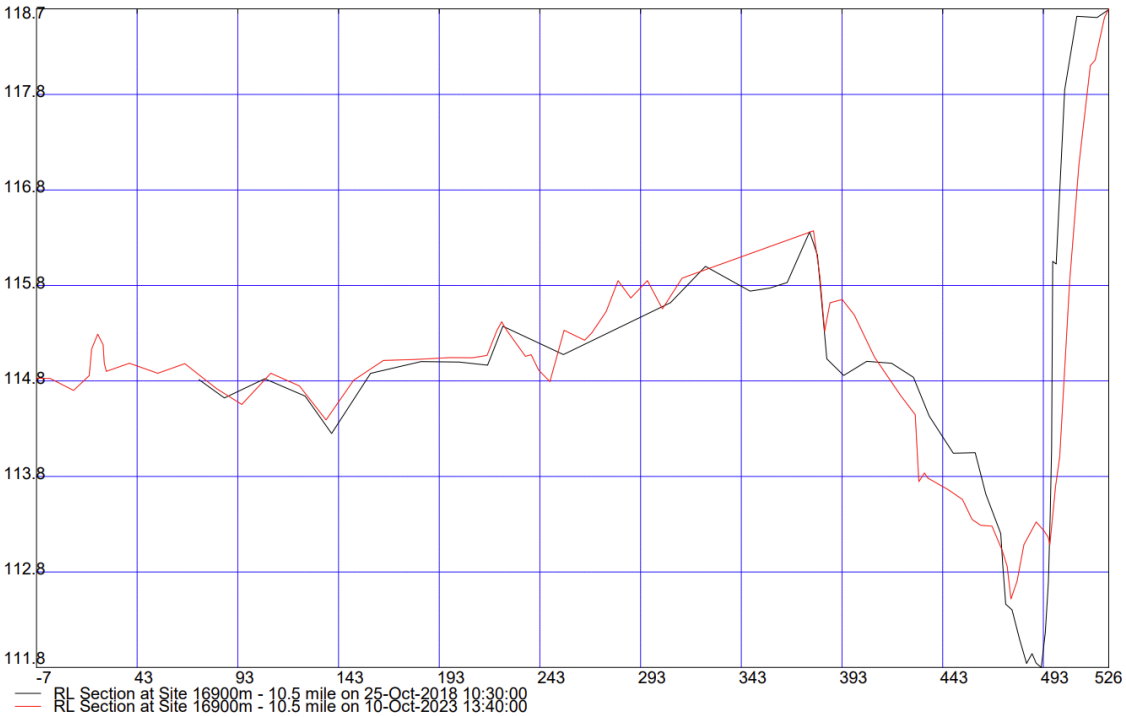
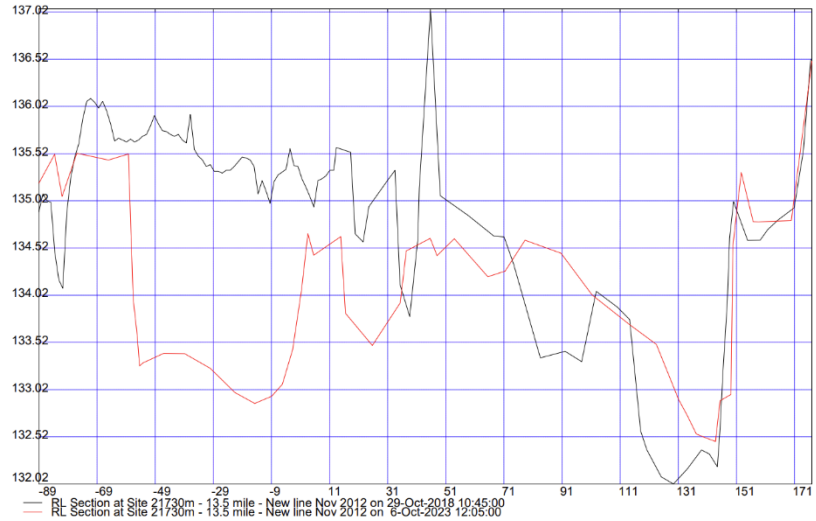


Figure 2.13: Aerial images 2021 (top left), 2023 (top right), and 10.5-mile cross-section (bottom)



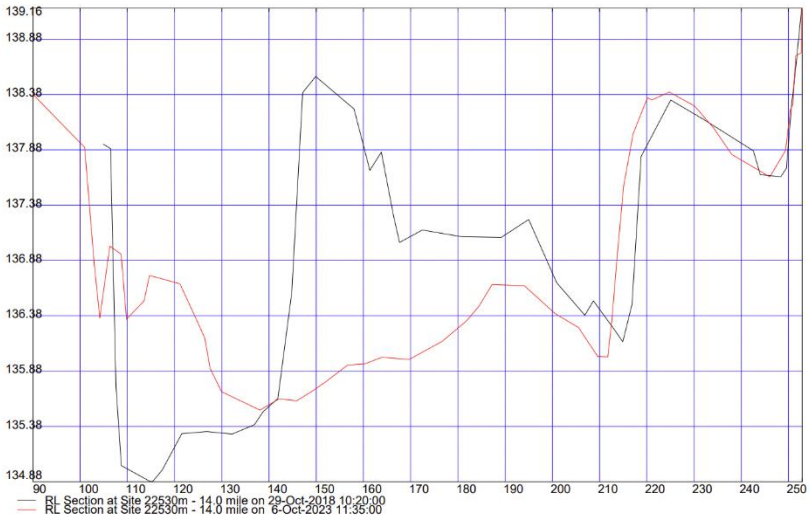


Figure 2.14: Aerial images 2021 (top left), 2023 (top right), and cross sections 13.5-mile (centre) and 14.0-mile (bottom)

2.5 Other Methods Used for Comparison

The cross-section data was analysed in three different ways to have some comparison.

1. New method and new formula

The new method and new formula were discussed in the previous sections 2.1 to 2.3. The new method refers to how the extents of the offsets were determined. The same values were used as new offsets for obtaining the area/volume and mean bed levels. They cover only the wetted channel and gravel beaches; it excludes the berm area. The new formula is found in section 2.2 of this report. The results of the first method can be found in Appendix A.

2. Old method and old formula

The old offsets for the area/volume includes the wetted channel, gravel beaches and the berm area (see Figure 2.15). For the mean bed level offsets, it covers the wetted channel and gravel beaches. The old formula used can be found below. The results from using the old method and old formula can be found in Appendix B1.

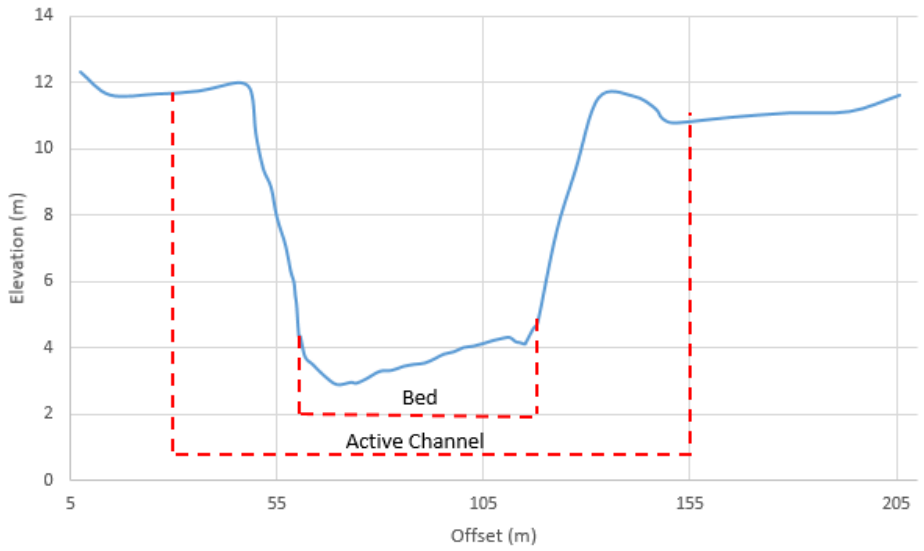


Figure 2.15: Old concept of offset extents

Old formula:

Change in volume = $(A_2–A_1)$ [½ $(X_3–X_2)$ + ½ $(X_2–X_1)$]

Where:

- X1 is the downstream section distance
- X2 is the distance of the cross-section of interest
- X3 is the upstream section distance
- A1 is the first area under the section (e.g. 2013)
- A2 is the second area under the section (e.g. 2019/2020)

3. New method and old formula

The third method combines the new method described in the first approach and the old formula in the second. The results of the third method can be found in Appendix B2.

2.6 Cumulative Volume Results

A comparison of the different methods and formulas was made and the cumulative change in volume is found in Figure 2.16. The results show that although the methods and formulas used were different, the overall trend appears to be similar and consistent. It shows that the upper reaches (16.5-mile to 21-mile marks) are in a stable trend. From cross-section 14.5-mile to 16-mile marks, there was a general upward trend and a general downward trend from 4.5-mile to 14-mile marks. The lower reaches below 4.0-mile mark saw an increasing trend.

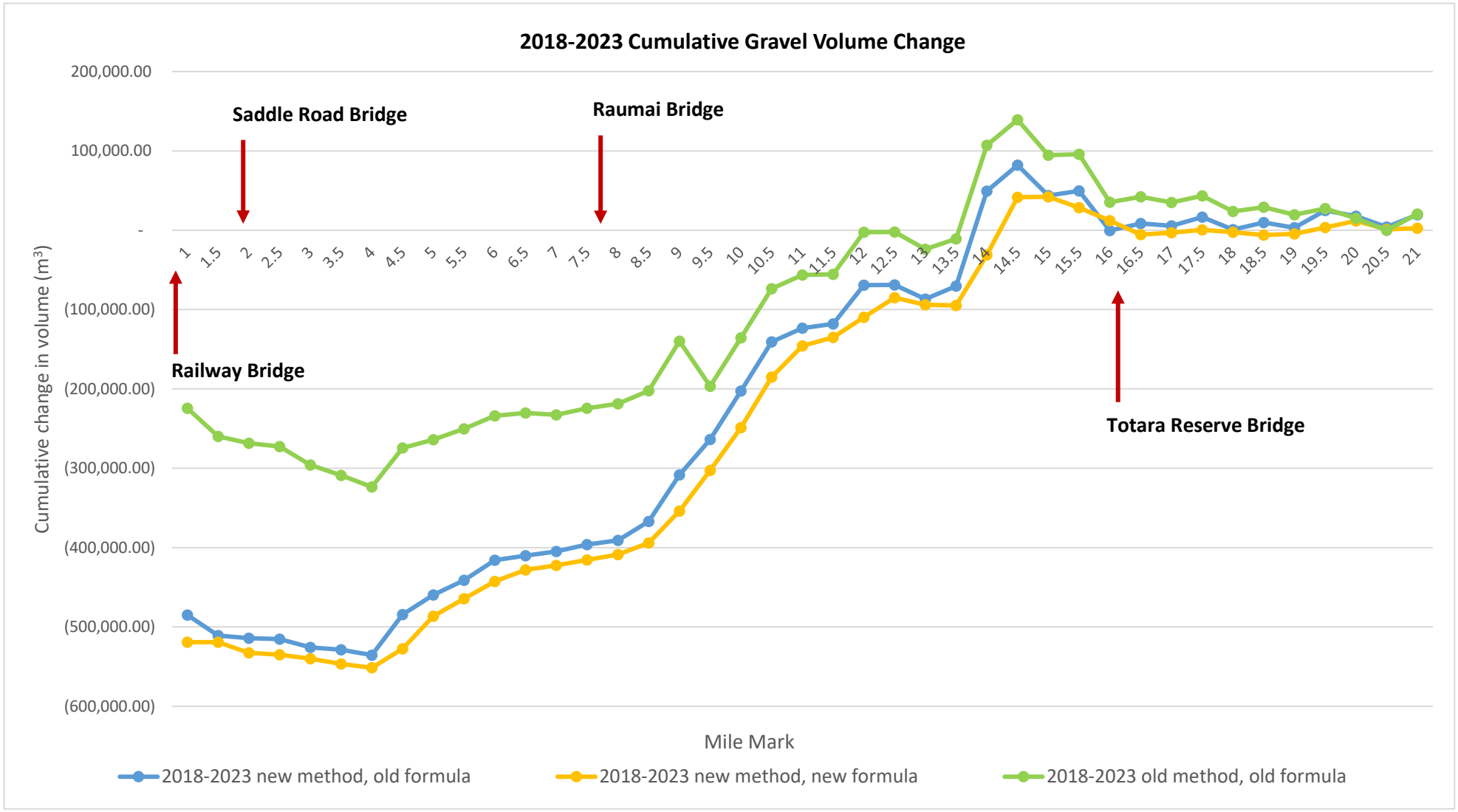


Figure 2.16: Cumulative Gravel Volume Change 2018-2023

3.0 Gravel Volume and MBL Change Map

Figure 3.1 shows the change in gravel volume and the mean bed level (MBL) in the Pohangina River from 2018 to 2023. Shades of red represent varying degrees of degradation while shades of green represent varying degrees of aggradation. White colour shows that minor changes were experienced in a particular cross-section. An MBL change of greater than 0.5m is being represented by a star while a diamond represents an MBL change of greater than 0.3m.

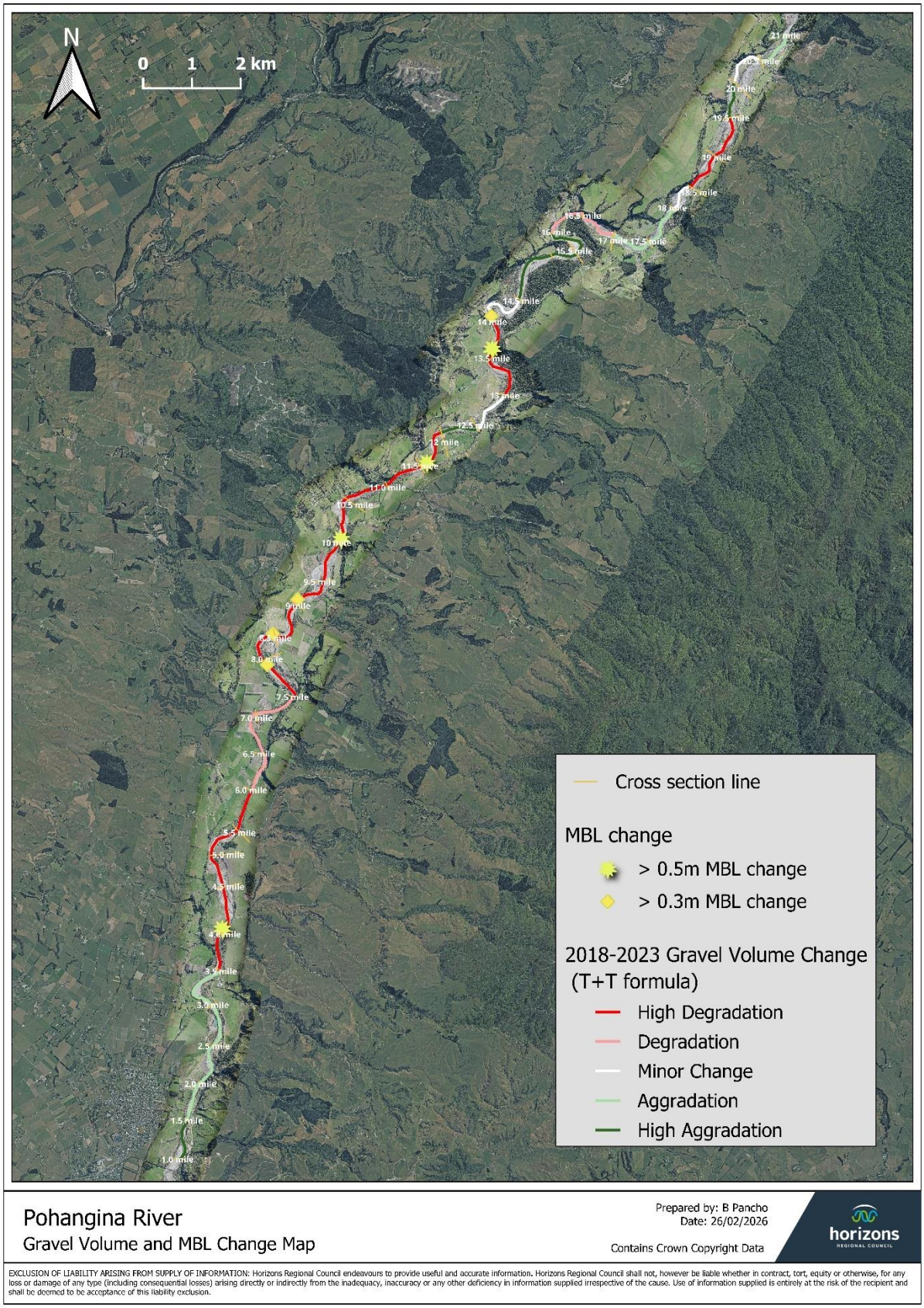


Figure 3.1: Gravel Volume and MBL Change Map

4.0 Gravel Extraction and One Plan

The 2012 gravel study found that since the survey in 2000, approximately 272,000 cubic meters of gravel have been extracted from the river reach at an average rate of 22,600 m^3/yr. The previous 2020 gravel study recorded that 95,641 m^3 of gravel has been extracted from the Pohangina River between 2012 and 2018.

There are currently no active consents operating in the river as of this gravel study's date. There was only one consent operating from 2018 to 2023, which was the Horizons Regional Council Global Consent 102511. To date, this global consent is on hold as it is awaiting the permission of existing use rights. The recorded gravel taken from the river is summarised in Table 4.1.

Year	Volume (m^3)
2018	16,050
2019	15,730
2020	8,270
2021	11,700
2022	3,985
2023	1,800
Total	*57,535*

Table 4.1: Recorded gravel extraction volumes from 2018 to 2023

The One Plan allocable volume for the Pohangina River is 25,000m^3/yr. Table 4.1 shows that the average extraction rate of 11,500m^3/yr did not exceed the One Plan volume. Additionally, the numbers in Table 4.1 are well below the gravel extraction limit of 20,000m^3/yr that the previous 2020 study recommended for the Pohangina River.

Figure 4.1 shows a map of the gravel extraction locations from the Catchment Operations' records from 2014 to 2020. It shows the approximate location only (e.g. "X Property between 15.5-17km mark") since the records did not indicate specific locations. The gravel extraction locations roughly correspond to the areas of degradation observed from the cross-section analysis results.

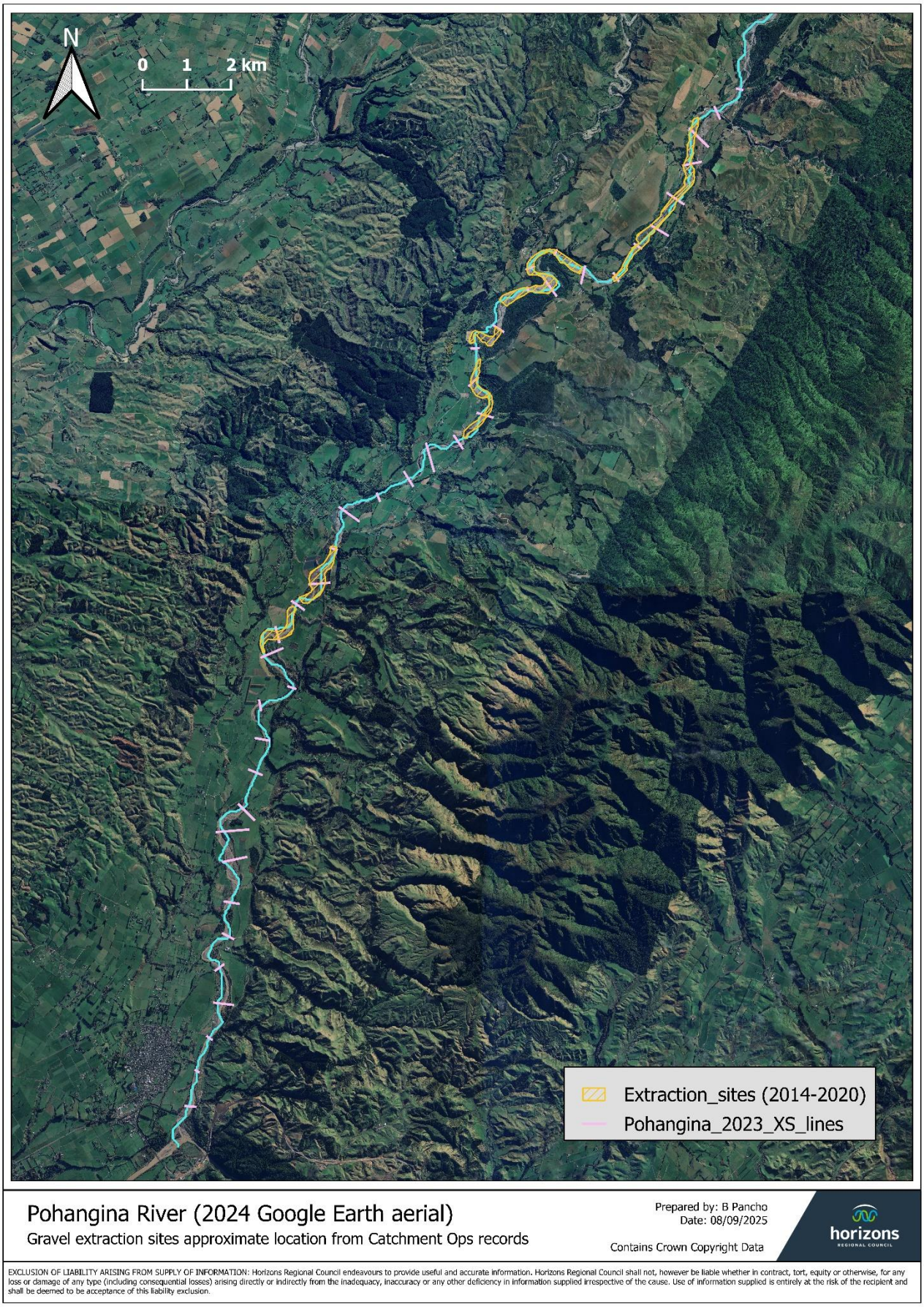


Figure 4.1: Gravel extraction sites from 2014 to 2020

5.0 Current status of the river

On 14 May 2025, site visits to the different locations of the Pohangina River cross-sections were conducted with engineering officer, Tom Coogan. This was done to ground truth the results of the gravel analysis. Below is a summary of the findings on site:

- In the 2020 gravel study, it was observed that aggradation has occurred because the piles underneath the abutments of the Railway Bridge have become less exposed than the 2013 study. Figure D1 of Appendix D shows that the piles beneath the abutments are still exposed, though it is hard to determine whether it has increased or decreased since the 2020 study. Only where the channel flows does the majority of the scouring take place; all other abutments were well anchored in the gravel beach. Gravel extraction is preferred in the area upstream of the bridge marked with the red arrow in Figure D1 of Appendix D.
- Although it is not very high, gravel beach can be found beneath the Saddle Road Bridge (see Figure D2 of Appendix D).
- The gravel beach encircled in red in Figure D3 of Appendix D, which is situated between the Saddle Road Bridge and 2.5-mile mark, is 2 meters high. It is recommended to extract the gravel from this gravel island. The engineering officer advised this would enhance sinuosity by directing the flow back through the established groynes and aiming the river and the bluff on the left bank to slow down the flows.
- The site upstream of 3.0-mile mark as seen in Figure D4 of Appendix D has a high gravel beach present marked as X, and gravel extraction is preferred here. Erosion is actively occurring at the site where the blue arrow is, and appropriate action is needed here.
- Figure D5 of Appendix D shows that near cross-section 9.0-mile mark, a gravel beach approximately 3m high was observed at the site marked in red. Extraction is recommended here as this beach is causing erosion to the adjacent works.
- High gravel beach is observed at 12.5-mile mark in Figure D6 of Appendix D, and is available for extraction, but it's not causing any issues until downstream of the red arrow. There are adjacent rock works on the left bank of which are under pressure from the river. The rocks occasionally get scoured out.
- Halfway between 13.0-mile and 13.5-mile marks, a high gravel beach marked in red was observed and gravel extraction is preferred here (see Figure D7 of Appendix D).

