Dŵr Cymru
Welsh Water

Developer Services Hydraulic Modelling Report

107 – PPA0002226 – Land off Stansty Chain Road, Wrexham – Five Fords WwTW - 00675

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Executive Summary

- This HMA has assessed the residential flows from a proposed development on Stansty Chain Road. The proposed development consists of 455 properties on a site of approximately 21.7 Ha. The site is currently a greenfield site and it is proposed that the 455 residential properties will be pumped to the public sewer at the south of the site at Connection Point 1 (Manhole SJ32517701). The development will be delivered in 6 phases; 80 properties will be delivered in each of the first 5 phases and 55 properties will be delivered in the final phase.

- The proposed development at Stansty Chain Road has been assessed using one connection point:

  - Connection Point 1: The proposed connection point for the residential properties is manhole SJ32517701 located on Stansty Road opposite Rhosddu Church (Colliery Road), which is to the south of the development.

- The proposed development is located within the Five Fords WwTW catchment. The existing model for Five Fords, which was recently upgraded in 2018 for a separate study within the catchment, was used as the basis for this HMA. The model required further modifications before being deemed suitable for the purpose of this HMA. Following these updates, the model was considered suitable for assessing the impact of the proposed development.

- The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.

- During the model build and verification process, it was found that there may be connectivity information missing at Wrexham Park Avenue CSO. The verification at the areas which could have been potentially affected by the missing information were considered acceptable based on the information currently held. It is recommended to further investigate the connectivity at this CSO during the detailed design stage.

- All phases of the development were predicted to cause flooding detriment in the network. The flooding is significant, and it is predicted to increase to 102m^3 over the total development. The potential flooding would be caused by a hydraulic incapacity in the network. The detriment is not considered acceptable and solutions would be required.

- Solution development has identified 4 solutions to resolve the predicted detriment. The solutions are:

  - Solution 1 – Surface Water Removal. This solution involves the removal of 0.338 ha contributing area from the combined system and connected to existing surface water systems discharging to River Gwenfro.
  - Solution 2 – Online Storage; three new 24m, 1800mm diameter pipes. The storage pipes would be connected to the eastern end of the existing Queens Park Y Wern Tanks (72378) located immediately upstream of the flooding detriment. The estimated cost of this solution is £256,000.
  - Solution 3 – Offline Storage; 205m^3 storage tank at manhole SJ34503102. The flows would return to the system at the same manhole via a pump at a rate of 9l/s. The estimated cost of this solution is £412,000.
  - Solution 4 – Offline Storage; 263m^3 storage tank at manhole SJ34505401. The flows would return to the system at the next manhole downstream via a pump at a rate of 12l/s. The estimated cost of this solution is £486,000.

1 Introduction

1.1 Appointment

WSP was appointed by Dŵr Cymru Welsh Water (DCWW) in May 2018 to assess the development impact at Stansty Chain Road, Wrexham.

The development is residential and consists of 455 properties. A potential connection point of manhole SJ32517701 on Stansty Road has been identified. Downstream of the connection point, the following assets could be possibly impacted on by the development: Wrexham Park Avenue CSO (2484) and Pont Wen CSO (2476).

DCWW has advised that the existing public sewerage system is unlikely to have sufficient capacity to accommodate the additional flows generated by the development. A HMA has been undertaken to establish whether a point of adequacy exists within the network. The purpose of this HMA is to quantify the effects that the development would have on the existing combined sewer network performance and identify notional solutions to resolve any potential detriment and consider further recommendations.

This report presents the findings of the HMA for the proposed development at Stansty Chain Road, Wrexham.

1.2 Development Site

- Size: Approximately 21.7 ha
- Location: The site is parted by Stansty Chain Road, the northern part of the site is bounded by farmland, Gwersyllt railway and the A483. The southern part of the development site is bounded by Stansty Lodge Ln, Mold Rd and A483.
- Topography: The development site ranges from approximately 86 mAOD to the south of the development near the A483, increasing to 94 mAOD at the north of the development.
- Previous / Current Usage: Greenfield site – currently open farmland / grassland.
- Proposed Usage: Entirely residential
- Sewerage Details: It is proposed that the 455 residential properties will drain via two pump stations to the public sewer at the south of the sites.
- Connection Type: Separate connections for 455 properties and pumped to the connection point.
- Phasing: The development will be delivered in 6 phases; 80 properties per year will be delivered in each of the first 5 phases and 55 properties will be delivered in the final phase.

1.3 Background Information

The proposed development is within the Five Fords Waste Water Treatment Works (WwTW) catchment.

A hydraulic model of this catchment exists. The model has recently been updated and verified as part of a separate study within the catchment; a Sustainable Drainage Plan (SDP). However, there is limited model detail within the vicinity of the development and therefore further model modifications are required for the purpose of this HMA. Targeted impermeable area surveys as well as manhole surveys were

undertaken to update the area in the model where the development assessment would be undertaken. For further information on amendments made to the model see Section 3.1.

2 Land Usage

The developer is proposing a development consisting of 455 units. The current land use for the site is greenfield. The development will be delivered in 6 phases, 80 properties will be delivered in each of the first 5 phases and 55 properties will be delivered in the final phase.

Initial Phase		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
		Total	200

Table 2-1 - Proposed Domestic Development Contribution – Phase 1 (Initial)

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
		Total	400

Table 2-2 - Proposed Domestic Development Contribution – Phase 2

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
		Total	600

Table 2-3 - Proposed Domestic Development Contribution – Phase 3

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
		Total	800

Table 2-4 - Proposed Domestic Development Contribution – Phase 4

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
		Total	1000

Table 2-5 - Proposed Domestic Development Contribution – Phase 5

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

Total Development		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	80	Unknown (assume 2.5 occupancy)	200
Housing	55	Unknown (assume 2.5 occupancy)	138
		Total	1138

Table 2-6 - Proposed Domestic Development Contribution – Phase 6 (Total)

Note: Population dwelling density based on Household characteristics (household size by type of accommodation and by number of bedrooms 2001-04_Sourced by Survey of English Housing). Household size is estimated as 1.3 for one bedroom; 1.9 for two bedrooms; 2.6 for three bedrooms and 3.2 for four or more bedrooms.

2.1 Proposed Connection Details

The following connection point was confirmed during the kick off meeting:

Connection Point 1: Manhole SJ32517701 located on Stansty Road opposite Rhosddu Church (Colliery Road), which is to the south of the development.

See Figure 1 for a plan of the development site and proposed connection point. Based on the development details provided, flows will be pumped to the connection point.

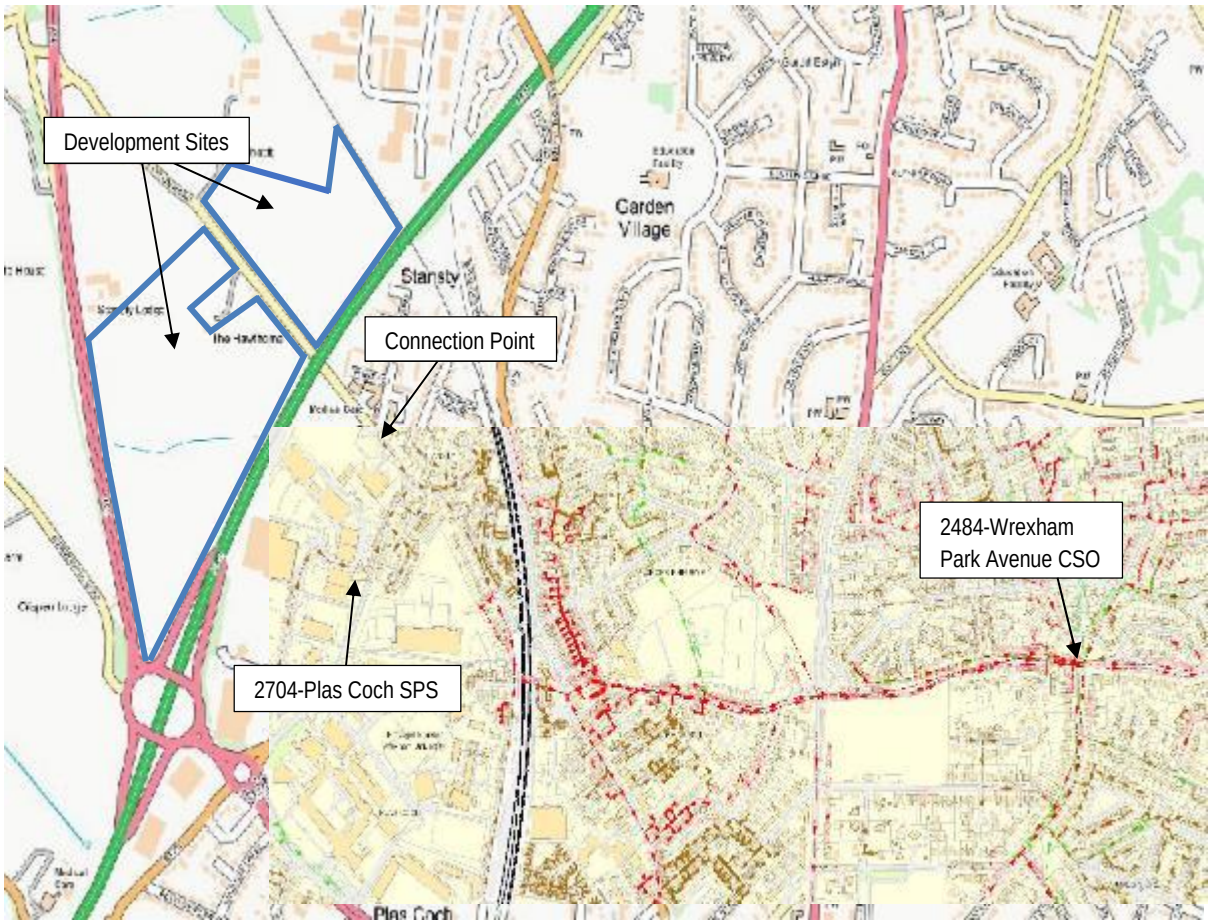


Figure 2-1 - Development Site Overview Plan – Including Connection Point

3 Developed System Modelling

3.1 Model Build / Enhancement

The proposed development is located within the Five Fords WwTW catchment. The existing model for Five Fords was used as the basis for this HMA. The model required further modifications before being deemed suitable for the purpose of this HMA.

Data to assist the model build / enhancement was obtained from the following sources:

- Existing DCWW Geographical Information Systems (GIS)
- Historic Survey Data
- DCWW Telemetry Data
- Manhole Survey
- SPS Survey
- CSO Survey
- Impermeable Area Survey (IAS)
- Flow Survey
- Site Visit Data

The following sections detail the infill data used to build / enhance the hydraulic model and the other model build activities undertaken to ensure the model was suitable to undertake the HMA assessment.

3.1.1 STC25 Manhole Survey

As part of this study a manhole survey consisting of 20 manholes was commissioned to supplement the existing DCWW GIS data. From the 20 manholes that were scheduled for survey, 11 manholes were successfully completed, and one manhole was unable to locate (UTL).

This survey data was identified with the InfoWorks flag “SA” and notes included within the model.

3.1.2 SPS Survey

Plas Coch SPS was surveyed as part of this study undertaken to improve confidence in the modelling of the asset. The pumps operate on duty/assist with a discharge of approximately 0.006 m^3/s. The survey found that there was a penstock at the pumping station, the model was then modified to include this.

This survey data was identified with the InfoWorks flag “SA” and detailed notes included within the model.

3.1.3 Impermeable Area Survey (IAS)

The Impermeable Area Survey covered 10 areas which were primarily commercial developments and some residential areas. The residential areas surveyed include Crispin Lane, Osborne Road and Balmoral Road. The survey indicated that Sainsbury’s and Wrexham Glyndwr University discharge to the surface water system. The roofs and roads of the other commercial developments discharge to the soakaway. The roofs of the residential areas were shown to discharge either to the foul system or soakaway and the roads to the surface water system. The survey data is given in Appendix B.

