Flood Risk Technical Note: Additional information

Regulation 25 Response

Didcot HIF 1

Oxfordshire County Council

July 2022

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Quality information

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1. Flood Risk and Modelling

Background

1.1 The Environment Agency (EA) have objected to the proposed Didcot HIF1 development (referred as the 'Scheme') on the land between Didcot and Clifton Hampden (Didcot to Culham River Crossing), on the grounds that there is an unacceptable risk to the environment. One of the reasons for this was stated that the Flood Risk Assessment (FRA) did not demonstrate that there will be no increase in flood risk to the surrounding area.

1.2 The EA have advised that to overcome this objection, any flood depth changes beyond the hydraulic model tolerance should be mitigated, and the preferred form of mitigation is level for level flood plain compensation.

1.3 The purpose of this report is to re-examine what an acceptable model tolerance should be from examination of detailed model results, and whether adequate mitigation has been included in the design of the Didcot to Culham River Crossing.

Summary of Findings

1.4 After more detailed analysis of model confidence, it is recommended that model results or impact assessments should not be assessed to a level of confidence higher than +/-20mm. This is because:

- Detailed analysis of time series outputs at different model locations shows model variances between 10mm and 50mm as a result of model instabilities;
- The existing EA model was calibrated to match the observed flood event data, and the level of accuracy established was 30-50mm;
- The model is discretised into grids of 10m size each, with a floodplain approx. 500m wide within the vicinity of the scheme and with baseline flood depths up to 2m, in the 1% AEP with a +35% climate change event. There is low confidence in reporting results to a model tolerance of less than 20mm is given the coarse scale of the model.

1.5 There is only one area where the model results are showing an actual impact greater than +/-20mm, which is to be incorporated to the Scheme so that flood risk increase in this area can be locally managed without any consequence to road users or third parties.

1.6 Storage compensation has been providing a net gain in the flood plain. The design is in excess of the minimum requirement (i.e., 1% AEP plus 26% climate change event), and is designed for the 1% AEP plus 35% climate change event[1].

[1] Following previous Climate Change guidance, a 35% Climate Change allowances was used and this was the 'Upper End' Allowance for the 2050s. The FRA also tested the Upper End allowance of 70% for the 2080's. Under updated Climate Change guidance in 2021, rules for flood risk assessments of infrastructure were changed, therefore the allowance of 26%, Central Allowance for the for the 2080's is used to define flood mitigation in the Gloucestershire and the Vale Management Catchment. The FRA tested the Higher allowance of 41% for the 2080's to consider impacts to the proposed scheme itself.

Water Level and Model tolerance

1.7 The EA have advised that depth changes beyond model tolerance should be mitigated. The FRA stated that depth changes of 10mm were within model tolerance. However after further review and analysis, it is considered that the level of confidence in the modelling does not allow an assessment to a +/-10mm level of detail.

1.8 As stated in the FRA, the EA's 2018 Sandford to Mapledurham hydraulic model was used as a basis for the baseline model, with selected updates such as climate change allowances and addition of cross sections close to the proposed location of the scheme. This was agreed in pre-application advice from the EA. Other than these updates, no further model updates have been undertaken.

1.9 To provide confidence in this analysis on acceptable model tolerance, additional work has been undertaken to establish and present confidence levels in the River Thames model in detail.

1.10 To carry out the analysis, the existing model scenarios have been used, but have been re-run with more TuFLOW Plot Output (PO) points to create a significantly higher resolution output. The higher resolution output has allowed a detailed analysis of the model results which are presented in this report.

1.11 The high resolution output takes longer for the model to run and produces simulation results files that are much larger in terms of file size. However, this means a greater level of detail available in the outputs for the results analysis, which was not included the previous FRA.

1.12 In addition, the calibration and stability of the original 2018 Sandford to Mapledurham Thames model has been re-examined.

Time Series Analysis

1.13 Figure 1 shows the location of 36 TuFLOW Plot Output (PO) points which were added to the model to extract high resolution water level time-series results. The water level difference mapping in this figure (previously included in the FRA) shows differences greater than +/-10mm. As described throughout this section, after undertaking more detailed analysis, it is not considered appropriate to present maps showing differences greater than +/-10mm. Instead, on consideration of model performance and model confidence, the final water level difference mapping has been adjusted to show differences greater than +/-20mm.

1.14 36 points were analysed in areas where the water level difference mapping included in the FRA indicated impacts of greater than +/-10mm. As shown in Figure 1 within these areas there was some variability in the magnitude of water level difference between model cells (a 'hatched' effect can be seen in the mapping). It is the variability in the water level difference mapping that has been the focus of further investigation.

1.15 The time series plots for each of these PO points can be found in Appendix A. A discussion of the water level variations for the different cluster of PO points is presented below.

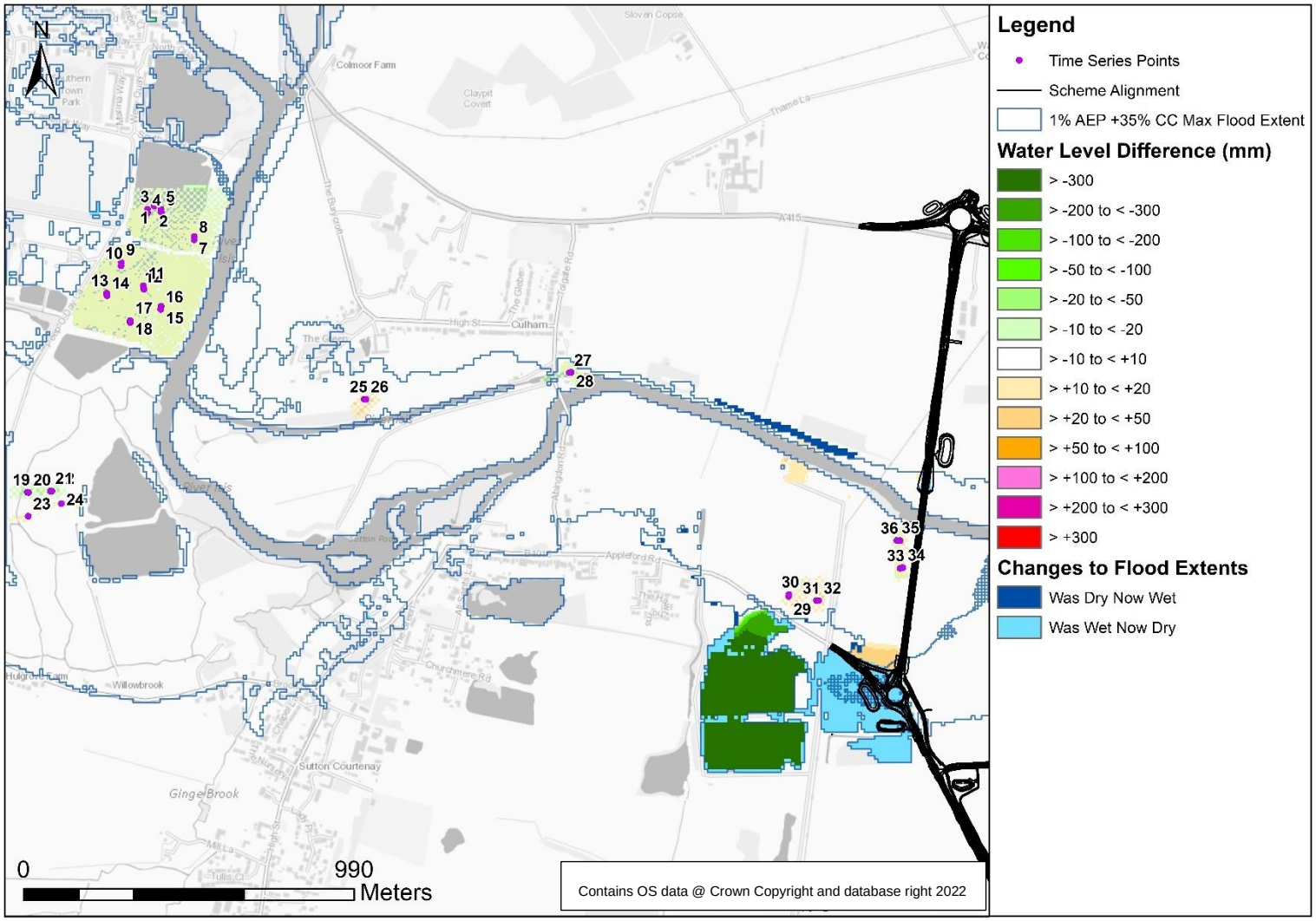


Figure 1 Water Level Difference Map between Baseline and Scheme with 10mm Model Tolerance banding applied

PO points 1-18

1.16 As seen in Figure 1, PO points 1-18 are located west of the River Thames, south of Abingdon (between the marina and wastewater treatment works). The time-series results in Appendix A show that at each point, the modelled water levels for the Baseline and Scheme models are within +/-10mm. This shows that across these areas there is no significant or systematic increase in flood level because of the scheme.

1.17 The variability in water level difference that is indicated by the hatching in Figure 1 indicates that there are minor variations in the maximum modelled water level between cells. This is illustrated in the cross-section of water surface profile taken across this area (from PO point 1 to PO point 2) shown in Figure 2. The variation in maximum water level between cells is minimal (approx. 0.01m) across 10m grid cells, with a baseline flood depth of approximately 2m in the 1% AEP plus 35% climate change event.

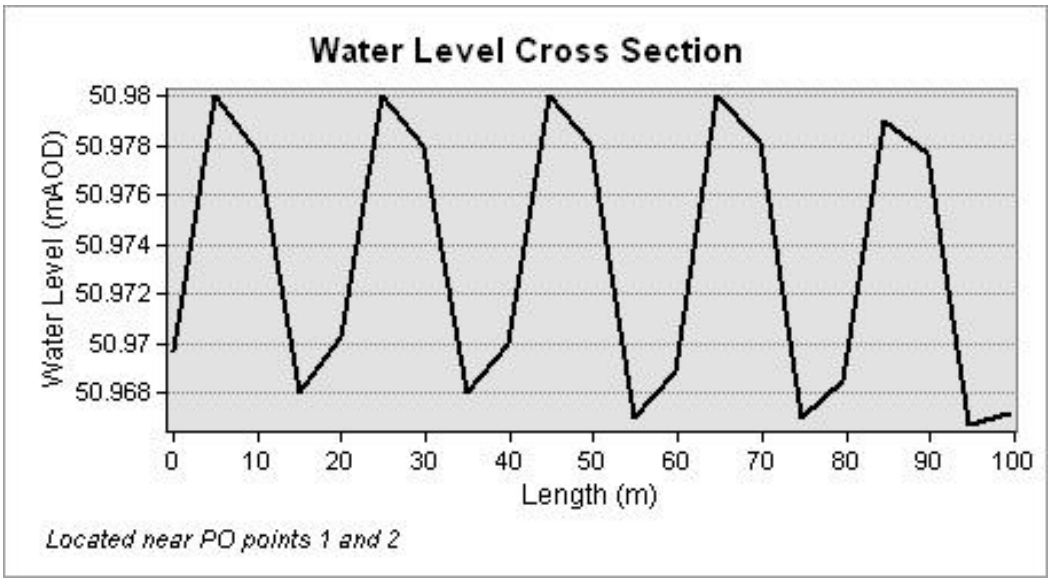


Figure 2 Cross-section of Water Level (HMAX) adjacent to PO points 1 and 2 in the Baseline 1% AEP event plus 35% climate change event

1.18 The minimal variability in water level between the cells is a consequence of minor instabilities in the 2D model in these areas of existing waterbodies. The instabilities were already present within the original 2018 Sandford to Mapledurham model. It is evident in the 2018 model and report that the previous project team had taken steps to reduce this instability but had not removed the instabilities completely. The 2018 model included stability patches at the 1D/2D interface along riverbanks but this did not completely resolve the stability issues. The sudden change in flow resistance/ Manning's roughness values (N) assigned in the model between the existing waterbodies and connecting floodplains further exacerbates these instabilities.

1.19 The minor instabilities in this area were in the original 2018 model and were not easily improved in that study. Given that legacy and the fact the instabilities are restricted to the existing waterbodies and not affecting the wider floodplain, this area of the model has not been altered for the purposes of this study. The instabilities explain the 'hatched' impacts shown in the mapping in the original FRA. However the consequence of those instabilities on modelled water level are minor and should not distract from the overall conclusion of this assessment that there is no increase in flood risk to third parties from this scheme.

PO points 19-36

1.20 The remainder of the PO points (points 19 – 36 in Figure 1) are more scattered throughout the model and not in single location like points 1 – 18. The time-series results at these points have

been assessed individually and are shown in Appendix A. The time-series results at many of these points show signs of model instability in the original 2018 Sandford to Mapledurham model, which are then carried through to the Didcot HIF1 Baseline and Scheme models.

1.21 The model instabilities are typically in the range 10-30mm, see PO points 19- 24, 31, 32, 35 and 36 where there are the most noticeable oscillations. In addition, there are also 'step changes' in the water level plot which is another sign of model instability. In some cases these variances exceed 50mm, as seen in the plot for PO point 32.

1.22 When the time-series results are analysed in detail, it can also be seen that a small shift in time between the peaks and troughs in the unstable model results can make the water level difference between the Baseline and Option scenario seem greater.

1.23 Whilst the water level graphs for 25-30 appear to be smoother with few oscillations, these points (along with points 19-36) intersect with areas where the 2D mass balance exceeds 2-3%, as seen in Appendix B.

1.24 Mass balance output is a measure of 'model health' and shows the balance of water flows in to and out of an area. A mass balance error of greater than +/- 1% can be a sign of model instabilities[2]. The mapped 2D mass balance outputs extracted from the model shown in Appendix B show that the areas of water level variability between cells (the hatched areas in Figure 1) coincide with areas of mass balance greater than 1%.

1.25 Overall, the mass balance of the model is within the normal healthy range of +/-1% when viewed as a time-series for the whole simulation. However as noted here, the areas where mass balance is relatively worse than others, does indicate some instabilities in 2D results which are impacting the assessment of the scheme. This variance of mass balance across the model does not mean the original model is not fit for purpose for assessing the impacts of flood risk.

1.26 This more detailed analysis of model stability and mass balance demonstrates that water level differences within +/-20mm should be considered to be within 'model tolerance'.

[2] https://downloads.tuflow.com/_archive/TUFLOW/Releases/2018-03/TUFLOW%20Manual.2018-03.pdf

Previous Model Calibration

1.27 As demonstrated in the analysis above, an “acceptable model tolerance” of +/-10mm is not appropriate in this case. This is further evidenced by the reported calibration of the original Sandford to Mapledurham Thames model, developed by the Environment Agency in 2018.

1.28 Following pre-application advice from the Environment Agency, the Sandford to Mapledurham Thames 2018 model was used as the baseline model for the Flood Risk Assessment, with minimal modifications made including additional survey data and updates to climate change allowances. These updates to the baseline model were accepted by the Environment Agency in August 2020.

1.29 According to Section 5.4 of the “Abingdon Flood Schemes - River Thames Modelling Report”, the Sandford to Mapledurham Thames model level is calibrated to +/-150mm.This is in line with the Environment Agency’s Minimum Technical standards (Reference LIT18686[3]) for hydraulic model calibration.

1.30 Further on in the report, Section 5.4.2 does present the results of calibration sensitivity tests for 2D roughness against the 2003, 2007, 2012 and 2014 flood events. At ‘Culham Tail’, which is located 1km upstream of the proposed scheme, these sensitivity tests improved the calibration of these events to between 30mm and 50mm.

1.31 Given this previous calibration of the model, and the advice to use this model as the basis of the Flood Risk assessment, it is not appropriate to report model results to 10mm with confidence, as the overall calibration is to +/-150mm, and local calibration is achieved to 30-50mm.

1.32 A model tolerance of +/-10mm is unlikely ever to be achieved here, given the scale of the model. For context, the floodplain in the Culham area is approximately 500m wide, and flood depths are more than 2m for the design events simulated (with a 2D grid size of 10m).

1.33 This understanding of model calibration further supports the recommendation that water level differences within +/-20mm should be considered to be within ‘model tolerance’.