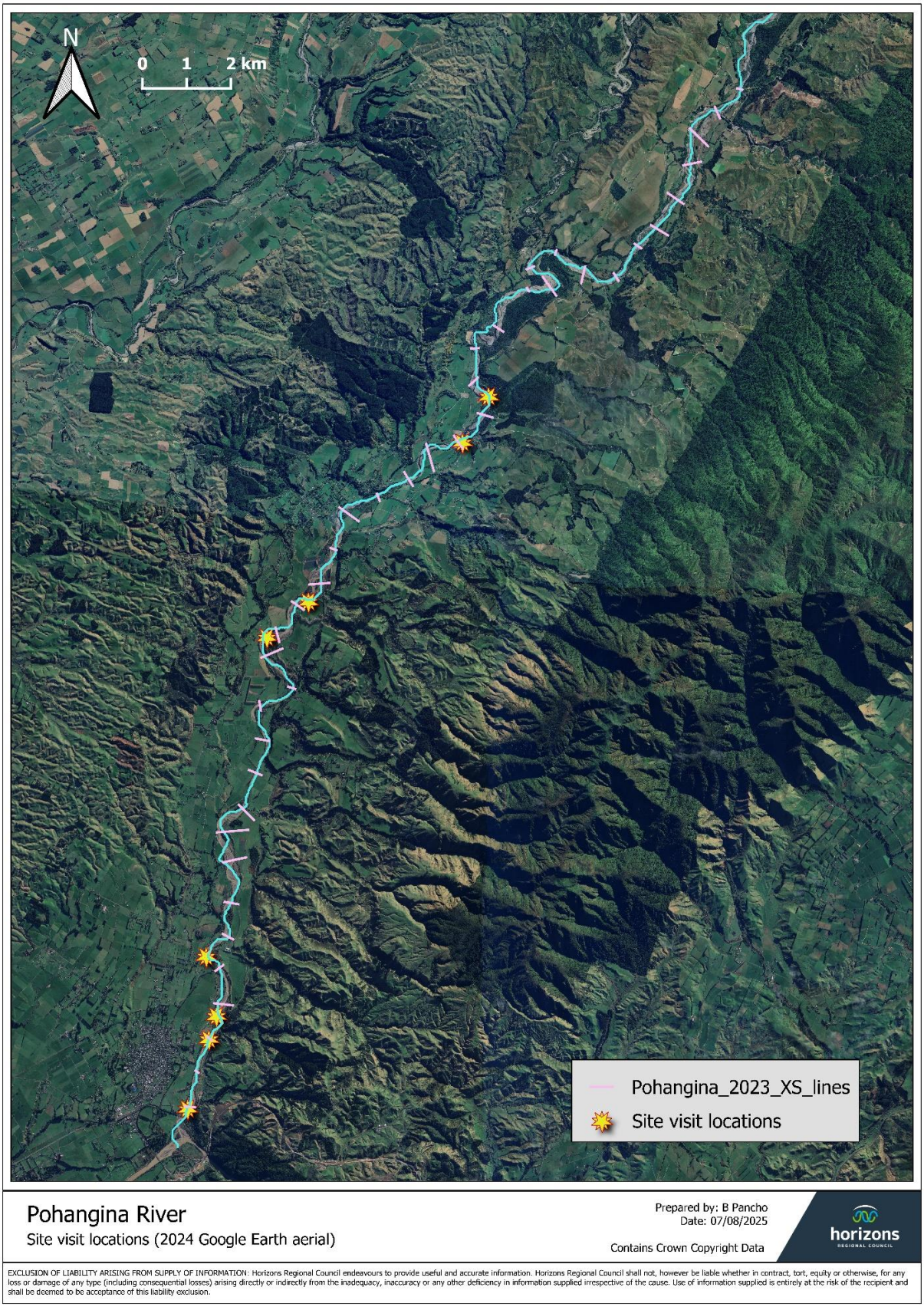


Figure 5.1: Map of the sites visited in the Pohangina River

6.0 Conclusion and Recommendations

The conclusions that can be drawn from the study are the following:

- The overall trend result of the Pohangina River from 2018 to 2023 is that of degradation at a rate of 104,000 m^3 loss of gravel per annum.
- Cyclone Gabrielle partly caused the present degradation results. This contributed to channel migration and channel deepening, evidence of which can be seen in the aerials and cross-sections.
- The change in mean bed levels showed a similar trend with the change in gravel volume, but no changes of more than one metre was observed.
- The One Plan allocable volume for the Pohangina River is 25,000m^3/yr. The recorded gravel extraction rate from 2018 to 2023 is 11,500m^3/yr, which is well below the recommended 20,000m^3/yr limit from the previous 2020 study.
- Overall results:
    - 1.0-mile to 4-mile: aggradation
    - 4-mile to 7-mile: degradation
    - 7.5-mile to 12-mile: degradation
    - 12.5-mile to 21-mile: degradation

  Recommendations:

    - 1.0-mile to 4-mile: cautioned extraction
    - 4-mile to 21-mile: extraction by discretion
    - 7.5-mile to 12-mile: extraction by discretion
    - 12.5-mile to 21-mile: extraction by discretion

- Since gravel below the 4-mile mark is still recovering from the earlier studies' gravel cessation recommendation, it is recommended to exercise caution when extracting gravel within this reach.
- It is recommended to cease any extraction, unless there is a river management need, within 4.0-mile to 12.0-mile and 13.5-mile to 14.0-mile marks because of the significant degradation that has occurred in these locations. The cessation of gravel extraction will allow the gravel to replenish naturally.
- The 2020 study recommended that gravel extraction limits within the 12-mile to 21-mile marks should be reconsidered if degradation trend continues. There is an overall loss of 109,500m^3 within this reach. Because of this significant degradation, it is therefore recommended that unless there is a river management need, extraction should be halted to allow natural restoration of gravel.
- Gravel extraction should target areas of aggradation, where the build-up of gravel beaches has occurred, in particular the beaches that have become armoured, which decreases gravel mobility, or beaches that are causing problems such as erosion and scouring.
- The removal of gravel from the more immobile, well-armoured beaches will aid in the overall management of the river while allowing the more mobile gravel to move downstream into the degrading reach.
- Given the degradation trend of the Pohangina River and the actual extraction rate of 11,500m^3/yr, the recommended overall extraction should be reduced from 20,000m^3/yr (2020 study) to 10,000m^3/yr.
- It is recommended to conduct a survey in 2028-2029 in the Pohangina River, including all the cross-sections surveyed in 2023.
- Additionally, it is recommended that a more recent LiDAR (Light Detection and Ranging) be flown to enable DoD (Difference of DEMs [Digital Elevation Model]) analysis. The DoD would enable a spatial representation (morphology) of the gravel volume and change of gravel volume along the river based on two DEMs of different years.

7.0 References

Bell, J. (2013). Pohangina River Gravel Resource Study 2013.

Horizons Regional Council (2014). One Plan.

Tonkin & Taylor Ltd (2024). Lower Manawatū Gravel Study 2024.

Whale, E. (2020). Pohangina River Gravel Resource Study 2020.

8.0 Appendices

Appendix A: Results using the New Method and New Formula

Appendix A1: 2018-2023 Change in Gravel Volume

Change in Gravel Volume								
Mile	Cross section	2025 Left Extent	2025 Right Extent	Area under section 2018	Area under section 2023	Volume 2018	Volume 2023	Change in volume 2018-2023 (m^3)
1.0	1610	40	244	11204.8	11237			-
1.5	2410	180	272	5244.6	5248.7	6,430,723.56	6,444,138.78	13,415
2.0	3220	34	109.5	4469.5	4471	3,930,029.22	3,932,271.51	2,242
2.5	4020	131	327	12523	12536.1	6,526,376.94	6,531,648.41	5,271
3.0	4830	228	369	9355.6	9359.2	8,829,717.00	8,836,316.70	6,600
3.5	5630	112.93	266	10815.8	10824.2	8,061,503.86	8,066,261.56	4,758
4.0	6440	168	277	7998.9	7935.4	7,591,324.66	7,567,430.63	- 23,894
4.5	7240	246	500	19775.8	19745	10,760,492.74	10,719,404.49	- 41,088
5.0	8050	614	707	7441.7	7418.8	10,624,144.07	10,602,053.81	- 22,090
5.5	8850	312	420	9012.4	8981	6,571,621.24	6,549,976.67	- 21,645
6.0	9660	317	365	4058.3	4051.1	5,161,975.76	5,147,260.11	- 14,716
6.5	10460	46	118	6308.8	6302.1	4,113,877.60	4,108,257.42	- 5,620
7.0	11260	-10	92	9285.3	9274.7	6,199,412.93	6,192,550.84	- 6,862
7.5	12070	-10.5	69	7472.6	7465.8	6,773,675.19	6,766,670.13	- 7,005
8.0	12870	353	435	7954.5	7925	6,169,836.21	6,155,406.42	- 14,430
8.5	13680	-157	85	24367.6	24294.8	12,486,003.87	12,445,797.06	- 40,207
9.0	14480	150	312	16905	16849.5	16,418,337.10	16,367,154.42	- 51,183
9.5	15290	1	411	44134.6	44058.8	23,855,673.74	23,801,781.08	- 53,893
10.0	16090	5	153.3	16398	16320.9	23,315,901.10	23,252,094.25	- 63,807
10.5	16900	387	508	13822.3	13800.8	12,224,376.29	12,185,031.71	- 39,345
11.0	17700	86	145	6860.6	6854.1	8,112,248.59	8,101,532.03	- 10,717
11.5	18510	80	183	12349.6	12288.9	7,672,010.73	7,646,576.82	- 25,434
12.0	19310	473	575	12579.2	12578.9	9,971,379.02	9,946,894.53	- 24,484
12.5	20120	23	124	12746.2	12768.3	10,256,712.67	10,265,520.47	8,808
13.0	20920	125	238	14657	14636.5	10,952,386.62	10,953,419.70	1,033
13.5	21730	-58	150	27971.6	27823.2	16,976,670.25	16,912,731.49	- 63,939
14.0	22530	108	218	15024	14982.9	16,932,129.55	16,859,613.06	- 72,516
14.5	23330	4	190.5	26366.3	26414.1	16,344,865.81	16,344,190.15	- 676
15.0	24140	-26.5	55.56	11972.1	11964.6	15,148,410.06	15,162,133.26	13,723
15.5	24940	143	500	53440.7	53503	24,188,537.82	24,204,967.34	16,430
16.0	25750	75.5	244	25668.7	25657.6	31,359,578.76	31,377,066.31	17,488
16.5	26550	75	170	14786.2	14789.9	15,983,133.69	15,980,686.78	- 2,447
17.0	27360	175	362	30048.3	30034.4	17,796,490.86	17,793,132.22	- 3,359
17.5	28160	28	162	22087.9	22107.5	20,772,973.41	20,775,950.95	2,978
18.0	28970	-43.75	85.15	21860.6	21849.7	17,799,063.15	17,802,563.94	3,501
18.5	29770	293	446.9	26702.6	26710.6	19,393,014.80	19,391,599.83	- 1,415
19.0	30580	160	286	22514.8	22487.7	19,908,950.99	19,900,799.58	- 8,151
19.5	31380	127	314	34617.7	34626.7	22,680,113.60	22,671,772.23	- 8,341
20.0	32190	273	462	35881.7	35898.9	28,550,727.16	28,561,318.82	10,592
20.5	32990	44	194	29324.6	29305.3	26,038,449.81	26,037,115.10	- 1,335
21.0	33800	6	124	23726.8	23750.8	21,445,835.82	21,448,360.66	2,525

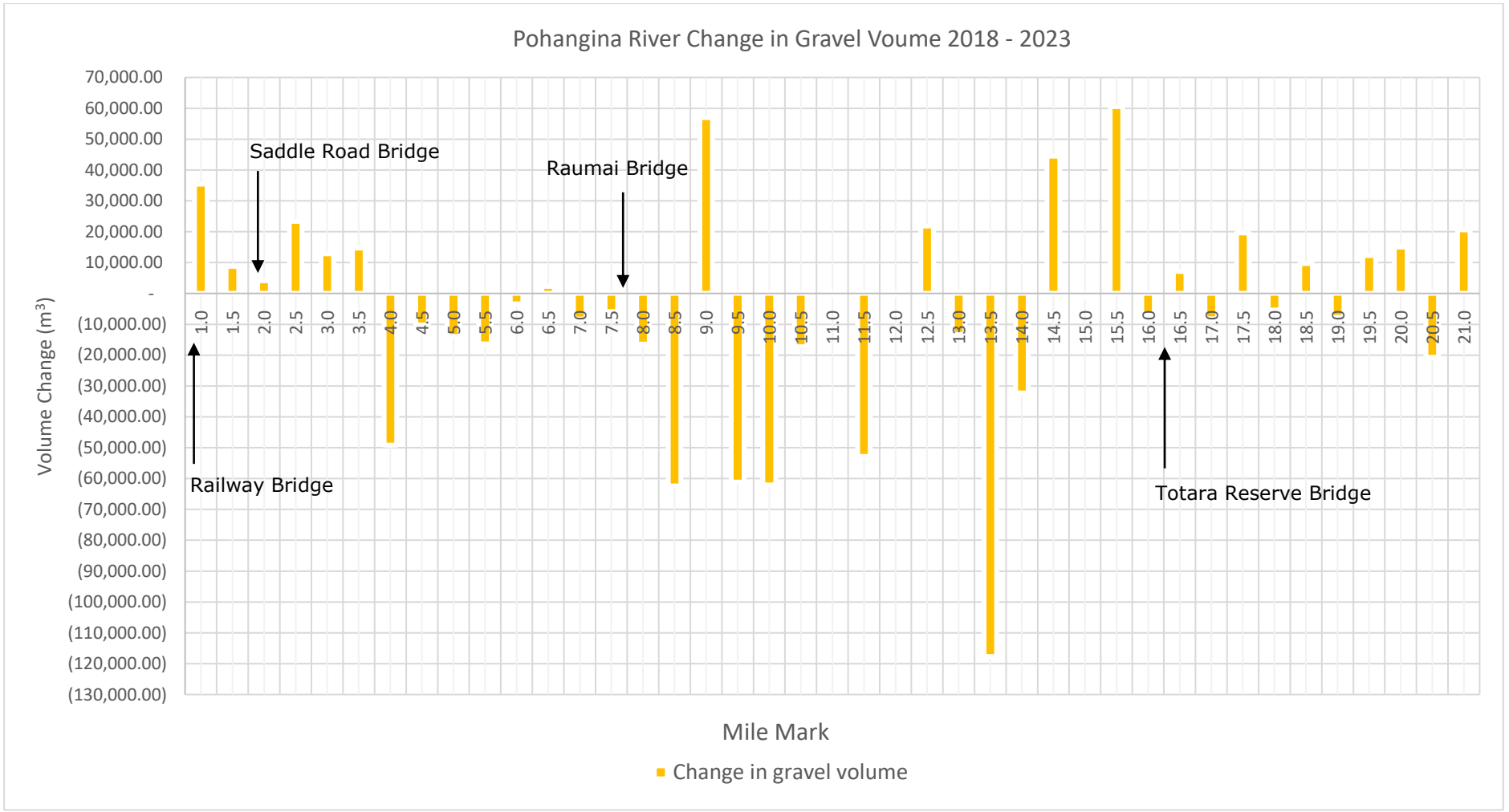
Appendix A2: 2018-2023 Change in Mean Bed Level

Change in Mean Bed Level						
Mile	Cross section	2025 Left Extent	2025 Right Extent	MBL 2018	MBL 2023	Change MBL 2018-2023 (m)
1.0	1610	40	244	54.926	55.083	0.1570
1.5	2410	180	272	57.007	57.052	0.0450
2.0	3220	34	109.5	59.199	59.219	0.0200
2.5	4020	131	327	63.893	63.96	0.0670
3.0	4830	228	369	66.351	66.377	0.0260
3.5	5630	112.93	266	70.659	70.714	0.0550
4.0	6440	168	277	73.384	72.802	-0.5820
4.5	7240	246	500	77.858	77.736	-0.1220
5.0	8050	614	707	80.018	79.772	-0.2460
5.5	8850	312	420	83.449	83.157	-0.2920
6.0	9660	317	365	84.548	84.397	-0.1510
6.5	10460	46	118	87.622	87.529	-0.0930
7.0	11260	-10	92	91.032	90.929	-0.1030
7.5	12070	-10.5	69	93.995	93.91	-0.0850
8.0	12870	353	435	97.006	96.646	-0.3600
8.5	13680	-157	85	100.693	100.392	-0.3010
9.0	14480	150	312	104.352	104.009	-0.3430
9.5	15290	1	411	107.645	107.46	-0.1850
10.0	16090	5	153.3	110.573	110.053	-0.5200
10.5	16900	387	508	114.234	114.056	-0.1780
11.0	17700	86	145	116.282	116.172	-0.1100
11.5	18510	80	183	119.899	119.31	-0.5890
12.0	19310	473	575	123.325	123.323	-0.0020
12.5	20120	23	124	126.2	126.418	0.2180
13.0	20920	125	238	129.708	129.526	-0.1820
13.5	21730	-58	150	134.479	133.765	-0.7140
14.0	22530	108	218	136.582	136.208	-0.3740
14.5	23330	4	190.5	141.374	141.63	0.2560
15.0	24140	-26.5	55.56	145.894	145.803	-0.0910
15.5	24940	143	500	149.694	149.868	0.1740
16.0	25750	75.5	244	152.336	152.271	-0.0650
16.5	26550	75	170	155.645	155.684	0.0390
17.0	27360	175	362	160.686	160.612	-0.0740
17.5	28160	28	162	164.835	164.981	0.1460
18.0	28970	-43.75	85.15	169.593	169.509	-0.0840
18.5	29770	293	446.9	173.506	173.558	0.0520
19.0	30580	160	286	178.689	178.474	-0.2150
19.5	31380	127	314	185.121	185.17	0.0490
20.0	32190	273	462	189.85	189.941	0.0910
20.5	32990	44	194	195.497	195.368	-0.1290
21.0	33800	6	124	201.075	201.278	0.2030

Appendix B: Results of the Comparison of Other Methods and Formulas

Appendix B1: Old method and old formula

Change in Gravel Volume						
Mile	Cross section	2025 Left Extent	2025 Right Extent	Area under section 2018	Area under section 2023	Change in volume 2018-2023 (m^3)
1.0	1610	0	300	16665.2	16709.5	35,440.00
1.5	2410	146	295	8628.3	8639.2	8,774.50
2.0	3220	11	141	7900.8	7905.9	4,105.50
2.5	4020	125.5	400	17590.8	17619.8	23,345.00
3.0	4830	200	400	13360.6	13376.6	12,880.00
3.5	5630	94	273.16	12691.1	12709.3	14,651.00
4.0	6440	152	290	10193.7	10132.6	- 49,185.50
4.5	7240	210	524	24488.8	24476.1	- 10,223.50
5.0	8050	500	707	16738.8	16721.5	- 13,926.50
5.5	8850	285	432	12331.2	12310.9	- 16,341.50
6.0	9660	303	383	6873.6	6869.4	- 3,381.00
6.5	10460	25	148	10919.5	10922.4	2,320.00
7.0	11260	-11	120	12006.8	11996.5	- 8,291.50
7.5	12070	-11.23	70	7637.8	7630.5	- 5,876.50
8.0	12870	317	468	14827.8	14807.4	- 16,422.00
8.5	13680	-168.16	140	31072.8	30995.3	- 62,387.50
9.0	14480	120	325	21452.8	21523.6	56,994.00
9.5	15290	-17	411	46089.7	46013.7	- 61,180.00
10.0	16090	5	153.3	16398	16320.9	- 62,065.50
10.5	16900	343	522	20578.5	20557	- 17,307.50
11.0	17700	65	170	12330	12329	- 805.00
11.5	18510	60	200	16850	16784.4	- 52,808.00
12.0	19310	450	596	18073.8	18073.2	- 483.00
12.5	20120	5	145	17739.3	17766.4	21,815.50
13.0	20920	100	260	20825.8	20809.3	- 13,282.50
13.5	21730	-88	176	35543.6	35397.4	- 117,691.00
14.0	22530	105.27	253	20229.8	20189.5	- 32,240.00
14.5	23330	-18	222	33986.2	34041.5	44,516.50
15.0	24140	-53	55.56	15872	15870.5	- 1,207.50
15.5	24940	120	502	57180.5	57255.7	60,536.00
16.0	25750	71.5	246.5	26665.9	26657.5	- 6,762.00
16.5	26550	64.5	174.5	17153.1	17161.9	7,084.00
17.0	27360	148	384	37962.3	37952.1	- 8,211.00
17.5	28160	10	180	28078.7	28103	19,561.50
18.0	28970	-46.13	104	25475.8	25469.1	- 5,393.50
18.5	29770	272	446	30203.1	30215.1	9,660.00
19.0	30580	115	300	33094.8	33085.2	- 7,728.00
19.5	31380	113	318	37956	37971.2	12,236.00
20.0	32190	273	464	36263.2	36281.9	15,053.50
20.5	32990	25	194	33051.7	33026	- 20,688.50
21.0	33800	4.1	124	24109.3	24134.7	20,574.00