3.1.4 Summary of Model Build / Enhancement Activities

The existing model for Five Fords was updated before undertaking the HMA. These updates included the verification of flows in the area by means of a short-term flow survey. The representation of the subcatchments, impermeable areas, manholes and ancillaries have all been reviewed and updated as per the surveys detailed in Section 3.1 of this report.

3.2 Verification

A short-term flow survey was carried out, comprising of 5 flow-monitors (FMs) and 3 rain-gauges (RGs) located within the Five Fords catchment.

FM01 was located opposite 93 Crispin Lane and installed to determine current catchment flows from Stansty Chain Road.

FM02 was installed opposite 61 Park Avenue and located downstream of the continuation at Wrexham Park Avenue CSO (2484) to determine continuation flow.

FM03 was located at the Rhosnesni Lane/The Beeches junction to help determine outgoing flow from the CSO and gain connectivity information.

FM04 was installed at Crispin Lane (entrance to Wrexham University) to determine flows from the university and other upstream areas.

FM05 was installed opposite 8 The Hawthorns to help determine flow towards the east from the bifurcation at Wrexham Park Avenue CSO.

The flow survey began on the 06/09/2019 and was terminated on 30/10/2019, a total duration of 54 days.

The performance of the system was initially verified for dry weather flows using diurnally varying profiles. The model was then run using 3 storm events observed during the flow survey that achieved the specific requirements as stipulated in the WaPUG Code of Practice.

The resulting model predictions of the flow, depth and velocity were compared to those observed during the flow survey. Where significant differences were found between predicted and observed data, justifiable amendments to the model were made, especially where previously interpolated levels had been used. The model was then refined by a process of continuing iteration until reasonable verification plots were obtained.

Flow/Depth Monitor	Manhole Ref.	Model Conduit Ref.	Pipe Size (mm)	Date Installed	Date Removed
FM01	SJ33510402	SJ33510401.1	300	06/09/2019	30/10/2019
FM02	SJ34511202	SJ34511301.1	375	06/09/2019	30/10/2019
FM03	SJ33517301	SJ33516305.1	375	06/09/2019	30/10/2019
FM04	SJ33510201	SJ32519201.1	300	06/09/2019	30/10/2019
FM05	SJ34512303	SJ34512303.1	455	06/09/2019	30/10/2019

Table 3-1 - Flow Monitor Location Details

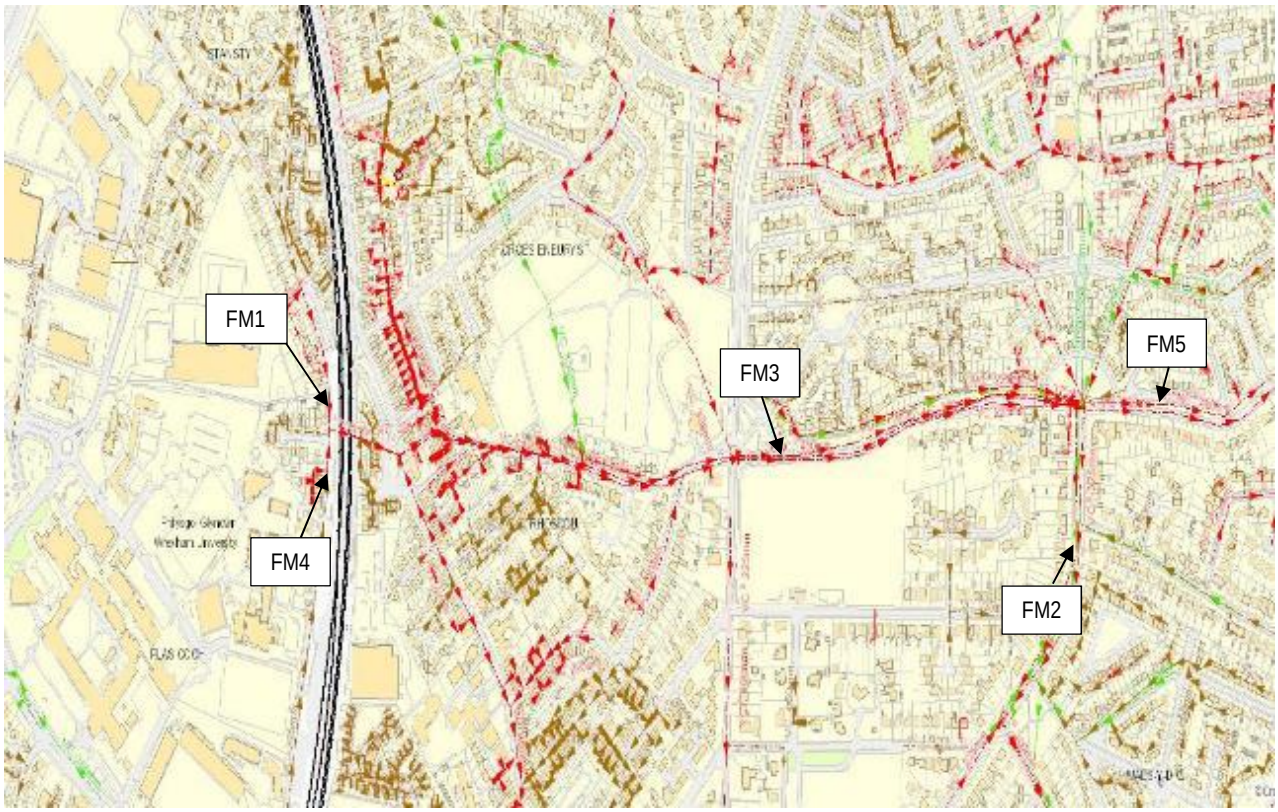


Figure 3-1 - Flow Monitor Location Plan

3.2.1 Dry Weather Flow Verification

Two dry days were selected for the Dry Weather Flow (DWF) verification:

- DD1: 14/09/19 (Saturday)
- DD2: 20/09/19 (Friday)

FM01

Poor velocity data was returned which gave unreliable monitored flows and volumes. Therefore, the flow monitor could only be verified to depth.

Initially, the depths given by the model were significantly lower than the depths that were observed. It was assumed that the depths were higher due to sedimentation based on the hydrographs and in order to produce a better verification and increase the depths in the model, 30mm of sediment was added to the conduit where the flow monitor was located (SJ33510401.1). The survey contractor confirmed there was sediment present.

The verification at this flow monitor is considered acceptable given the low velocities recorded.

FM02

The flow monitor recorded poor data which indicated low depths and flows.

The model peak flows were within the WaPUG criteria for DD1 but not DD2 which caused marginal peak flows across both the selected dry days. This may have been due to the low flows recorded. The volumes given by the model were initially acceptable, therefore no changes were made to the model to adjust volumes. Overall, the peak flow and volume were within the required criteria.

The verification is acceptable at this flow monitor.

FM03

The observed data indicated that there were low flows which may have been caused by the velocity drop out. The survey contractor confirmed that there was ragging present in the chamber.

Initially, the depths given by the model were significantly lower than the depths that were observed. The observed depths were replicated in the model and verified by adding 20mm sediment to the conduit where the FM was located (SJ33516305.1), which was downstream of FM01 where significant silt was observed, and it was suspected to have been transient. The sediment was removed for the purpose of the assessments. The volumes are within the criteria for both selected dry days. However, the model under-predicts peak flows due to the erratic nature of low flows.

The verification at this flow monitor is considered acceptable given the low velocities recorded.

FM04

The flow monitor recorded very poor data which may have been due to the small upstream catchment area. The depths and velocities in the observed data spiked erratically and the monitor was then changed as a precaution. Very low flows and volumes were also recorded for DD1 so the peak flows and volumes were not verified using this flow monitor as the data was unreliable and not suitable for verification.

FM05

The flow monitor recorded poor velocity data as the velocity dropped out at various points, therefore the monitored flows and volumes were considered unreliable. The model predicted similar flows as the observed data and the peak flows were marginal overall. However, the model over-predicted volumes.

The verification at this flow monitor is considered acceptable, but with limitation, given the low velocities recorded. The limitation would be low model confidence at Wrexham Park Avenue CSO which is also explained in section 3.5.

3.2.2 Storm Flow Verification

Three storm events were selected for storm flow verification. These are detailed in Table 3-2 below.

Event	Date	Weekday	Start Time	End Time	Duration (hrs.)	Peak Intensity (mm/hr.)
A	24/09/2019	Tuesday	04:46	00:00	19	6
B	28/09/2019	Saturday	18:56	12:00	17	12
C	30/09/2019	Monday	13:56	06:00	16	12

Table 3-2 - Flow Survey Storm Events

FM01

The observed data at this flow monitor included poor velocity data. The flow monitor responded to rainfall. However, ragging affected the recorded depth and velocity.

The initial verification plots show that the model over-predicted the peak flow and volumes across all the selected storm events. This was caused by the low velocities recorded which affected the total observed flow volumes.

A subcatchment upstream of the monitor location (alongside Stansty Rd & Railway Rd) showed an old development in the model which no longer exists and is currently a residential area. Changes were made to the Impermeable Area layer, and the recent development was modelled. Also, the runoff areas within the subcatchment were updated which produced a better fit overall. Further upstream of this area is a care home (on 34 Stansty Rd) which appeared to have a separate drainage system on street view. After making changes to the model, the depth and peak flow at the FM were within the criteria. The predicted volumes improved after making the changes, however, they were still not within the criteria and this was assumed to be due to the poor velocity data.

The verification at this flow monitor is considered acceptable given the velocities recorded.

FM02

The observed data at this flow monitor shows relatively good data for the selected storm events. The flow monitor showed a good response to rainfall.

The initial verification plots for this flow monitor show that the model was over-predicting depths and under-predicting velocities. In addition, the flows and volumes were not within the criteria either. The

verification at this flow monitor and FM05 were completed last as these are located the furthest downstream. After verifying the other areas, the peak depths were within WaPUG criteria at this flow monitor. The model under-predicted the total flow volumes here in addition to the peak flows. The flows and volumes at this flow monitor could not be verified as it is suspected that there may be a model connectivity issue at Wrexham Park Avenue CSO. This is because the flows and volumes at FM03 which is directly upstream of this flow monitor are within criteria and verified, however, after the CSO the model under-predicts the flow at FM02 and over-predicts the flow at FM05. Therefore, increasing the flows and volumes at FM02 would not solve this issue as it would lead to an increase in flows at FM05 where the model currently predicts excess flow volume.

Further investigation would be required to confirm whether the connectivity information at Wrexham Park Avenue CSO is correct in the model prior to any detailed design based on this model at this location. This flow monitor is considered unverified.

FM03

The observed data at this flow monitor indicated that there were low flows which was likely due to velocity drop out. The velocity data was affected by ragging. Generally, the observed data was reasonable as it showed a good response to rainfall.

The initial verification plots illustrate that the depth and peak flows predicted by the model were within WaPUG criteria, however, the data was not within the criteria after verifying the flow monitors upstream of this flow monitor. In addition, the initial verification plots showed that there were high surcharge levels observed during the larger storm events, which was not predicted by the model.

The observed surcharge conditions were replicated by modelling an orifice (SJ33517308.1) directly downstream of where the flow monitor was located to replicate a blockage downstream. The IAS upstream of the flow monitor at the residential areas on Balmoral Road and Osborne Road indicates that the roads discharge to the surface water system, which is later combined with the foul system downstream. The runoff areas in the storm subcatchments where the IAS was conducted were updated in the model which provided a better fit overall.

The final verified plots show a good level of verification across all the selected storm events. Most of the predicted levels were within the criteria. However, the predicted peak flows for storm events B and C were marginal overall which may have been caused by the velocity drop out.

FM04

The observed data indicated there were generally low flows which is likely due to the small upstream catchment area. The flow monitor showed an unclear response to rainfall and there was also velocity dropout during storm event B.

The initial verification plots show that the depths followed a similar pattern as the observed data and they were also within the WaPUG criteria. However, the model over-predicted peak flows and volumes across all the storm events.