Revised model tolerance

1.34 The evidence above and in Appendix A and B supports the recommendation that water level differences within +/-20mm are within ‘model tolerance’. Local calibration of the 2018 model was achieved to within 30 – 50mm of observed data. Instabilities in the model results are typically in the range of 10 – 20mm (with some points up to 50mm). This is a sufficient level of confidence in the model results and assessment for the purpose of FRA and planning.

1.35 Therefore there is not sufficient confidence in the model to report differences greater than +/-10mm as outside of model tolerance. A +/-10mm level of confidence would not be achievable for this model and it not considered necessary for the purpose of FRA and planning.

1.36 The time-series water level results at all 36 points on the floodplain has either shown no difference between baseline and with scheme water level, or has shown instabilities, inherent in the original 2018 model, carried into the results of the baseline and scheme scenarios.

1.37 Figure 3 is an update of the water level difference map, showing impacts greater than +/-20mm. The re-formatted figure shows more clearly where there are predicted to be impacts of the scheme.

1.38 There is one area where water levels are predicted to increase by more than 20mm. This is directly adjacent to the northern arm of the Sutton Courtenay roundabout. This is highlighted in red in Figure 3.

1.39 This area is showing an increase of water level of up to 40mm between the baseline and scheme scenarios. This impact is caused because the proposed scheme cuts off an existing

[3] https://www.gov.uk/government/publications/river-modelling-technical-standards-and-assessment/hydraulic-modelling-best-practice-model-approach

overland flow path at the roundabout. Where most of the overland flow passes through the viaducts in the proposed scheme, there is a small area of pooling which cannot flow through these viaducts where these depth increases are seen. This area is now incorporated into the scheme and is to be purchased by OCC, who can locally manage this increase in flood risk without any consequence on road users or third parties.

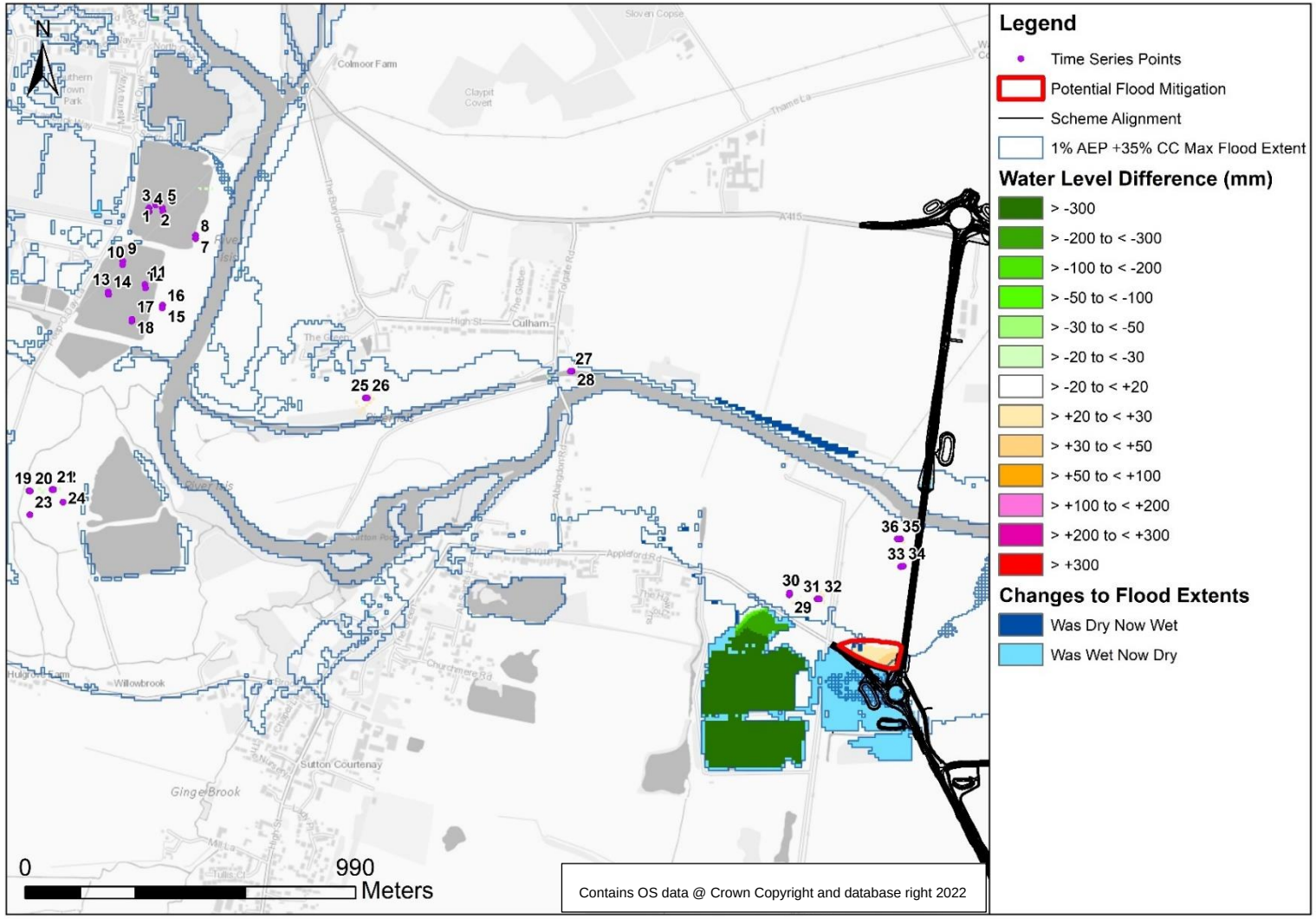


Figure 3 Water Level Difference Map between Baseline and Scheme with 20mm Model Tolerance banding applied

Flood Mitigation and Storage Compensation

1.40 Regarding mitigation, two approaches have been taken for the Didcot to Culham River Crossing section of the scheme.

1.41 Firstly, the main concern was around conveyance of river flows for the Thames crossing, as land raising (i.e. embankments) in the flood plain was found to significantly impact depths and extent of flooding, impacting local receptors. Therefore, the crossing design chosen was an open viaduct span bridge. This design allows flows to move under the structure and through the area without impediment, therefore maintaining current flood extents and minimising flood depth changes. In turn, this reduces the need for large flood storage areas.

1.42 Secondly, in addition to the approach of an open span viaduct crossing design, Level for Level Flood Compensation is presented in Table 4.3 of the FRA and drawing RIV_PD-ACM-GEN-SW_ZZ_ZZ_ZZ-DR-CH-0011 (Appendix C).

1.43 The purpose of this compensation is to offset the footprint of the scheme within the floodplain, and within the redline boundary, as seen in Appendix C. This was calculated in 200mm increments in the FRA. This has now been revised to the 100mm increments as requested and is shown in Table 1.

1.44 This revised table shows that there is no loss of floodplain volume in any increment of level, and indeed there is a net gain at each ground level increment as a result of the scheme.

1.45 As discussed in the FRA sections 7.1.8 to 7.1.15, the design of the floodplain compensation is currently based upon the 1% AEP event plus 35% climate change allowance. With the updated climate change guidance published in July 2021, this is in excess of the minimum requirement of the 1% AEP event plus 26% climate change allowance, and therefore provides additional flood storage.

Table 1 Level for Level Flood Compensation

Plane Height mAOD	Volume lost due to Scheme (m^3)	Volume provided from Storage compensation (m^3)	+/- Volume gain (m^3) in Flood Plain from storage compensation
48.1	1	2	+1
48.2	23	31	+8
48.3	44	53	+9
48.4	76	82	+6
48.5	102	110	+8
48.6	110	125	+15
48.7	155	163	+8
48.8	233	257	+24
48.9	503	538	+35
49	758	773	+15
49.1	854	864	+10
49.2	925	942	+17
49.3	987	1040	+53
49.4	1073	1082	+9
49.5	1174	1196	+22
49.6	1257	1275	+18
49.7	1356	1382	+26
49.8	1448	1470	+22
49.9	1506	1540	+34
50	1557	1643	+86

Conclusion

1.46 The purpose of this analysis is to re-examine what an acceptable model tolerance should be for assessment of flood modelling results, and whether adequate mitigation has been included in the design of the Didcot to Culham River Crossing.

1.47 On further examination of the model results and the design for mitigation the conclusions are:

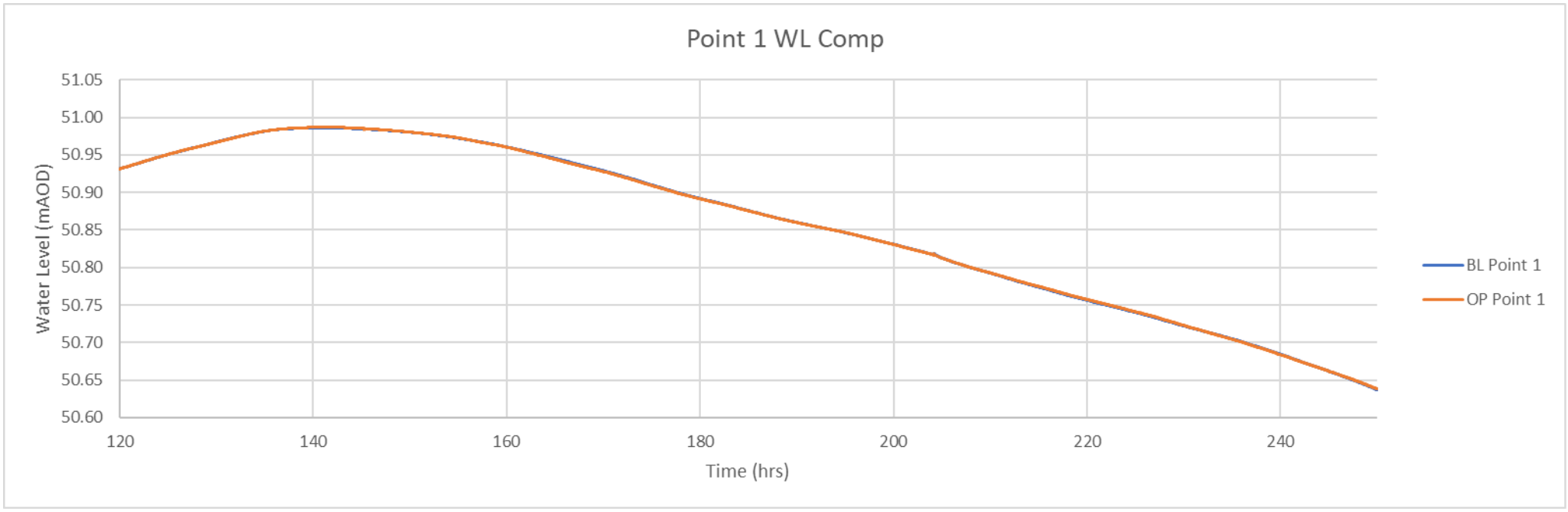
- Based on a detailed analysis of time series data model results, mass balance and calibration and sensitivity tests from original model, it is recommended that water level differences are outside 'model tolerance' when greater than +/-20mm;
- On this basis, there is one area where increases in modelled flood level are predicted to be greater than 20mm, immediately adjacent to the proposed Sutton Courtenay Roundabout
- This impacted parcel of land is to be subject to a compulsory purchase order to enable management of the residual increase in flood levels, ensuring no impacts to third parties or users of the road
- Level for Level storage compensation design creates a net gain in flood plain storage at each plane height (mAOD) and is designed for the 1% AEP plus 35% climate change event therefore providing storage over and above the minimum requirements.

Appendix A PO Time-series Water Level Plots

Abbreviations on graphs:

BL = Baseline Scenario

OP = Scheme Scenario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50.90
50.85
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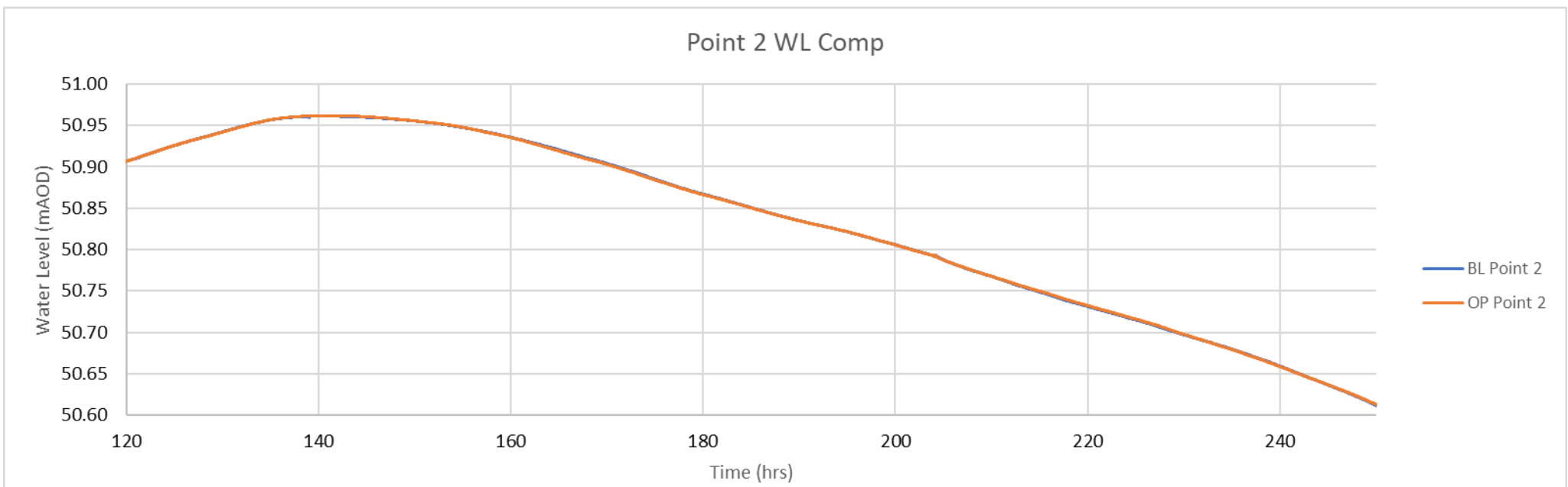
240
Time (hrs)
BL Point 1
OP Point 1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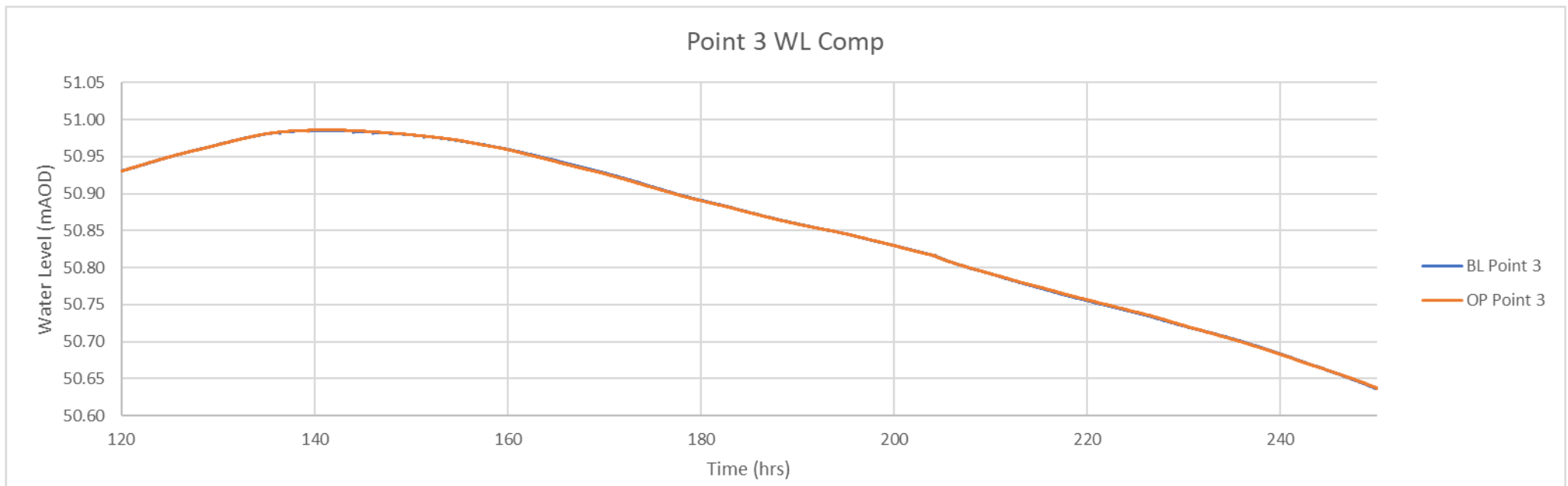
OP Point 2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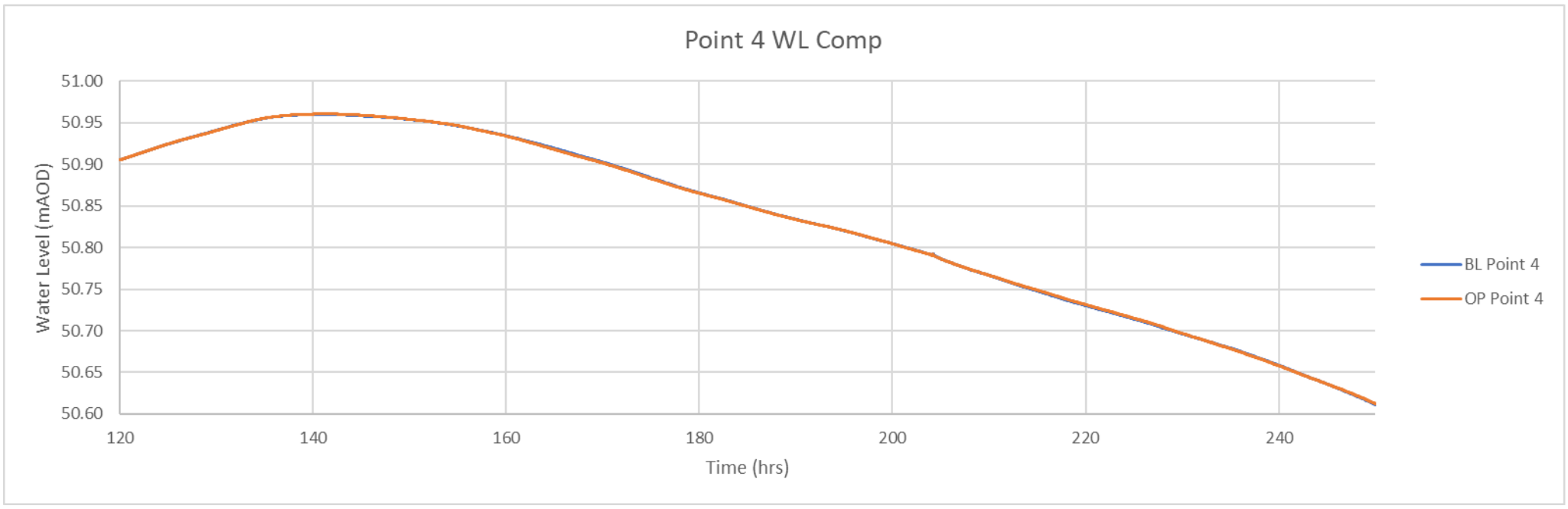
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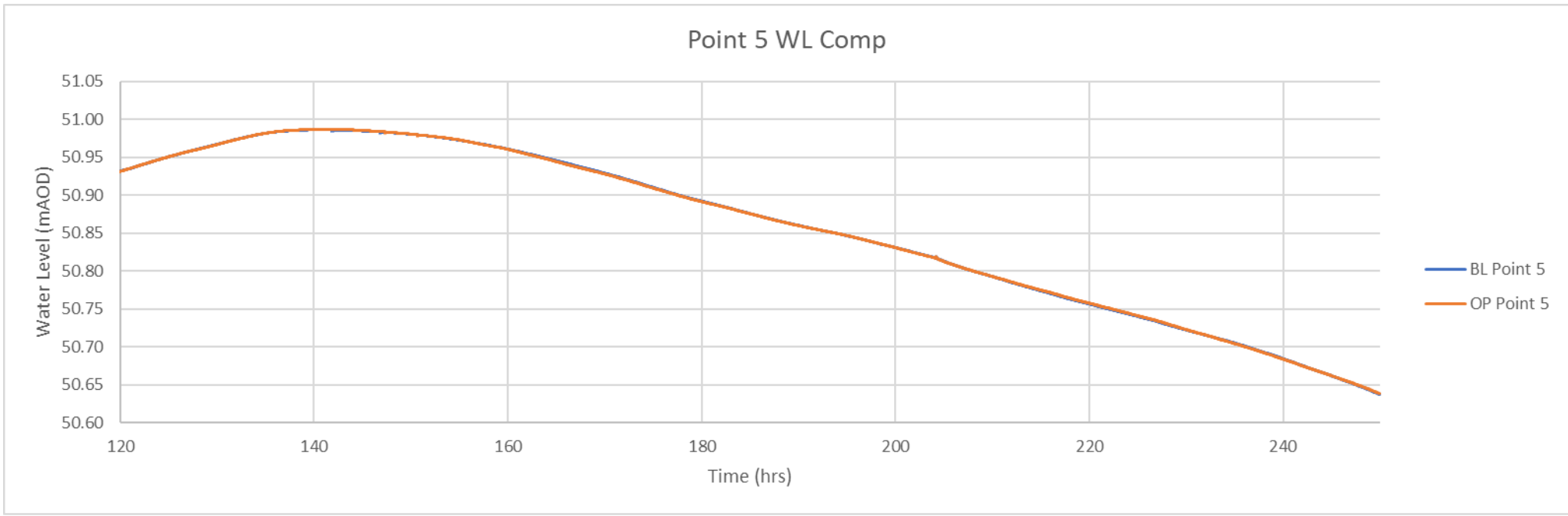
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Time (hrs)
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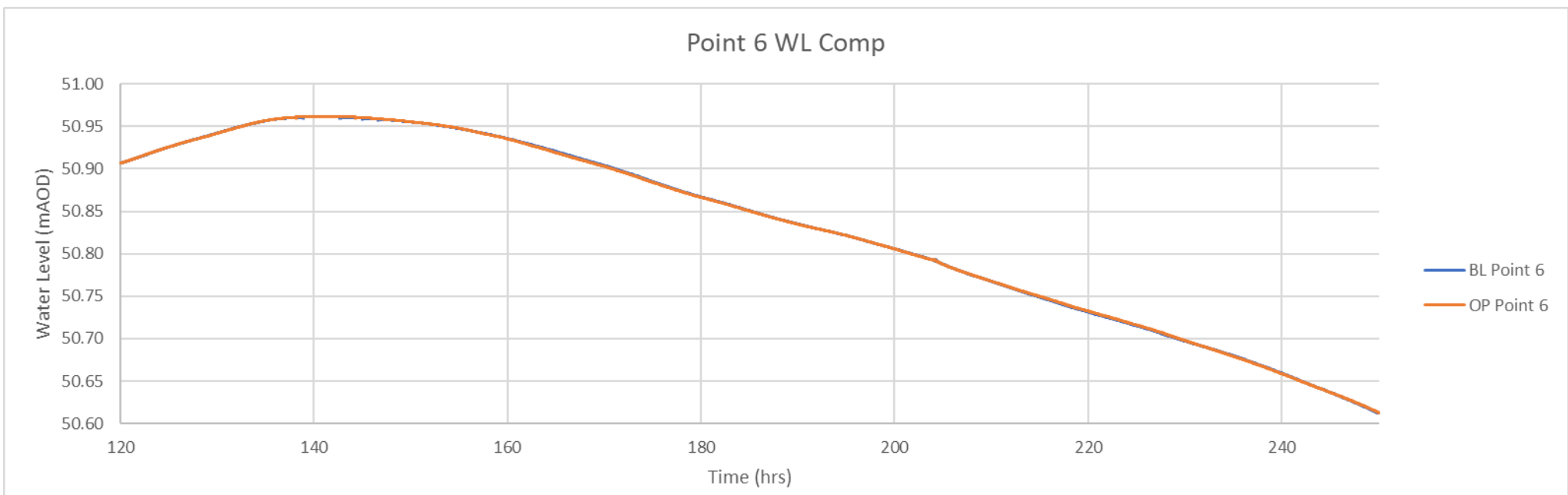
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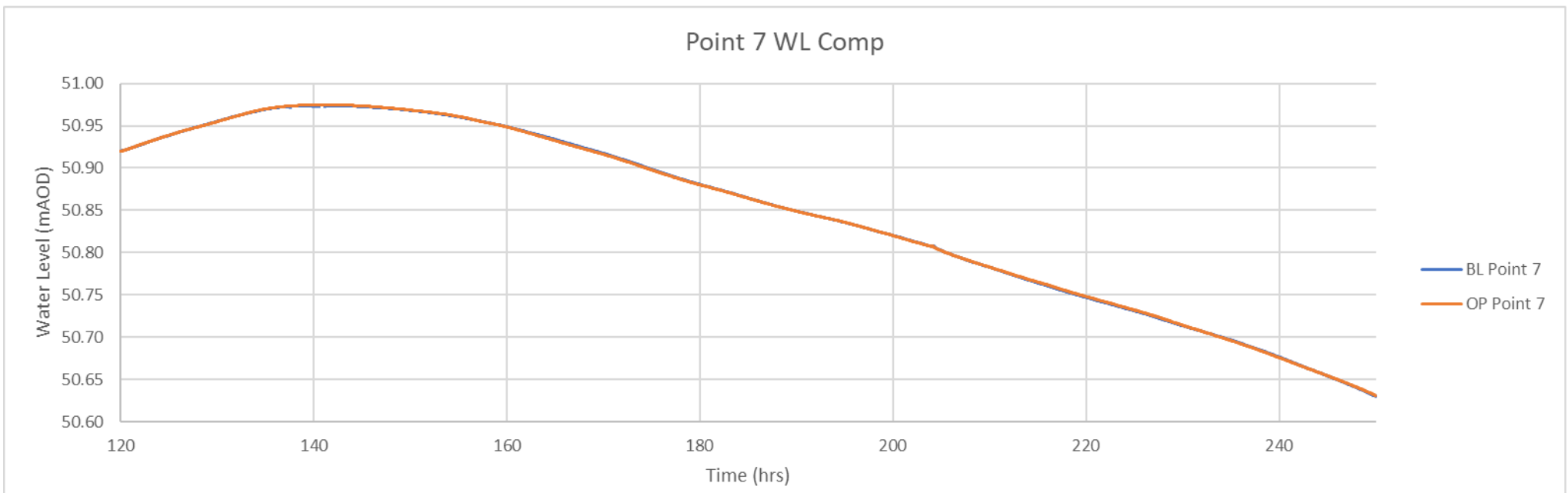
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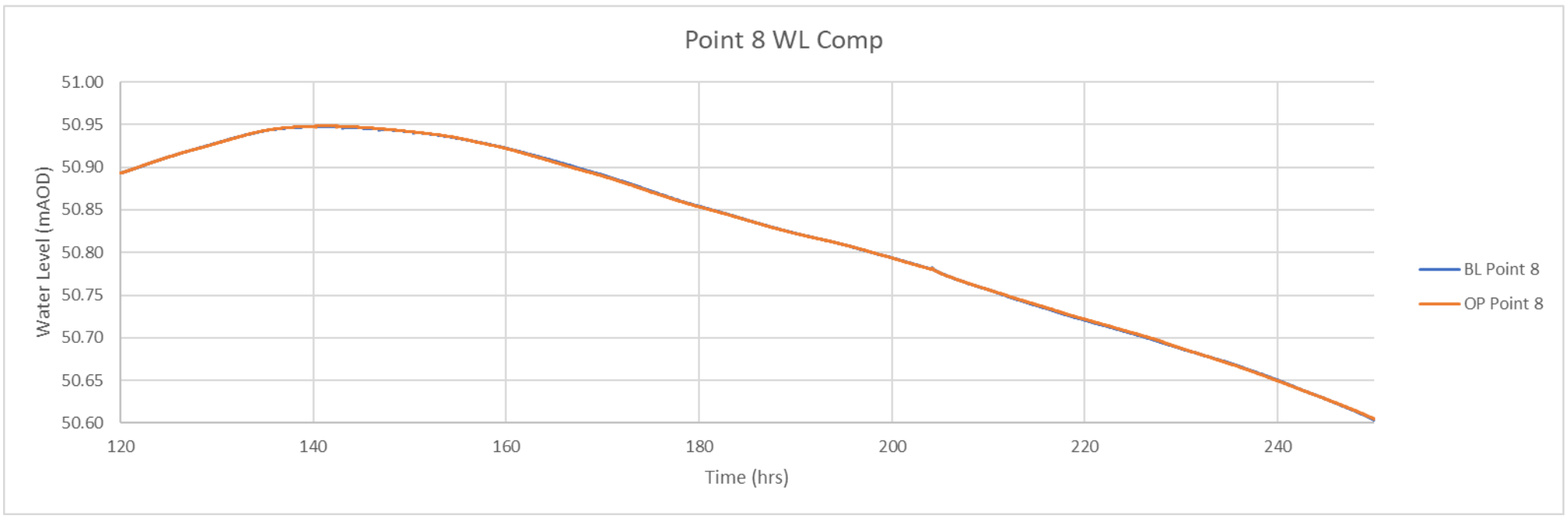
OP Point 7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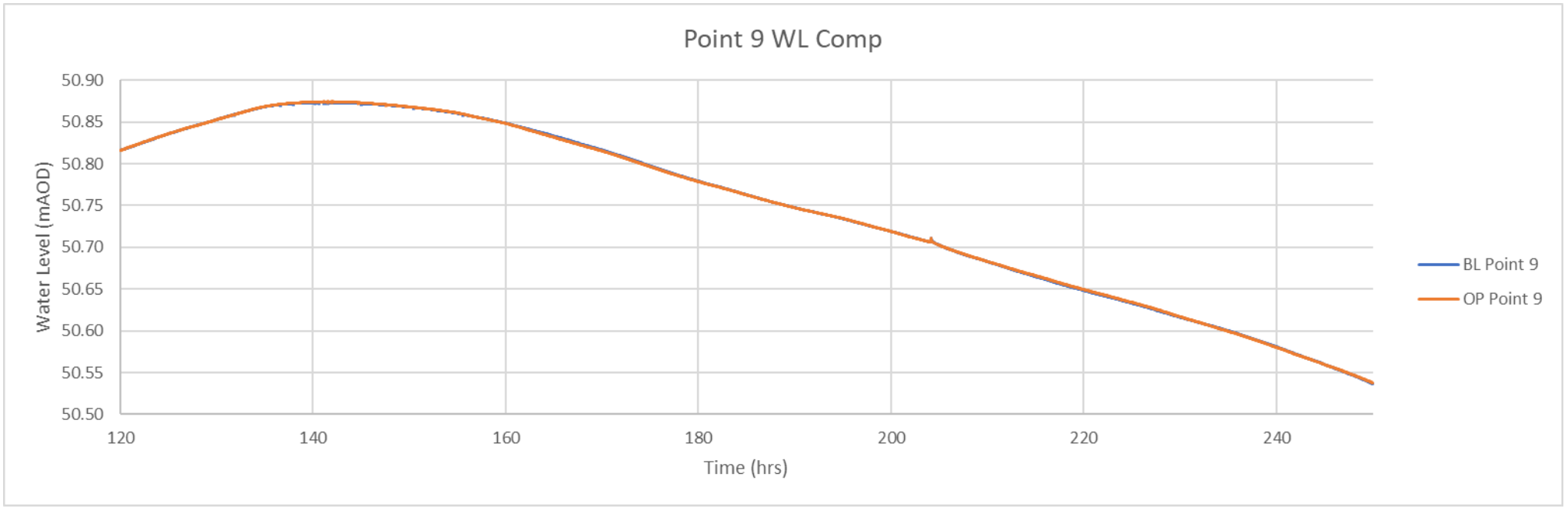
OP Point 8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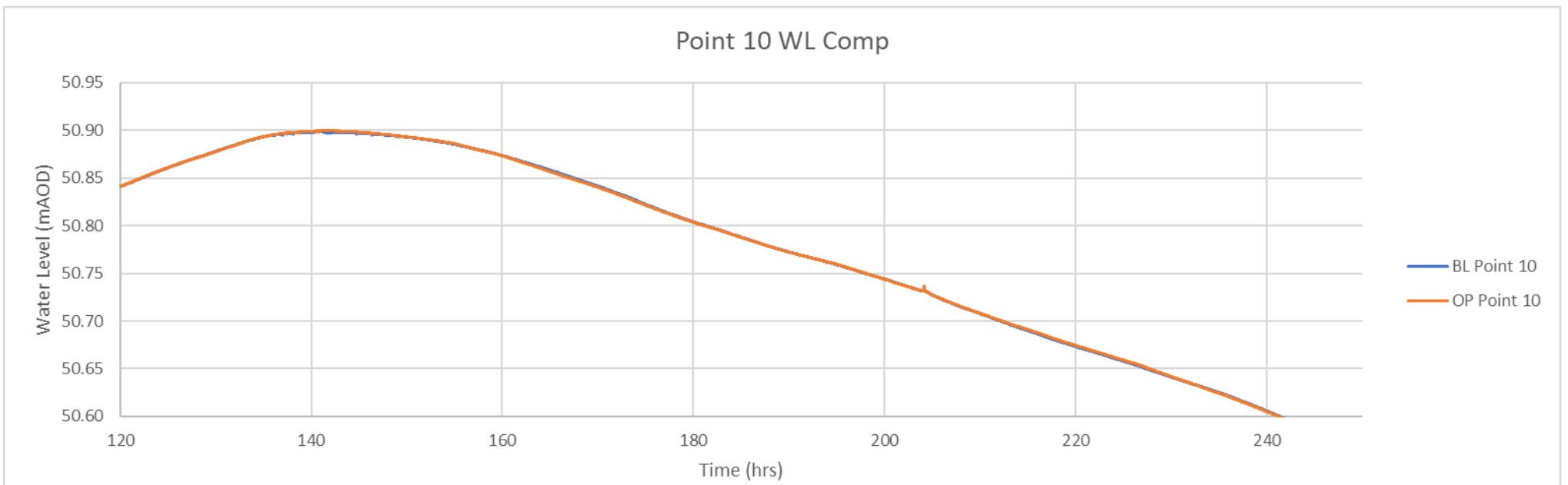
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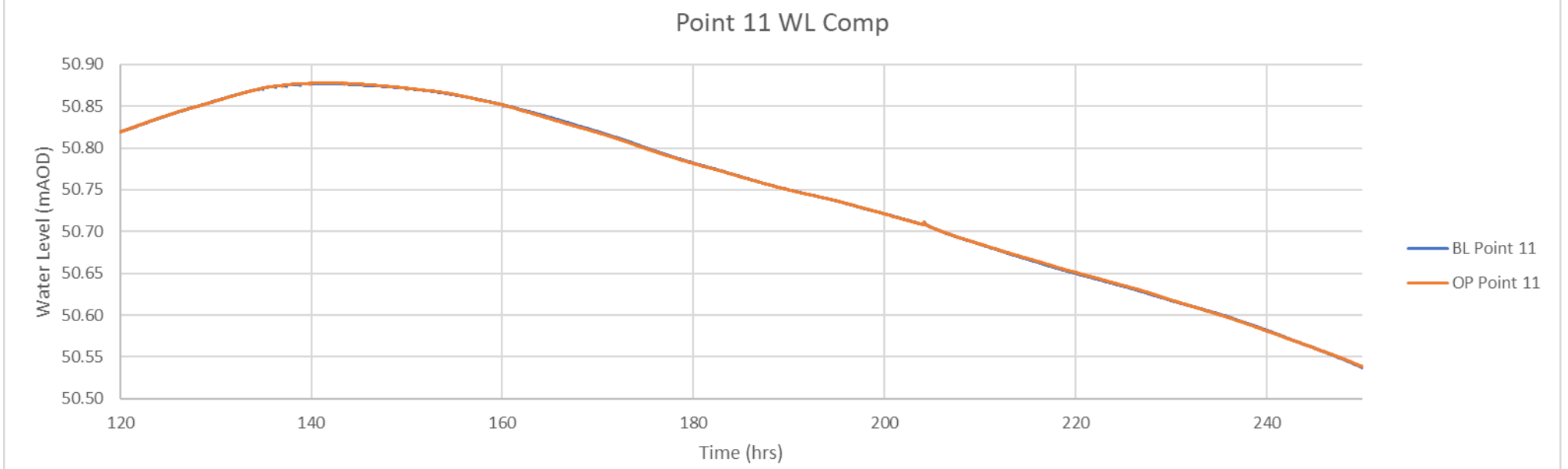
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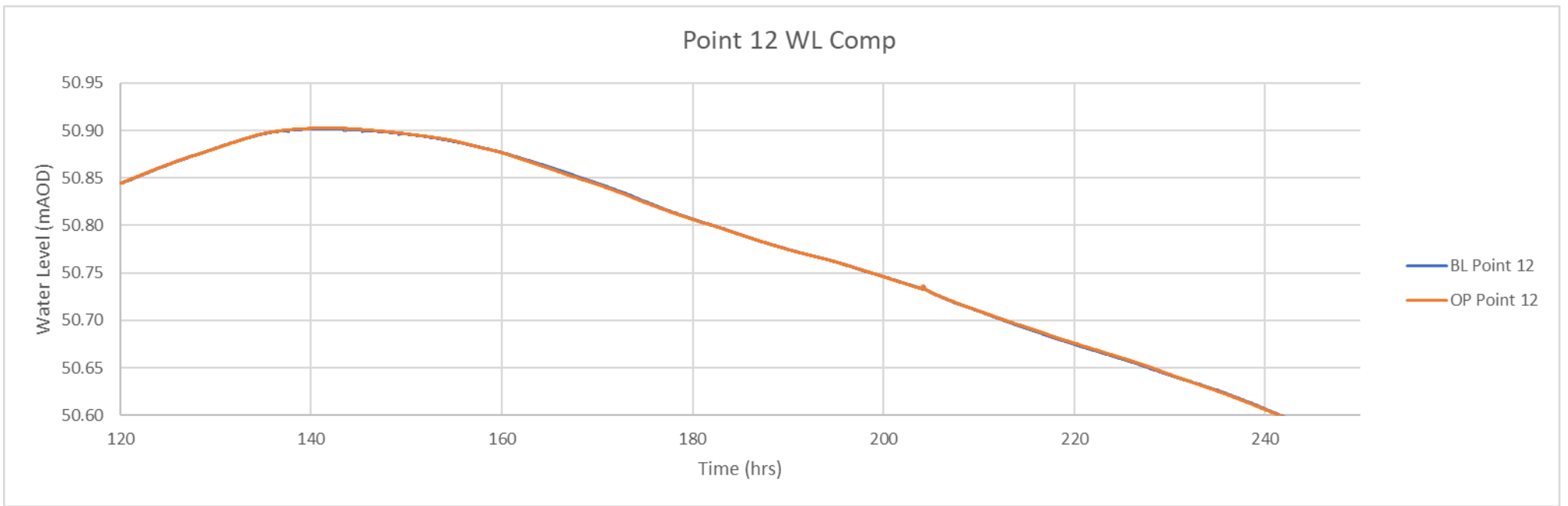
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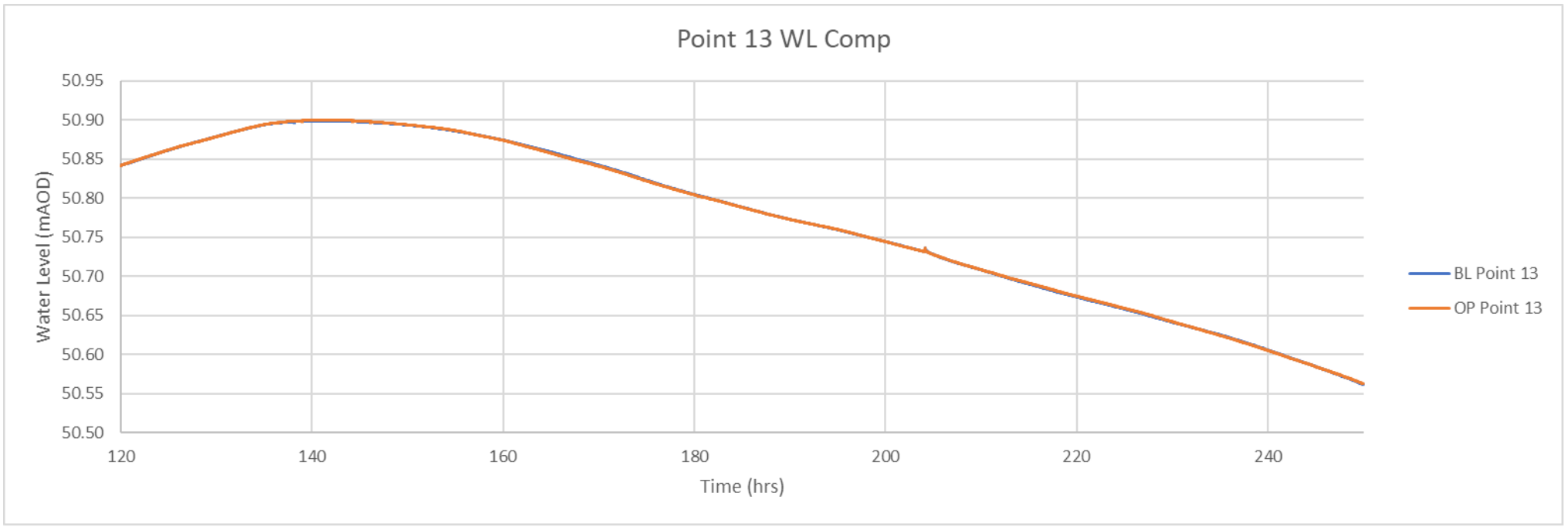
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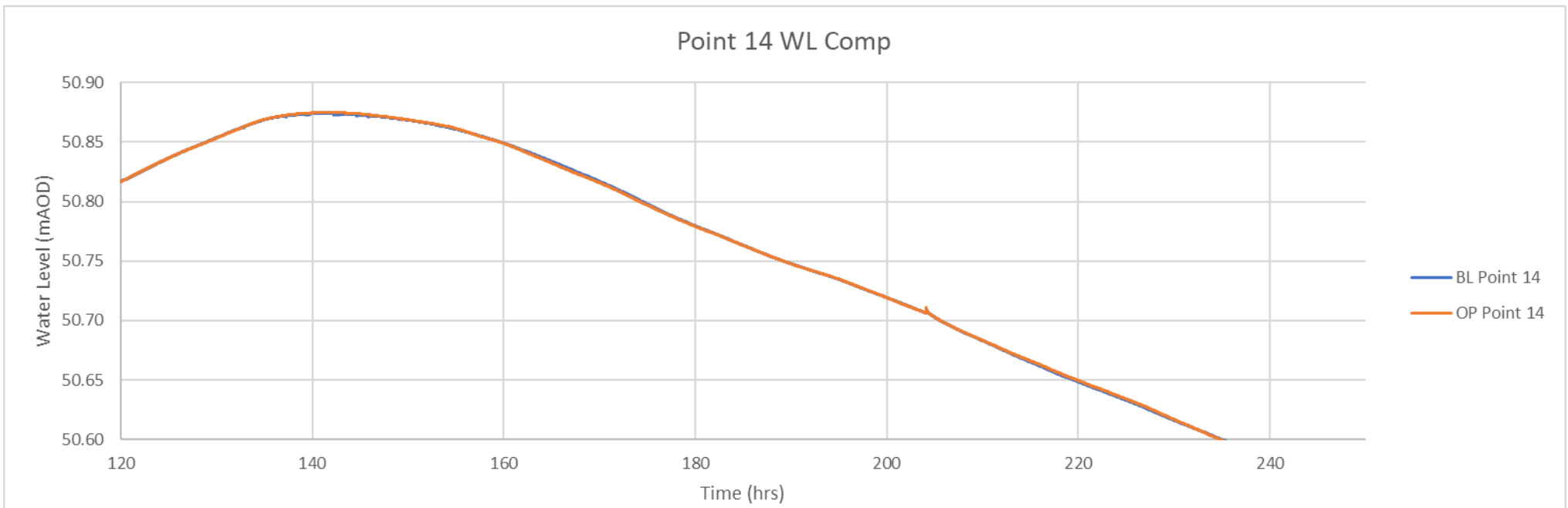
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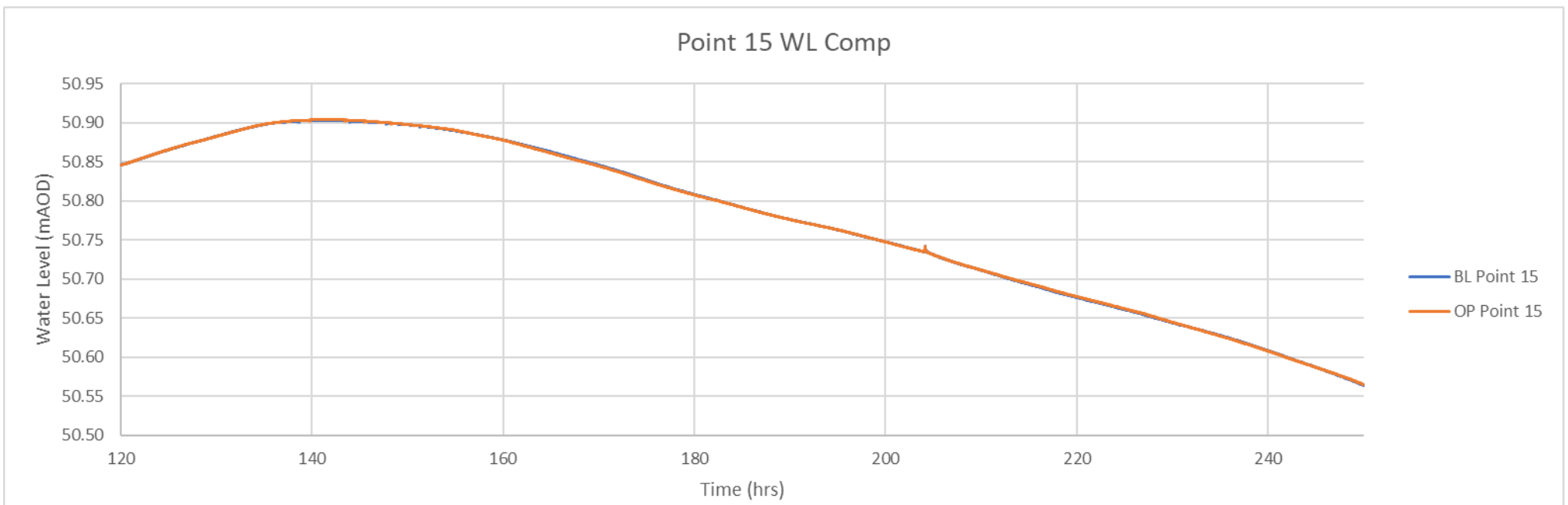
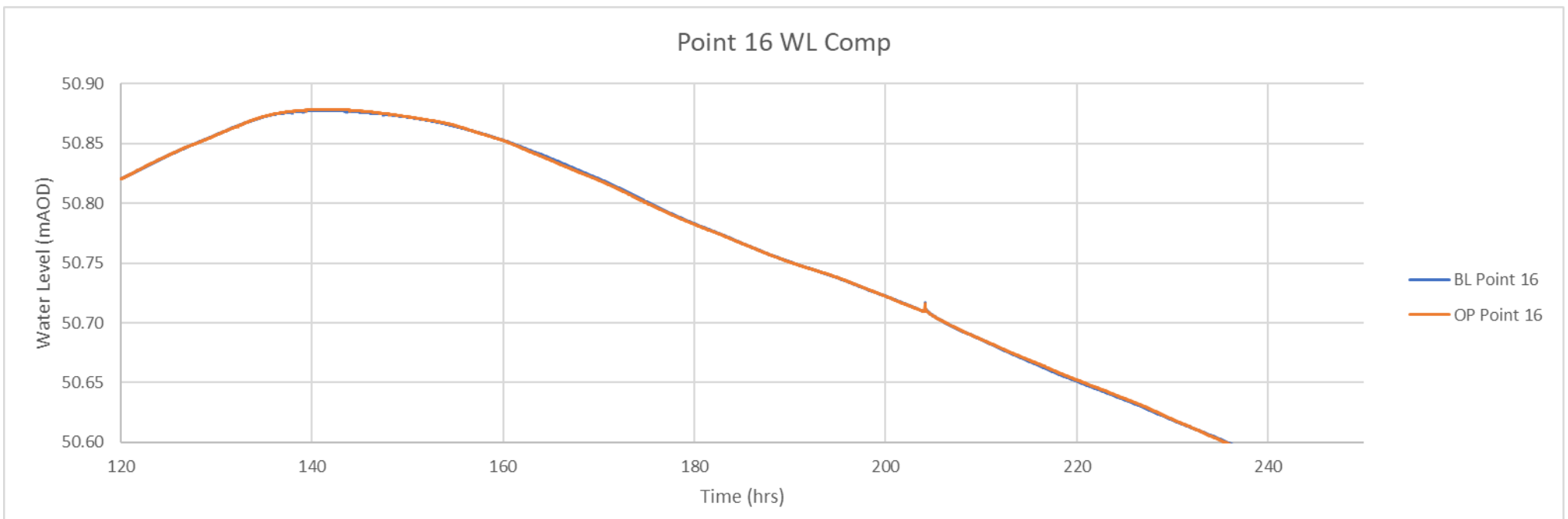
Time (hrs)
BL Point 14
OP Point 14