Pohangina River Change in Gravel Voume 2018 - 2023
Volume Change (m³)
70,000.00
60,000.00
50,000.00
40,000.00
30,000.00
20,000.00
10,000.00
-
(10,000.00)
(20,000.00)
(30,000.00)
(40,000.00)
(50,000.00)
(60,000.00)
(70,000.00)
(80,000.00)
(90,000.00)
(100,000.00)
(110,000.00)
(120,000.00)
(130,000.00)
Saddle Road Bridge
Raumai Bridge
Railway Bridge
Totara Reserve Bridge
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
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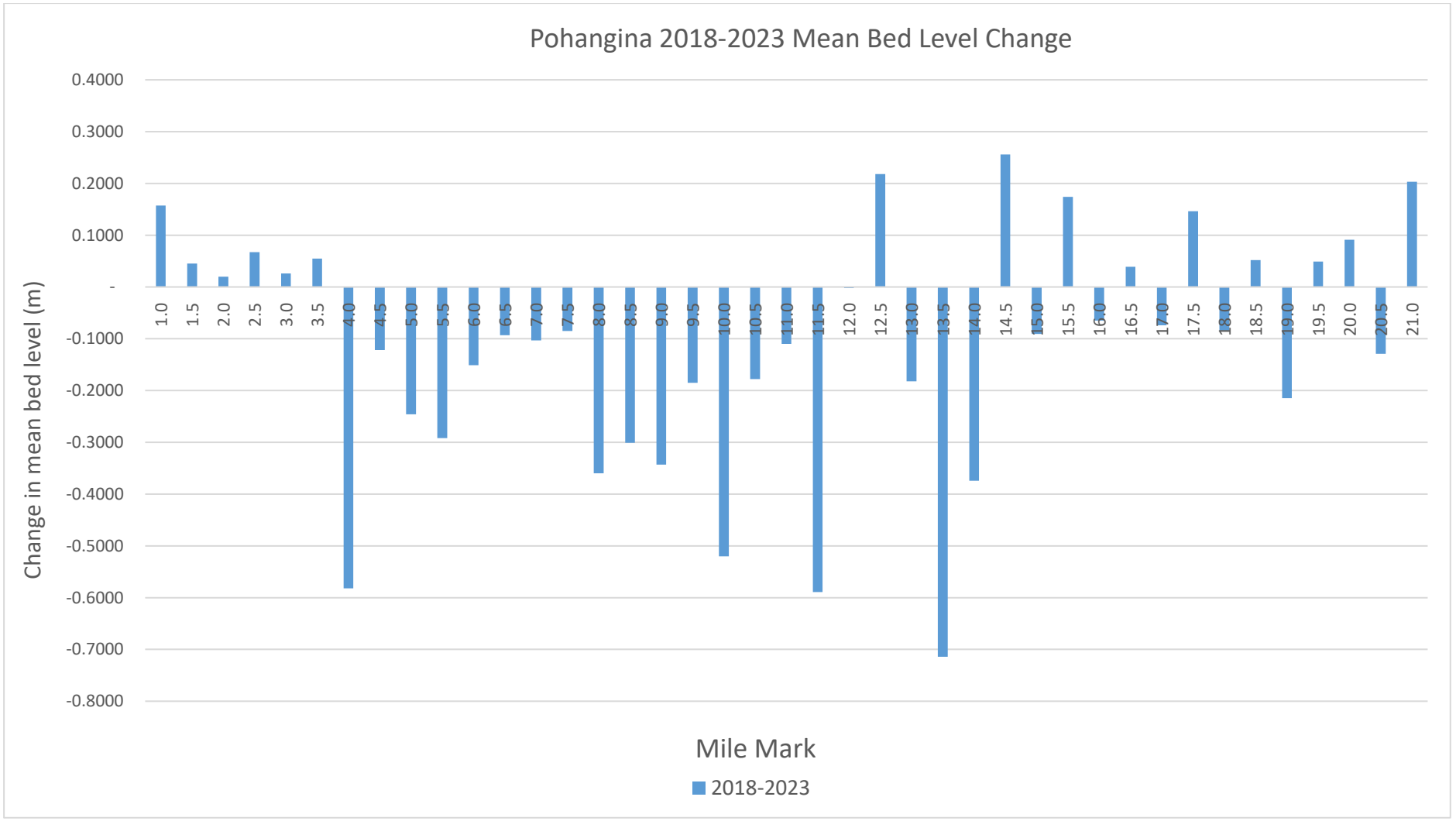
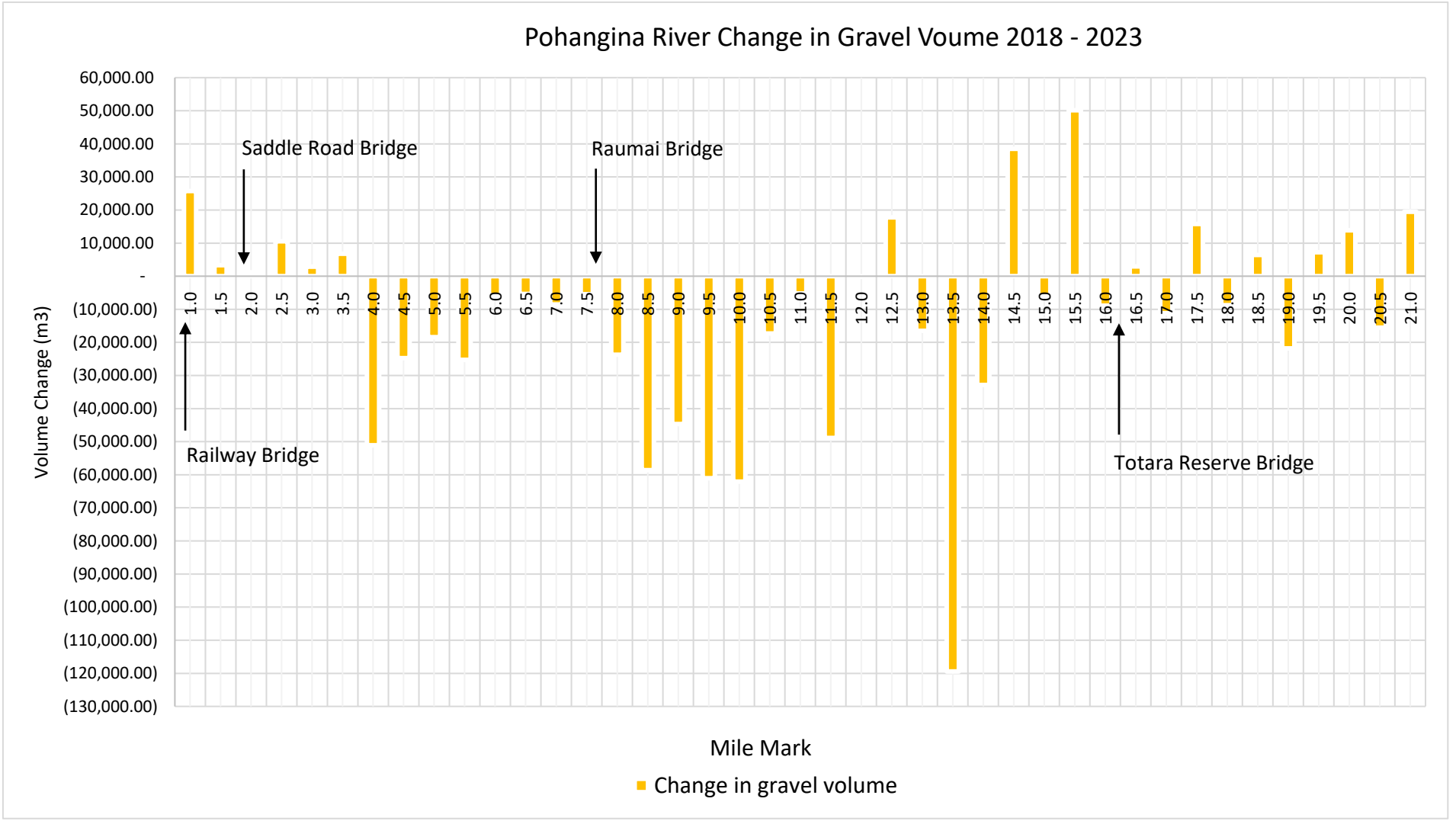
13.0
13.5
14.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
Mile Mark
Change in gravel volume

Change in Mean Bed Level						
Mile	Cross section	2025 Left Extent	2025 Right Extent	MBL 2018	MBL 2023	Change in MBL (2018-2023)
1.0	1610	40	244	54.926	55.083	0.1570
1.5	2410	180	272	57.007	57.052	0.0450
2.0	3220	34	109.5	59.199	59.219	0.0200
2.5	4020	131	327	63.893	63.96	0.0670
3.0	4830	228	369	66.351	66.377	0.0260
3.5	5630	112.93	266	70.659	70.714	0.0550
4.0	6440	168	277	73.384	72.802	-0.5820
4.5	7240	246	500	77.858	77.736	-0.1220
5.0	8050	614	707	80.018	79.772	-0.2460
5.5	8850	312	420	83.449	83.157	-0.2920
6.0	9660	317	365	84.548	84.397	-0.1510
6.5	10460	46	118	87.622	87.529	-0.0930
7.0	11260	-10	92	91.032	90.929	-0.1030
7.5	12070	-10.5	69	93.995	93.91	-0.0850
8.0	12870	353	435	97.006	96.646	-0.3600
8.5	13680	-157	85	100.693	100.392	-0.3010
9.0	14480	150	312	104.352	104.009	-0.3430
9.5	15290	1	411	107.645	107.46	-0.1850
10.0	16090	5	153.3	110.573	110.053	-0.5200
10.5	16900	387	508	114.234	114.056	-0.1780
11.0	17700	86	145	116.282	116.172	-0.1100
11.5	18510	80	183	119.899	119.31	-0.5890
12.0	19310	473	575	123.325	123.323	-0.0020
12.5	20120	23	124	126.2	126.418	0.2180
13.0	20920	125	238	129.708	129.526	-0.1820
13.5	21730	-58	150	134.479	133.765	-0.7140
14.0	22530	108	218	136.582	136.208	-0.3740
14.5	23330	4	190.5	141.374	141.63	0.2560
15.0	24140	-26.5	55.56	145.894	145.803	-0.0910
15.5	24940	143	500	149.694	149.868	0.1740
16.0	25750	75.5	244	152.336	152.271	-0.0650
16.5	26550	75	170	155.645	155.684	0.0390
17.0	27360	175	362	160.686	160.612	-0.0740
17.5	28160	28	162	164.835	164.981	0.1460
18.0	28970	-43.75	85.15	169.593	169.509	-0.0840
18.5	29770	293	446.9	173.506	173.558	0.0520
19.0	30580	160	286	178.689	178.474	-0.2150
19.5	31380	127	314	185.121	185.17	0.0490
20.0	32190	273	462	189.85	189.941	0.0910
20.5	32990	44	194	195.497	195.368	-0.1290
21.0	33800	6	124	201.075	201.278	0.2030

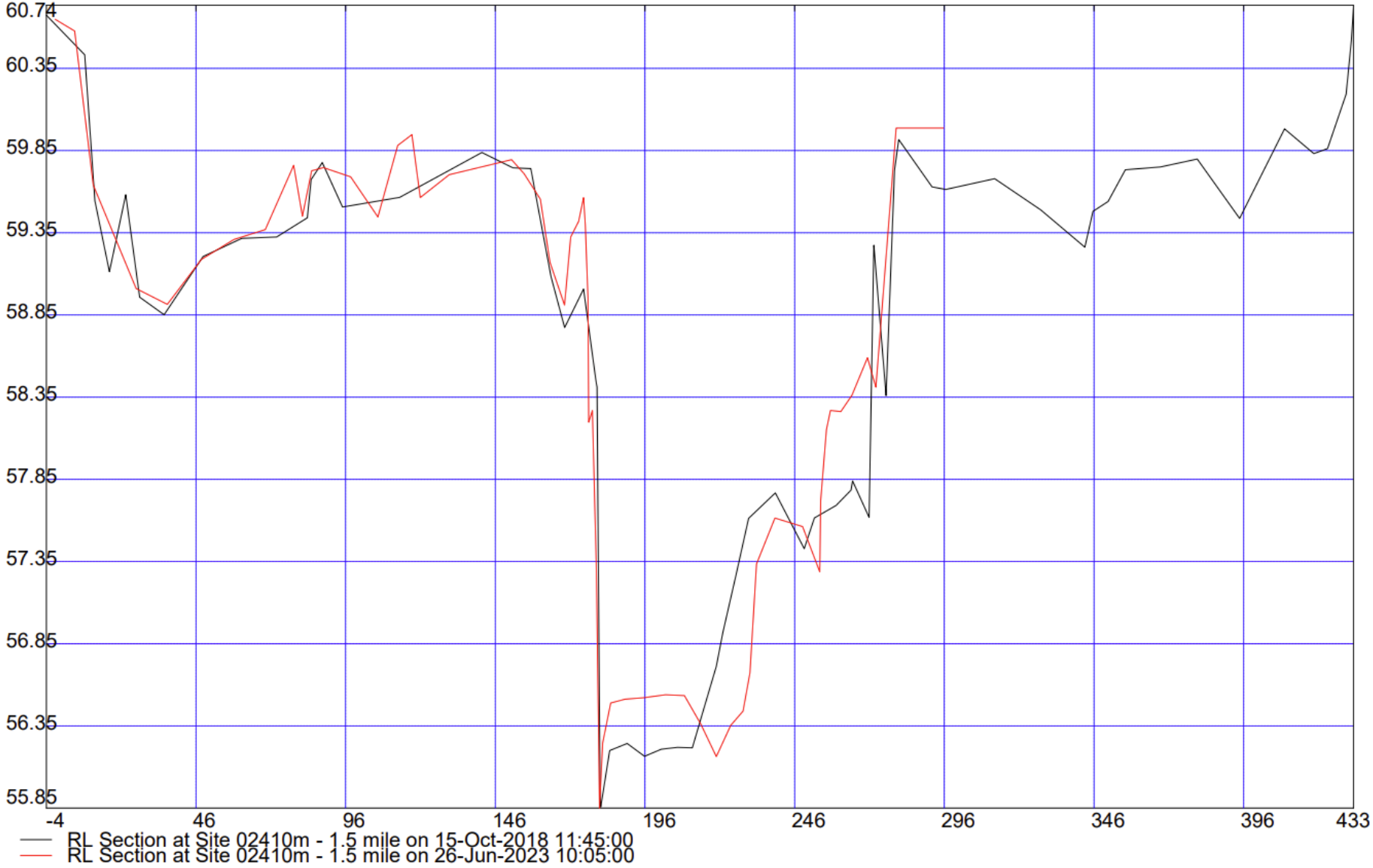

Pohangina 2018-2023 Mean Bed Level Change
0.4000
0.3000
0.2000
0.1000
-
-0.1000
-0.2000
-0.3000
-0.4000
-0.5000
-0.6000
-0.7000
-0.8000
Change in mean bed level (m)
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
Mile Mark
2018-2023

Appendix B2: New method and old formula

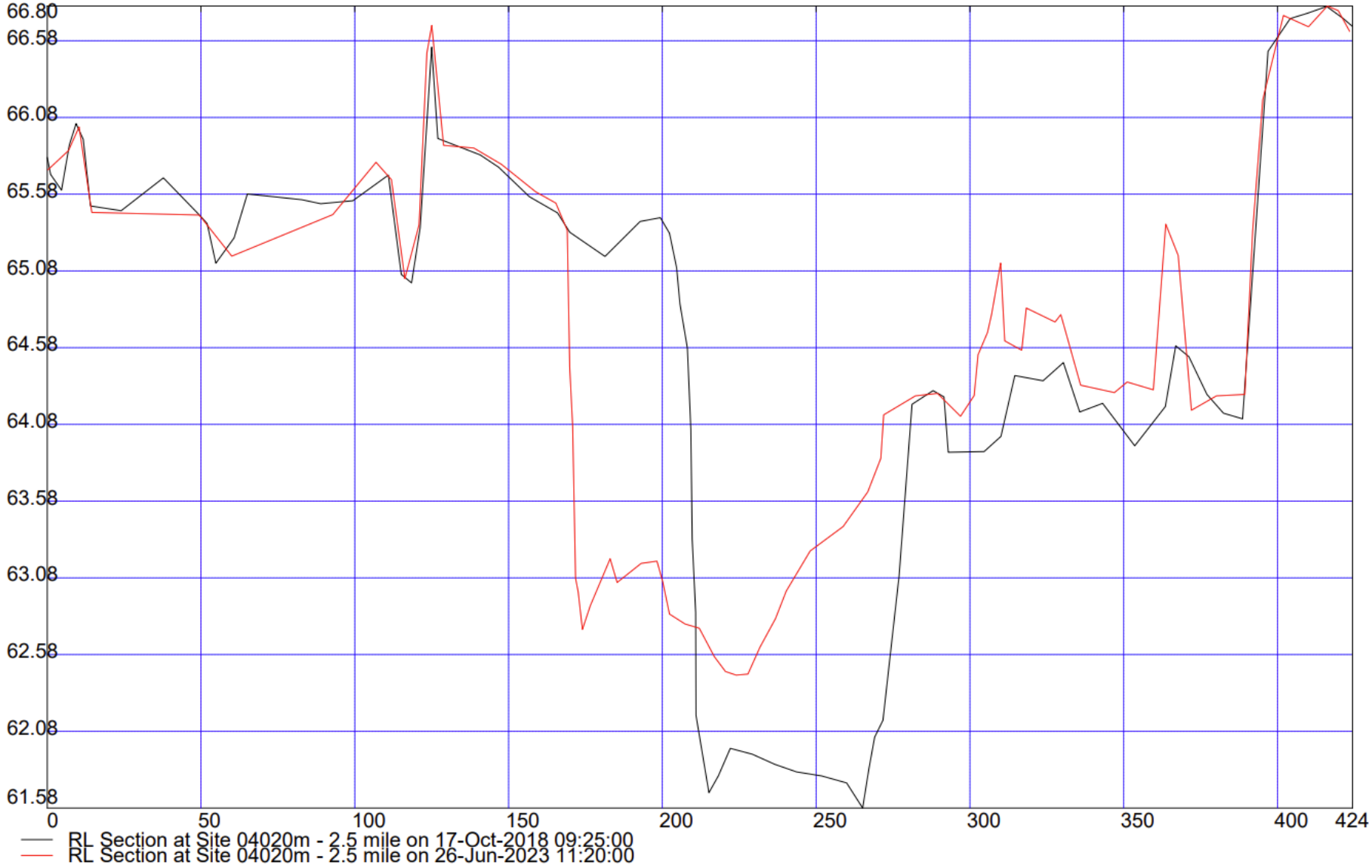
Change in Gravel Volume						
Mile	Cross section	2025 Left Extent	2025 Right Extent	Area under section 2018	Area under section 2023	Change in volume 2018-2023 (m^3)
1.0	1610	40	244	11204.8	11237	25,760.00
1.5	2410	180	272	5244.6	5248.7	3,300.50
2.0	3220	34	109.5	4469.5	4471	1,207.50
2.5	4020	131	327	12523	12536.1	10,545.50
3.0	4830	228	369	9355.6	9359.2	2,898.00
3.5	5630	112.93	266	10815.8	10824.2	6,762.00
4.0	6440	168	277	7998.9	7935.4	- 51,117.50
4.5	7240	246	500	19775.8	19745	- 24,794.00
5.0	8050	614	707	7441.7	7418.8	- 18,434.50
5.5	8850	312	420	9012.4	8981	- 25,277.00
6.0	9660	317	365	4058.3	4051.1	- 5,796.00
6.5	10460	46	118	6308.8	6302.1	- 5,360.00
7.0	11260	-10	92	9285.3	9274.7	- 8,533.00
7.5	12070	-10.5	69	7472.6	7465.8	- 5,474.00
8.0	12870	353	435	7954.5	7925	- 23,747.50
8.5	13680	-157	85	24367.6	24294.8	- 58,604.00
9.0	14480	150	312	16905	16849.5	- 44,677.50
9.5	15290	1	411	44134.6	44058.8	- 61,019.00
10.0	16090	5	153.3	16398	16320.9	- 62,065.50
10.5	16900	387	508	13822.3	13800.8	- 17,307.50
11.0	17700	86	145	6860.6	6854.1	- 5,232.50
11.5	18510	80	183	12349.6	12288.9	- 48,863.50
12.0	19310	473	575	12579.2	12578.9	- 241.50
12.5	20120	23	124	12746.2	12768.3	17,790.50
13.0	20920	125	238	14657	14636.5	- 16,502.50
13.5	21730	-58	150	27971.6	27823.2	- 119,462.00
14.0	22530	108	218	15024	14982.9	- 32,880.00
14.5	23330	4	190.5	26366.3	26414.1	38,479.00
15.0	24140	-26.5	55.56	11972.1	11964.6	- 6,037.50
15.5	24940	143	500	53440.7	53503	50,151.50
16.0	25750	75.5	244	25668.7	25657.6	- 8,935.50
16.5	26550	75	170	14786.2	14789.9	2,978.50
17.0	27360	175	362	30048.3	30034.4	- 11,189.50
17.5	28160	28	162	22087.9	22107.5	15,778.00
18.0	28970	-43.75	85.15	21860.6	21849.7	- 8,774.50
18.5	29770	293	446.9	26702.6	26710.6	6,440.00
19.0	30580	160	286	22514.8	22487.7	- 21,815.50
19.5	31380	127	314	34617.7	34626.7	7,245.00
20.0	32190	273	462	35881.7	35898.9	13,846.00
20.5	32990	44	194	29324.6	29305.3	- 15,536.50
21.0	33800	6	124	23726.8	23750.8	19,440.00

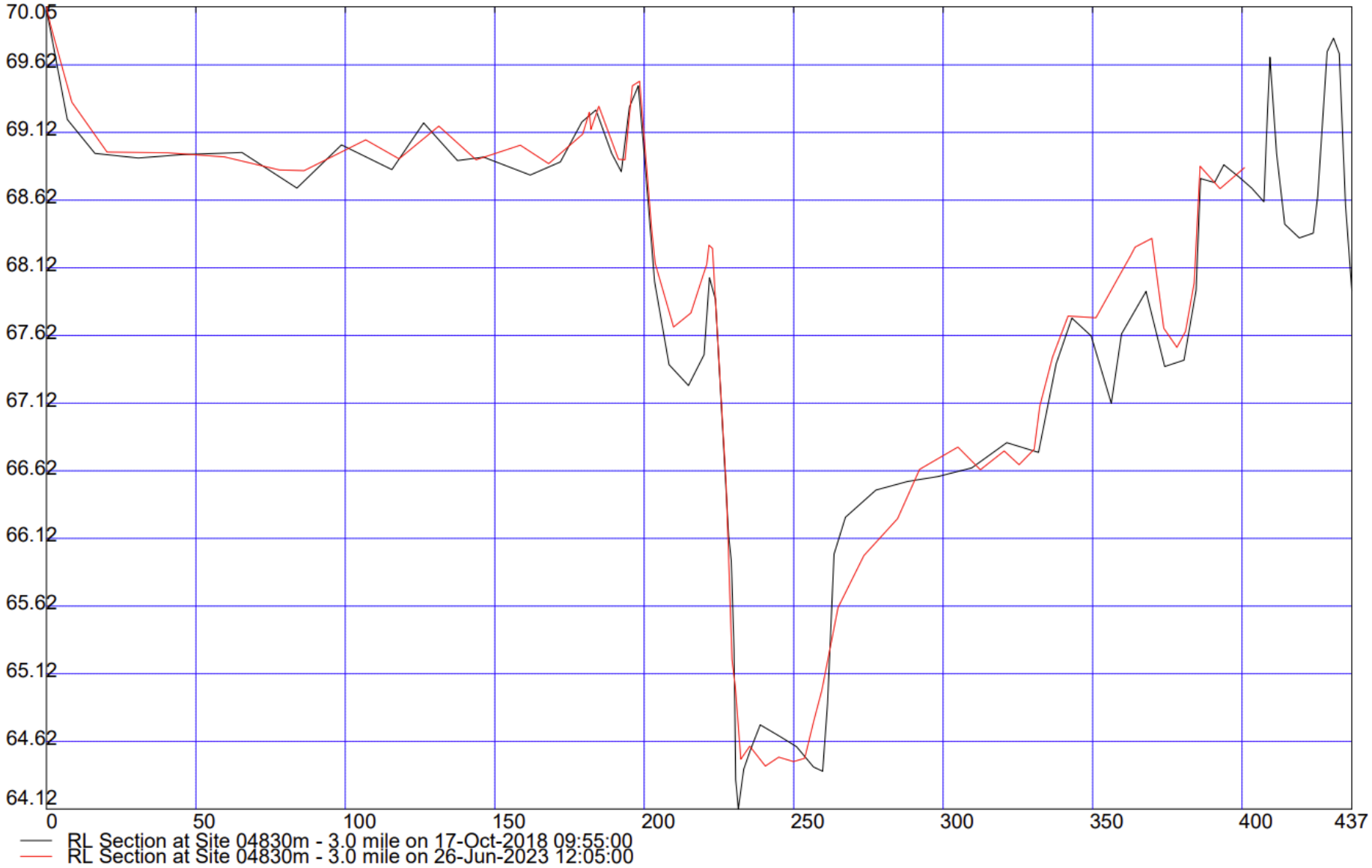

Pohangina River Change in Gravel Voume 2018 - 2023
60,000.00
50,000.00
40,000.00
30,000.00
20,000.00
10,000.00
-
(10,000.00)
(20,000.00)
(30,000.00)
(40,000.00)
(50,000.00)
(60,000.00)
(70,000.00)
(80,000.00)
(90,000.00)
(100,000.00)
(110,000.00)
(120,000.00)
(130,000.00)
Volume Change (m3)
Saddle Road Bridge
Raumai Bridge
Railway Bridge
Totara Reserve Bridge
1.0
1.5
2.0
2.5
3.0
3.5
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0
10.5
11.0
11.5
12.0
12.5
13.0
13.5
14.0
14.5
15.0
15.5
16.0
16.5
17.0
17.5
18.0
18.5
19.0
19.5
20.0
20.5
21.0
Mile Mark
Change in gravel volume