Initially the model showed that the racecourse stadium located upstream of the flow monitor discharged to the foul system. However, after research and use of street view, it was found that parts of the development were built recently. It was assumed that the recently built areas discharge to a surface water system and the older areas (The Kop and University End stands) discharge to the foul system. A better fit was obtained overall after updating the model. The model-predicted peak flows and volumes

reduced and were within the criteria. The predicted total flow volume for storm event B was not within the acceptable criteria and this may have been caused by the velocity drop-out.

FM05

The observed data at this flow monitor was reasonable as the flow monitor responded to rainfall. However, the velocity was masked due to ragging at one point during storm event C. The peak depths and flows were within criteria after verifying the areas upstream. However, the model over-predicts total flow volume which may be due to a connectivity issue near the CSO. The verification at this flow monitor is considered acceptable based on the information currently held. It is recommended that further investigation is undertaken at this CSO to confirm connectivity prior to detailed design use of the model at this location for the CSO.

3.3 Historical Verification

A review of DCWW's flooding incident databases has been undertaken to determine where historical reports of flooding have been recorded within the catchment.

Design storms based on a 2, 5, 10, 20 and 30 year return periods were simulated with the verified model to determine where the model predicts flooding.

There are numerous reported flooding locations identified on the DFL, which were used as part of the historical verification process. The results for each reported flooding cluster are explained below.

Wrexham (Jeffreys Road) SEF (2:10)

There have been recent flooding incidents reported in this cluster and the properties are on Warrenwood Road. The model predicts flooding downstream of this cluster. Surcharge at the south of the catchment has impacted upstream areas and caused the flooding near this cluster. The flooding is predicted at a manhole with low model confidence and flagged as 'OM'. The manhole which is directly upstream has a higher model confidence as it has been surveyed.

Wrexham (The Triangle) SEF (2:10)

The model predicts flooding at the reported flooding locations in the vicinity of The Triangle for a 2 in 10 year design storm. The flooding in this area may be linked to the flooding at Birkdale Road which is nearby. The model predicts it will flood at 2 of the manholes at The Triangle, one of these manholes has been surveyed whereas the other manhole has low model confidence as the majority of the asset data is flagged 'OM'. The sewers that have been surveyed in this area have been found to have a diameter of 150mm.

Wrexham (Wynnstay Avenue) SEF (1:20)

The model predicts flooding at the reported flooding location. The model predicts flooding at only one manhole at this location. There have been many properties which have been reported to flood and these are all connected to this manhole, and the model shows that the manhole has been surveyed in the past. The sewers at the flooding location have been surveyed to be 225mm in diameter.

3.4 Verification Summary

The model has been verified and is considered acceptable for assessing the impact of the proposed housing development on the existing combined network. Verification graphs and the reported compliance with WaPUG criteria are presented in Appendix C.

3.5 Model Assumptions & Limitations

A number of assumptions have been made during the model build and verification, these include:

- The data sets supplied are correct.

The hydraulic model utilised for this HMA study is considered to have the following limitations:

- The verification has been focused for the purpose of this HMA only.
- Detailed modelling of the surface water system was not included as part of this study. The impact of the development is limited to the impact on the foul/combined system which is deemed acceptable for the purpose of this HMA.
- There is low model confidence near Wrexham Park Avenue CSO. It is suggested to further investigate the connectivity here during the detailed design stage.

4 Development System Analysis

4.1 Dry Weather Flow

The DWF for the residential properties has been calculated as below for the 6 phases.

Parameter	Value	Comment
Population - P	200	80 properties with population as outlined in Table 2-1 - Proposed Domestic Development Contribution – Phase 1 (Initial)
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.042 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	0.417 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	0.459 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-1 - HMA - DWF Parameters – Phase 1 (Initial)

Parameter	Value	Comment
Population - P	400	160 properties with population as outlined in Table 2-2 - Proposed Domestic Development Contribution – Phase 2
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.083 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	0.833 l/s	Population multiplied by the per capita return to sewer flow rate.

Total DWF	0.916 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-2 - HMA - DWF Parameters – Phase 2

Parameter	Value	Comment
Population - P	600	240 properties with population as outlined in Table 2-2 - Proposed Domestic Development Contribution – Phase 2
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.125 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	1.250 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	1.375 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-3 - HMA - DWF Parameters – Phase 3

Parameter	Value	Comment
Population - P	800	320 properties with population as outlined in Table 2-2 - Proposed Domestic Development Contribution – Phase 2
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.167 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	1.667 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	1.834 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-4 - HMA - DWF Parameters – Phase 4

Parameter	Value	Comment
Population - P	1000	400 properties with population as outlined in Table 2-2 - Proposed Domestic Development Contribution – Phase 2
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.208 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	2.083 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	2.291 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-5 - HMA - DWF Parameters – Phase 5

Parameter	Value	Comment
Population - P	1138	455 properties with population as outlined in Table 2-2 - Proposed Domestic Development Contribution – Phase 2
Per Capita Return to Sewer Flow Rate – G	180 l//hd/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/hd/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.237 l/s	10% DWF (PG) assumed
Total DWF Calculations		

P * G	2.371 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	2.608 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for CSO (1) and flooding (2) level of performance investigation.

Table 4-6 - HMA - DWF Parameters – Phase 6 (Total)

4.2 Surface Water Run-off

The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.

Whilst the surface water network of the proposed development has not been modelled, a nominal allowance of 2% of the total contributing area has been allocated to represent possible future misconnections between the foul and storm systems and the impact of urban creep. This has been applied to each of the road and roof runoff surfaces within the foul sub-catchment.

Detailed layout plans of this development are not available. Therefore, the impermeable area for this site has been determined based on estimated values. An even distribution between road (2%) and roof (2%) surfaces was applied (i.e. 2% of total contributing area). As no details have been provided, it is assumed that the housing density will be medium (60%).

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
3.60	1.801	0.036	1.801	0.036

Table 4-7 - Development Impermeable Areas – Northern Subcatchment

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
9.48	4.741	0.095	4.741	0.095

Table 4-8 - Development Impermeable Areas – Southern Subcatchment

5 Existing / Developed Comparison

5.1 Hydraulic Assessment

Design storms based on a 30 year return period were used to determine the potential flood volumes in the existing and development scenarios.

Winter and summer design storms with durations of 15, 30, 60, 90, 120, 240, 360, 480, 720, 960 and 1440 minutes were applied to the existing and developed models. Winter events were considered the 'worst case' scenario. It has been found that most flooding incidents occur during the 1440 minute winter storm duration. However, model predicted flood volumes vary with the duration of event and therefore all storm durations have been assessed to highlight the worst case scenario.

Existing flooding is predicted at a number of locations downstream of manhole SJ32517701. The flooding is caused by a localised hydraulic incapacity and is affected by the development flows. The flooding reported in the tables below focus on the locations where the model predicts detriment greater than 1m^3 or new flooding. See **Error! Reference source not found.**.

5.1.1 Scenario 1 – Phase 1 (Initial)

This scenario assesses the impact of the development connecting to SJ32517701 for the initial phase of 80 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3296.7	52.0	1.60

Table 5-1 - Hydraulic Assessment Results – Scenario 1 Phase 1 (Initial)

5.1.2 Scenario 2 – Phase 2

This scenario assesses the impact of the development connecting SJ32517701 for the second phase of 160 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3312.7	68.0	2.10

Table 5-2 - Hydraulic Assessment Results – Scenario 2 Phase 2

5.1.3 Scenario 3 – Phase 3

This scenario assesses the impact of the development connecting to SJ32517701 for the third phase of 240 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3326.9	82.2	2.53

Table 5-3 - Hydraulic Assessment Results – Scenario 3 Phase 3

5.1.4 Scenario 4 – Phase 4

This scenario assesses the impact of the development connecting to SJ32517701 for the fourth phase of 320 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3336.9	92.2	2.84

Table 5-4 - Hydraulic Assessment Results – Scenario 4 Phase 4

5.1.5 Scenario 5 – Phase 5

This scenario assesses the impact of the development connecting to SJ32517701 for the fifth phase of 400 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3346.7	102.0	3.14

Table 5-5 - Hydraulic Assessment Results – Scenario 5 Phase 5

5.1.6 Scenario 6 – Phase 6 (Total)

This scenario assesses the impact of the development connecting to SJ32517701 for the total development of 455 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3346.1	101.4	3.13

Table 5-6 - Hydraulic Assessment Results – Scenario 6 Phase 6 (Total)

The model predicts a flooding detriment of approximately 52m^3 during the initial phase, which increase in detriment with each additional phase rising to 102m^3 in the fifth phase. The detriment is located downstream of the connection point.

Figure 5-1 - Model Predicted Flooding Location Plan – Total Development

5.2 CSO Assessment

Spill volume analysis of the Pont Wen CSO overflow was carried out using a typical year rainfall dataset which was created as there was not one available. The first overflow downstream of the development, Wrexham Park Avenue overflow, is a bifurcation and does not spill to the environment. If there was excess flow at this overflow caused by the development, the impact would likely be flooding manholes.

A summary of the analysis is shown in the tables below.

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-7 - CSO Assessment – Phase 1 Initial Development

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-8 - CSO Assessment – Phase 2

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-9 - CSO Assessment – Phase 3

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-10 - CSO Assessment – Phase 4

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-11 - CSO Assessment – Phase 5

CSO Name	Spill Frequency							
	Existing		Developed		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 5-12 - Phase 6 Total Development

The development has not had a significant impact on Pont Wen CSO. The spill count has not changed. The spill volume has increased slightly over the total development; however, the increase was less than 1L and therefore not considered significant.

5.3 Formula 'A' Assessment

The value of Formula 'A' has been determined at Wrexham Park Avenue CSO, considered to be impacted on by the development. The Formula 'A' flow is a measure of the continuation flow required at a CSO prior to spill occurring.

The calculated Formula 'A' figures are presented in the table below.

Model	Pass Forward Flow (l/s)	Formula A (l/s)	DWF (l/s)	Passes Formula A
Existing	80	75.7	10	Yes
Phase 1 (Initial)	80	75.7	10	Yes
Phase 2	80	75.7	10	Yes
Phase 3	80	75.7	10	Yes
Phase 4	80	75.7	10	Yes
Phase 5	80	75.7	10	Yes
Phase 6 (Total)	80	75.7	10	Yes

Table 5-13 - Formula 'A' Assessment – Pont Wen CSO

The model has been assessed to ensure that the SPS and CSO meet the requirements to pass forward Formula 'A' flows and that this requirement is not unduly affected by the addition of the development. The CSO setting has been determined by assessing the flow at first spill for a range of low return period events (such as the verification events and 1 in 1 year return period design events).

The model shows that Pont Wen CSO is passing Formula A in the existing system and the development is not predicted to cause significant detriment to this. Pont Wen CSO is located off the trunk of the downstream line which is why the pass forward flow and Formula A was not affected during the different phases of the development. The location of Pont Wen CSO is shown in Figure 6-1.

5.4 Flows Arriving at Five Fords WwTW

Using the annual time series 'typical year', it was calculated that 13,515,303m^3 of flow arrives at Five Fords WwTW. With the new development, this figure increases to 13,594,725m^3. This corresponds to an increase of 79,422m^3.

5.5 Network Performance Assessment Summary

Flooding summary:

The flooding detriment assessment undertaken predicts an unacceptable level of detriment during the initial phase of the development and all the following phases. The flooding is caused by a hydraulic incapacity in the network. A solution is required to mitigate the flooding detriment.

CSO summary:

The CSO detriment assessment undertaken predicts no increase in spill volume or spill frequency at Pont Wen CSO.

6 Solution Development

The hydraulic assessment has indicated that the addition of the development flows has caused detriment with regards to network performance. Therefore, solutions have been investigated to resolve this detriment caused by the development flows. Solutions have not been derived for the initial phase, but for the total development only.

The notional solutions described in the following sections show conceptual arrangements only and are presented to illustrate the adequacy of the solutions in terms of gross parameters (e.g. pipe capacities); their inclusion does not infer buildability and they are not to be considered as detailed design proposals.

6.1 Discounted Solutions

A number of solutions were considered but discounted because they did not resolve the predicted detriment and / or were not considered feasible.