Point 15 WL Comp
Water Level (mAOD)
50.95
50.90
50.85
50.80
50.75
50.70
50.65
50.60
50.55
50.50
120
140
160
180
200
220
240
Time (hrs)
BL Point 15
OP Point 15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Water Level (mAOD)
50.90
50.85
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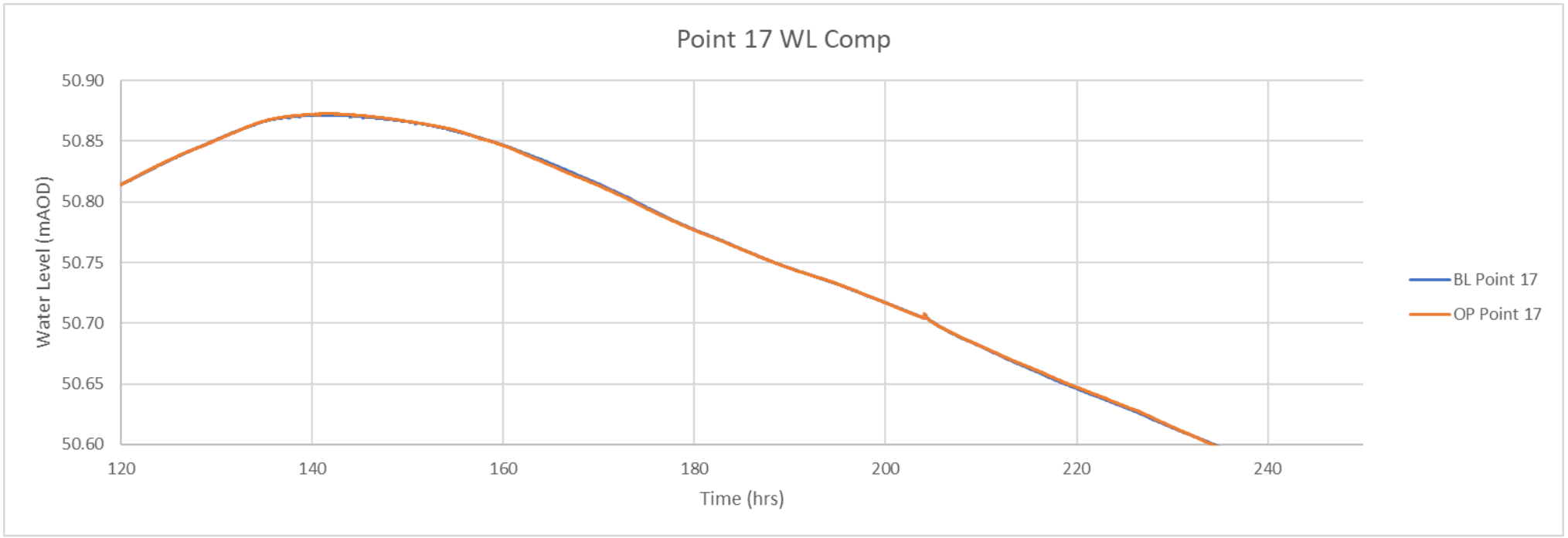
50.65
50.60
120
140
160
180
200
220
240
Time (hrs)
BL Point 16
OP Point 16