Appendix C: Cross-sections

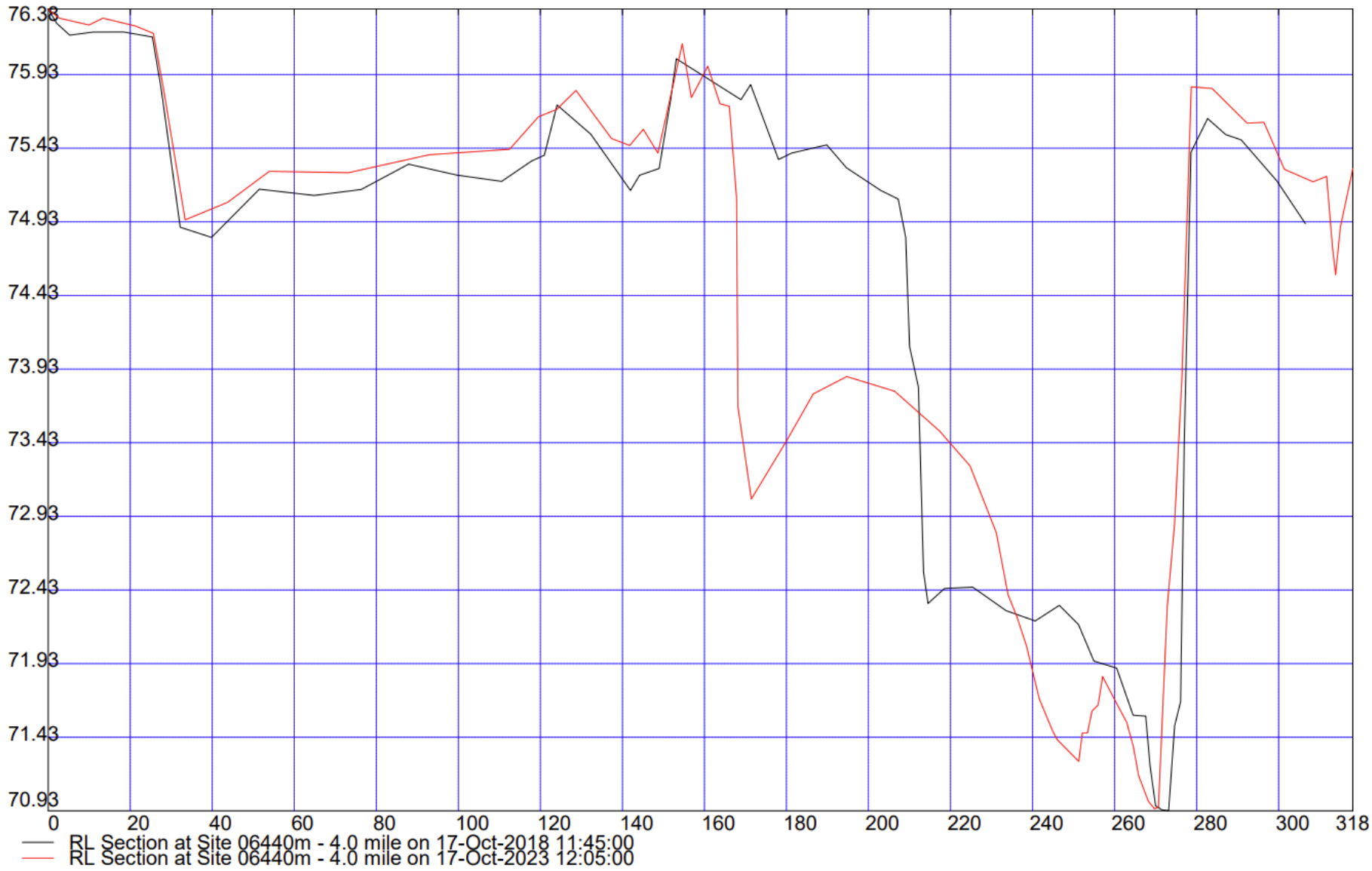

60.74
60.35
59.85
59.35
58.85
58.35
57.85
57.35
56.85
56.35
55.85
-4
46
96
146
196
246
296
346
396
433
RL Section at Site 02410m - 1.5 mile on 15-Oct-2018 11:45:00
RL Section at Site 02410m - 1.5 mile on 26-Jun-2023 10:05:00


74.4
73.3
71.3
69.3
67.3
65.3
63.3
61.3
59.3
57.3
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
RL Section at Site 03220m - 2.0 mile - us new bridge on 15-Oct-2018 13:15:00
RL Section at Site 03220m - 2.0 mile - us new bridge on 26-Jun-2023 10:50:00

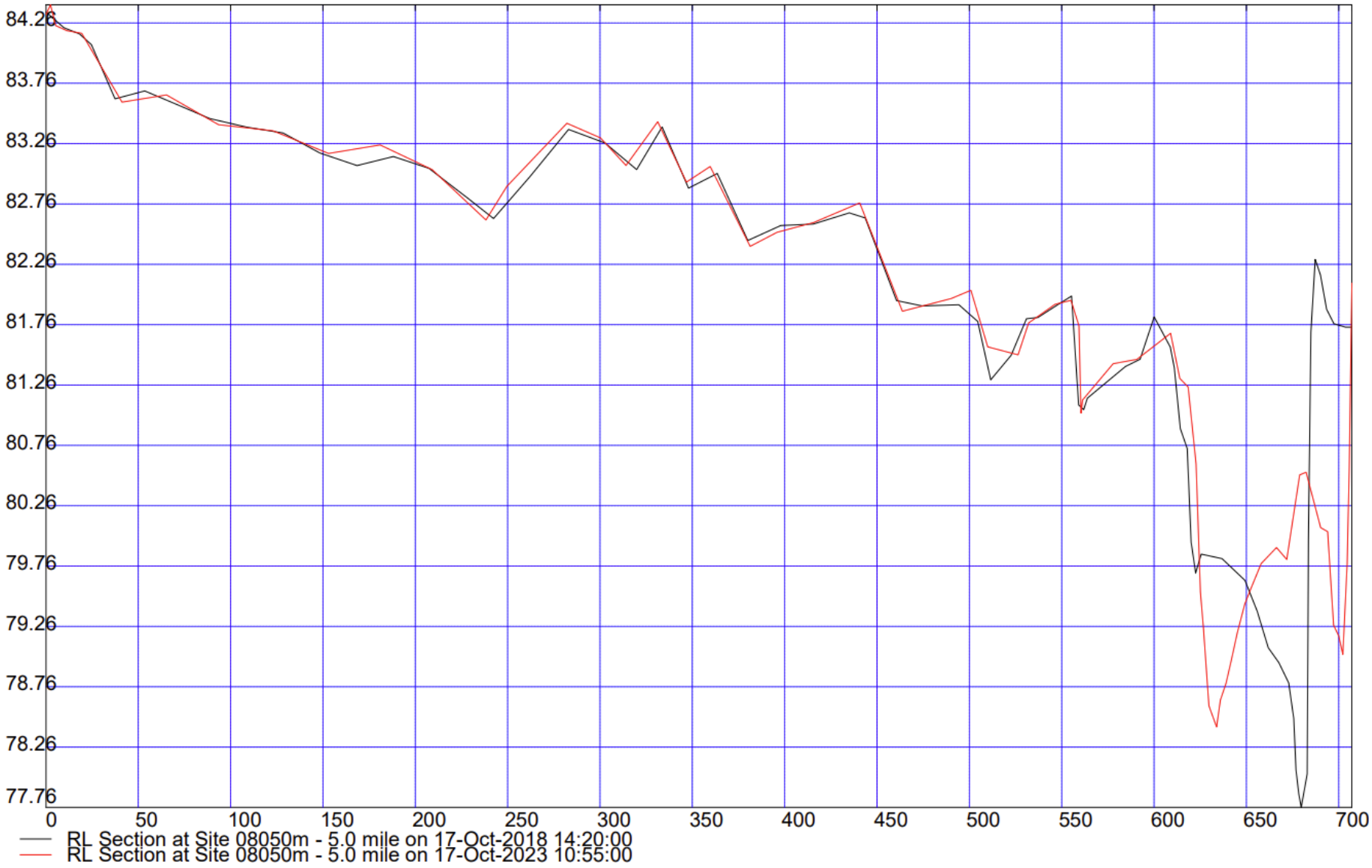

66.80
66.58
66.08
65.58
65.08
64.58
64.08
63.58
63.08
62.58
62.08
61.58
0
50
100
150
200
250
300
350
400
424
RL Section at Site 04020m - 2.5 mile on 17-Oct-2018 09:25:00
RL Section at Site 04020m - 2.5 mile on 26-Jun-2023 11:20:00

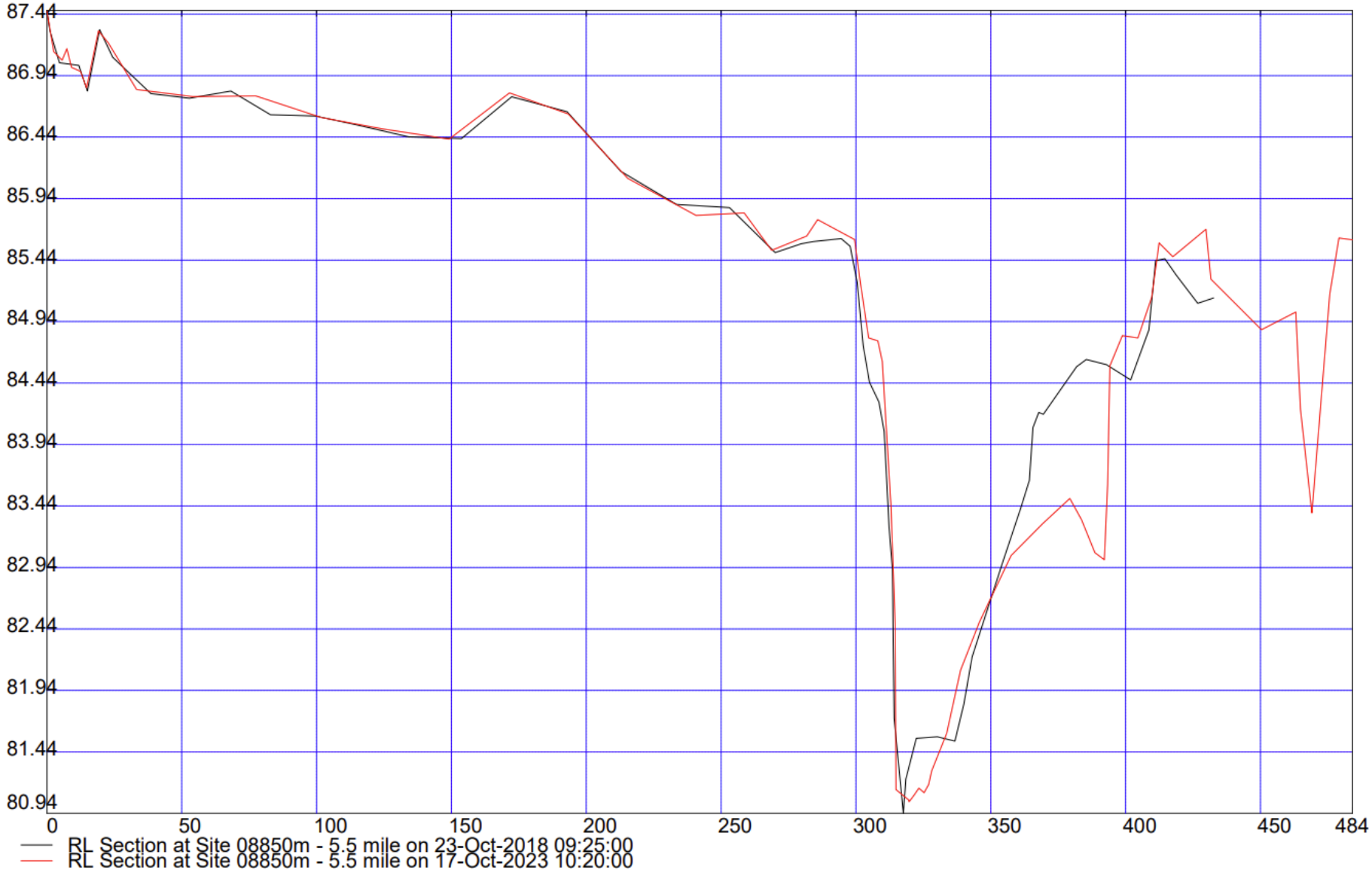

70.05
69.62
69.12
68.62
68.12
67.62
67.12
66.62
66.12
65.62
65.12
64.62
64.12
0
50
100
150
200
250
300
350
400
437
RL Section at Site 04830m - 3.0 mile on 17-Oct-2018 09:55:00
RL Section at Site 04830m - 3.0 mile on 26-Jun-2023 12:05:00

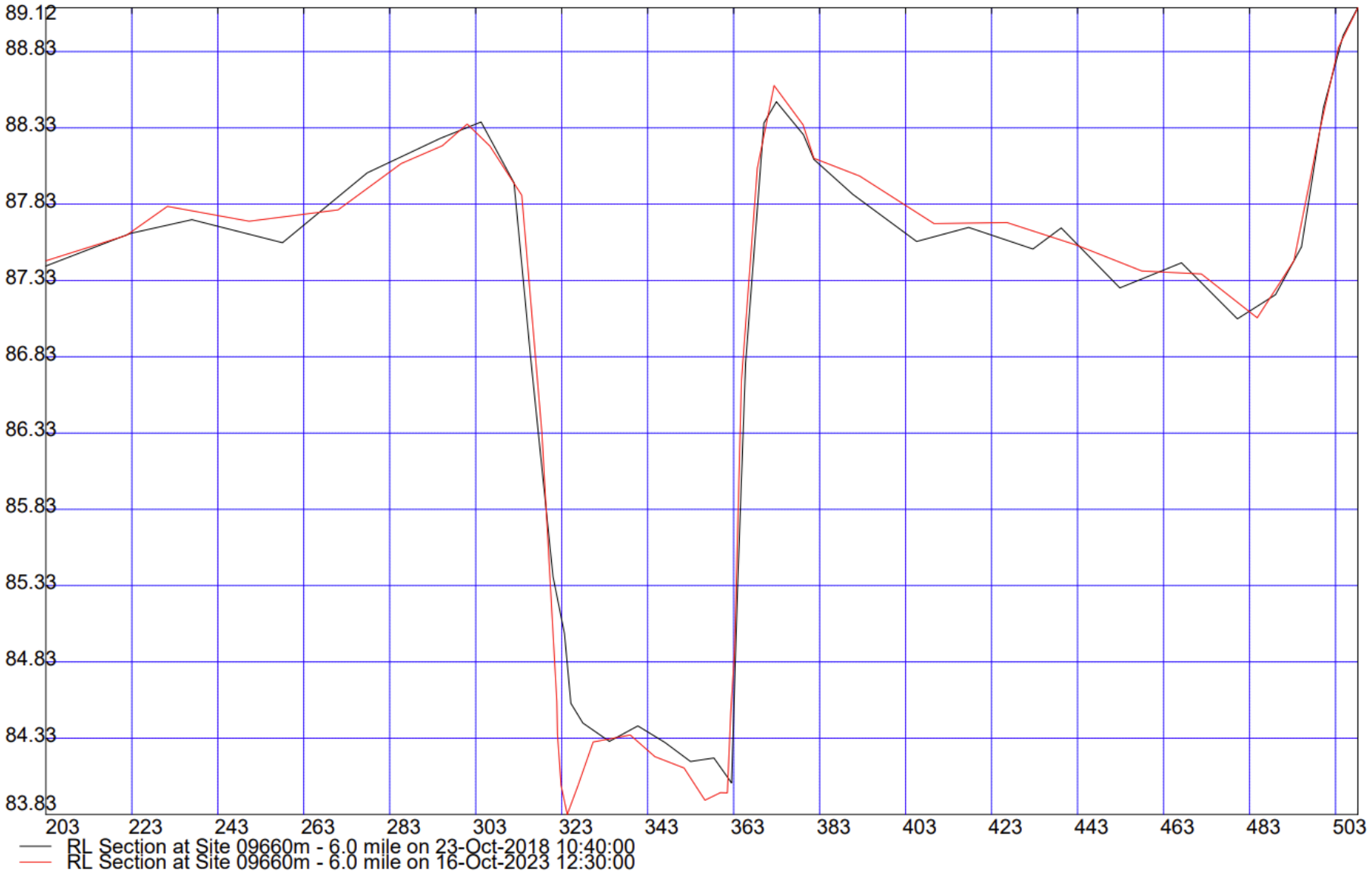

83.2
82.2
80.2
78.2
76.2
74.2
72.2
70.2
68.2
2
22
42
62
82
102
122
142
162
182
202
222
242
262
280
RL Section at Site 05630m - 3.5 mile on 17-Oct-2018 11:15:00
RL Section at Site 05630m - 3.5 mile on 26-Jun-2023 14:05:00


76.38
75.93
75.43
74.93
74.43
73.93
73.43
72.93
72.43
71.93
71.43
70.93
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
318
RL Section at Site 06440m - 4.0 mile on 17-Oct-2018 11:45:00
RL Section at Site 06440m - 4.0 mile on 17-Oct-2023 12:05:00

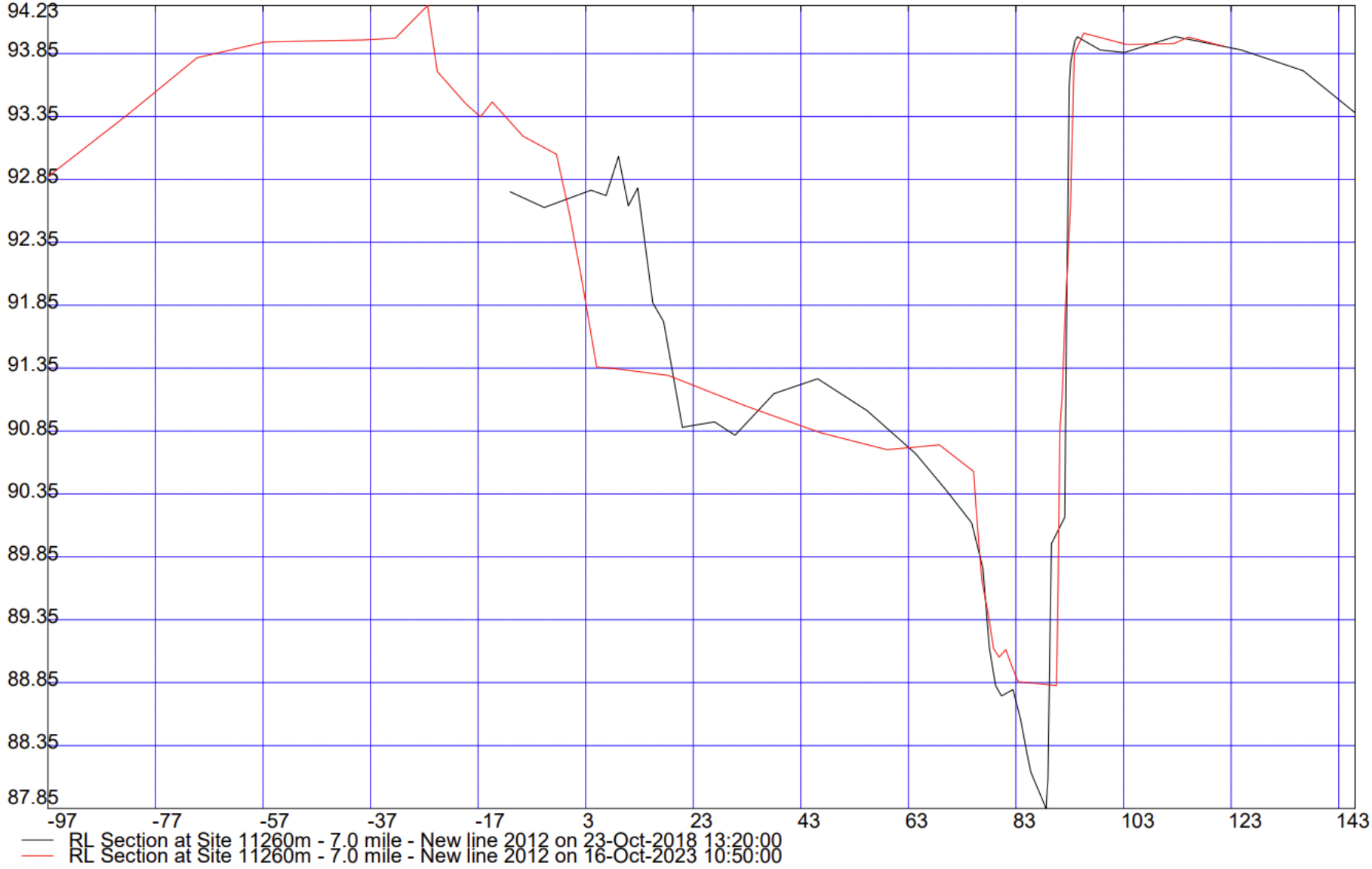

81.26
81.05
80.55
80.05
79.55
79.05
78.55
78.05
77.55
77.05
76.55
76.05
0
50
100
150
200
250
300
350
400
450
500
530
RL Section at Site 07240m - 4.5 mile on 17-Oct-2018 13:30:00
RL Section at Site 07240m - 4.5 mile on 17-Oct-2023 11:35:00


84.26
83.76
83.26
82.76
82.26
81.76
81.26
80.76
80.26
79.76
79.26
78.76
78.26
77.76
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
RL Section at Site 08050m - 5.0 mile on 17-Oct-2018 14:20:00
RL Section at Site 08050m - 5.0 mile on 17-Oct-2023 10:55:00


87.44
86.94
86.44
85.94
85.44
84.94
84.44
83.94
83.44
82.94
82.44
81.94
81.44
80.94
0
50
100
150
200
250
300
350
400
450
484
RL Section at Site 08850m - 5.5 mile on 23-Oct-2018 09:25:00
RL Section at Site 08850m - 5.5 mile on 17-Oct-2023 10:20:00

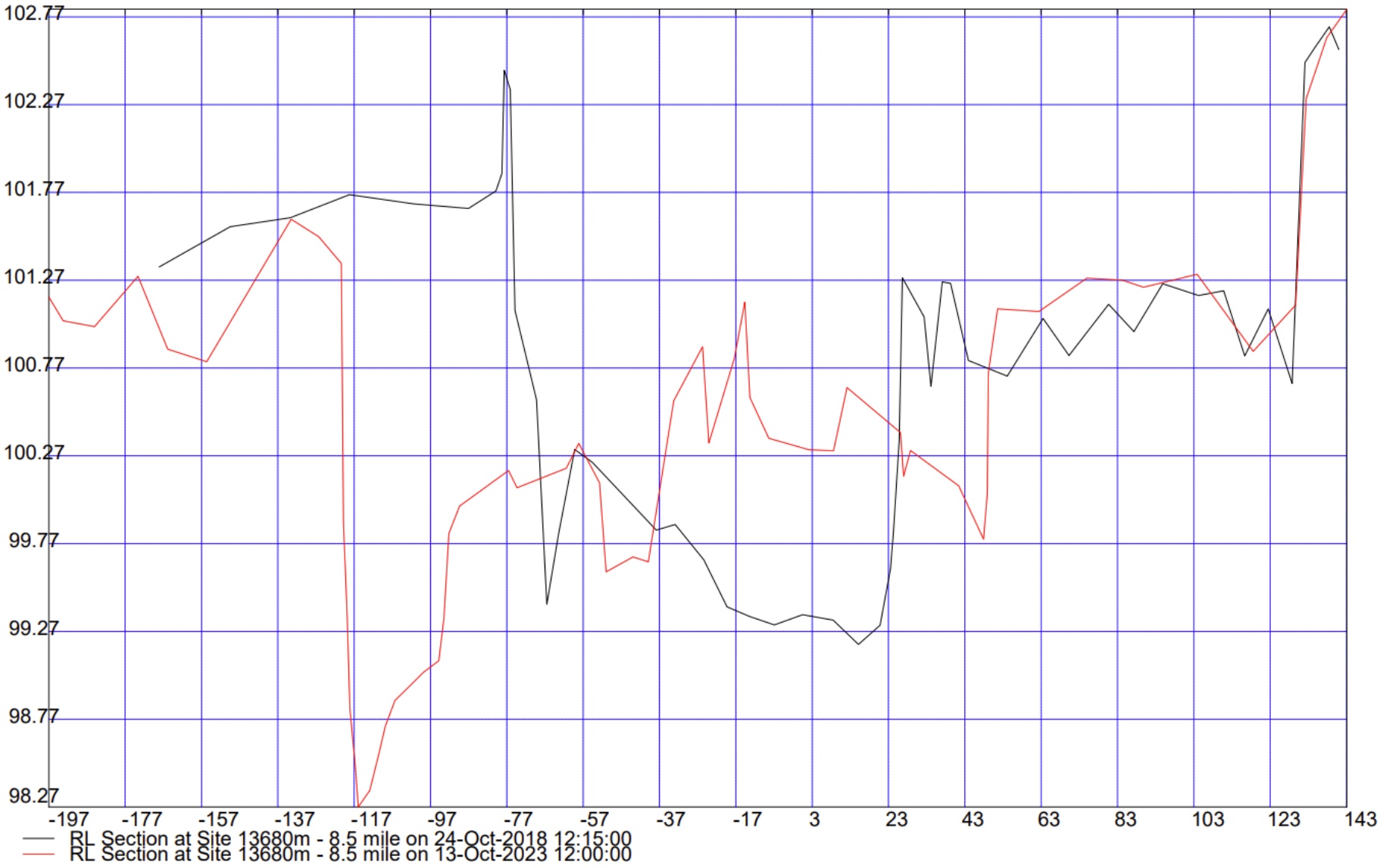

89.12
88.83
88.33
87.83
87.33
86.83
86.33
85.83
85.33
84.83
84.33
83.83
203
223
243
263
283
303
323
343
363
383
403
423
443
463
483
503
RL Section at Site 09660m - 6.0 mile on 23-Oct-2018 10:40:00
RL Section at Site 09660m - 6.0 mile on 16-Oct-2023 12:30:00