1. The two sewer lengths downstream of the connection point were upsized from 375mm and 225mm to 825mm. This could have allowed the sewers to store excess flow coming from the development. A 200mm orifice was modelled, in addition, with a limiting discharge of what the maximum flow was prior to the development (50l/s). This significantly reduced the total detriment at manhole SJ34495901. The size of the two pipes were then upsized to further lessen the level of detriment; however, this did not resolve the detriment.
2. An online storage at the predicted flooding location (manhole SJ34495901) was considered, which consisted of two 179m, 375mm diameter pipes. The online storage solved the detriment. However, the solution was discounted as the construction of the pipes at the flooding location would require pipe bridges. Also, a site visit by DCWW showed an online storage at manhole SJ34495901 would not be suitable as it would impose a flooding and damage/vandalism risk.

6.2 Solution 1; Surface Water Removal

6.2.1 Description

This solution addresses the total development flows utilising Connection Point 1. It requires the removal of 0.338 ha impermeable area contributing flows to the combined network upstream of manhole SJ34495901.

The solution elements are as follows:

- The removal of 0.338ha of impermeable area contributing flows to the combined network upstream of manhole SJ34495901.

6.2.2 Notional Design Solution

There is model predicted flooding downstream of the connection point. The solution proposes to remove surface water from the combined system, creating headroom for the development flows to connect to the network.

Figure 6-1 - Solution 1

6.2.3 Solution Assessment

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Solution 1	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3242.2	-2.5	-0.08

Table 6-1 - Solution 1 Hydraulic Analysis

CSO Name	Spill Frequency							
	Existing		Solution		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 6-2 - Solution 1 CSO Analysis

Solution 1 mitigates the detriment caused by the development at the flooding location which was predicted by the model. In addition, there is no negative impact on the downstream network.

6.2.4 Option Considerations

The surface water system which currently exists in the area discharges to River Gwenfro and it is assumed that the surface water system and River Gwenfro has the capacity to accept the additional flow. Confirmation of this is beyond the scope of this HMA. However, it is recommended this is investigated further at the design stage.

If impermeable area connections are located upstream of manhole SJ34495901 the surface water could also be removed through rain gardens, swales and other SuDs.

6.3 Solution 2; Online Storage

6.3.1 Description

This solution addresses the total development flows utilising Connection Point 1. This solution requires an increase in storage at Queens Park Y Wern Tanks (72378) which are located immediately upstream of manhole SJ34495901. This solution requires the construction of three new 24m, 1800mm diameter pipes at the eastern end of the existing storage tanks. The new pipes would be the same size in diameter as the existing pipes and would also have similar gradients. The proposed storage pipes have an upstream invert level of 63.310 mAOD and a downstream invert level of 63.210 mAOD.

The solution elements are as follows:

- Construction of three 24m, 1800mm diameter storage pipes at the eastern end of Queens Park Y Wern Tanks (72378), and
- Two new 3600mm diameter manholes.

6.3.2 Notional Design Solution

This solution proposes to mitigate the flooding detriment by providing additional online storage at the existing Queens Park Y Wern Tanks located immediately upstream of where the flooding is predicted. The downstream catchment will be unaffected by the additional online storage because the pipes downstream would be at full capacity.

Figure 6-2 - Solution 2

6.3.3 Solution Assessment

Comparison Analysis

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Solution	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3244.4	-0.3	-0.01

Table 6-3 - Solution 2 Hydraulic Analysis

CSO Name	Spill Frequency							
	Existing		Solution		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 6-4 - Solution 2 CSO Analysis

Solution 2 mitigates the detriment caused by the development at the flooding detriment location which was predicted by the model. In addition, there is no negative impact on the downstream network. The solution has not had a significant impact on the existing CSO spills at Pont Wen CSO.

6.3.4 Option Considerations

The construction of this online storage is more viable in comparison to the online storage which was discounted as it would not impose any risks to the surrounding areas. The detriment can also be resolved by upsizing five of the existing storage pipes at Queens Park Y Wern from 1800mm to 2400mm. However, this would not be cost-beneficial, and it is more feasible to connect three smaller storage pipes at the eastern end. It would be more difficult to construct the storage pipes at the western end of the tanks as there is an existing surface water sewer. A site visit identified a possible root complex near the area of the tank upsizing that should be investigated at the detail design stage.

6.4 Solution 3; Offline Storage

6.4.1 Description

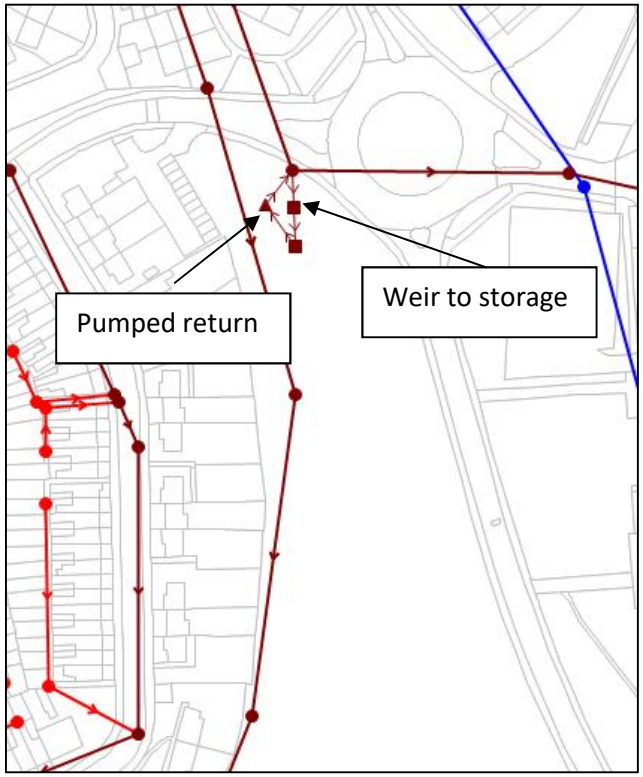
This solution addresses the total development flows utilising Connection Point 1. This solution requires an offline storage at manhole SJ34503102 which is located 0.35km upstream of the flooding detriment. This solution requires a weir to direct the excess flows to a storage tank, and the flows would return to the same manhole via a pump. A storage tank with a volume of 205m^3 is required and a weir at a level of 67.530 mAOD. The return pump would discharge at a rate of 9l/s.

The solution elements are as follows:

- Construction of a 205m^3 storage tank,
- A weir (crest of 67.530 mAOD), and
- A return pump discharging at a rate of 9l/s controlled by RTC.

6.4.2 Notional Design Solution

This solution proposes to mitigate the flooding detriment by providing additional offline storage at a manhole located 0.35km upstream of the flooding detriment. The downstream catchment will be unaffected by the additional offline storage. The minimum discharge rate of 9l/s at the return pump is based on a 6-hour retention at the storage tank. RTC will be required to determine when there is capacity in the network for the return pumps to turn on, this will be confirmed at detail design.



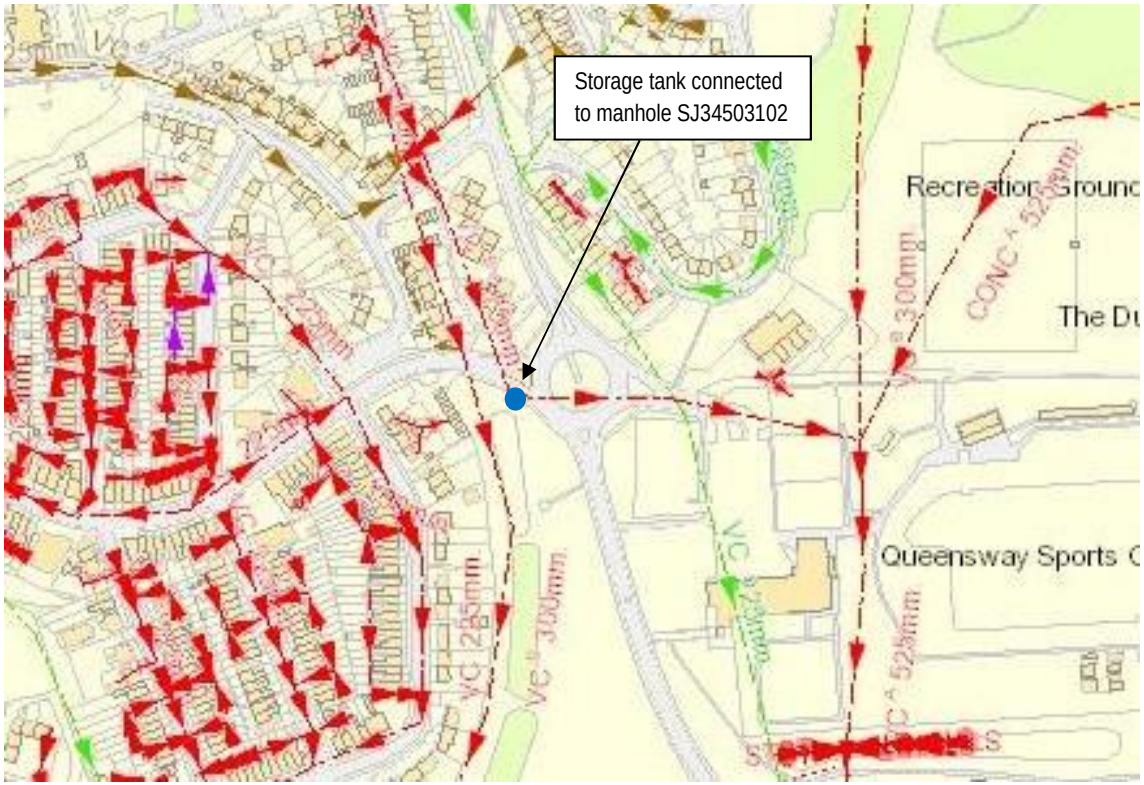


Figure 6-3 - Solution 4

6.4.3 Solution Assessment

Comparison Analysis

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Solution	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3242.6	-2.1	-0.06

Table 6-5 - Solution 4 Hydraulic Analysis

CSO Name	Spill Frequency							
	Existing		Solution		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 6-6 - Solution 4 CSO Analysis

Solution 3 mitigates the detriment caused by the development at the flooding detriment location which was predicted by the model. In addition, there is no negative impact on the downstream network and overflows.

6.4.4 Option Considerations

The solution should still work if the pump returns to the next manhole downstream (SJ34504101); however, this would be difficult to construct as the pump would have to cross a roundabout.

6.5 Solution 4; Offline Storage

6.5.1 Description

This solution addresses the total development flows utilising Connection Point 1. This solution requires an offline storage at manhole SJ34505401 which is located 0.4km upstream of the flooding detriment. This solution requires a weir to direct the excess flows to a storage tank, where the flows would return to the next manhole downstream (SJ34505202) via a pump. A storage tank with a volume of 263m^3 is required and a weir at a level of 67.455 mAOD. The return pump would discharge at a rate of 12l/s.

The solution elements are as follows:

- Construction of a 263m^3 storage tank with,
- A weir (crest of 67.455 mAOD), and
- A return pump discharge rate of 12l/s controlled by RTC.

6.5.2 Notional Design Solution

This solution proposes to mitigate the flooding detriment by providing additional offline storage at a manhole located 0.4km upstream of the flooding detriment. The downstream catchment will be unaffected by the additional offline storage. The minimum discharge rate of 12l/s at the return pump is based on a 6-hour retention at the storage tank. RTC will be required to determine when there is capacity in the network for the return pumps to turn on, this will be confirmed at detail design.