Point 17 WL Comp
Water Level (mAOD)
50.90
50.85
50.80
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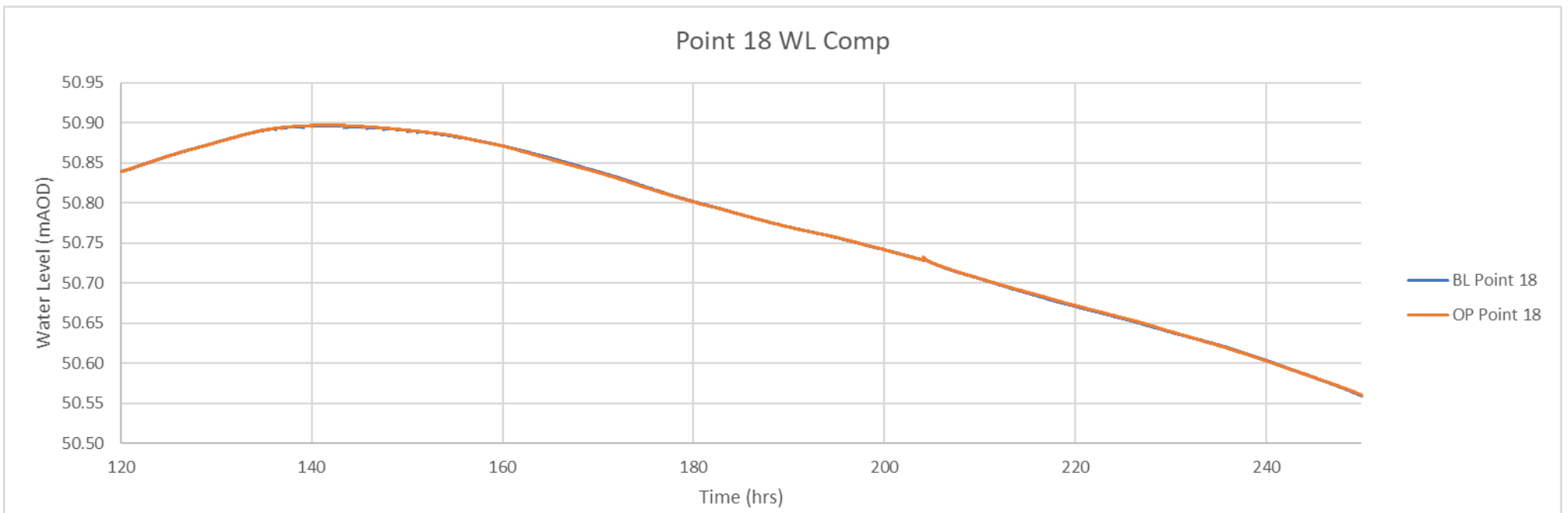
50.60
120
140
160
180
200
220
240
Time (hrs)
BL Point 17
OP Point 17


Point 18 WL Comp
Water Level (mAOD)
50.95
50.90
50.85
50.80
50.75
50.70
50.65
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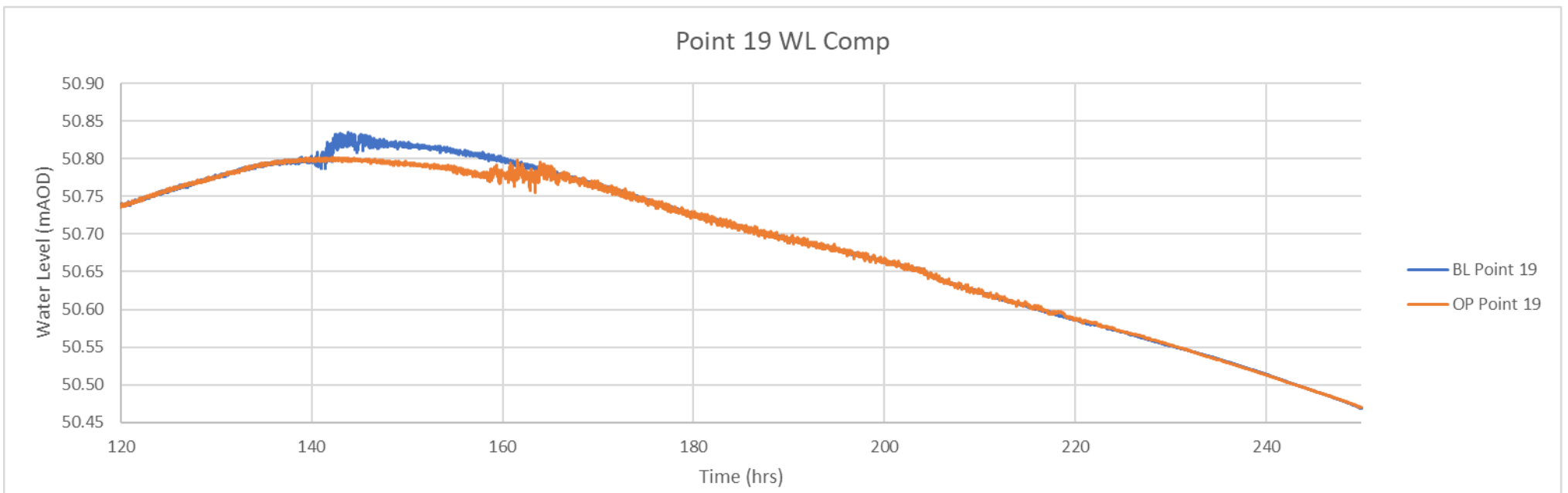
50.55
50.50
120
140
160
180
200
220
240
Time (hrs)
BL Point 18
OP Point 18


Point 19 WL Comp
Water Level (mAOD)
50.90
50.85
50.80
50.75
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50.65
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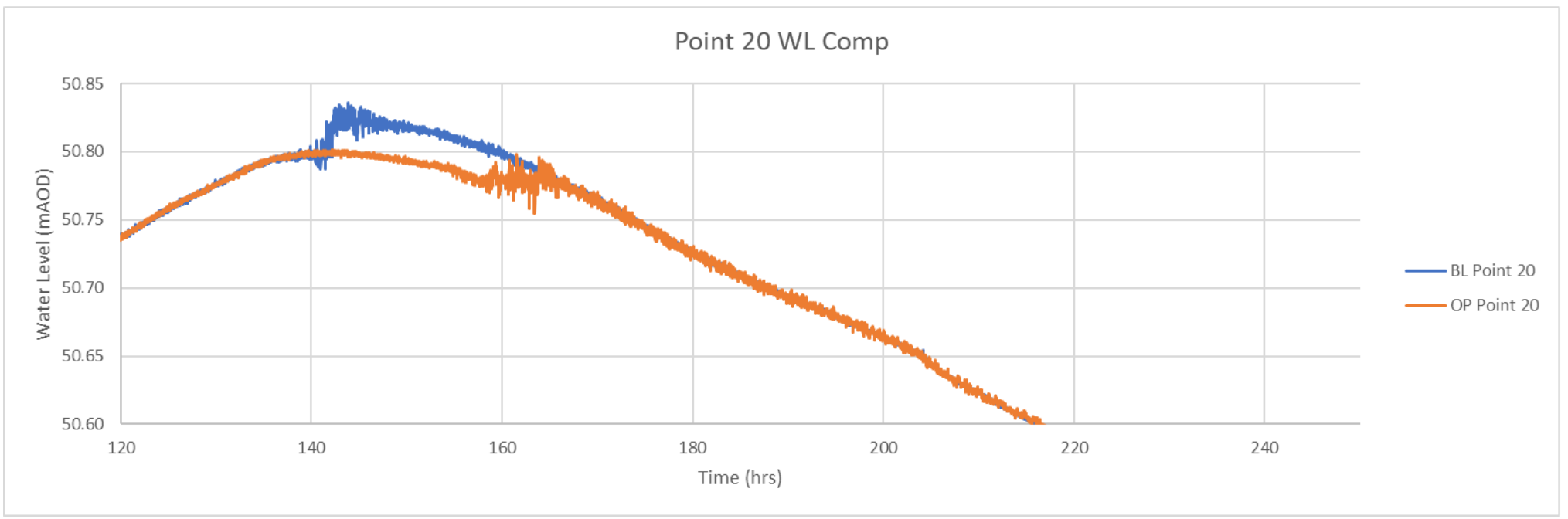
140
160
180
200
220
240
Time (hrs)
BL Point 19
OP Point 19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Water Level (mAOD)
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50.80
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120
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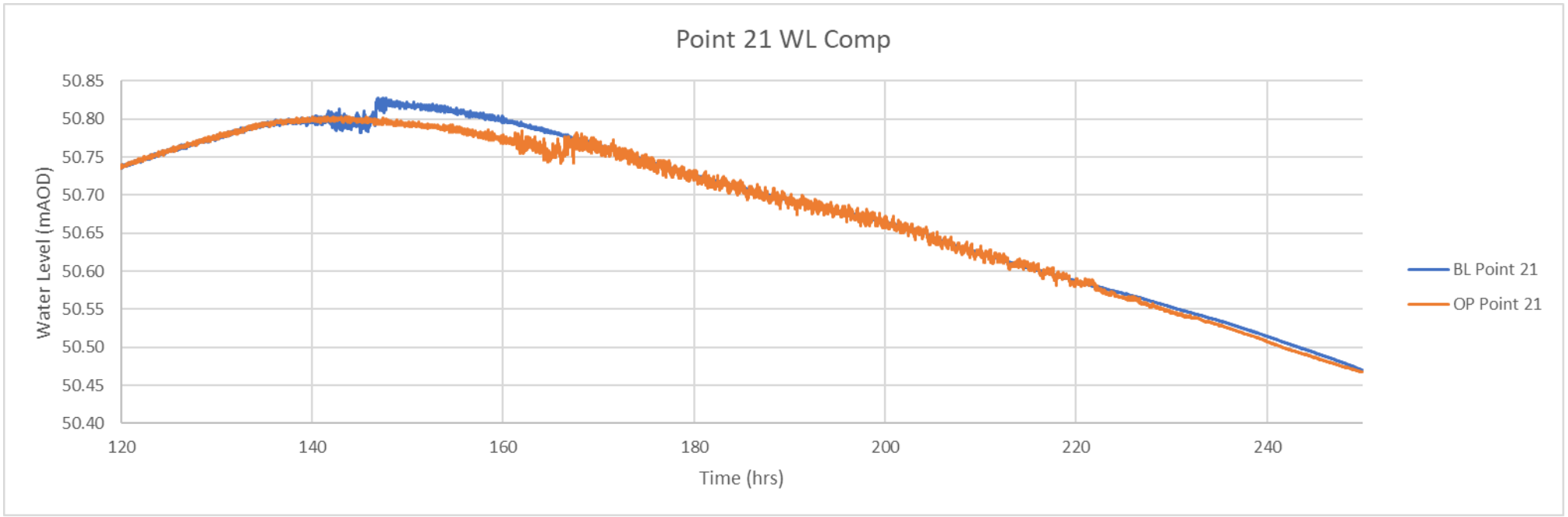
160
180
200
220
240
Time (hrs)
BL Point 20
OP Point 20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Water Level (mAOD)
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50.80
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50.65
50.60
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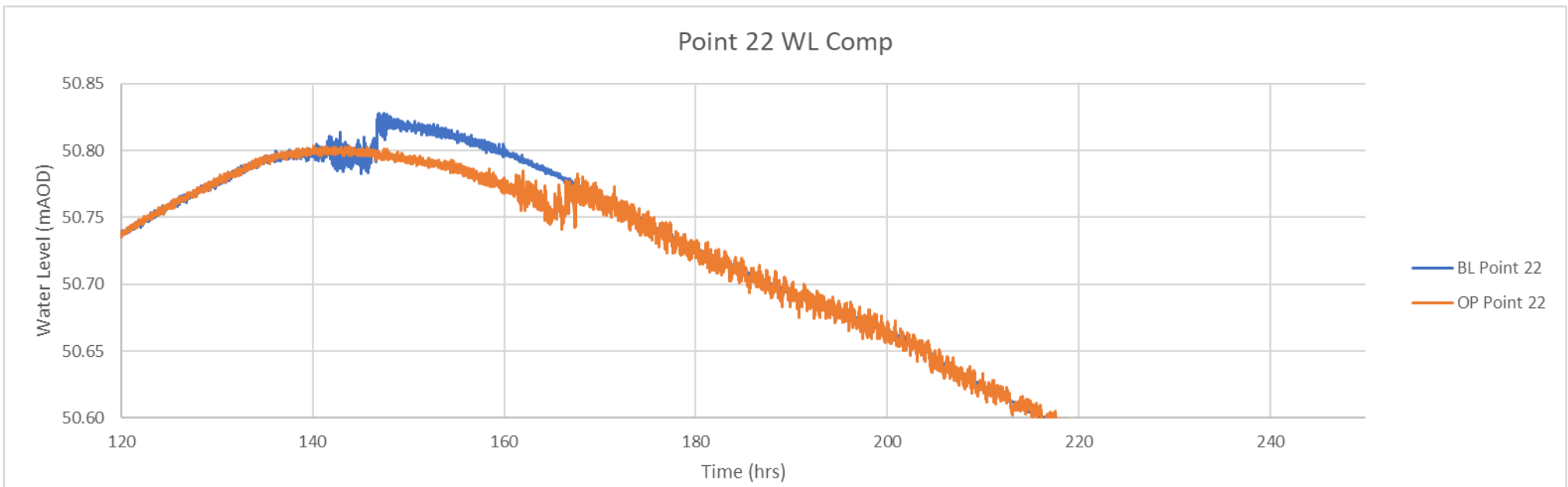
50.45
50.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 21
OP Point 21