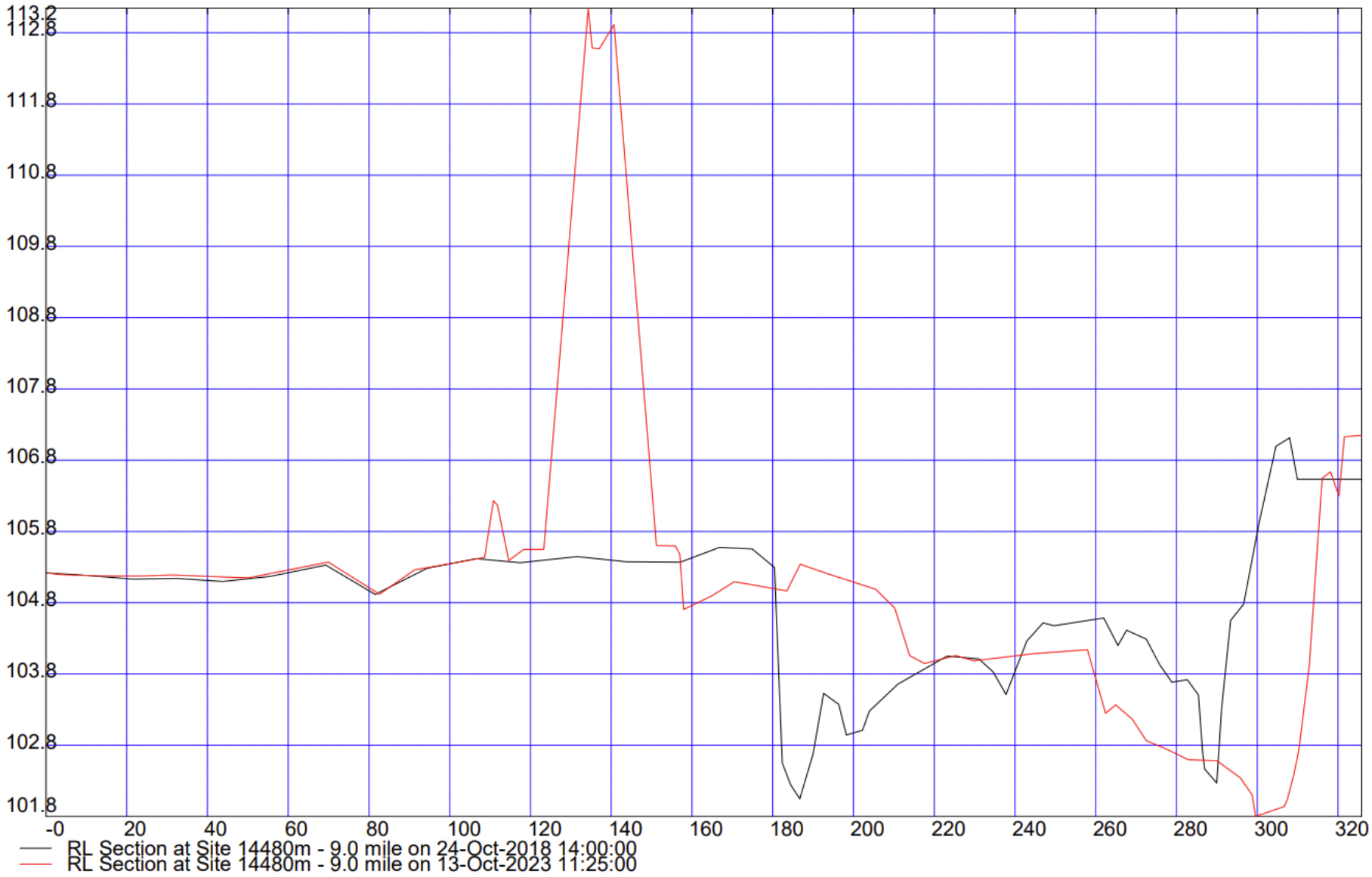

91.22
90.96
90.46
89.96
89.46
88.96
88.46
87.96
87.46
86.96
86.46
14
34
54
74
94
114
134
154
174
194
214
234
254
274
294
314
334
RL Section at Site 10460m - 6.5 mile on 23-Oct-2018 11:30:00
RL Section at Site 10460m - 6.5 mile on 16-Oct-2023 11:20:00

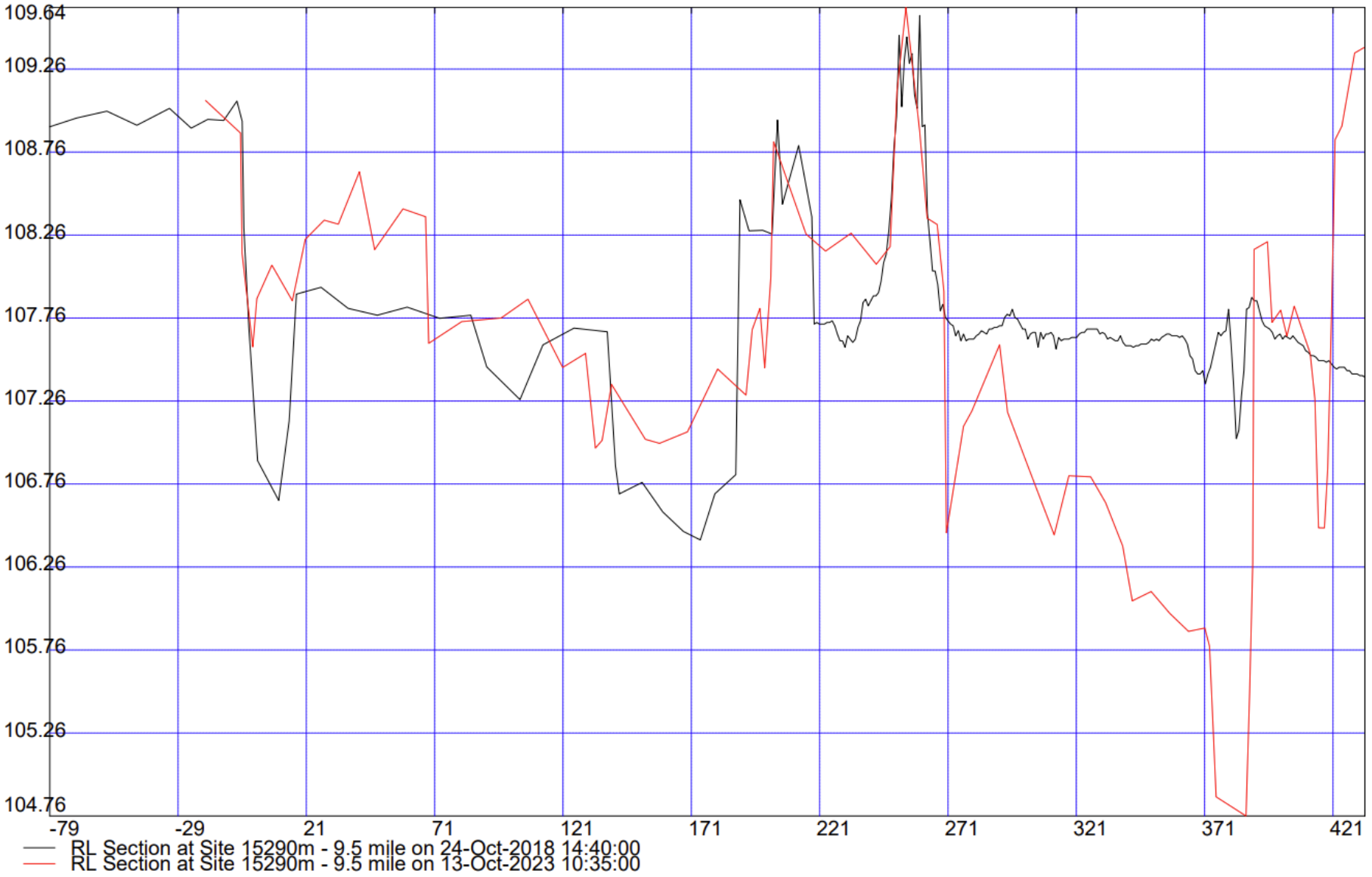

94.23
93.85
93.35
92.85
92.35
91.85
91.35
90.85
90.35
89.85
89.35
88.85
88.35
87.85
-97
-77
-57
-37
-17
3
23
43
63
83
103
123
143
RL Section at Site 11260m - 7.0 mile - New line 2012 on 23-Oct-2018 13:20:00
RL Section at Site 11260m - 7.0 mile - New line 2012 on 16-Oct-2023 10:50:00

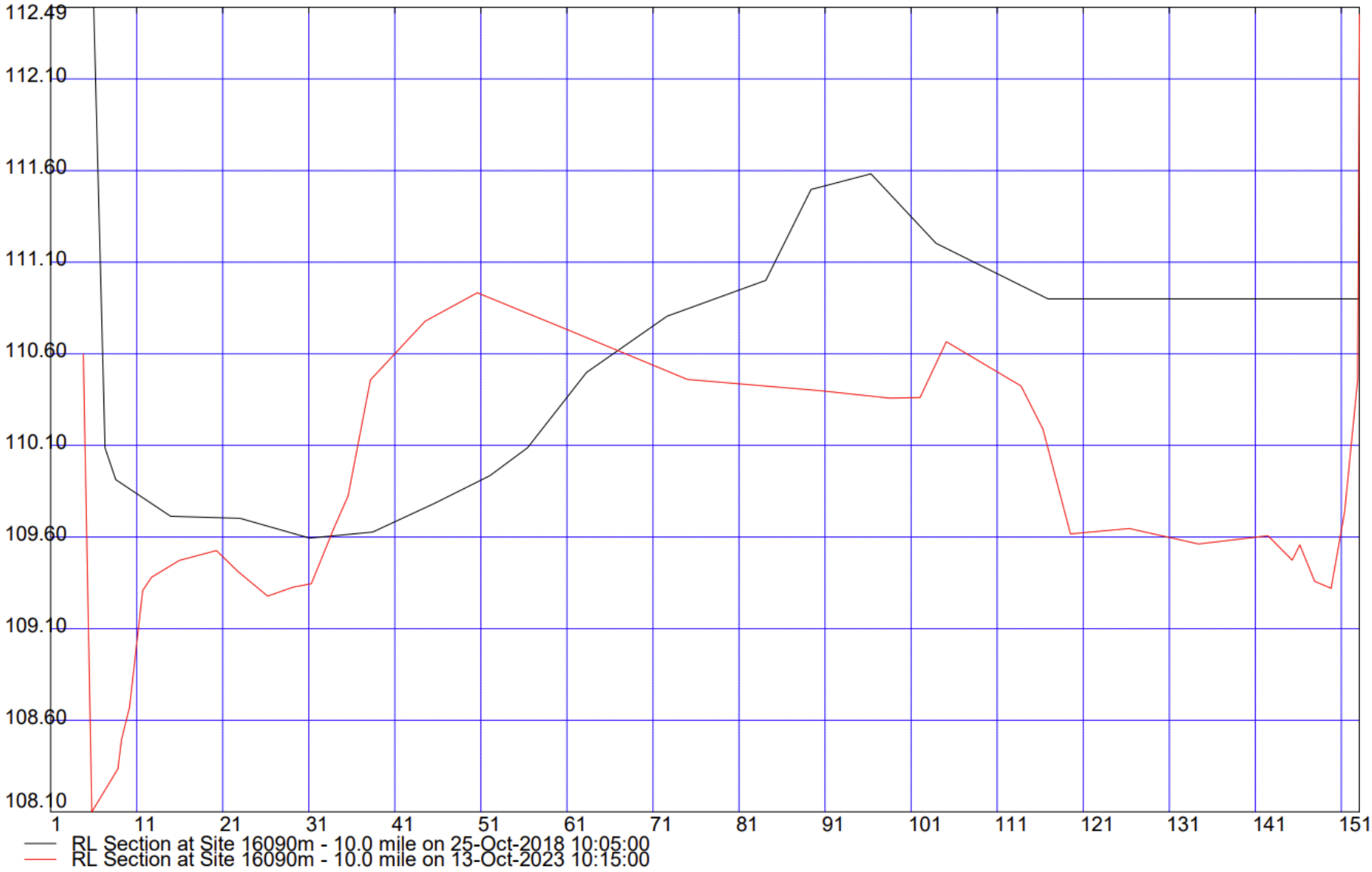

98.6
98.3
97.3
96.3
95.3
94.3
93.3
92.3
91.3
-11
-1
9
19
29
39
49
59
69
79
89
99
109
119
129
139
149
153
RL Section at Site 12070m - 7.5 mile - old Raumai bridge on 24-Oct-2018 11:05:00
RL Section at Site 12070m - 7.5 mile - old Raumai bridge on 13-Oct-2023 13:45:00


101.03
100.53
100.03
99.53
99.03
98.53
98.03
97.53
97.03
96.53
96.03
95.53
-1
49
99
149
199
249
299
349
399
449
515
RL Section at Site 12870m - 8.0 mile - New line 2012 on 24-Oct-2018 11:40:00
RL Section at Site 12870m - 8.0 mile - New line 2012 on 13-Oct-2023 13:15:00

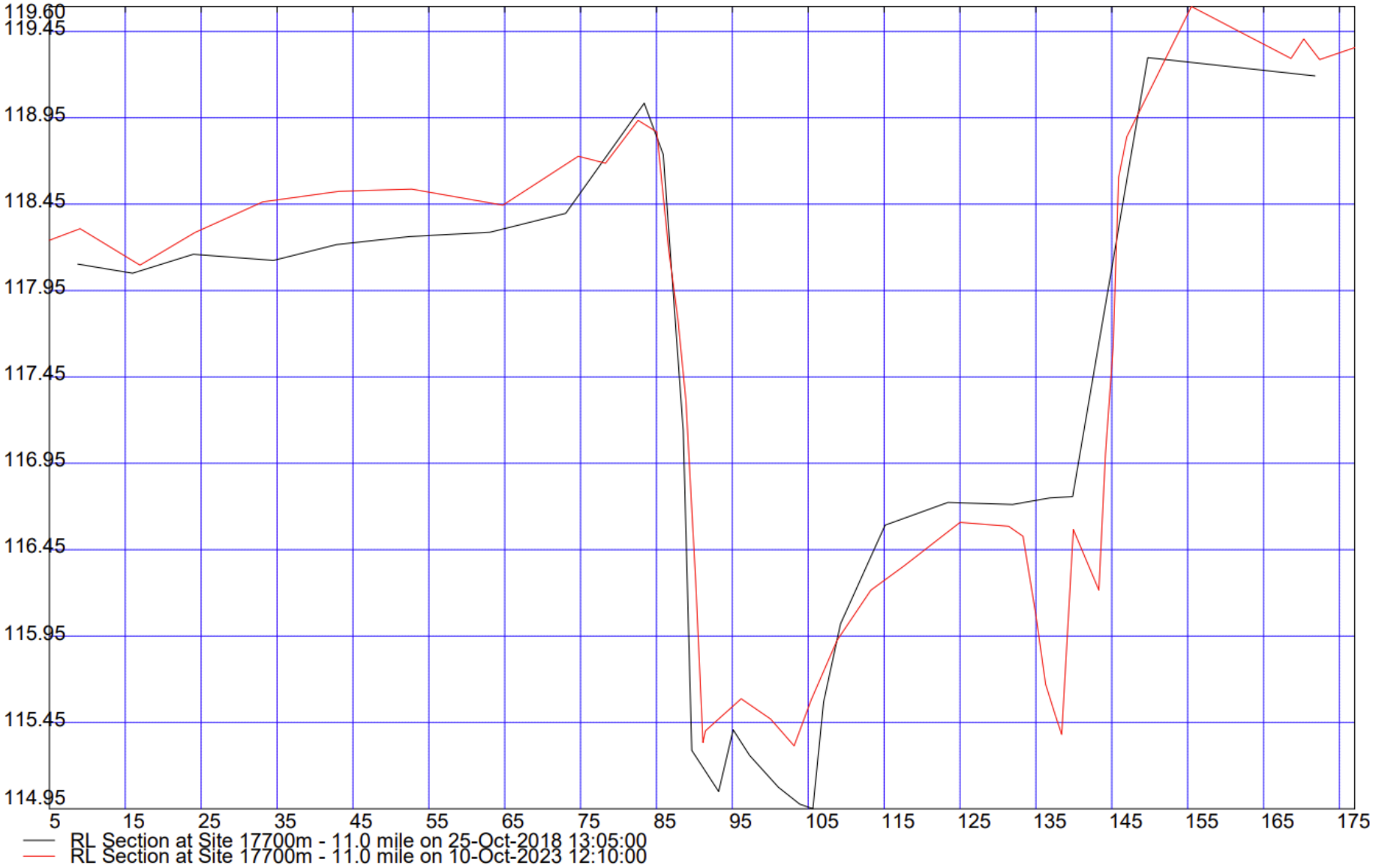

102.77
102.27
101.77
101.27
100.77
100.27
99.77
99.27
98.77
98.27
-197
-177
-157
-137
-117
-97
-77
-57
-37
-17
3
23
43
63
83
103
123
143
RL Section at Site 13680m - 8.5 mile on 24-Oct-2018 12:15:00
RL Section at Site 13680m - 8.5 mile on 13-Oct-2023 12:00:00

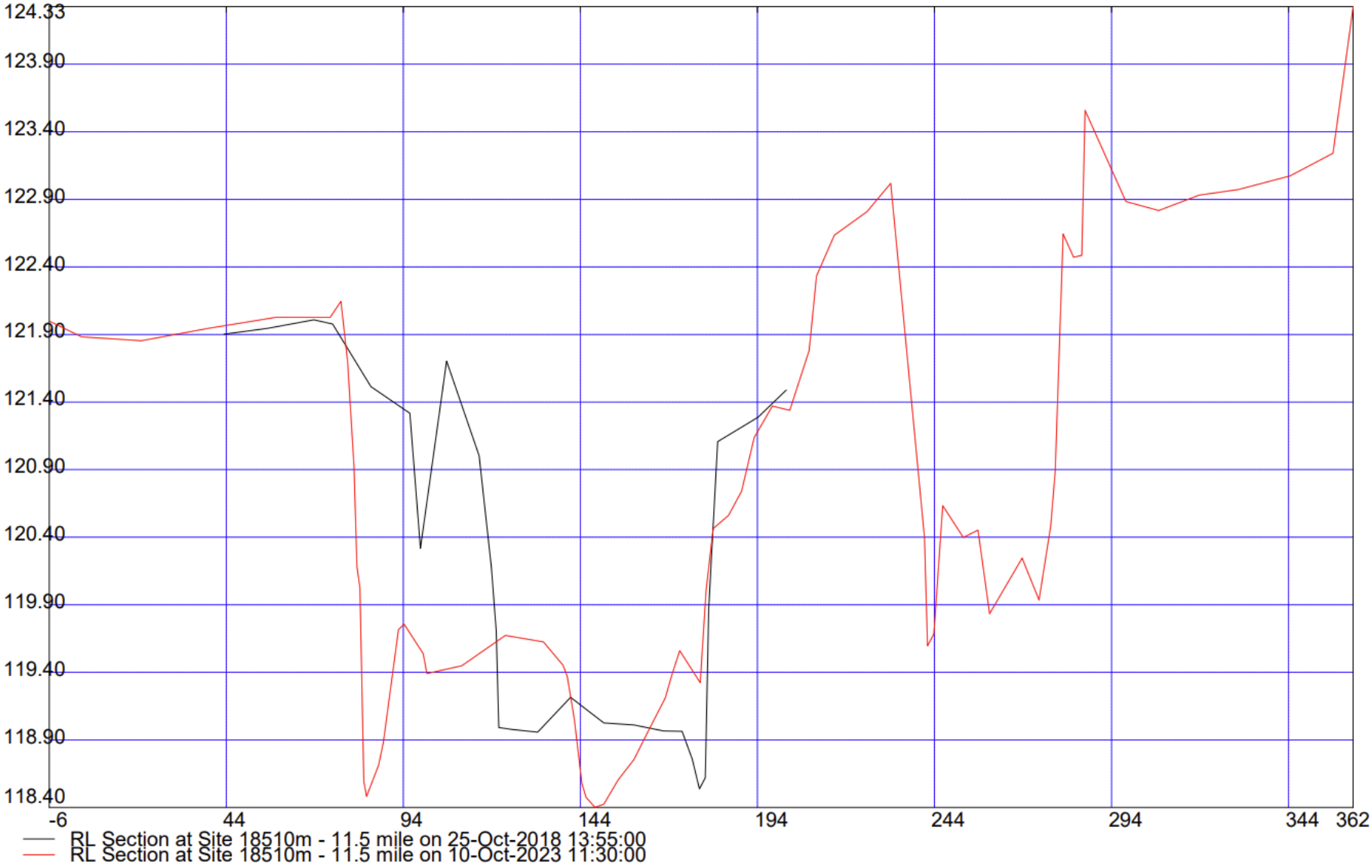

113.2
112.8
111.8
110.8
109.8
108.8
107.8
106.8
105.8
104.8
103.8
102.8
101.8
-0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
RL Section at Site 14480m - 9.0 mile on 24-Oct-2018 14:00:00
RL Section at Site 14480m - 9.0 mile on 13-Oct-2023 11:25:00

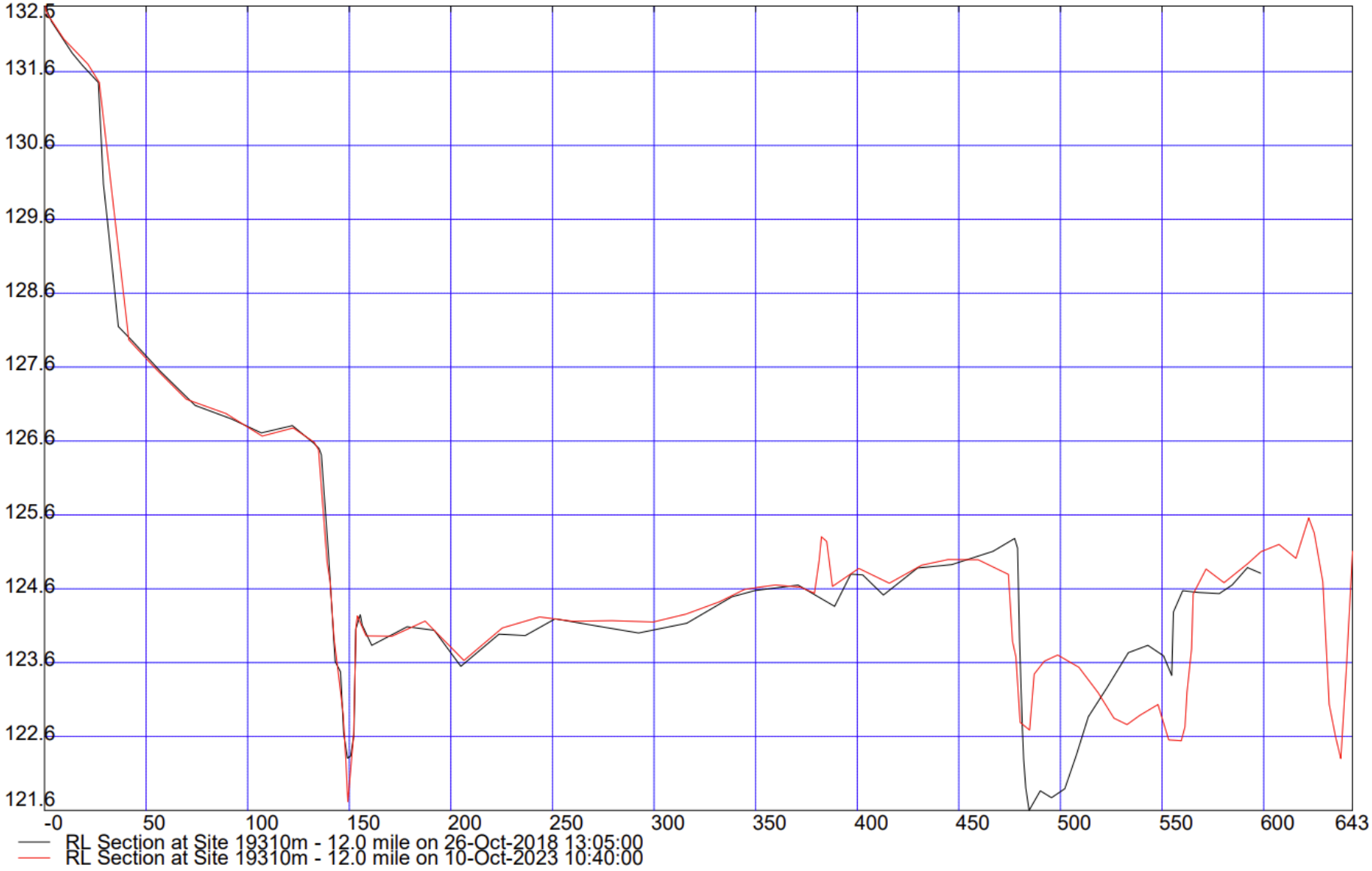

109.64
109.26
108.76
108.26
107.76
107.26
106.76
106.26
105.76
105.26
104.76
-79
-29
21
71
121
171
221
271
321
371
421
RL Section at Site 15290m - 9.5 mile on 24-Oct-2018 14:40:00
RL Section at Site 15290m - 9.5 mile on 13-Oct-2023 10:35:00