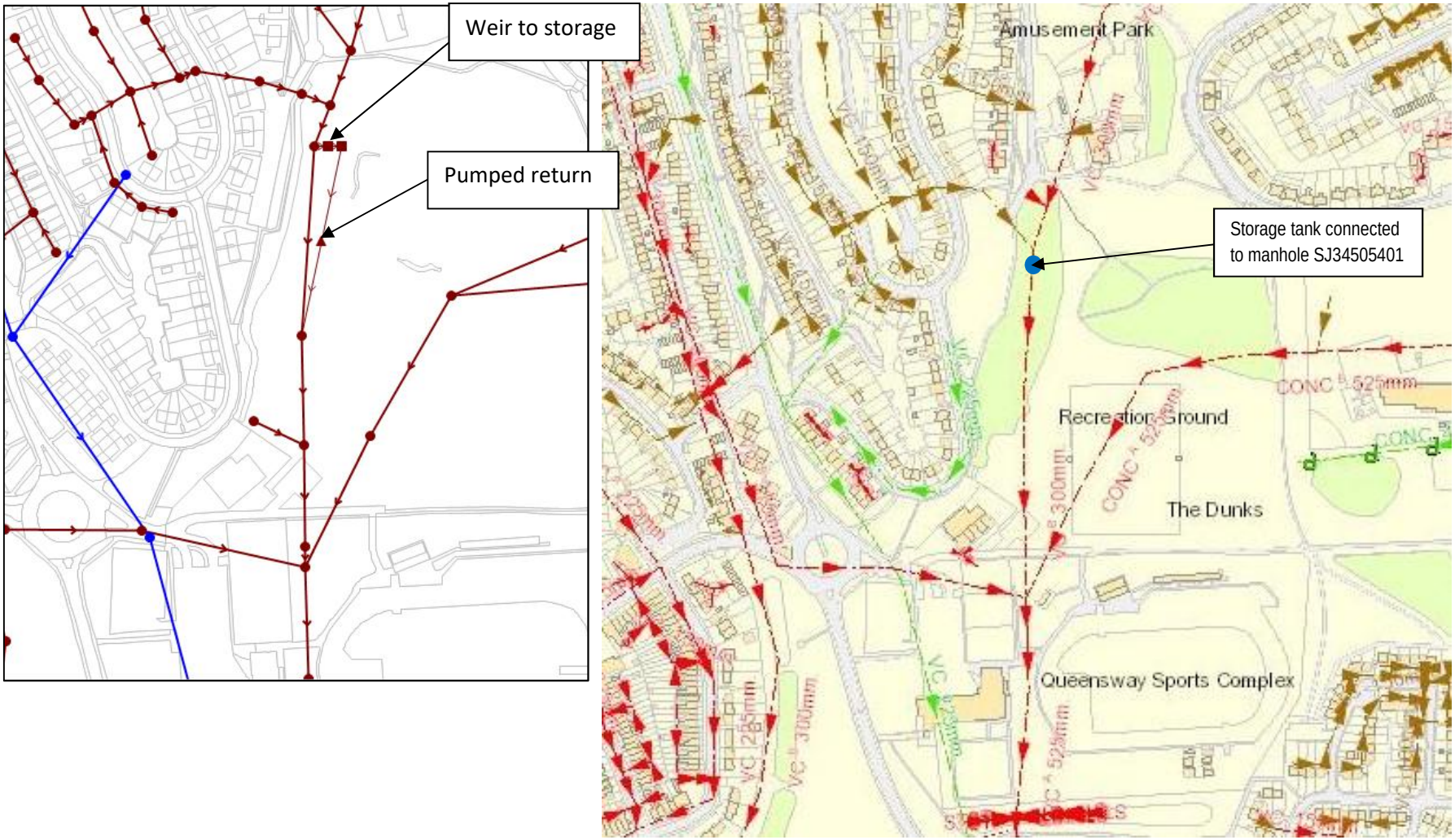


Figure 6-4 - Solution 3

6.5.3 Solution Assessment

Comparison Analysis

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Solution	Absolute (m^3)	Percentage (%)
SJ34495901	SJ34495901	1440 (winter)	3244.7	3244.1	-0.6	-0.02

Table 6-7 - Solution 3 Hydraulic Analysis

CSO Name	Spill Frequency							
	Existing		Solution		Spill Frequency Difference		Spill Volume Difference	
	Spills (No.)	Total Spill Vol. (m^3)	Spills (No.)	Total Spill Vol. (m^3)	Absolute (No.)	Percentage (%)	Absolute (m^3)	Percentage (%)
Pont Wen CSO	1	3	1	3	0	0	0	0

Table 6-8 - Solution 3 CSO Analysis

Solution 4 mitigates the detriment caused by the development at the flooding detriment location which was predicted by the model. In addition, there is no negative impact on the downstream network. The solution has not had a significant impact on the existing CSO spills at Pont Wen CSO.

6.5.4 Option Considerations

In addition, the solution would still work if the pump returns to the same manhole (SJ34505401) rather than the next manhole downstream.

7 Solution Costs

The solution costs provided are based on the DCWW Solution Target Pricing Tool (STPT). This cost model predicts costs based on final costs of completed schemes. **These are intended to be high level cost estimates and are for option comparison only**. It is recommended that a detailed cost estimate is undertaken during the detailed design phase.

Solution	Description	Cost
1	Surface Water Removal*	N/A
2	Online Storage	£256,000
3	Offline Storage	£412,000
4	Offline Storage	£486,000

Table 7-1 - Solution Costs

* The cost for surface water removal have not been included due to variability between schemes.

8 Conclusions & Recommendations

- This HMA has assessed the residential flows from a proposed development on Stansty Chain Road, Wrexham. The proposed development consists of 455 properties on a site of approximately 21.7 Ha. The site is currently a greenfield site and it is proposed that the 455 residential properties will be pumped to the public sewer at the south of the site at Connection Point 1 (Manhole SJ32517701). The development will be delivered in 6 phases; 80 properties will be delivered in each of the first 5 phases and 55 properties will be delivered in the final phase.

- The proposed development at Stansty Chain Road has been assessed using one connection point:

  - Connection Point 1: The proposed connection point for the residential properties is manhole SJ32517701 located on Stansty Road opposite Rhosddu Church (Colliery Road), which is to the south of the development.

- The proposed development is located within the Five Fords WwTW catchment. The existing model for Five Fords, which was recently upgraded in 2018 for a separate study within the catchment, was used as the basis for this HMA. The model required further modifications before being deemed suitable for the purpose of this HMA. Following these updates, the model was considered suitable for assessing the impact of the proposed development.

- The developer has been advised that surface water runoff is to be separated from foul flows and it will not be discharged into the existing foul/combined system. The scope of this HMA is limited to the impact on the existing combined system, hence surface water systems within the separated areas have not been considered.

- During the model build and verification process, it was found that there may be connectivity information missing at Wrexham Park Avenue CSO. The verification at the areas which could have been potentially affected by the missing information were considered acceptable based on the information currently held. It is recommended to further investigate the connectivity at this CSO during the detailed design stage.

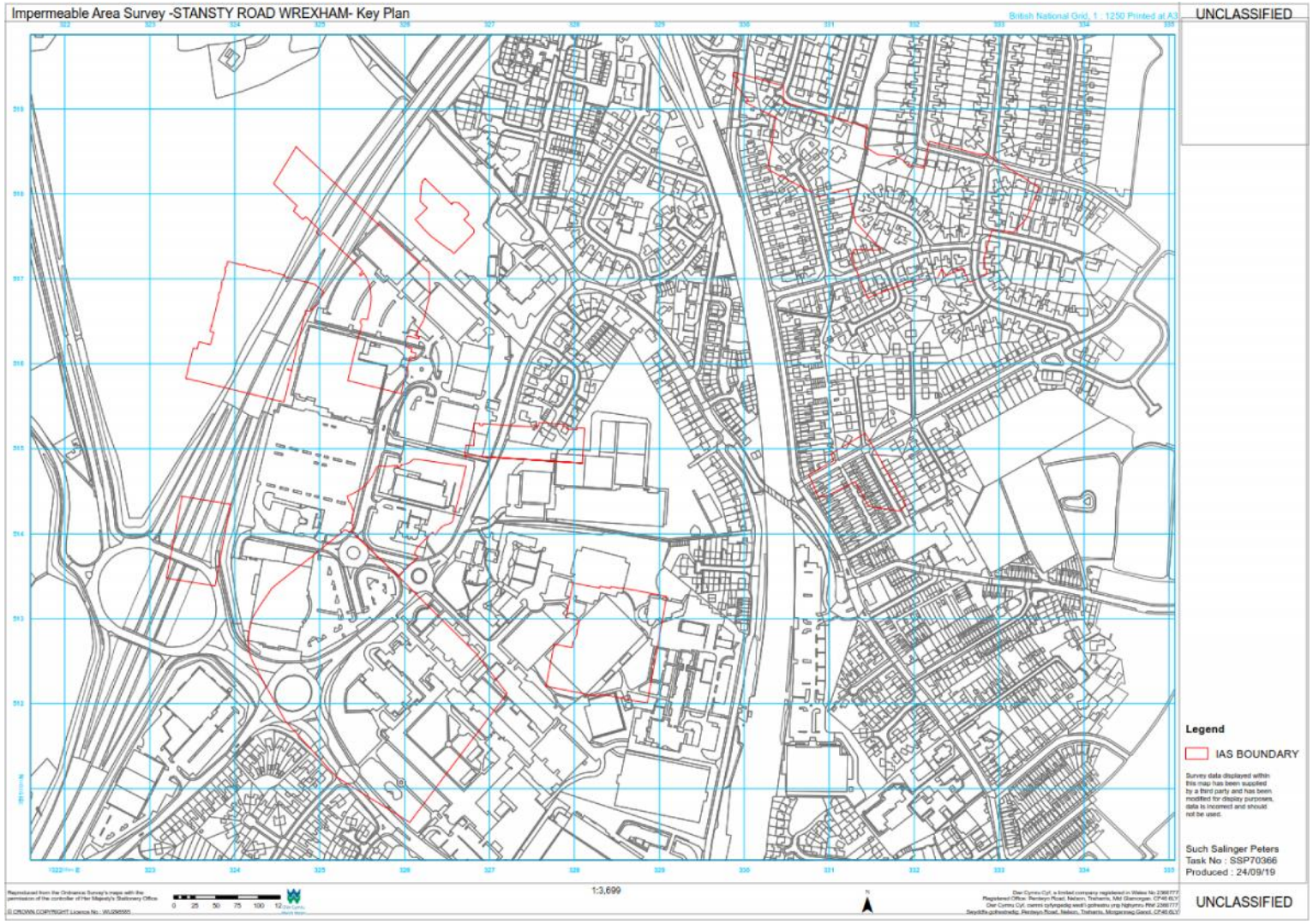
- All phases of the development were predicted to cause flooding detriment in the network. The flooding is significant, and it is predicted to increase to 102m^3 over the total development. The potential flooding would be caused by a hydraulic incapacity in the network. The detriment is not considered acceptable and solutions would be required prior to any connection of the development to the existing network.