Point 22 WL Comp
Water Level (mAOD)
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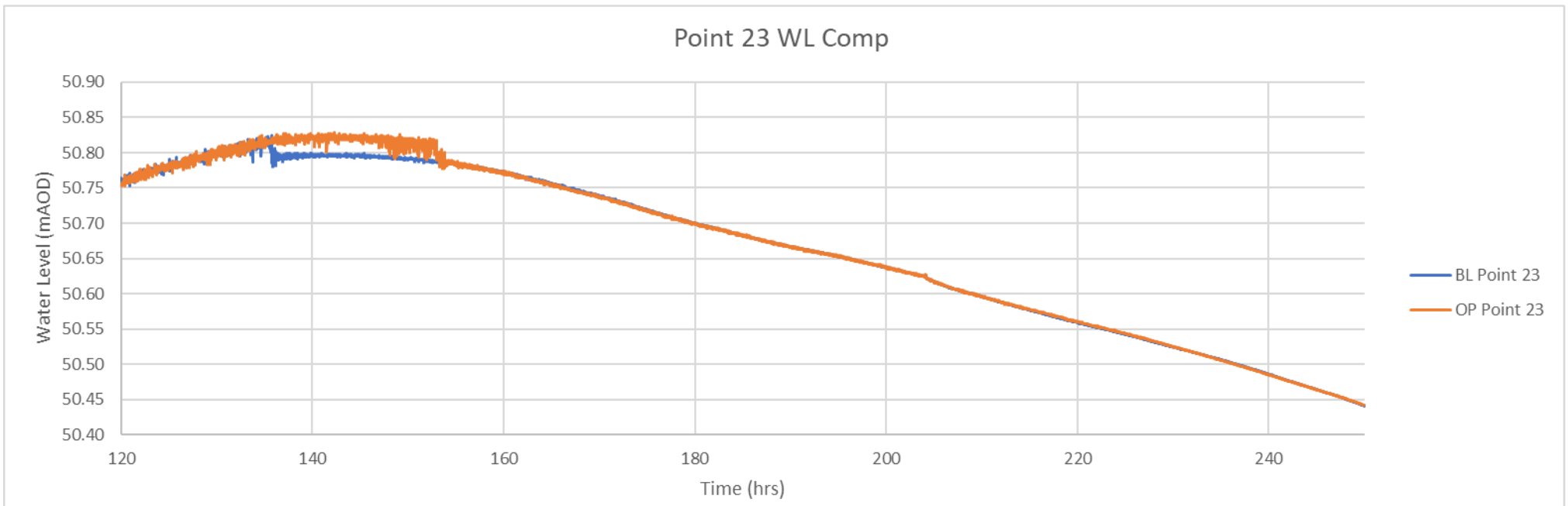
50.65
50.60
120
140
160
180
200
220
240
Time (hrs)
BL Point 22
OP Point 22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Water Level (mAOD)
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50.85
50.80
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50.70
50.65
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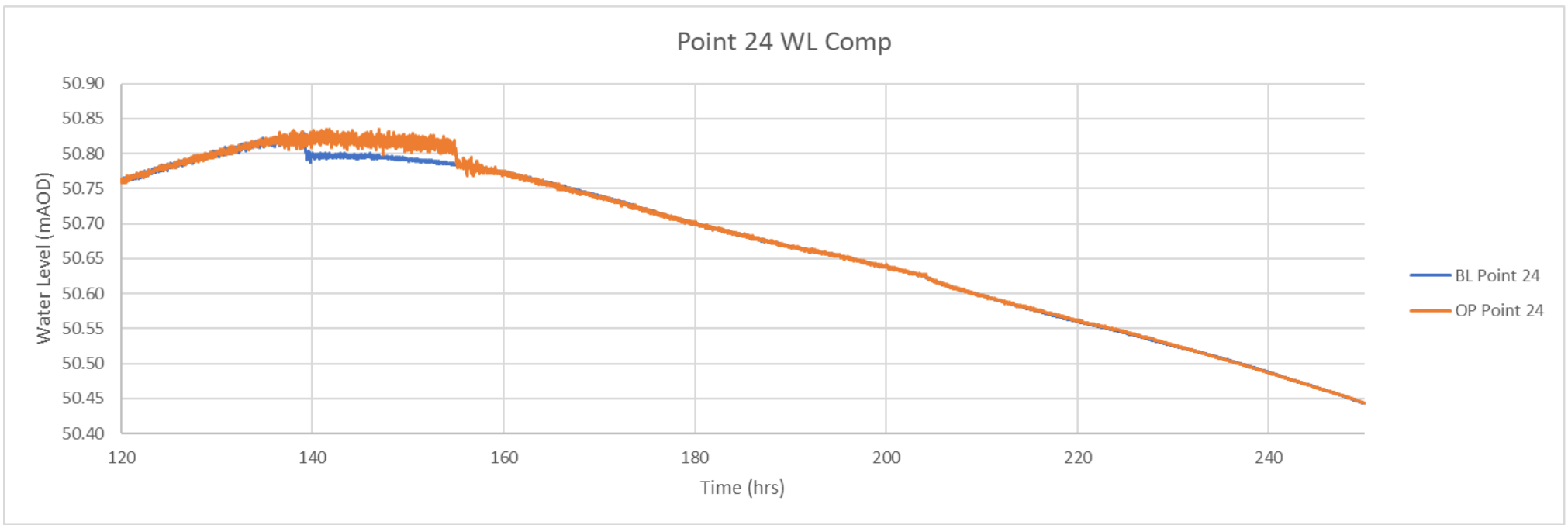
50.45
50.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 23
OP Point 23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Water Level (mAOD)
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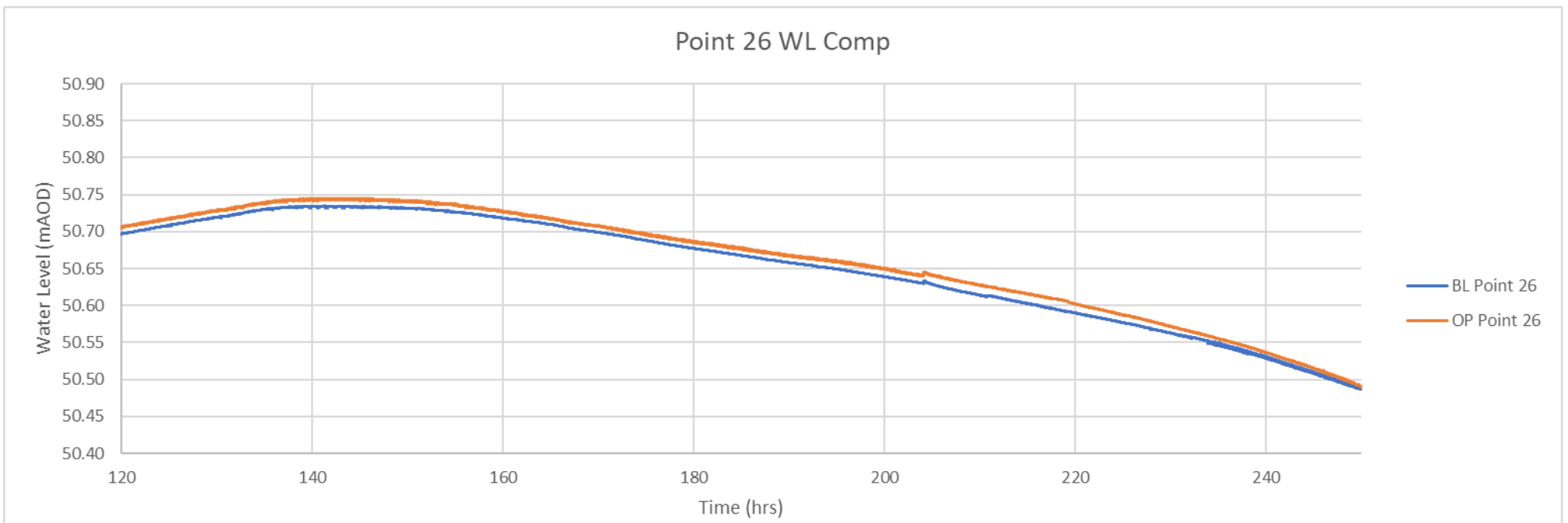
50.60
50.55
50.50
50.45
50.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 24
OP Point 24


Point 25 WL Comp
Water Level (mAOD)
50.90
50.85
50.80
50.75
50.70
50.65
50.60
50.55
50.50
50.45
50.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 25
OP Point 25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Water Level (mAOD)
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50.80
50.75
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50.65
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50.45
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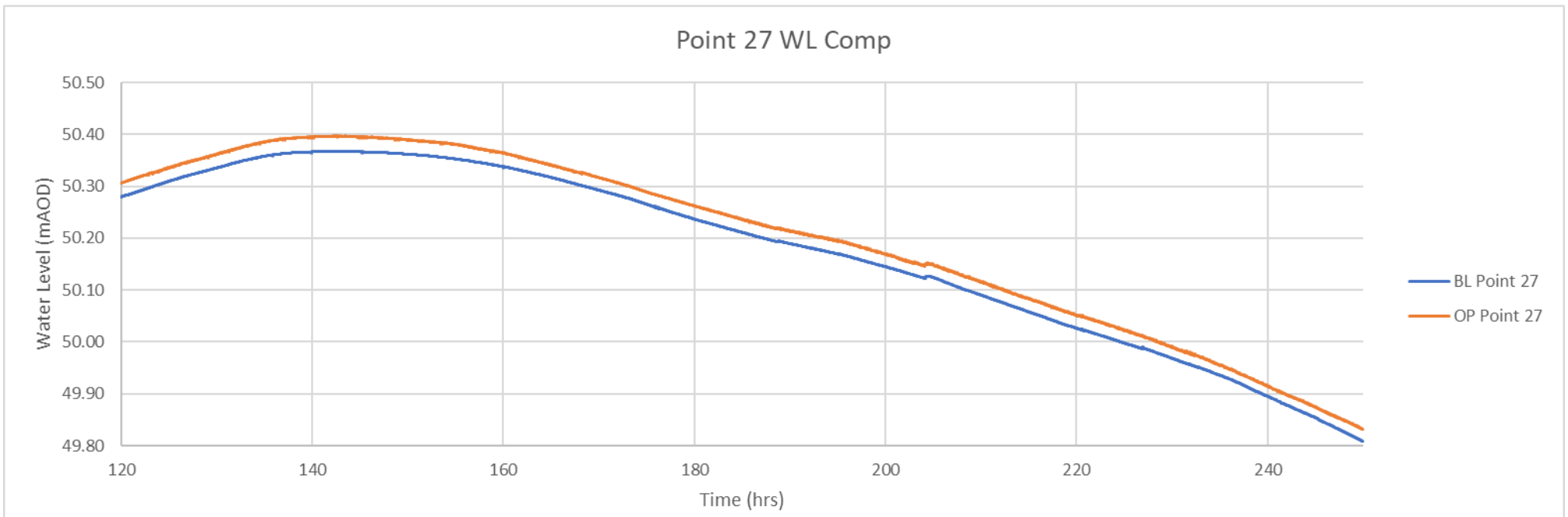
120
140
160
180
200
220
240
Time (hrs)
BL Point 26
OP Point 26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Water Level (mAOD)
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50.30
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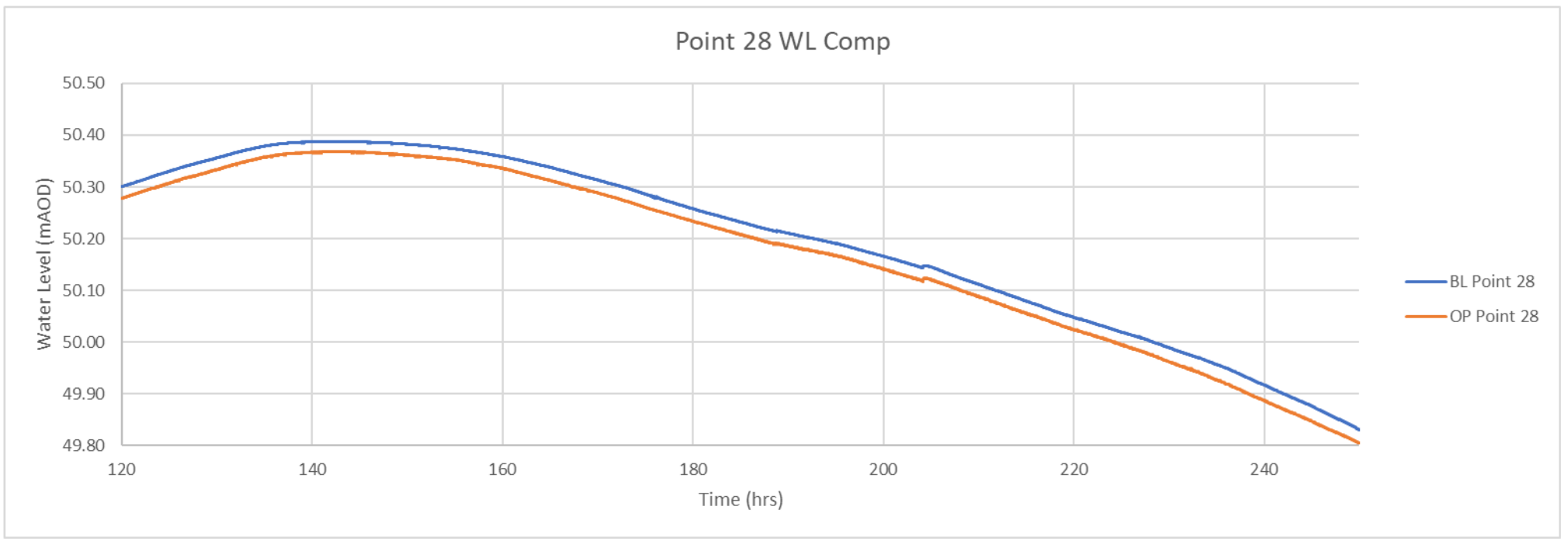
49.90
49.80
120
140
160
180
200
220
240
Time (hrs)
BL Point 27
OP Point 27