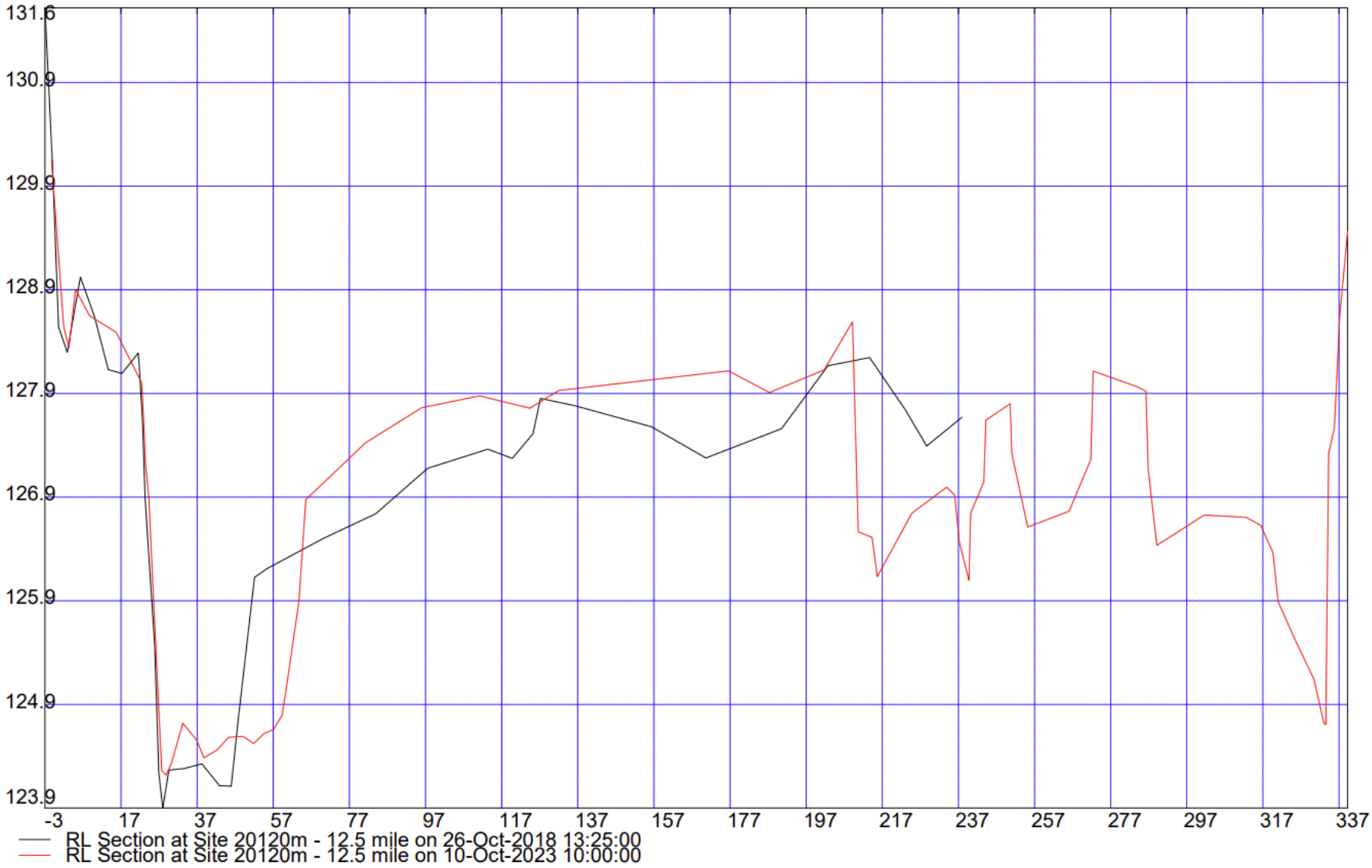

112.49
112.10
111.60
111.10
110.60
110.10
109.60
109.10
108.60
108.10
1
11
21
31
41
51
61
71
81
91
101
111
121
131
141
151
RL Section at Site 16090m - 10.0 mile on 25-Oct-2018 10:05:00
RL Section at Site 16090m - 10.0 mile on 13-Oct-2023 10:15:00

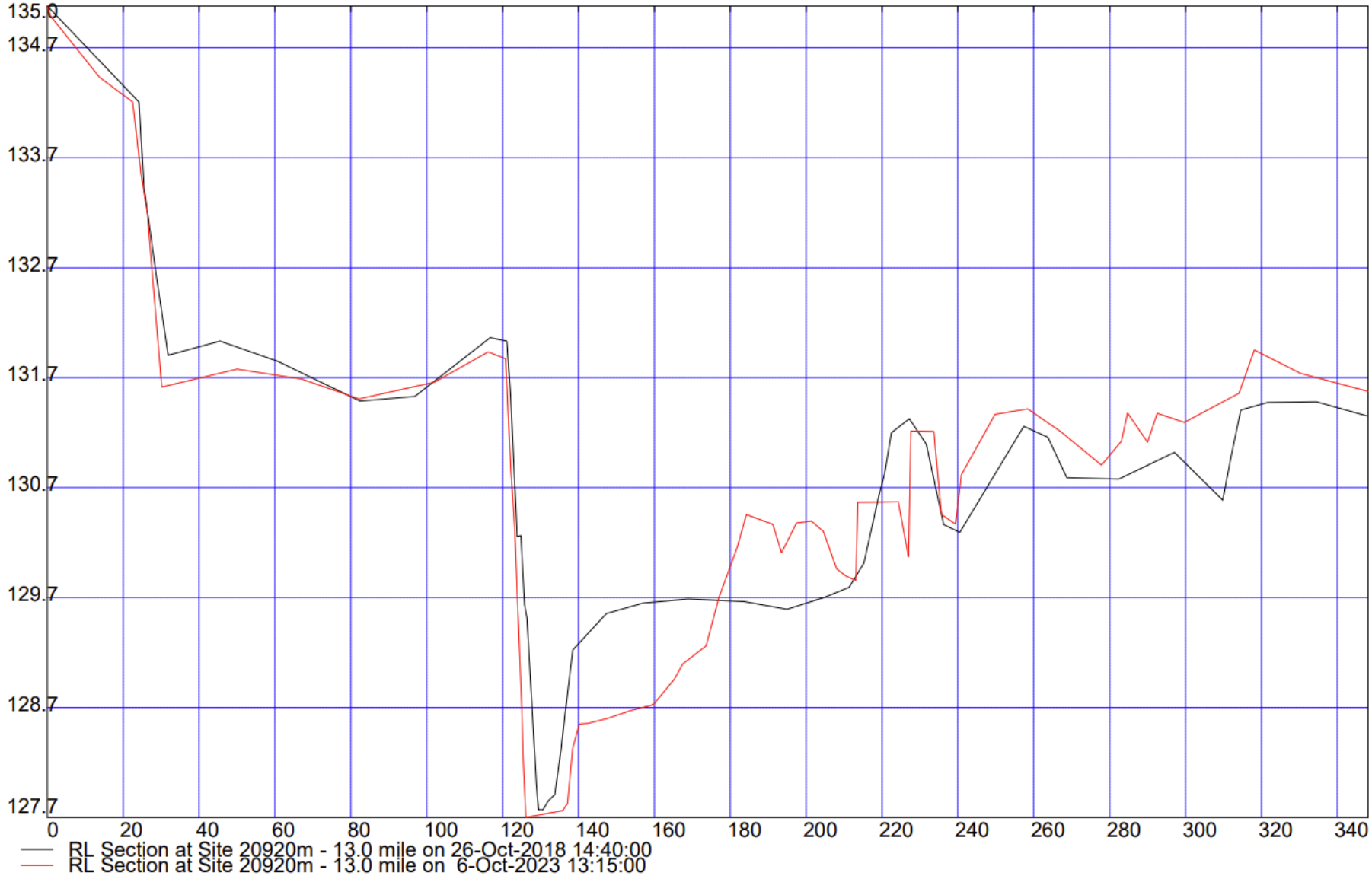

118.7
117.8
116.8
115.8
114.8
113.8
112.8
111.8
-7
43
93
143
193
243
293
343
393
443
493
526
RL Section at Site 16900m - 10.5 mile on 25-Oct-2018 10:30:00
RL Section at Site 16900m - 10.5 mile on 10-Oct-2023 13:40:00

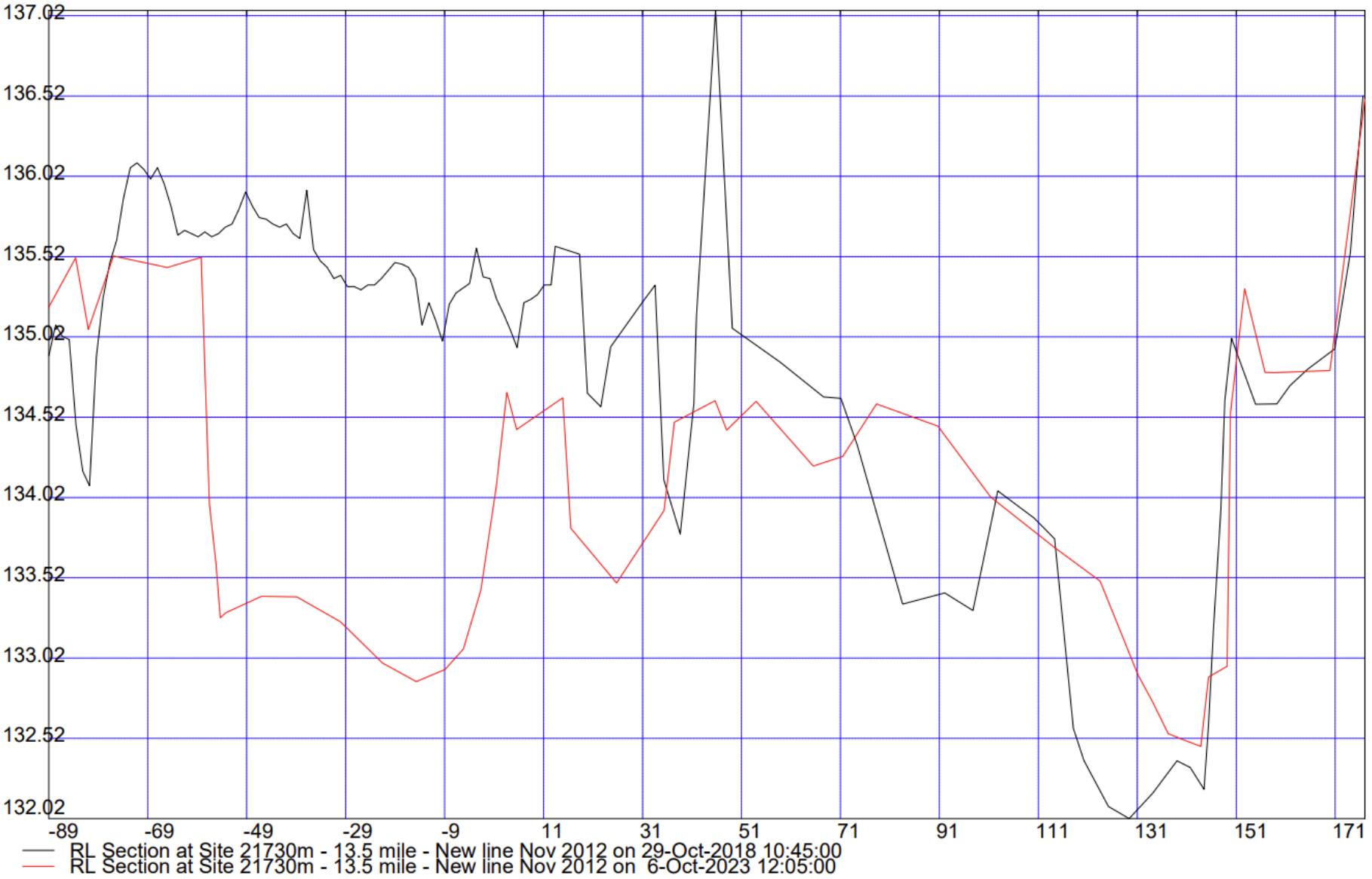

119.60
119.45
118.95
118.45
117.95
117.45
116.95
116.45
115.95
115.45
114.95
5
15
25
35
45
55
65
75
85
95
105
115
125
135
145
155
165
175
RL Section at Site 17700m - 11.0 mile on 25-Oct-2018 13:05:00
RL Section at Site 17700m - 11.0 mile on 10-Oct-2023 12:10:00


124.33
123.90
123.40
122.90
122.40
121.90
121.40
120.90
120.40
119.90
119.40
118.90
118.40
-6
44
94
144
194
244
294
344
362
RL Section at Site 18510m - 11.5 mile on 25-Oct-2018 13:55:00
RL Section at Site 18510m - 11.5 mile on 10-Oct-2023 11:30:00

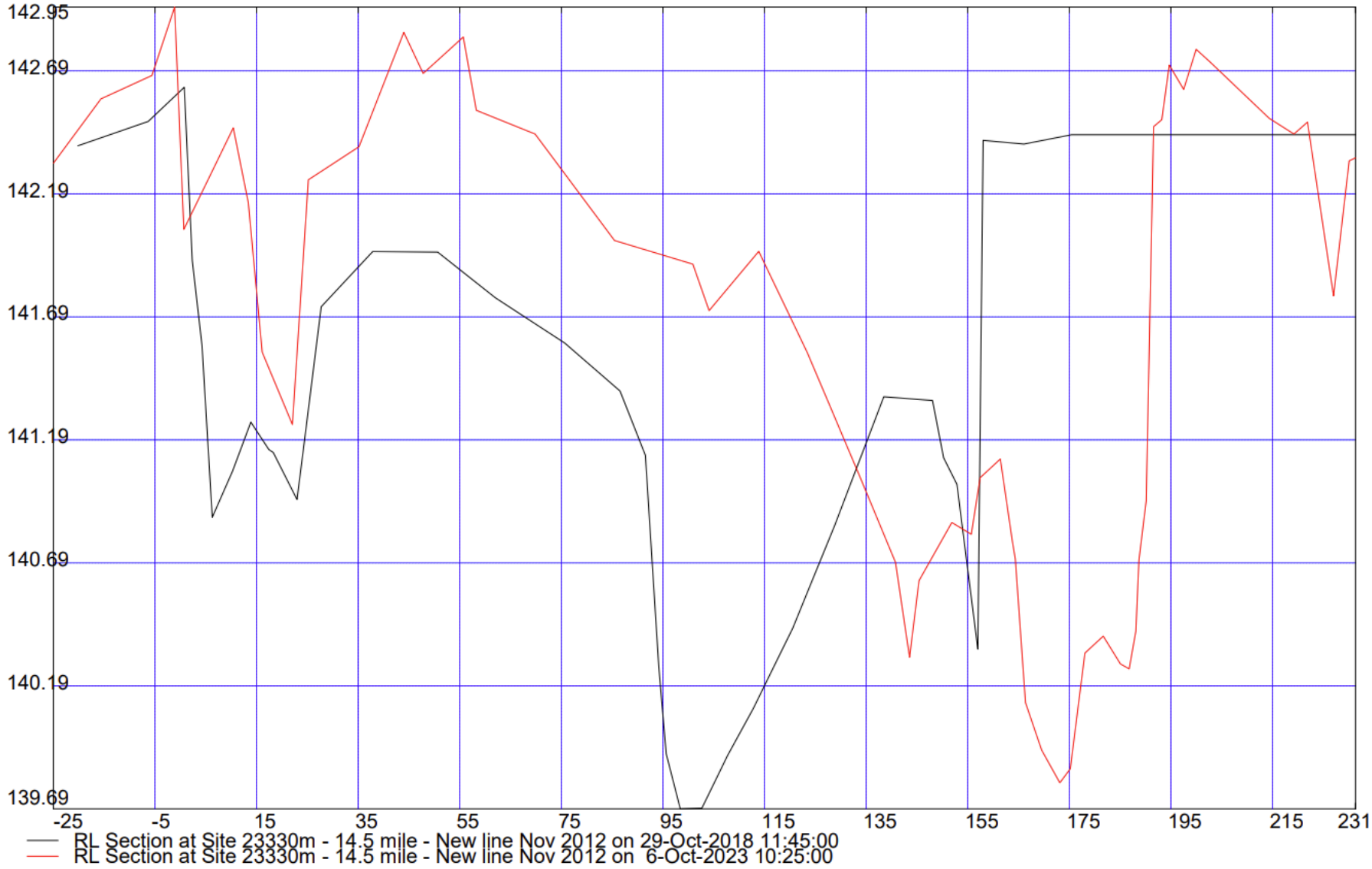

132.5
131.6
130.6
129.6
128.6
127.6
126.6
125.6
124.6
123.6
122.6
121.6
-0
50
100
150
200
250
300
350
400
450
500
550
600
643
RL Section at Site 19310m - 12.0 mile on 26-Oct-2018 13:05:00
RL Section at Site 19310m - 12.0 mile on 10-Oct-2023 10:40:00

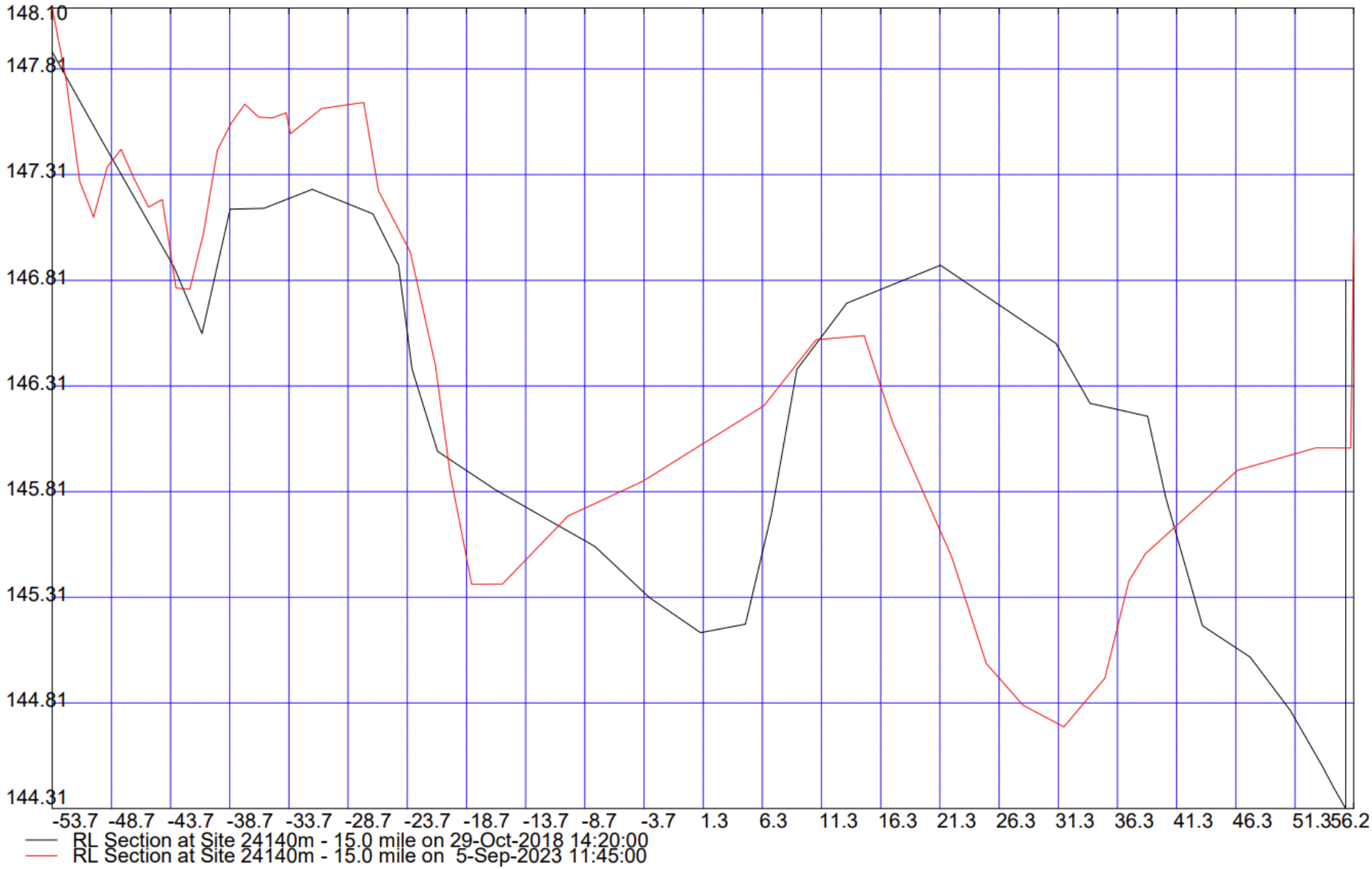

131.6
130.9
129.9
128.9
127.9
126.9
125.9
124.9
123.9
-3
17
37
57
77
97
117
137
157
177
197
217
237
257
277
297
317
337
RL Section at Site 20120m - 12.5 mile on 26-Oct-2018 13:25:00
RL Section at Site 20120m - 12.5 mile on 10-Oct-2023 10:00:00

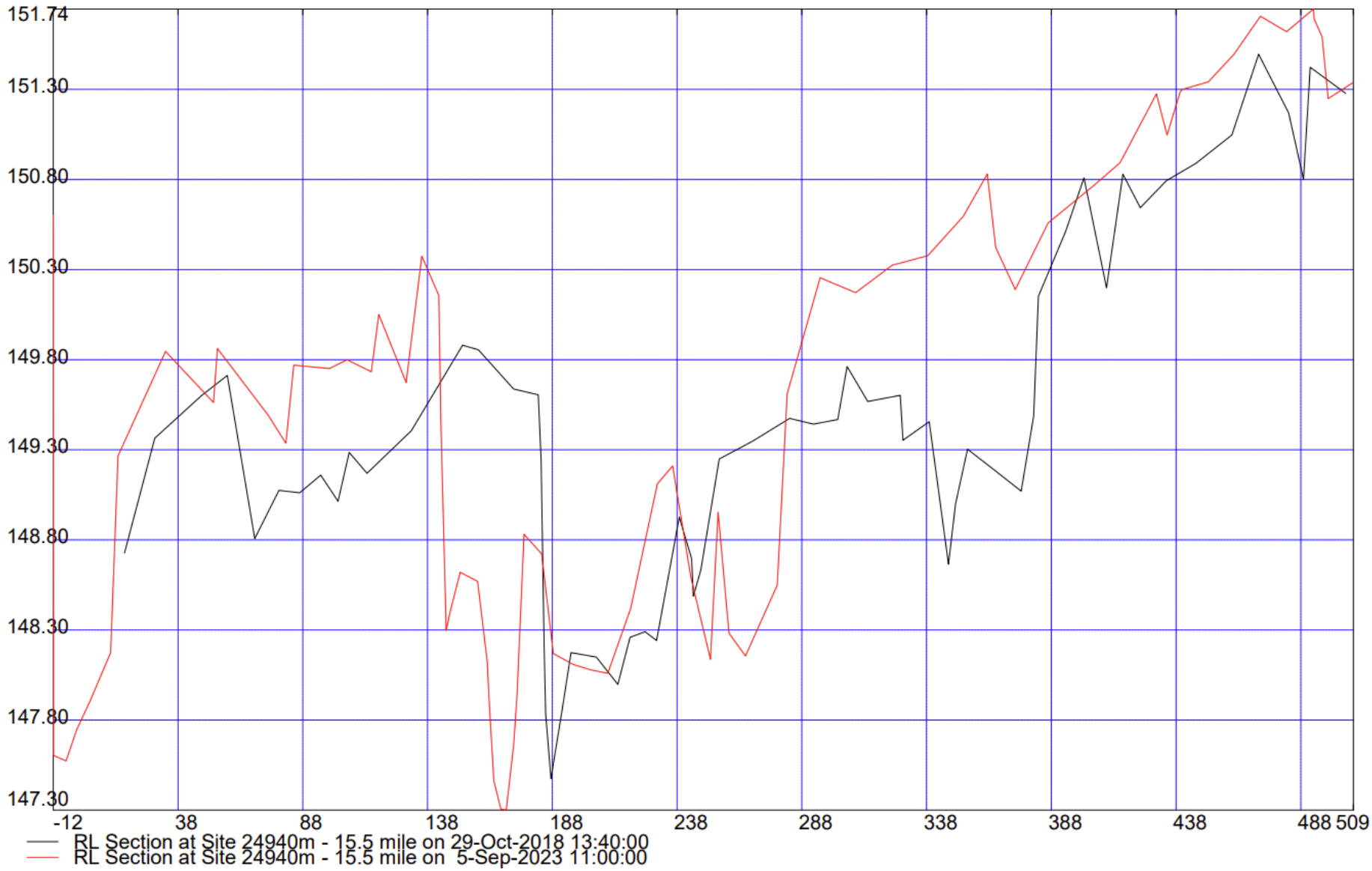

135.0
134.7
133.7
132.7
131.7
130.7
129.7
128.7
127.7
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300
320
340
RL Section at Site 20920m - 13.0 mile on 26-Oct-2018 14:40:00
RL Section at Site 20920m - 13.0 mile on 6-Oct-2023 13:15:00