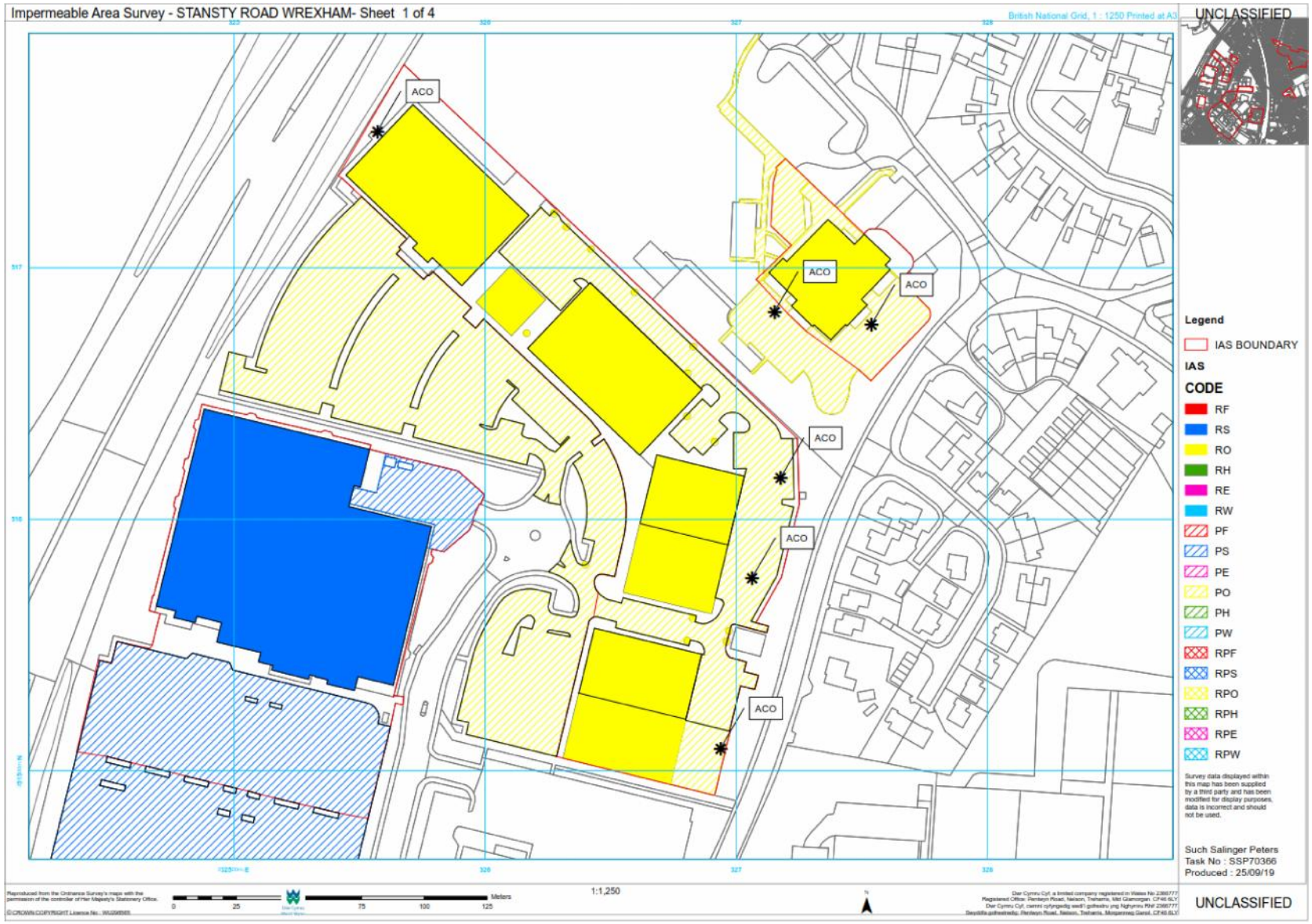
- Solution development has identified 4 solutions to resolve the predicted detriment. The solutions are:

  - Solution 1 – Surface Water Removal. This solution involves the removal of 0.338 ha contributing area from the combined system.
  - Solution 2 – Online Storage; three new 24m, 1800mm diameter pipes. The storage pipes would be connected to the eastern end of the existing Queens Park Y Wern Tanks (72378) located immediately upstream of the flooding detriment. The estimated cost of this solution is £256,000.
  - Solution 3 – Offline Storage; 205m^3 storage tank at manhole SJ34503102. The flows would return to the system at the same manhole via a pump at a rate of 9l/s. The estimated cost of this solution is £412,000.
  - Solution 4 – Offline Storage; 263m^3 storage tank at manhole SJ34505401. The flows would return to the system at the next manhole downstream via a pump at a rate of 12l/s. The estimated cost of this solution is £486,000.