Point 28 WL Comp
Water Level (mAOD)
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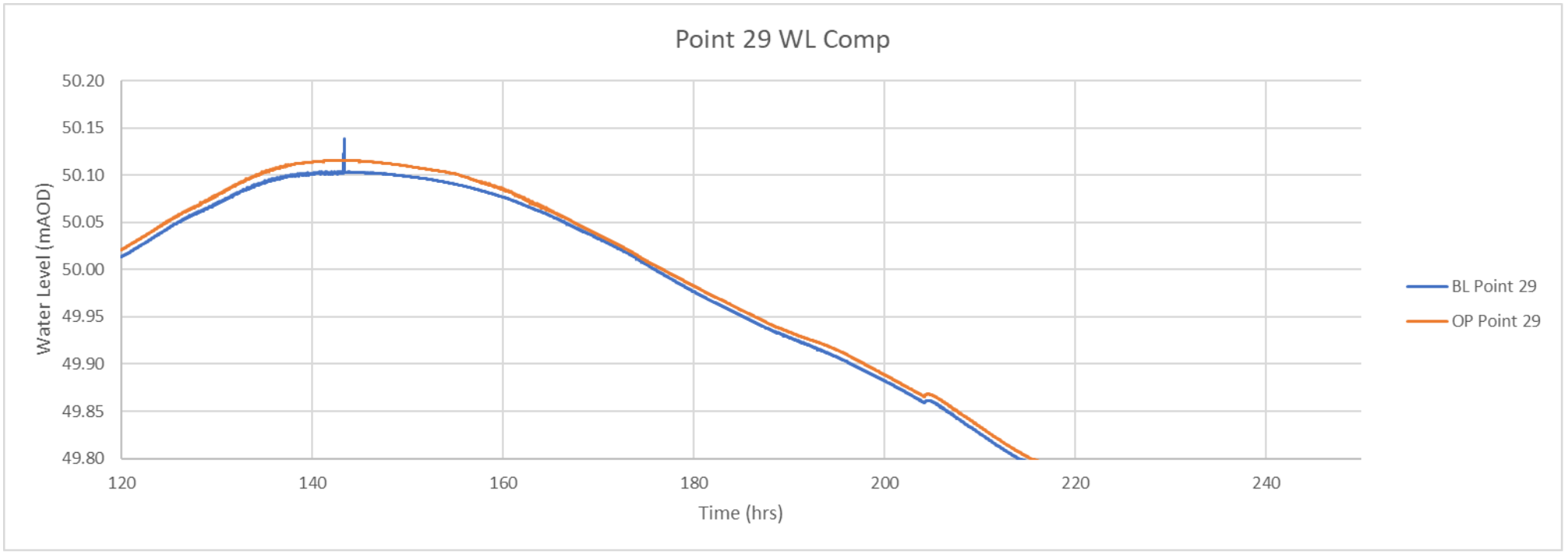
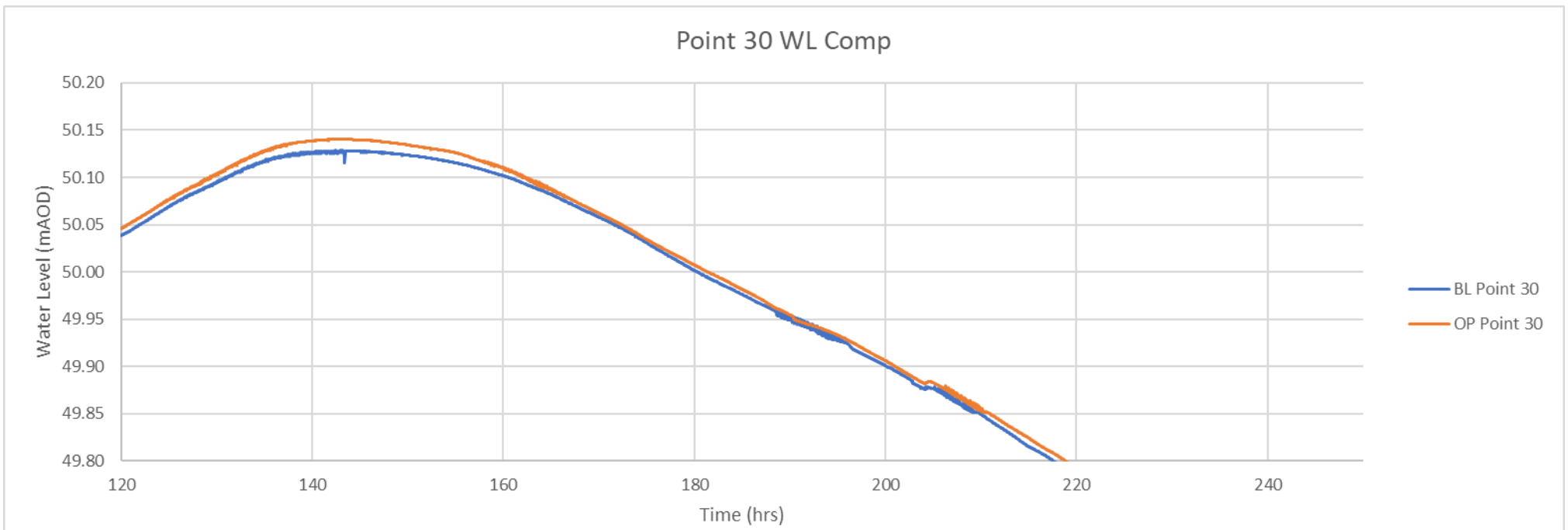
50.40
50.30
50.20
50.10
50.00
49.90
49.80
120
140
160
180
200
220
240
Time (hrs)
BL Point 28
OP Point 28


Point 29 WL Comp
Water Level (mAOD)
50.20
50.15
50.10
50.05
50.00
49.95
49.90
49.85
49.80
120
140
160
180
200
220
240
Time (hrs)
BL Point 29
OP Point 29


Point 30 WL Comp
Water Level (mAOD)
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50.10
50.05
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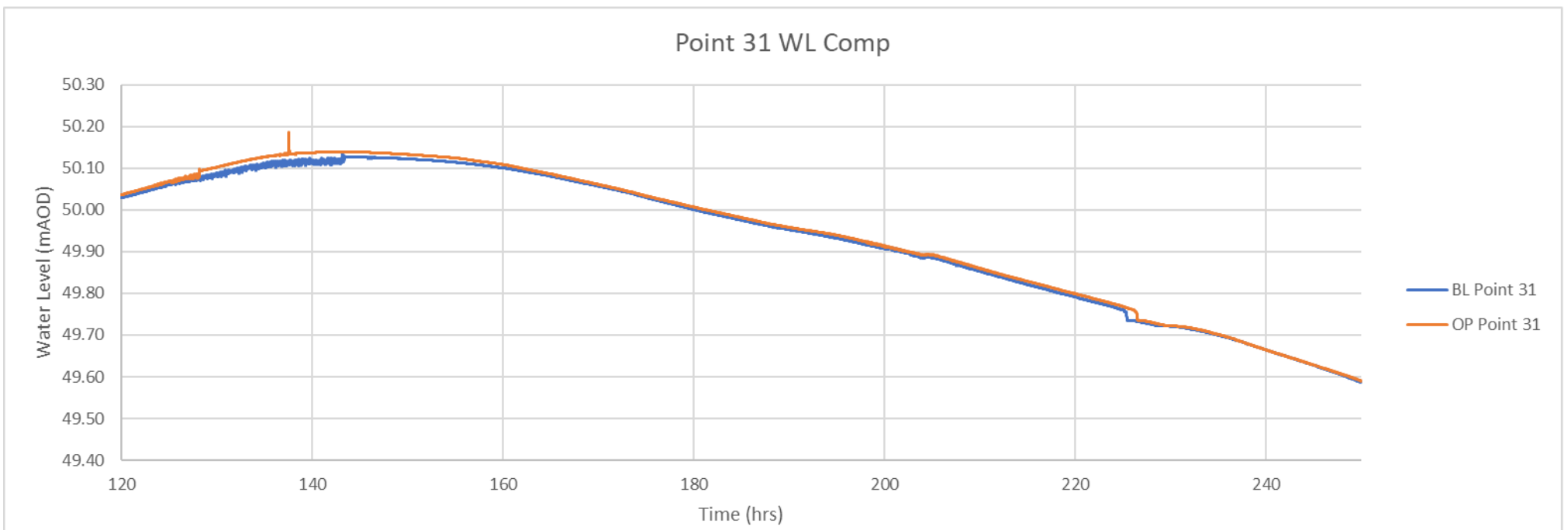
49.85
49.80
120
140
160
180
200
220
240
Time (hrs)
BL Point 30
OP Point 30


Point 31 WL Comp
Water Level (mAOD)
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50.10
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49.50
49.40
120
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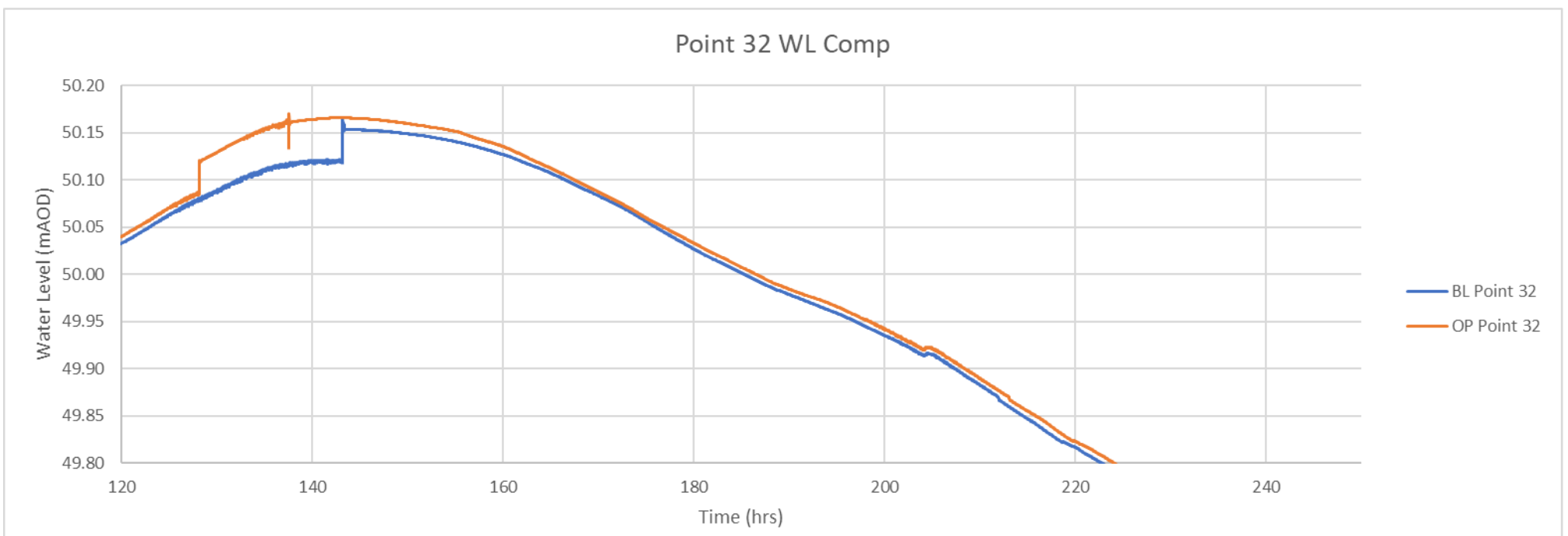
200
220
240
Time (hrs)
BL Point 31
OP Point 31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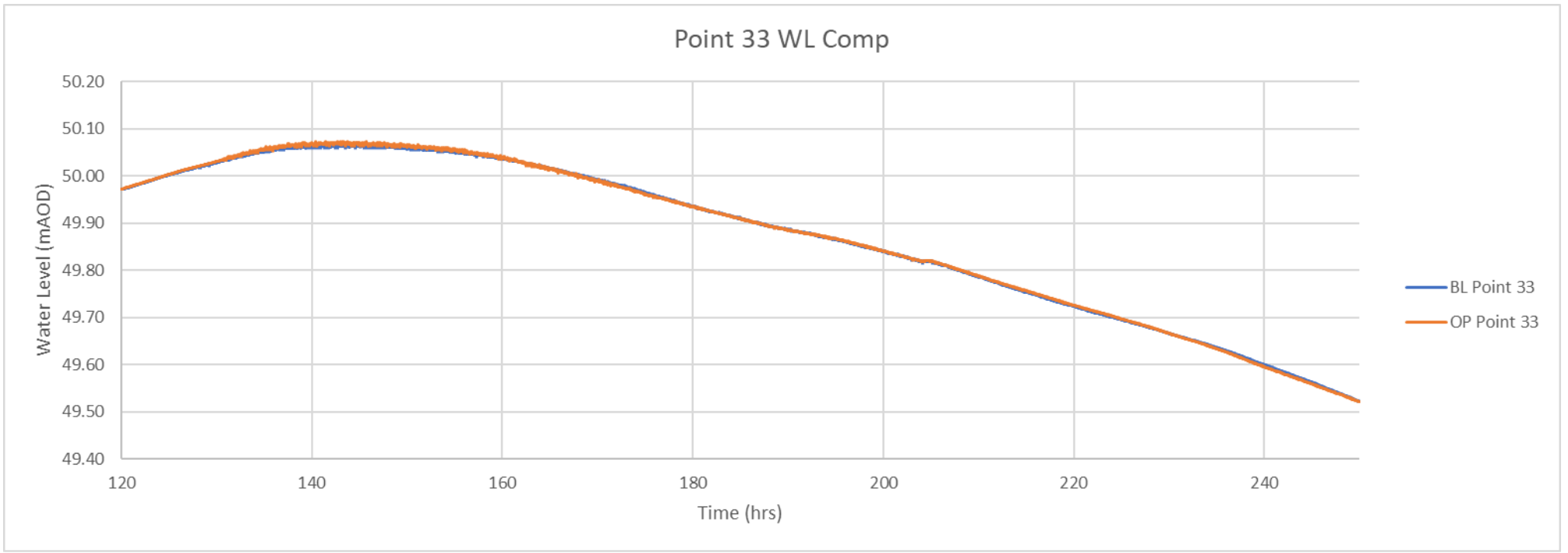
200
220
240
Time (hrs)
BL Point 32
OP Point 32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Water Level (mAOD)
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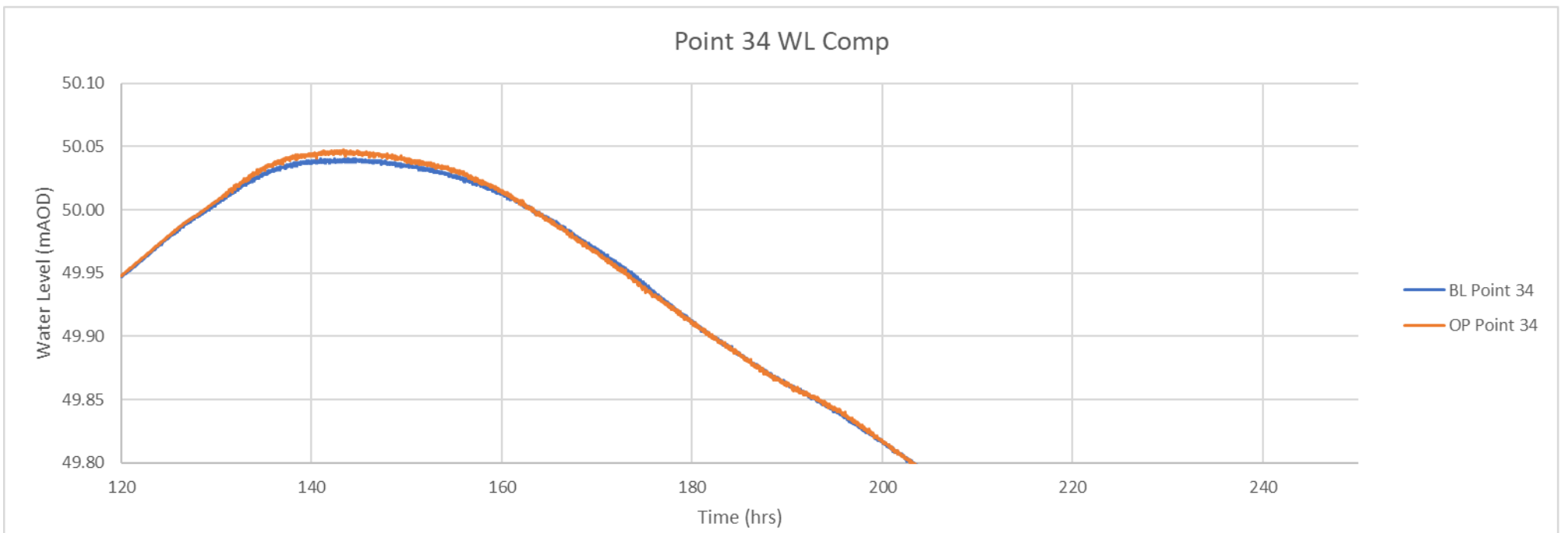
220
240
Time (hrs)
BL Point 33
OP Point 33