137.02
136.52
136.02
135.52
135.02
134.52
134.02
133.52
133.02
132.52
132.02
-89
-69
-49
-29
-9
11
31
51
71
91
111
131
151
171
RL Section at Site 21730m - 13.5 mile - New line Nov 2012 on 29-Oct-2018 10:45:00
RL Section at Site 21730m - 13.5 mile - New line Nov 2012 on 6-Oct-2023 12:05:00

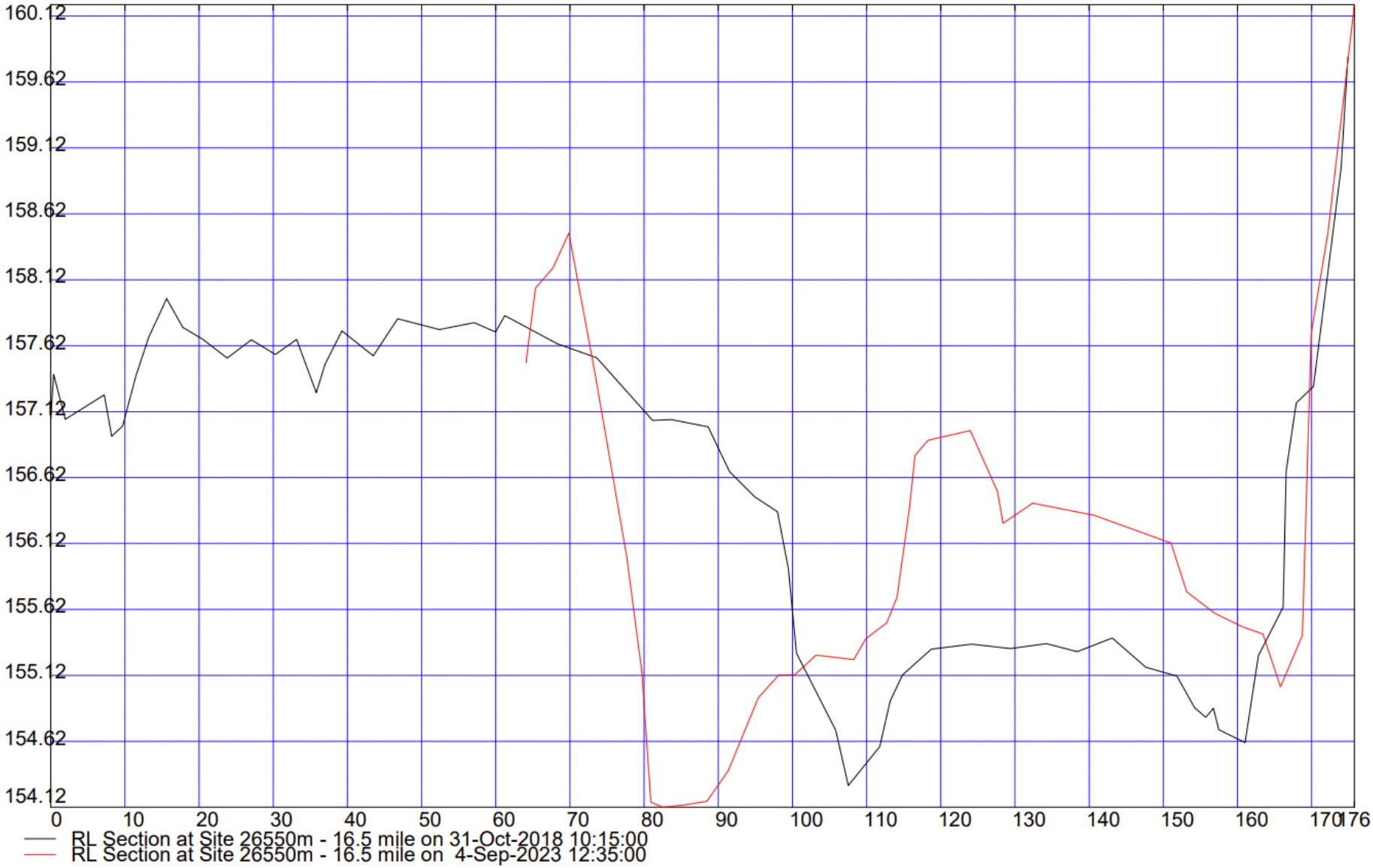

139.16
138.88
138.38
137.88
137.38
136.88
136.38
135.88
135.38
134.88
90
100
110
120
130
140
150
160
170
180
190
200
210
220
230
240
250
RL Section at Site 22530m - 14.0 mile on 29-Oct-2018 10:20:00
RL Section at Site 22530m - 14.0 mile on 6-Oct-2023 11:35:00

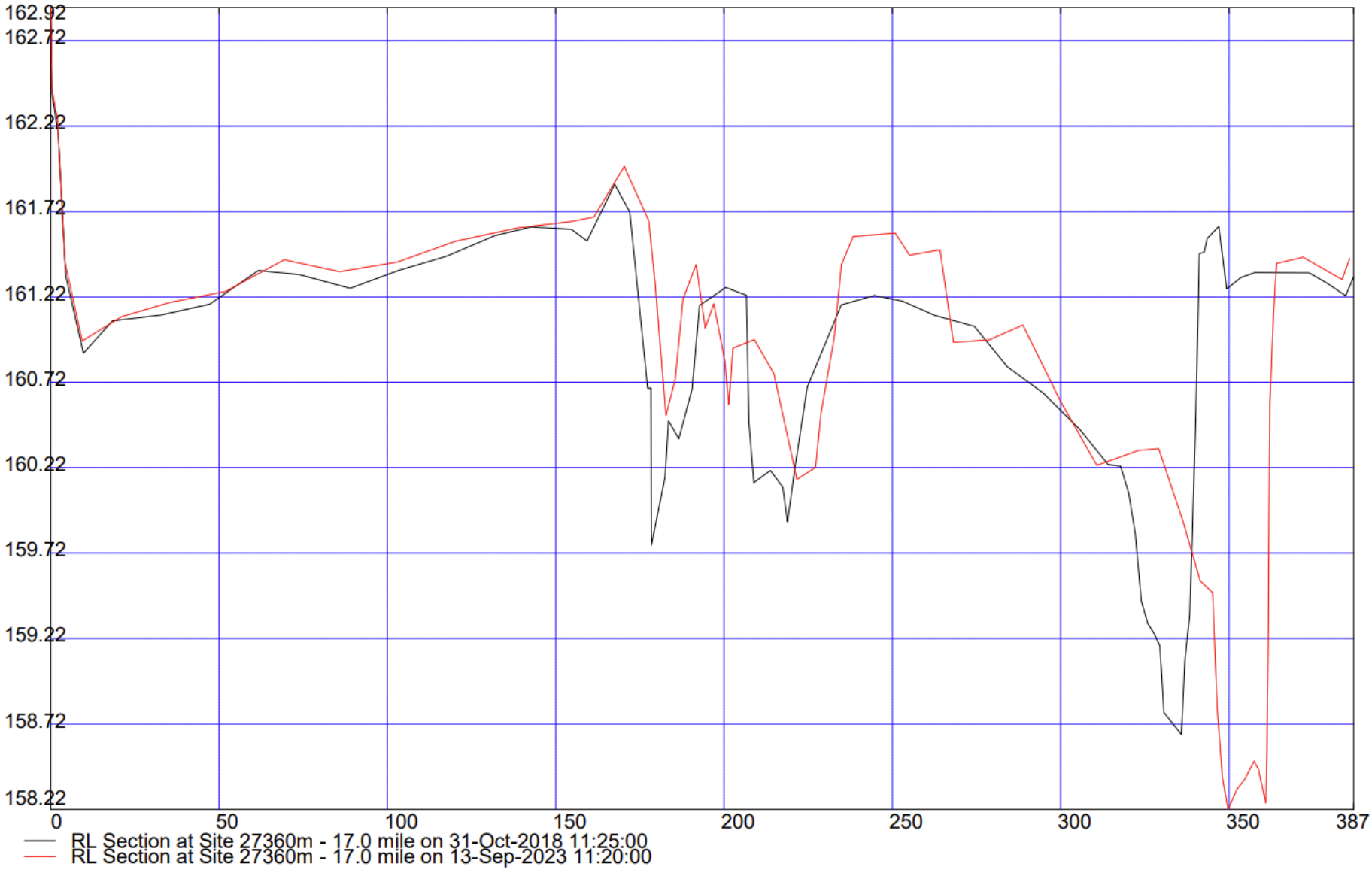

142.95
142.69
142.19
141.69
141.19
140.69
140.19
139.69
-25
-5
15
35
55
75
95
115
135
155
175
195
215
231
RL Section at Site 23330m - 14.5 mile - New line Nov 2012 on 29-Oct-2018 11:45:00
RL Section at Site 23330m - 14.5 mile - New line Nov 2012 on 6-Oct-2023 10:25:00

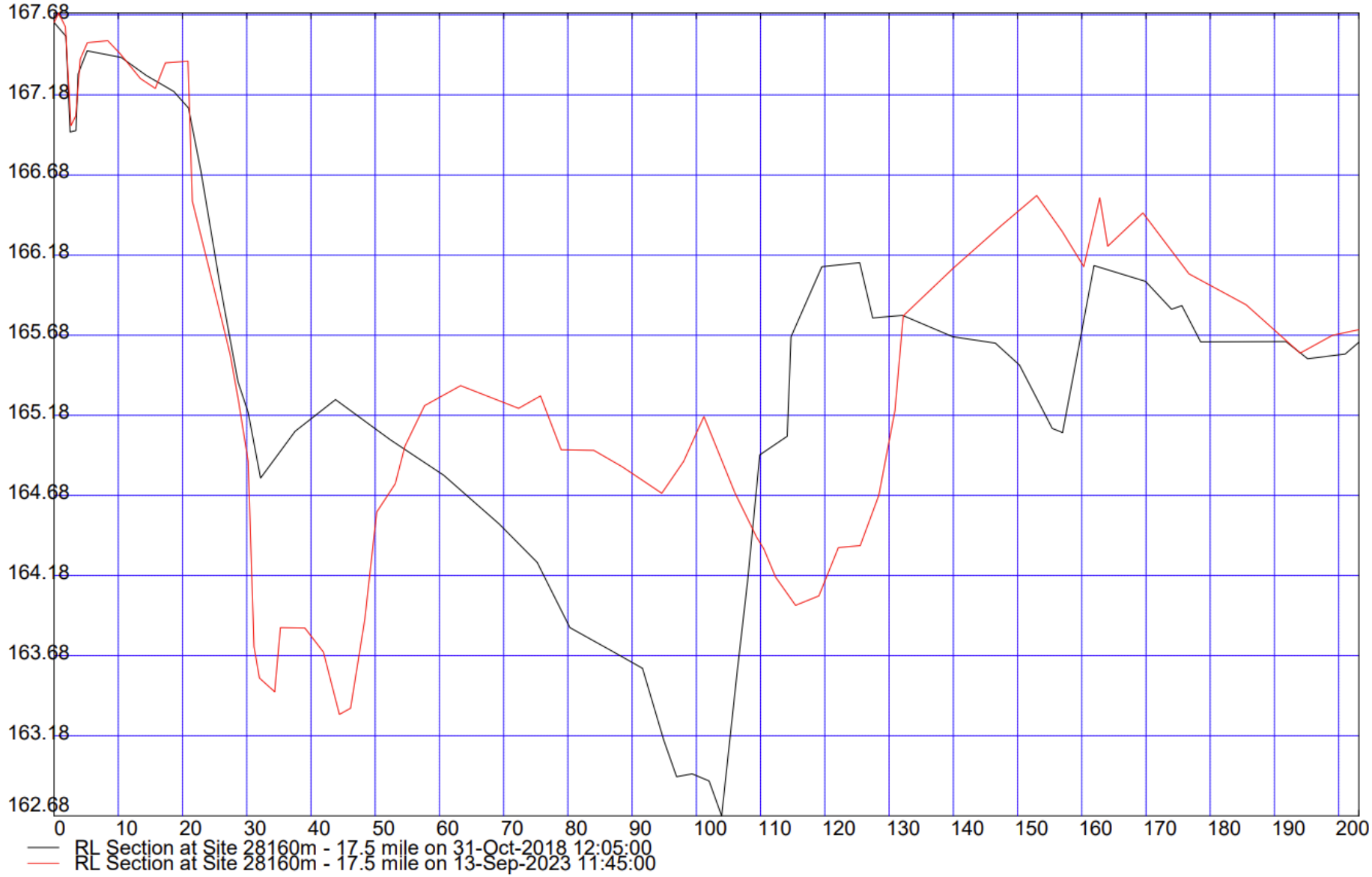

148.10
147.81
147.31
146.81
146.31
145.81
145.31
144.81
144.31
-53.7 -48.7 -43.7 -38.7 -33.7 -28.7 -23.7 -18.7 -13.7 -8.7 -3.7 1.3 6.3 11.3 16.3 21.3 26.3 31.3 36.3 41.3 46.3 51.356.2
RL Section at Site 24140m - 15.0 mile on 29-Oct-2018 14:20:00
RL Section at Site 24140m - 15.0 mile on 5-Sep-2023 11:45:00


151.74
151.30
150.80
150.30
149.80
149.30
148.80
148.30
147.80
147.30
-12
38
88
138
188
238
288
338
388
438
488 509
RL Section at Site 24940m - 15.5 mile on 29-Oct-2018 13:40:00
RL Section at Site 24940m - 15.5 mile on 5-Sep-2023 11:00:00

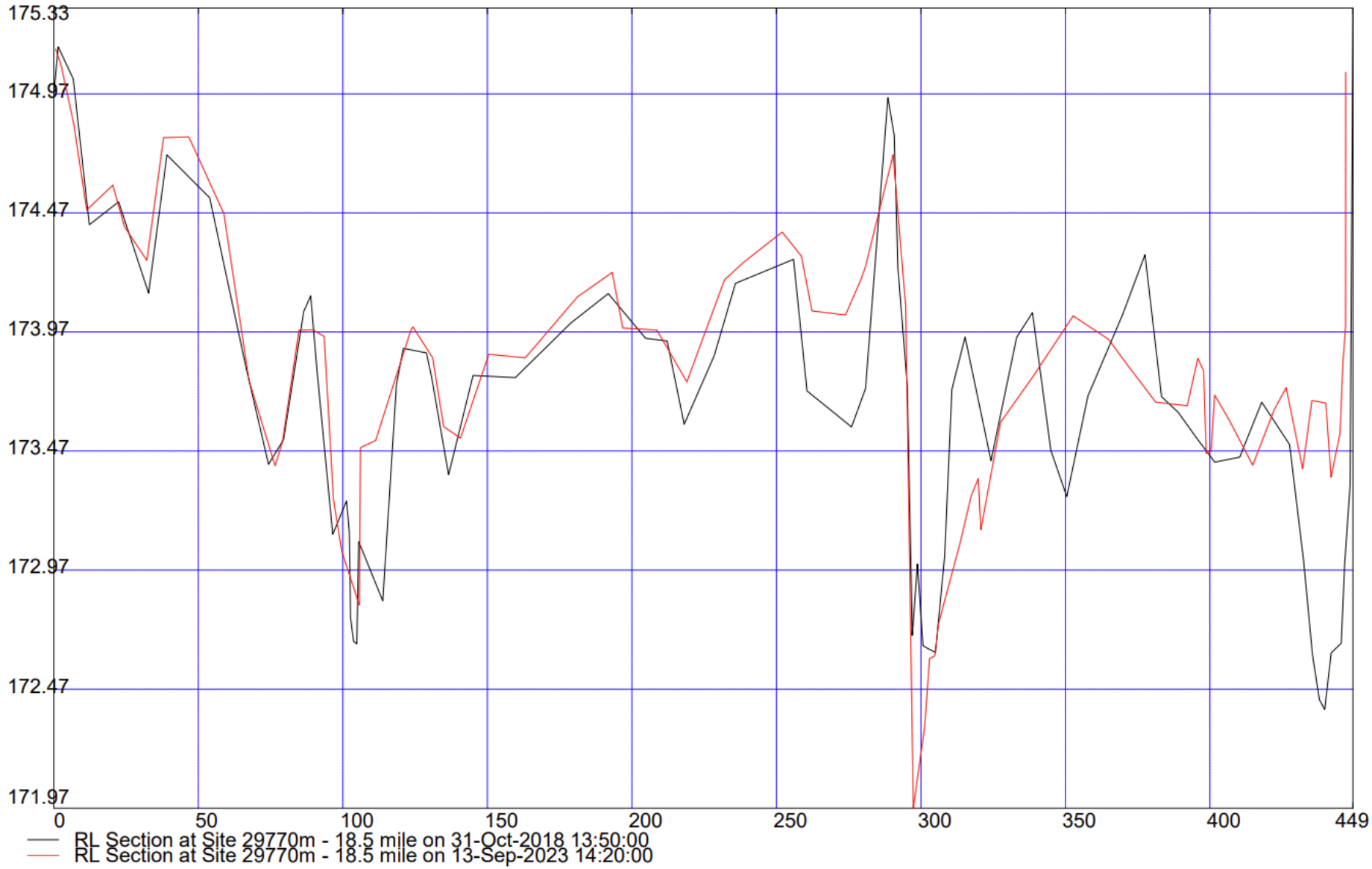

154.97
154.56
154.06
153.56
153.06
152.56
152.06
151.56
151.06
150.56
71
81
91
101
111
121
131
141
151
161
171
181
191
201
211
221
231
241
249
RL Section at Site 25750m - 16.0 mile on 29-Oct-2018 14:00:00
RL Section at Site 25750m - 16.0 mile on 4-Sep-2023 14:30:00

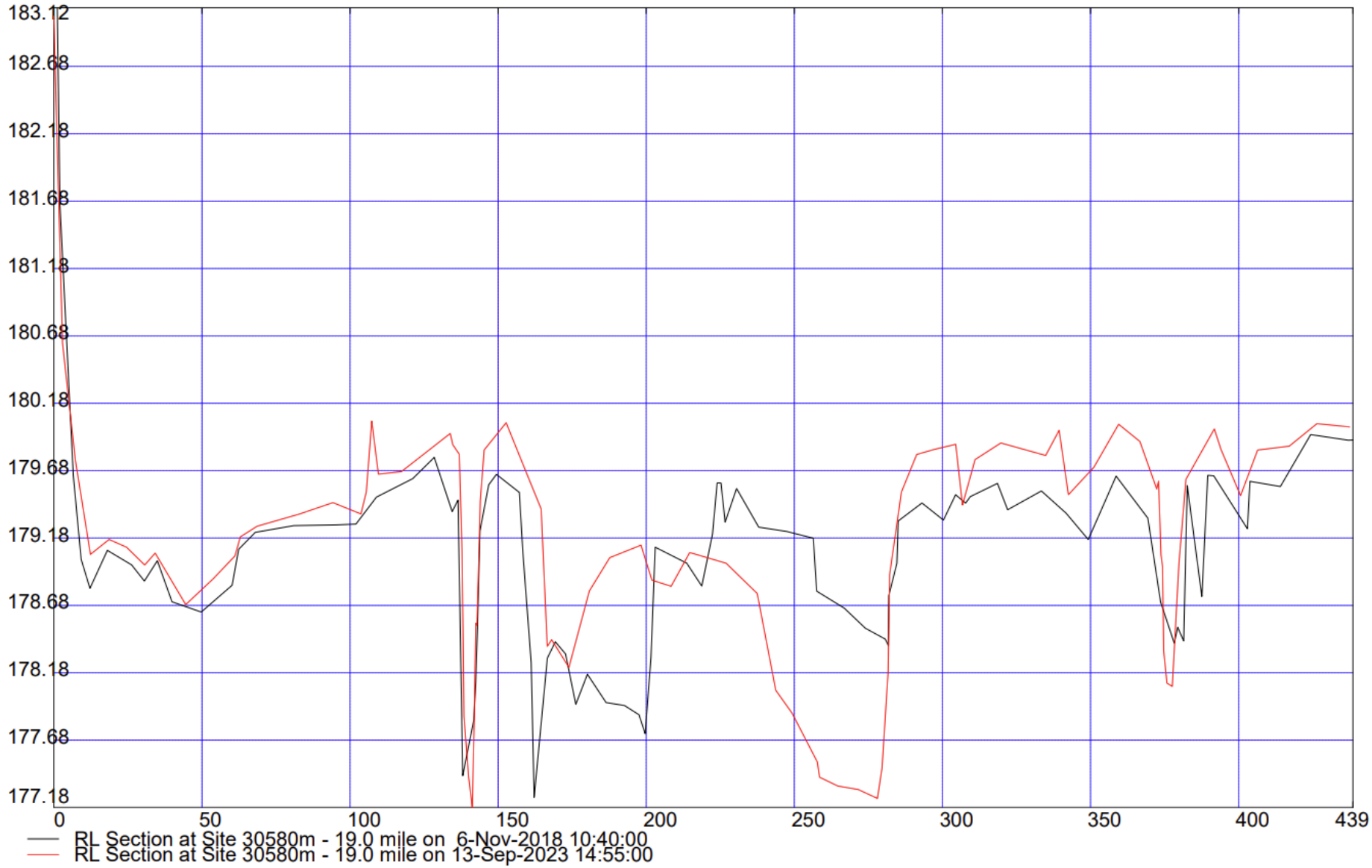

160.12
159.62
159.12
158.62
158.12
157.62
157.12
156.62
156.12
155.62
155.12
154.62
154.12
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
176
RL Section at Site 26550m - 16.5 mile on 31-Oct-2018 10:15:00
RL Section at Site 26550m - 16.5 mile on 4-Sep-2023 12:35:00