Appendix A – Drawings & Plans

Appendix B – Impermeable Area Survey Results




Impermeable Area Survey - STANSTY ROAD WREXHAM- Sheet 1 of 4
British National Grid, 1 : 1250 Printed at A3
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Survey data displayed within this map has been supplied by a third party and has been modified for display purposes, data is incorrect and should not be used.
Such Salinger Peters
Task No : SSP70366
Produced : 25/09/19
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Meters
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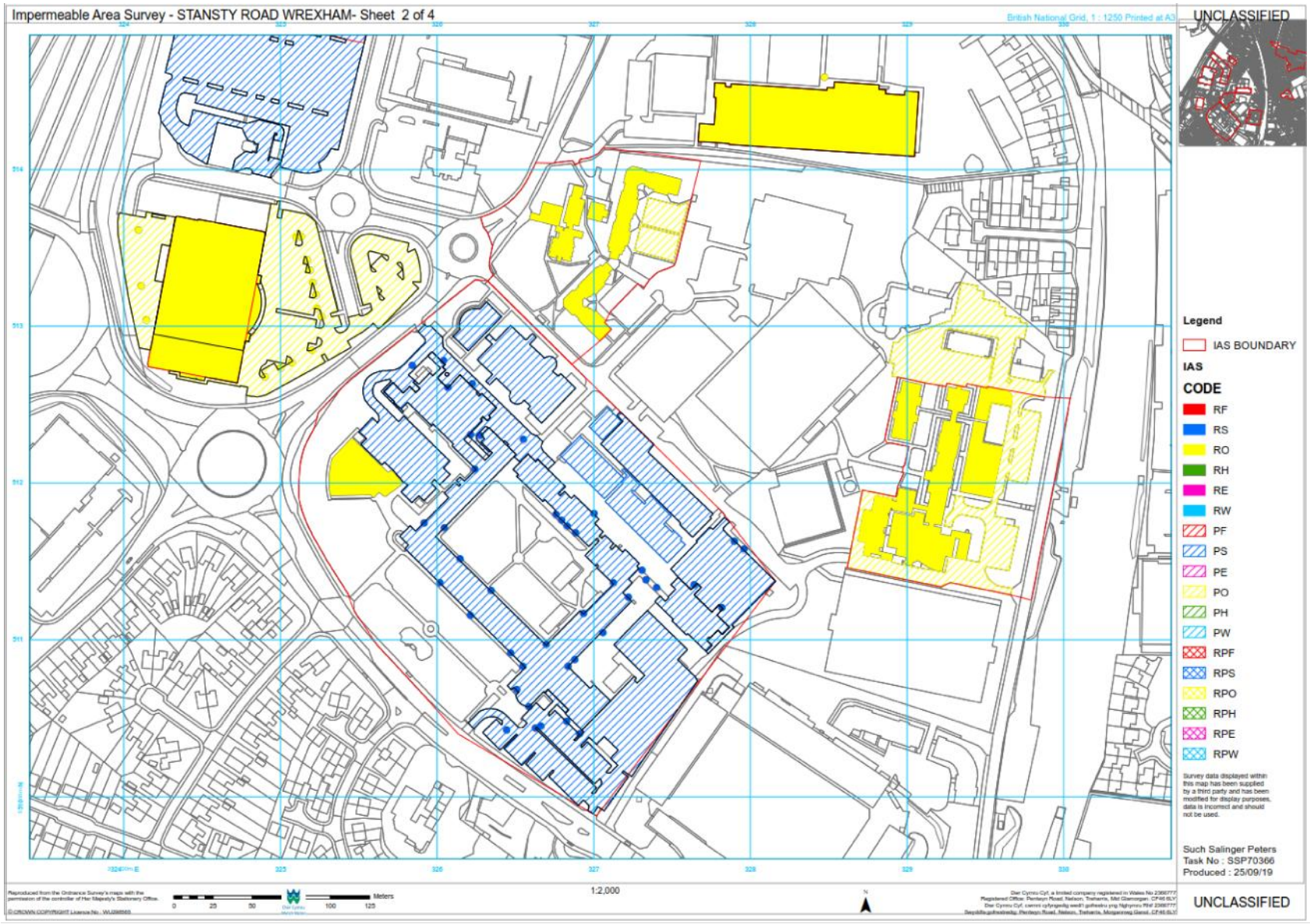
75
100
125
UNCLASSIFIED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British National Grid, 1 : 1250 Printed at A3
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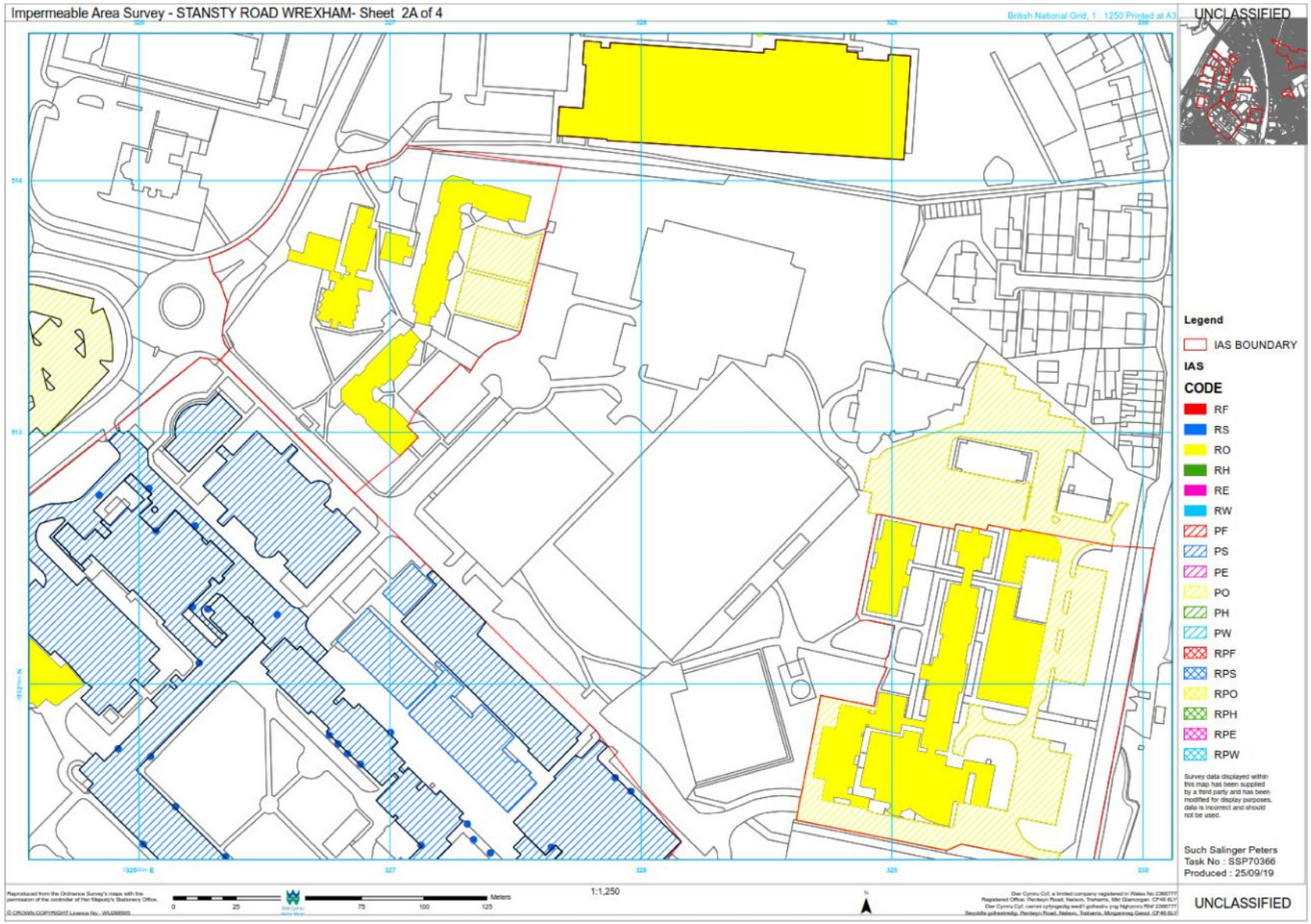
Impermeable Area Survey - STANSTY ROAD WREXHAM- Sheet 2A of 4
British National Grid, 1 : 1250 Printed at A3
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Survey data displayed within this map has been supplied by a third party and has been modified for display purposes, data is incorrect and should not be used.
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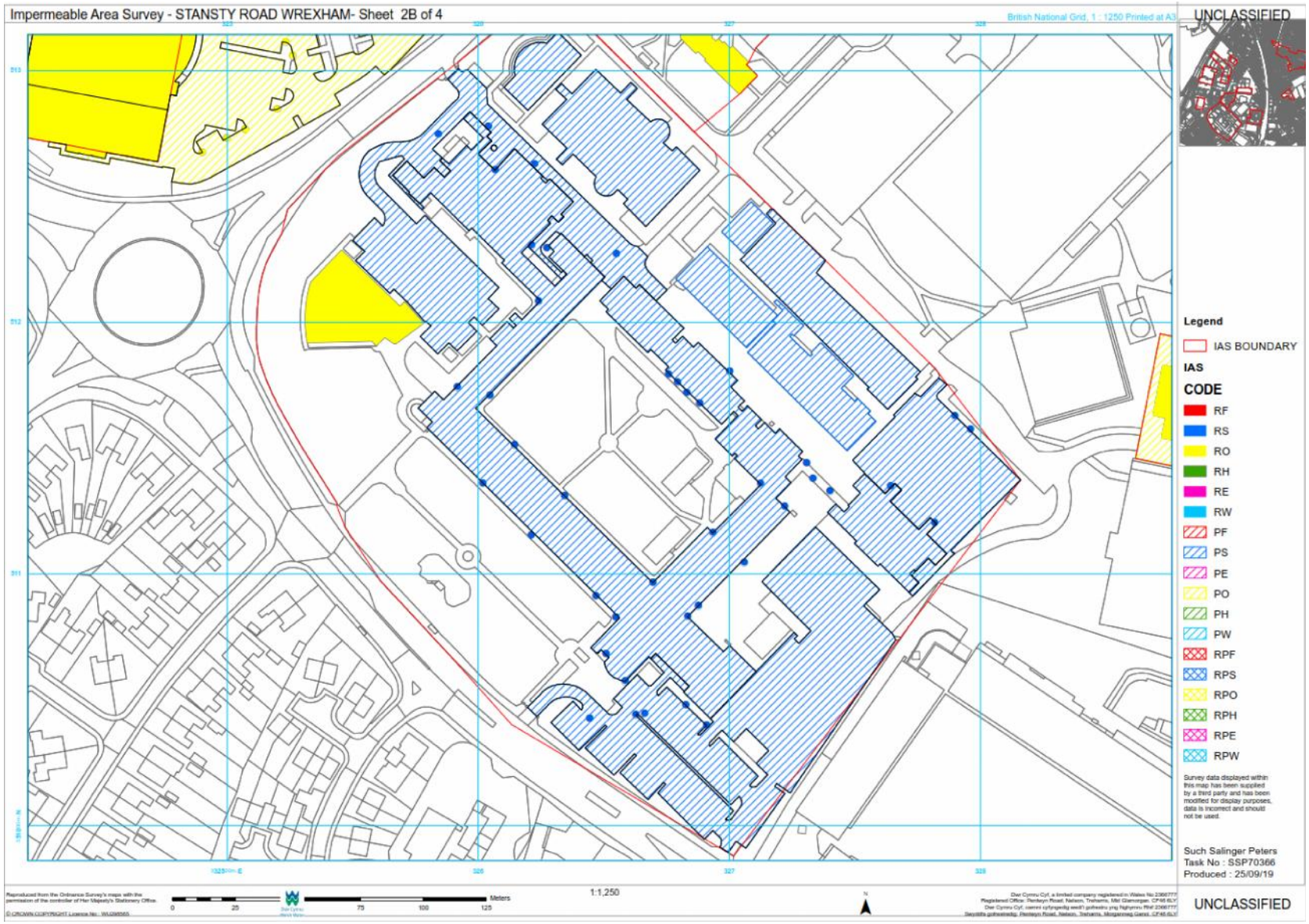
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British National Grid, 1 : 1250 Printed at A3
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Survey data displayed within this map has been supplied by a third party and has been modified for display purposes. data is incorrect and should not be used.
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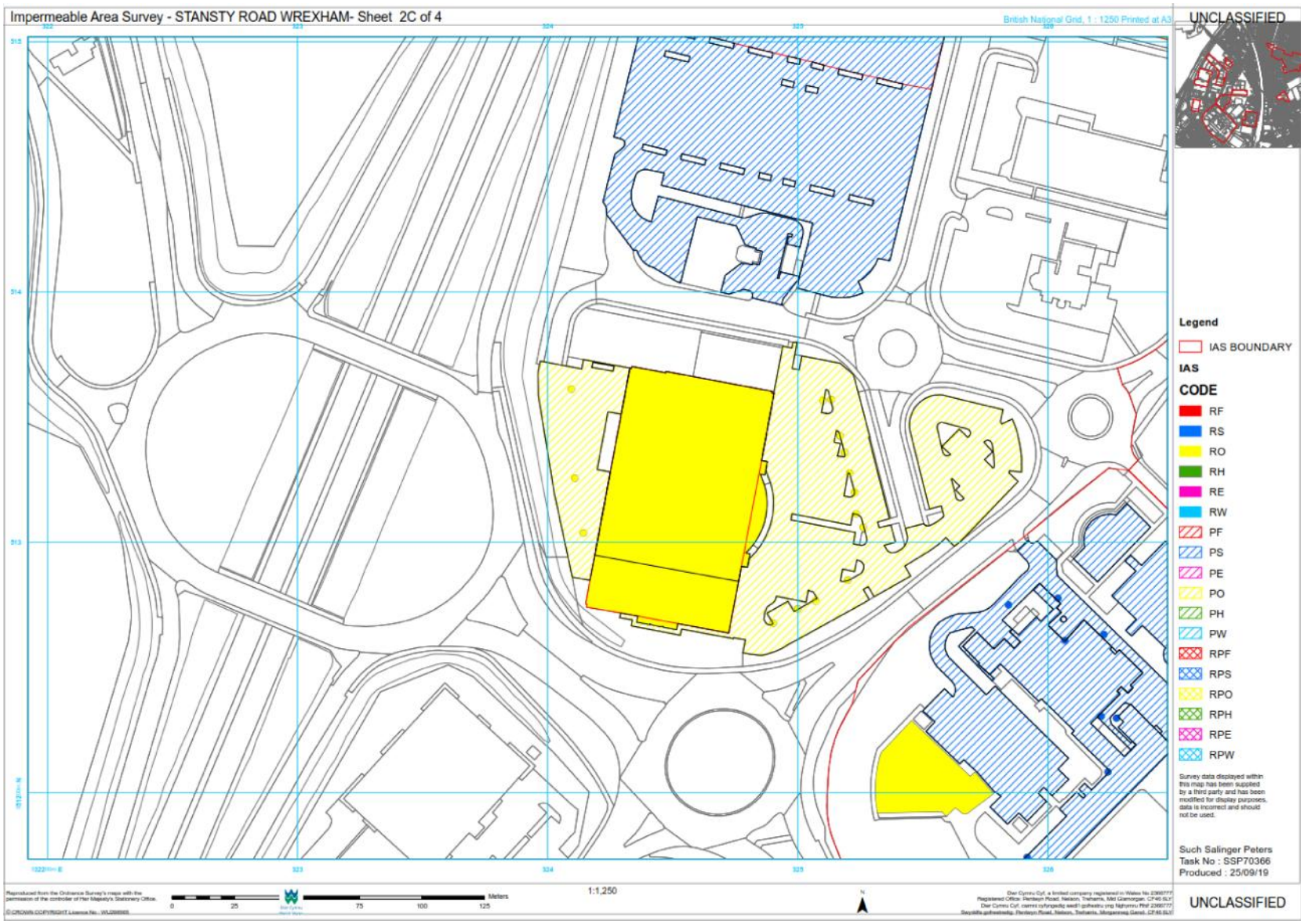
UNCLASSIFIED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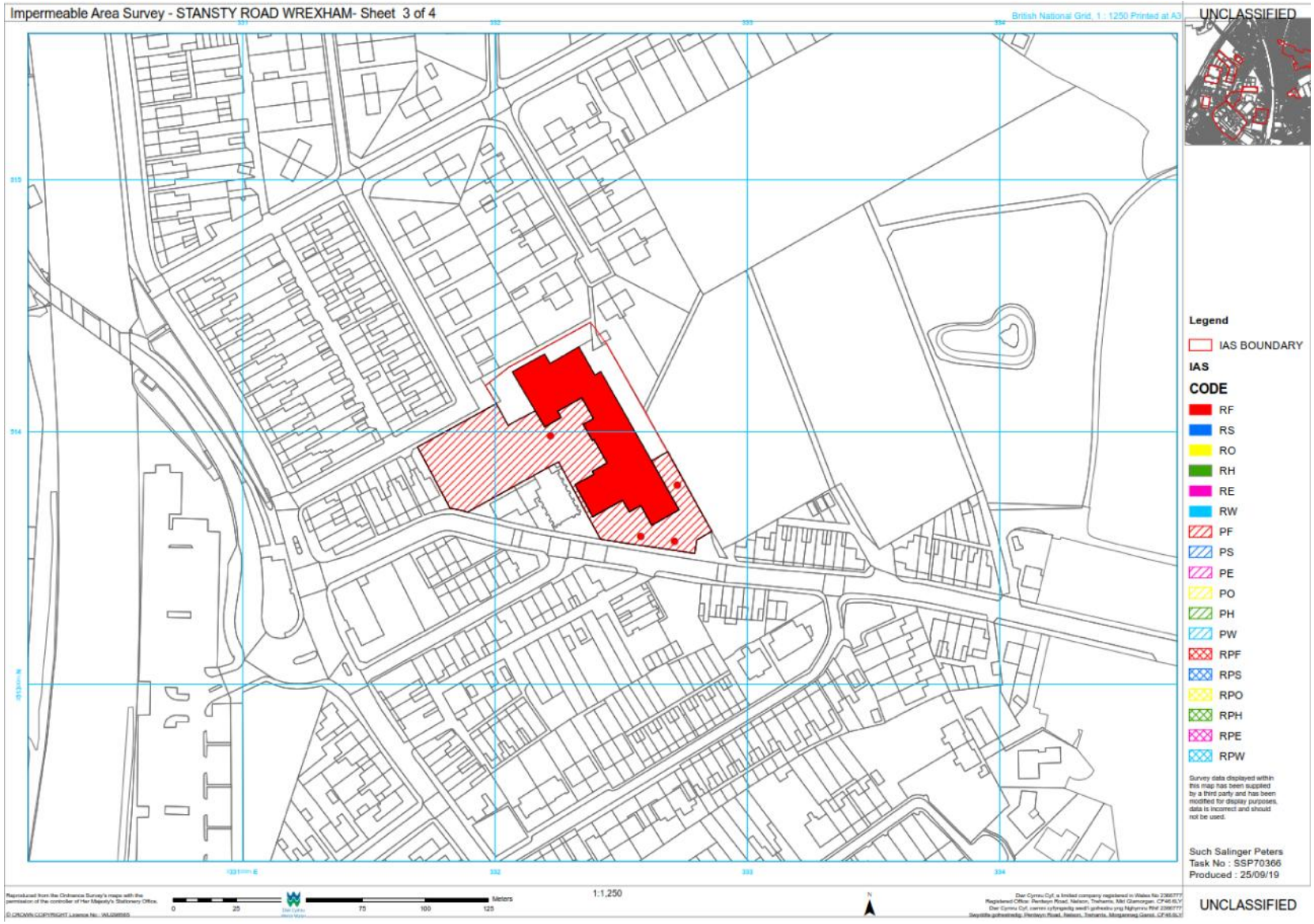
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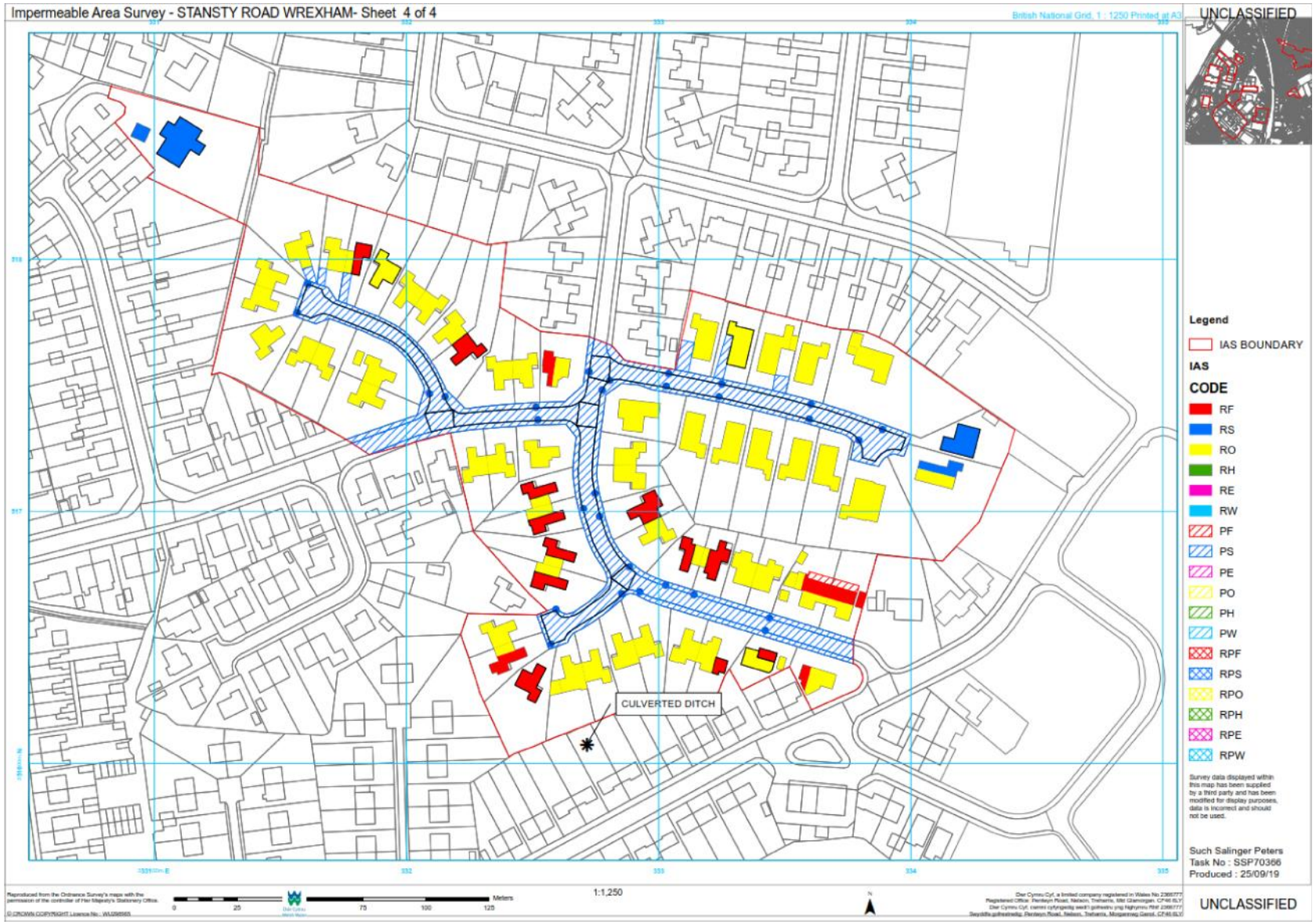
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British National Grid, 1 : 1250 Printed at A3
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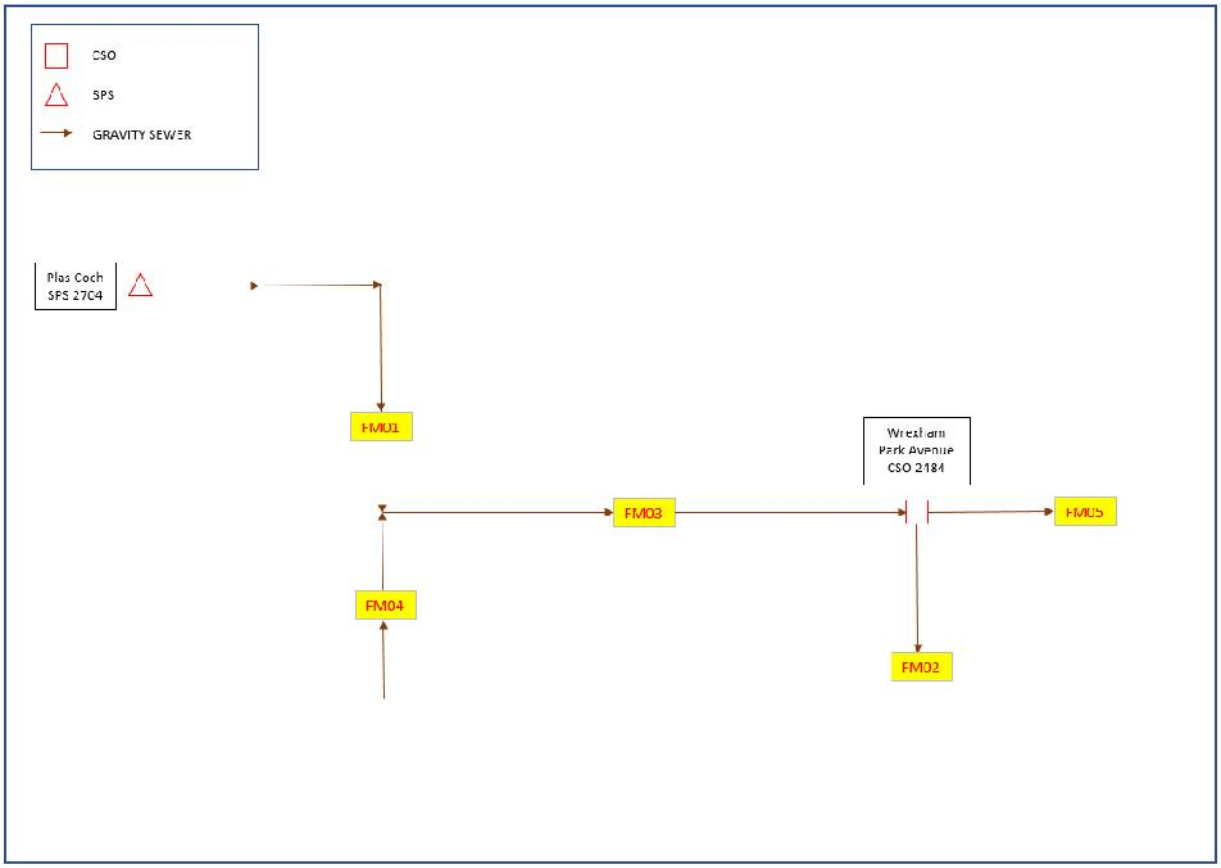
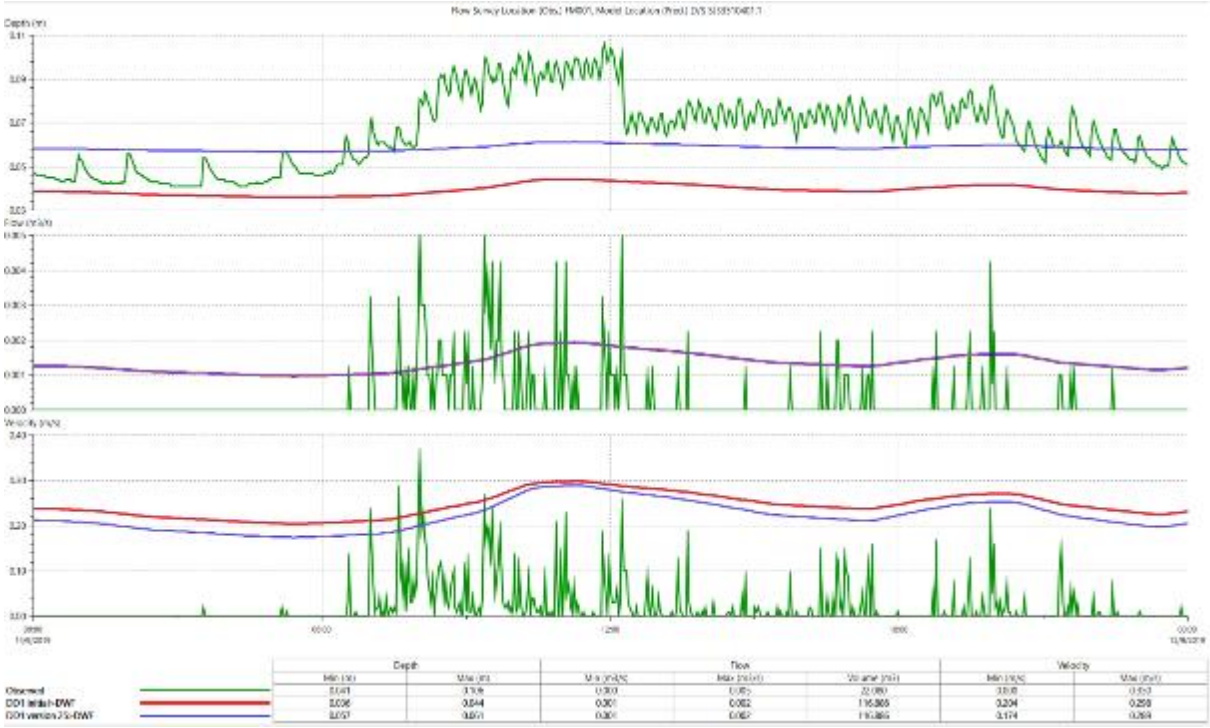
Appendix C – Verification Plots & Comparative Analysis