Point 34 WL Comp
Water Level (mAOD)
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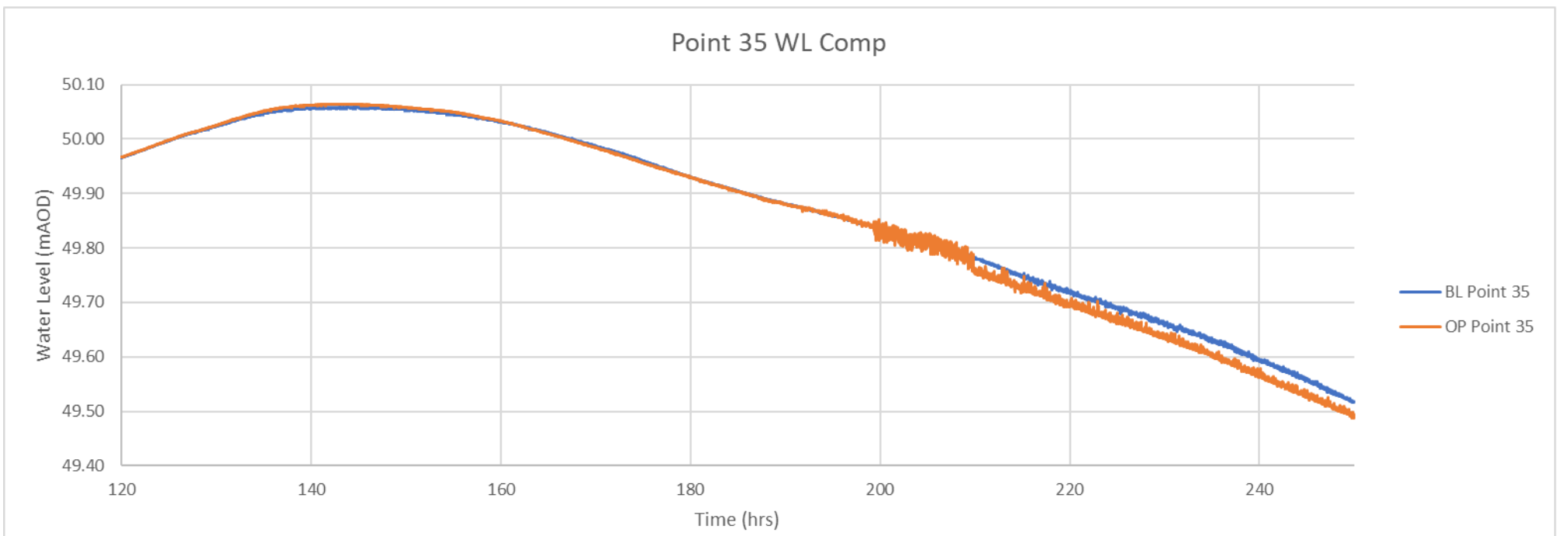
180
200
220
240
Time (hrs)
BL Point 34
OP Point 34


Point 35 WL Comp
Water Level (mAOD)
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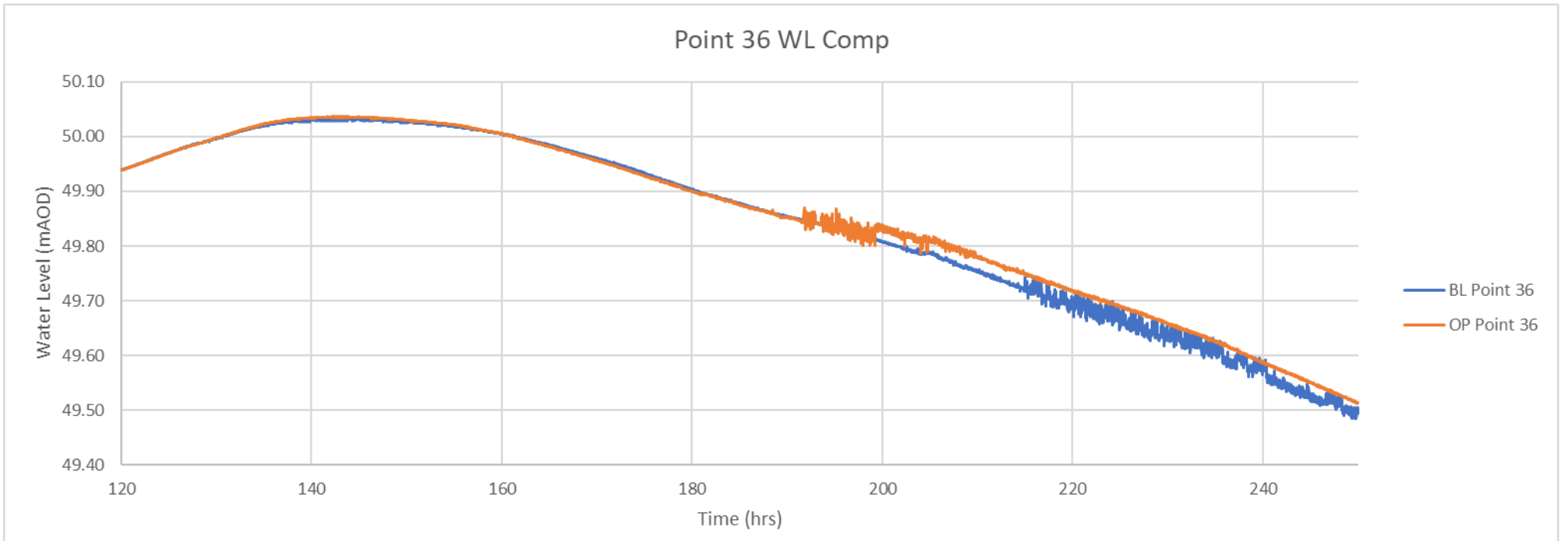
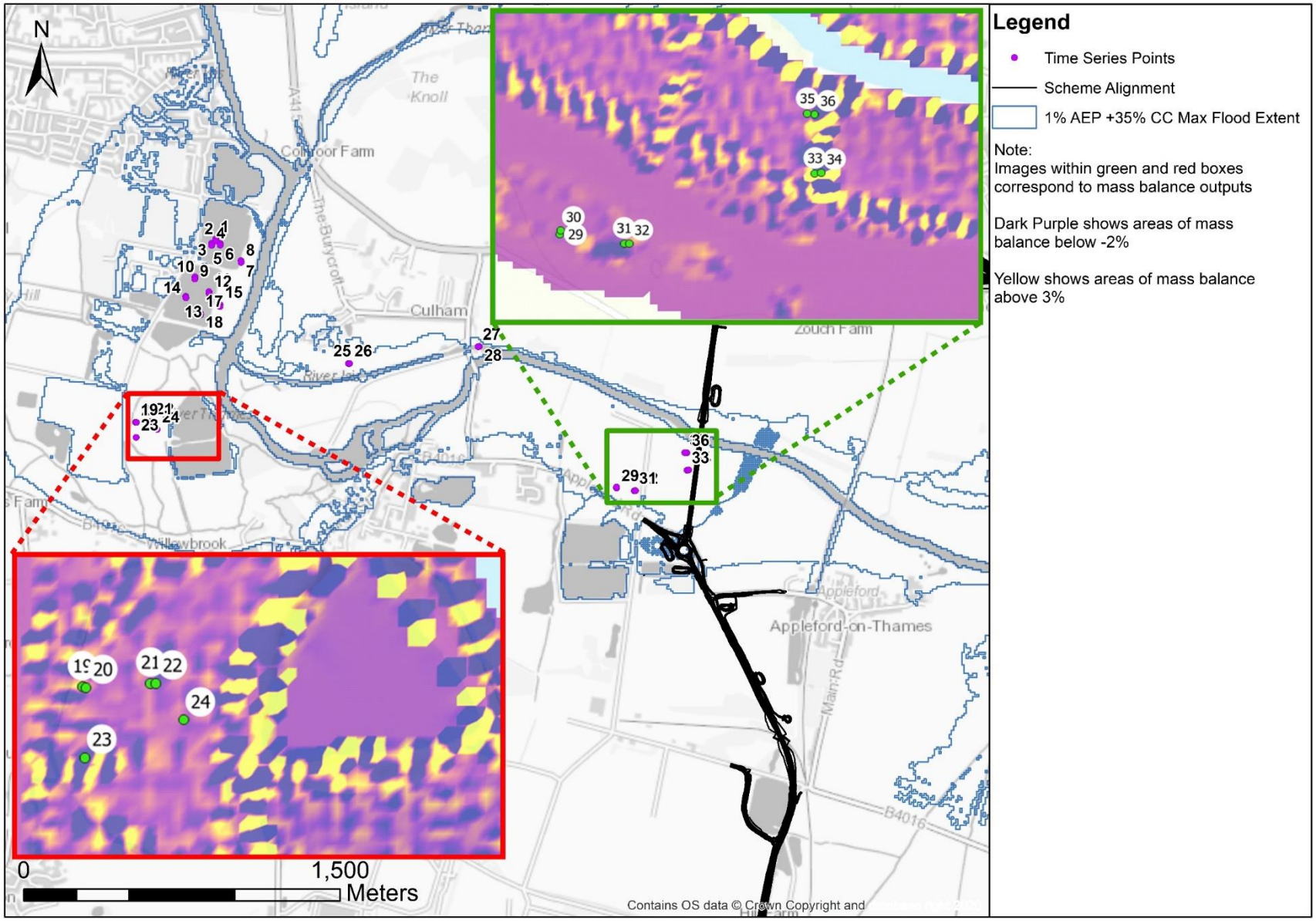
49.50
49.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 35
OP Point 35


Point 36 WL Comp
Water Level (mAOD)
50.10
50.00
49.90
49.80
49.70
49.60
49.50
49.40
120
140
160
180
200
220
240
Time (hrs)
BL Point 36
OP Point 36

Appendix B Model Mass Balance

Below are two screenshots of the model Mass Balance, from the baseline 1% AEP +35% Climate Change event. As discussed, values of +/- 1% are considered to be an indicator of model instability. In the maps, areas shown in dark purple have a mass balance of -2%, and yellow areas have a mass balance of +3%. It can be seen that the PO points placed in the areas of ‘hatched’ Water level difference results coincide with the areas of high mass balance variation. This means that the variations here are a result of model stabilities, not a result of the proposed scheme.


N
Legend
Time Series Points
Scheme Alignment
1% AEP +35% CC Max Flood Extent
Note:
Images within green and red boxes correspond to mass balance outputs
Dark Purple shows areas of mass balance below -2%
Yellow shows areas of mass balance above 3%
0
1,500
Meters
Contains OS data © Crown Copyright and
Culham
Appleford-on-Thames
Willowbrook
Corncroft Farm
Zouch Farm
The Knoll
The Burycroft
B4016

Appendix C Storage Compensation Drawing

Level (m)	Flood Storage Area	
	Required Volume (m^3)	Available Volume (m^3)
48.1	1	2.3
48.2	23	30.9
48.3	44	53.4
48.4	76	81.6
48.5	102	110
48.6	110	125
48.7	155	163.2
48.8	233	257.1
48.9	503	538
49	758	773.1
49.1	854	863.7
49.2	925	941.5
49.3	987	1039.9
49.4	1073	1081.8
49.5	1174	1195.9
49.6	1257	1274.7
49.7	1356	1381.6
49.8	1448	1470.2
49.9	1506	1539.5
50	1557	1643.4

IT IS ASSUMED THAT ALL WORKS ON THIS DRAWING WILL BE CARRIED OUT BY A COMPETENT CONTRACTOR WORKING, WHERE APPROPRIATE, TO AN APPROPRIATE METHOD STATEMENT.

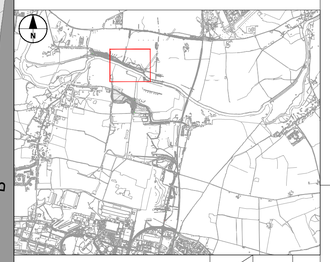
THIS DRAWING IS TO BE USED ONLY FOR THE PURPOSE OF ISSUE THAT IT WAS ISSUED FOR AND IS SUBJECT TO AMENDMENT.

LEGEND - PLAN

- Scheme boundary
- Top of excavation slope
- Excavation at 1:1 slope (slope stability measures required)
- Indicative floodplain compensation area
- Major contour (0.5m)
- Minor contour (0.1m)
- Indicative Thames Path route

LEGEND - SECTIONS

- Existing land
- Proposed flood storage area
- Proposed scheme



FIRST ISSUE	AZ / DR	10/11/21	P01
FInal	AZ / DR	20/10/22	P02
REVISION DETAILS	By / Check	Date	Suffix

Purpose of issue

SUITABLE FOR INFORMATION

Client

OXFORDSHIRE COUNTY COUNCIL

Project Title

DIDCOT GARDEN TOWN HIF 1 SCHEMES PRELIMINARY DESIGN

Drawing Title

FLOODPLAIN COMPENSATION AREA SHEET 1 OF 1

Designed	Drawn	Checked	Approved	Date
AZ	AZ	DR	KC	20/10/22

Internal Project No.	Suitability
60632497	S2
Scale @ A1	Discipline
1:1000	Flood Impacts

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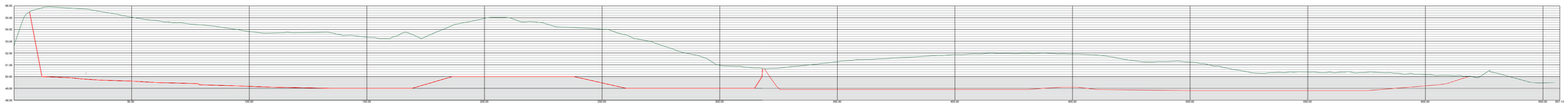
Drawing Number

RIV_PD - ACM - GEN - SW_ZZ_ZZ_ZZ - DR - HF - 0011

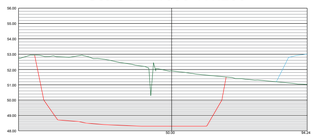
Work Package ID | Originator | Volume | Location | Type | Role | Number

Rev P02

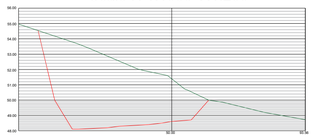
RIVER CROSSING FLOOD COMPENSATION
A-A CROSS SECTION
Scale H 1:1000 V:1:200



RIVER CROSSING FLOOD COMPENSATION
B-B CROSS SECTION
Scale H 1:1000 V:1:200



RIVER CROSSING FLOOD COMPENSATION
C-C CROSS SECTION
Scale H 1:1000 V:1:200



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