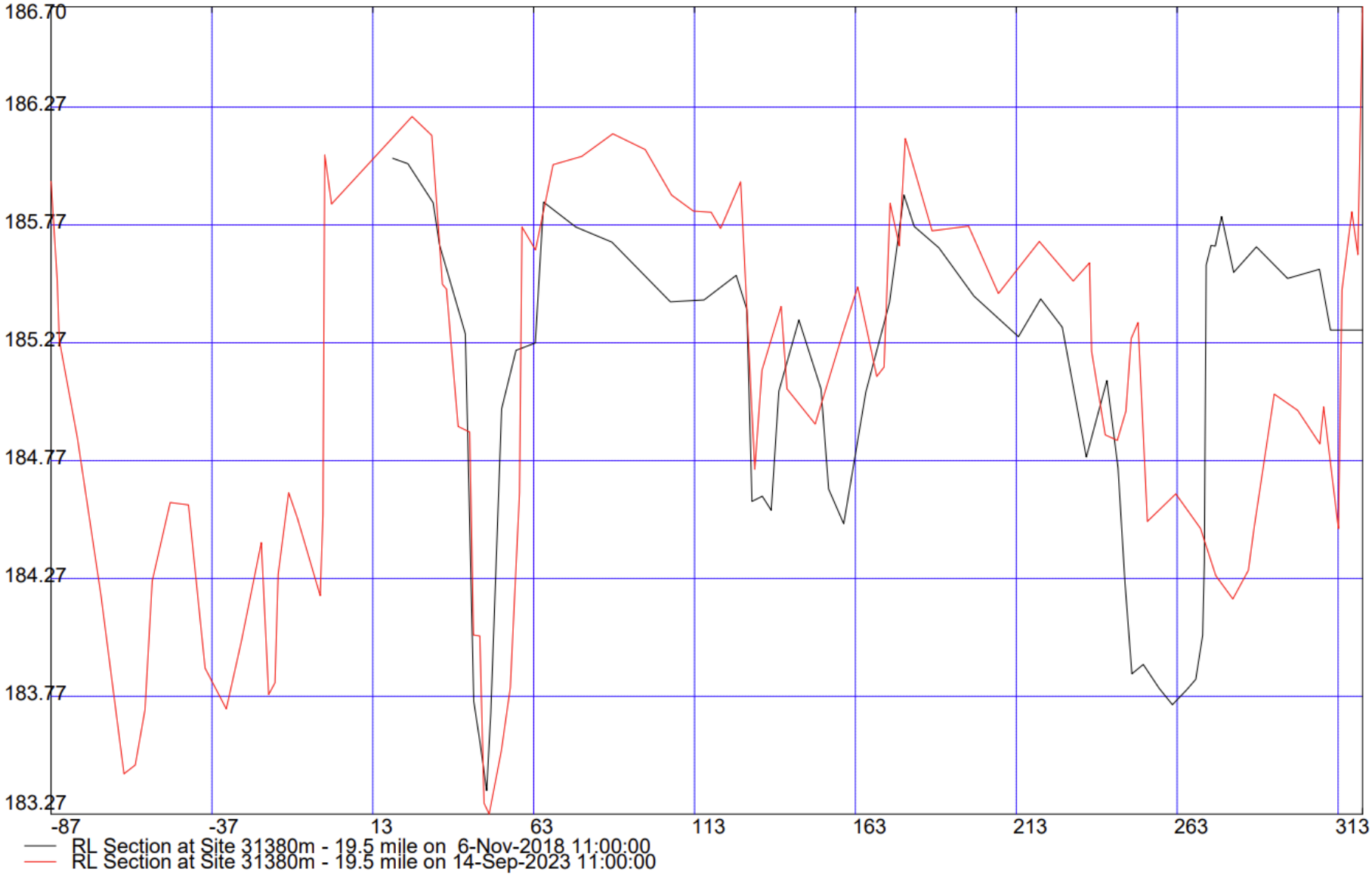

162.92
162.72
162.22
161.72
161.22
160.72
160.22
159.72
159.22
158.72
158.22
0
50
100
150
200
250
300
350
387
RL Section at Site 27360m - 17.0 mile on 31-Oct-2018 11:25:00
RL Section at Site 27360m - 17.0 mile on 13-Sep-2023 11:20:00

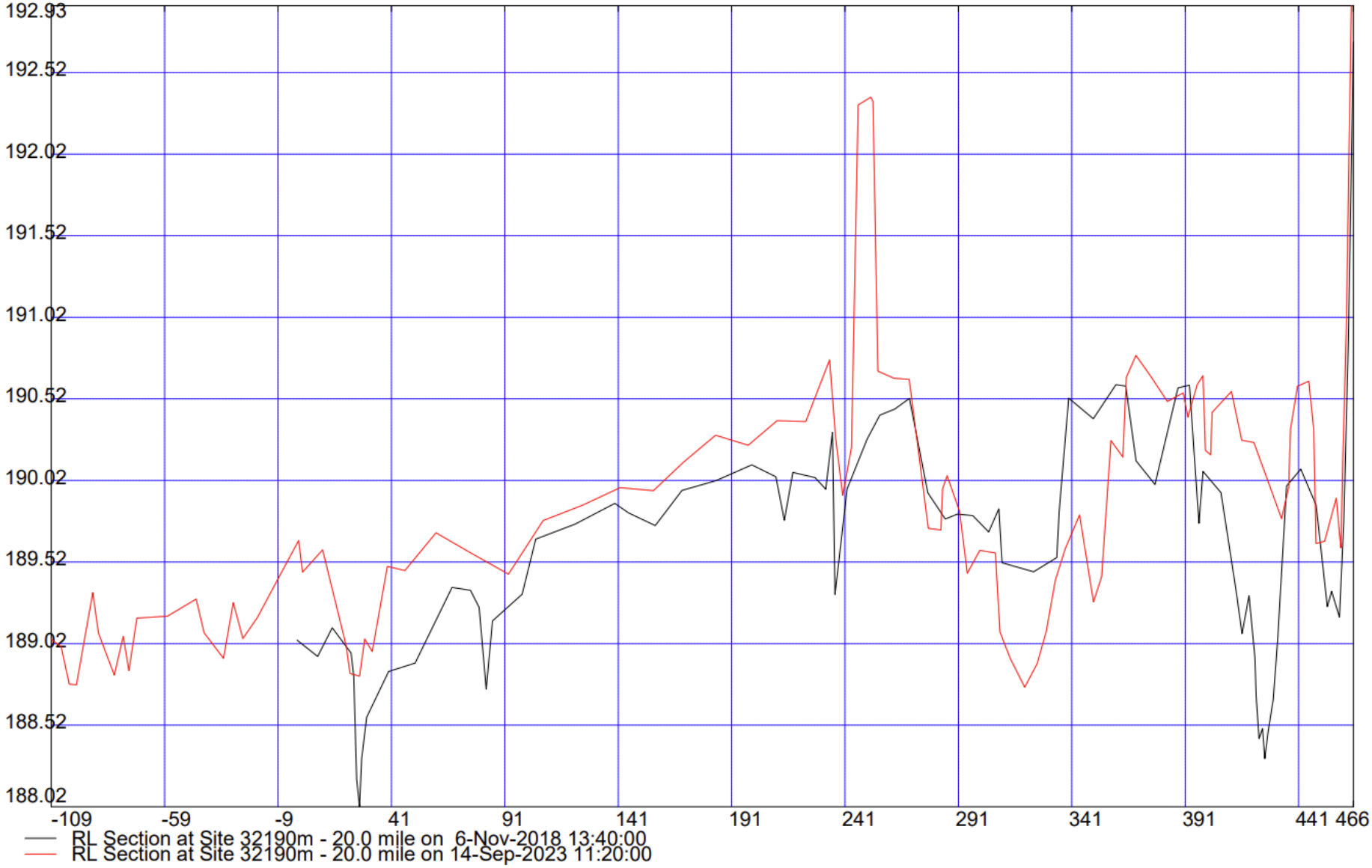

167.68
167.18
166.68
166.18
165.68
165.18
164.68
164.18
163.68
163.18
162.68
0
10
20
30
40
50
60
70
80
90
100
110
120
130
140
150
160
170
180
190
200
RL Section at Site 28160m - 17.5 mile on 31-Oct-2018 12:05:00
RL Section at Site 28160m - 17.5 mile on 13-Sep-2023 11:45:00

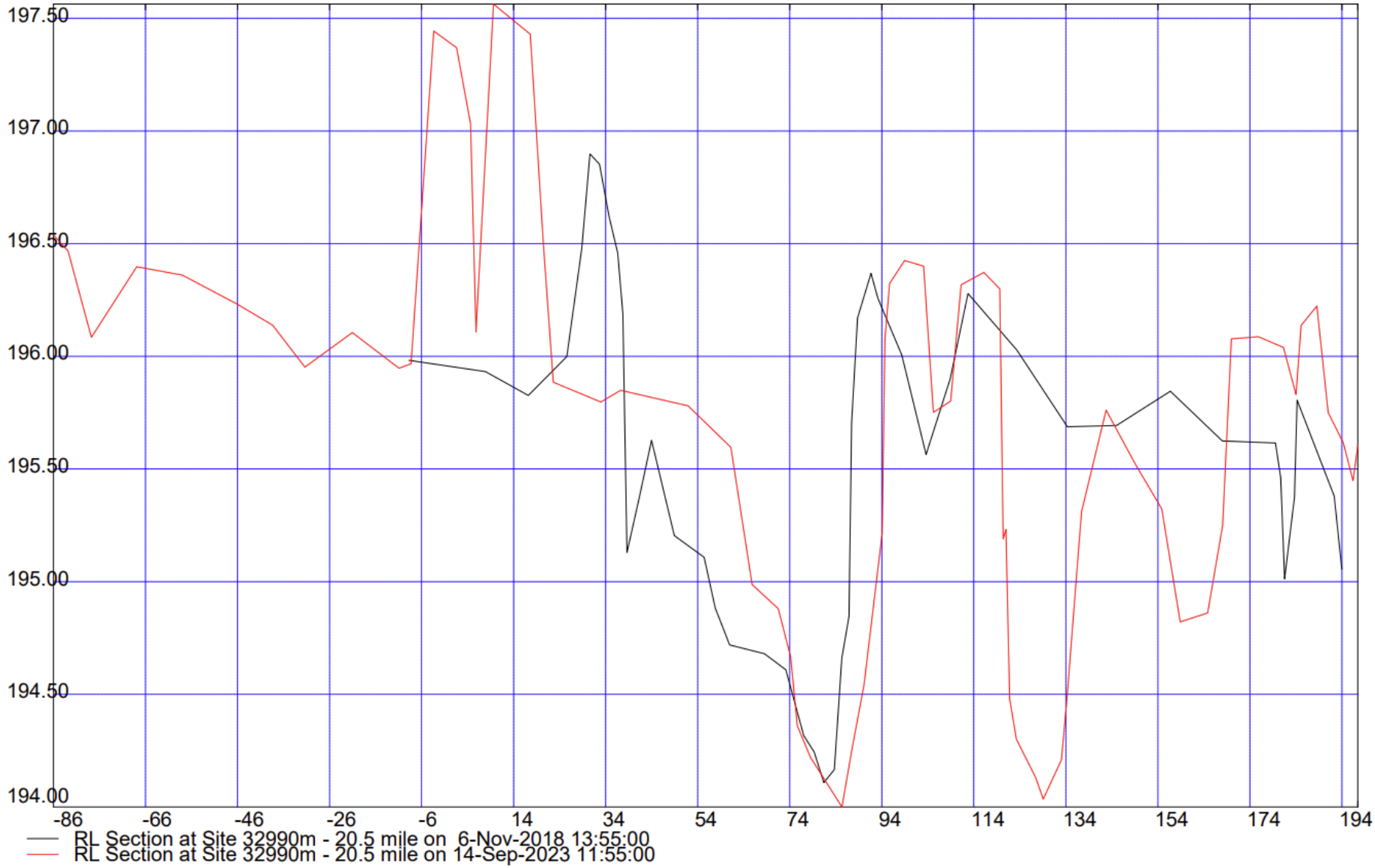

170.81
170.31
169.81
169.31
168.81
168.31
167.81
-46
-36
-26
-16
-6
4
14
24
34
44
54
64
74
84
94
104
114
124
134
RL Section at Site 28970m - 18.0 mile on 31-Oct-2018 14:10:00
RL Section at Site 28970m - 18.0 mile on 13-Sep-2023 12:30:00


175.33
174.97
174.47
173.97
173.47
172.97
172.47
171.97
0
50
100
150
200
250
300
350
400
449
RL Section at Site 29770m - 18.5 mile on 31-Oct-2018 13:50:00
RL Section at Site 29770m - 18.5 mile on 13-Sep-2023 14:20:00


183.12
182.68
182.18
181.68
181.18
180.68
180.18
179.68
179.18
178.68
178.18
177.68
177.18
0
50
100
150
200
250
300
350
400
439
RL Section at Site 30580m - 19.0 mile on 6-Nov-2018 10:40:00
RL Section at Site 30580m - 19.0 mile on 13-Sep-2023 14:55:00


186.70
186.27
185.77
185.27
184.77
184.27
183.77
183.27
-87
-37
13
63
113
163
213
263
313
RL Section at Site 31380m - 19.5 mile on 6-Nov-2018 11:00:00
RL Section at Site 31380m - 19.5 mile on 14-Sep-2023 11:00:00

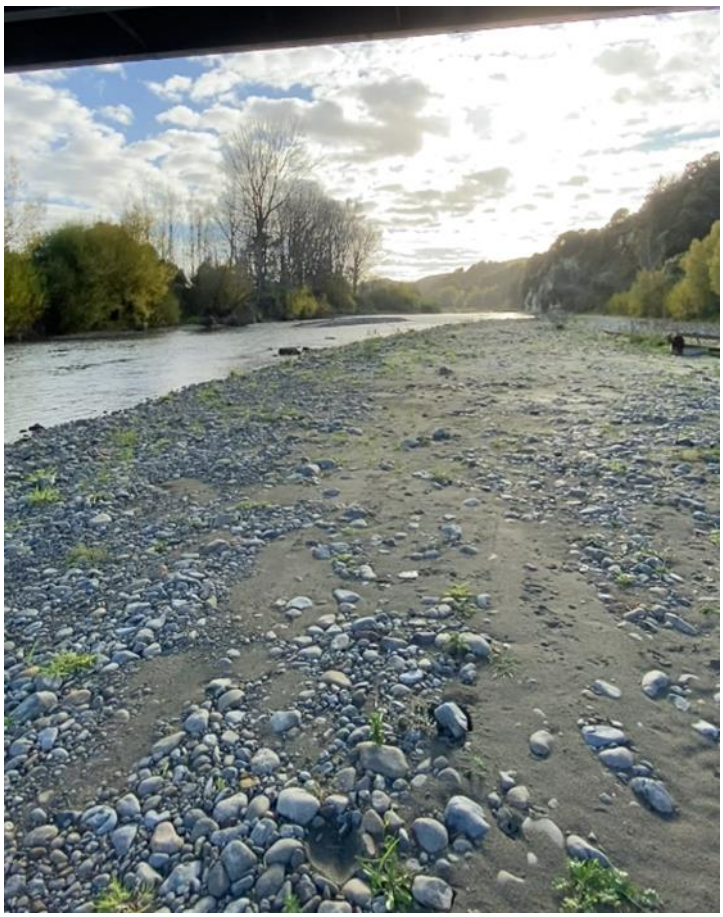

192.93
192.52
192.02
191.52
191.02
190.52
190.02
189.52
189.02
188.52
188.02
-109
-59
-9
41
91
141
191
241
291
341
391
441 466
RL Section at Site 32190m - 20.0 mile on 6-Nov-2018 13:40:00
RL Section at Site 32190m - 20.0 mile on 14-Sep-2023 11:20:00


197.50
197.00
196.50
196.00
195.50
195.00
194.50
194.00
-86
-66
-46
-26
-6
14
34
54
74
94
114
134
154
174
194
RL Section at Site 32990m - 20.5 mile on 6-Nov-2018 13:55:00
RL Section at Site 32990m - 20.5 mile on 14-Sep-2023 11:55:00


204.56
204.14
203.64
203.14
202.64
202.14
201.64
201.14
200.64
200.14
199.64
199.14
0
10
20
30
40
50
60
70
80
90
100
110
120
130
RL Section at Site 33800m - 21 Mile Totara XS 36 on 6-Nov-2018 14:20:00
RL Section at Site 33800m - 21 Mile Totara XS 36 on 14-Sep-2023 13:10:00

Appendix D: Site visit photos of the Pohangina River

Figure D1: Railway Bridge



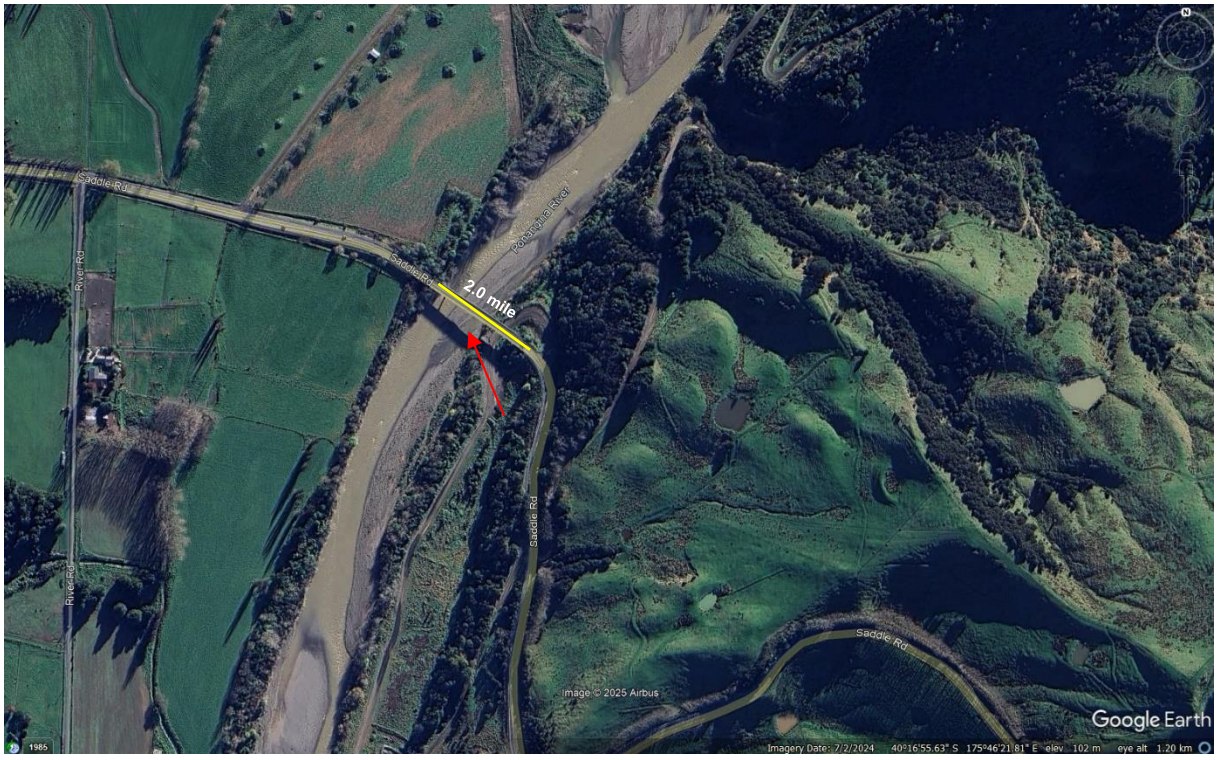


Figure D2: Saddle Road Bridge

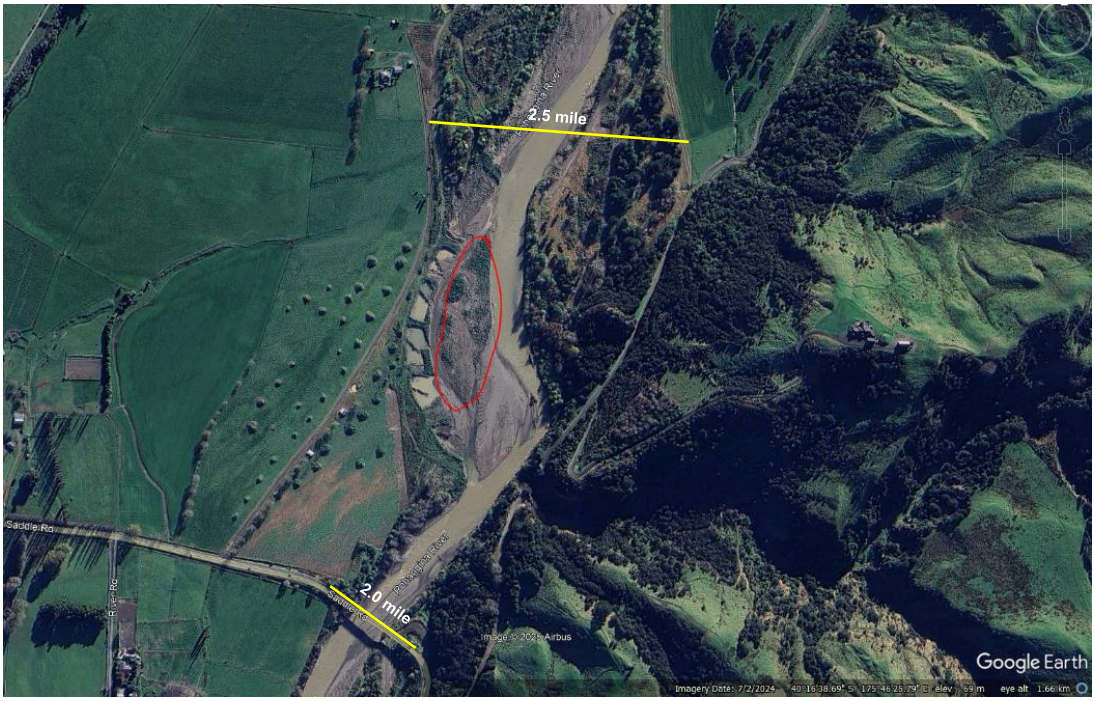


Figure D3: Between Saddle Road Bridge and 2.5 mile

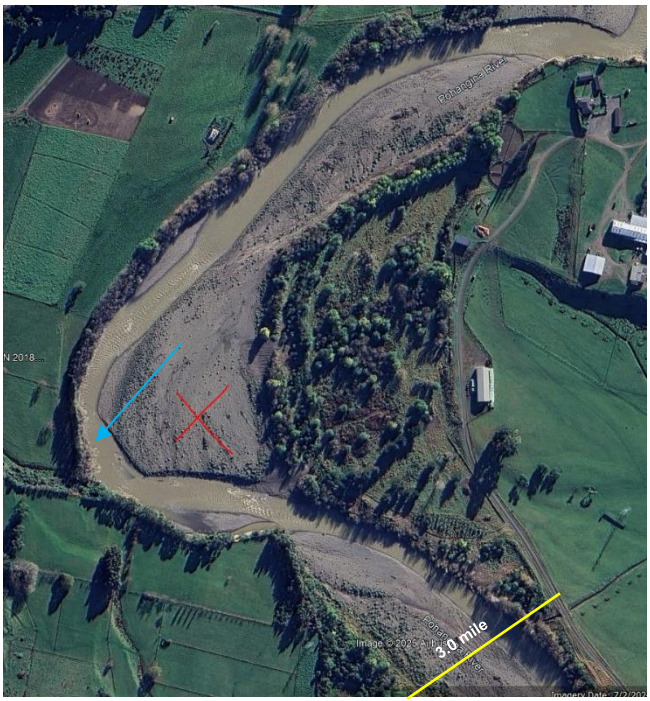


Figure D4: Upstream of 3.0 mile

Figure D5: 9.0 mile

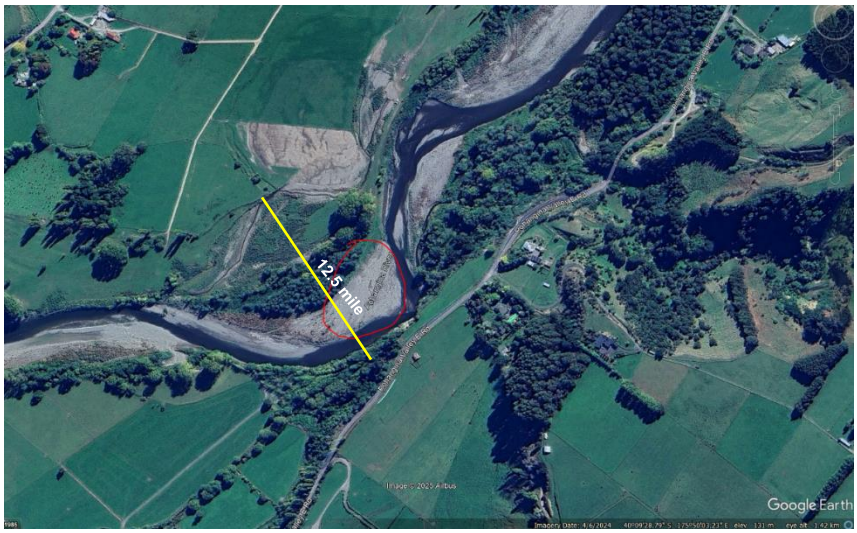


Figure D6: 12.5 mile

Figure D7: Halfway between 13.0 mile and 13.5 mile

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fax 06 952 2929 | **email** help@horizons.govt.nz
Private Bag 11025, Manawatu Mail Centre, Palmerston North 4442