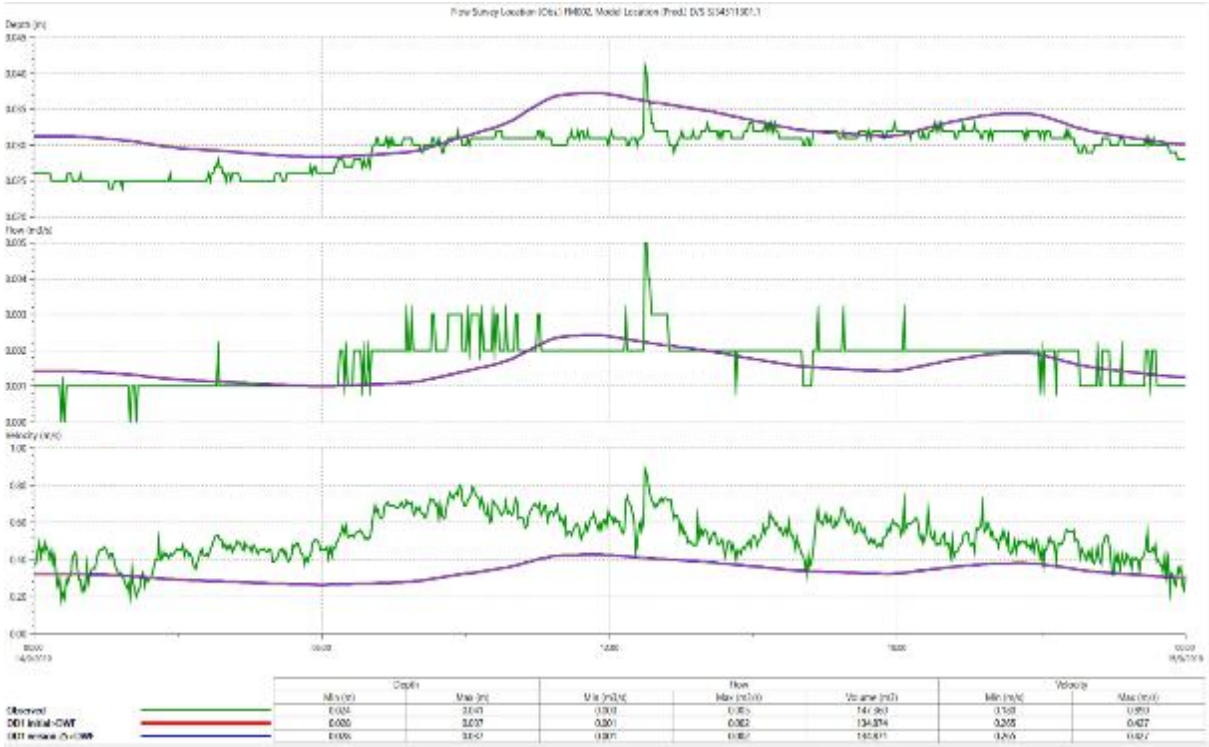


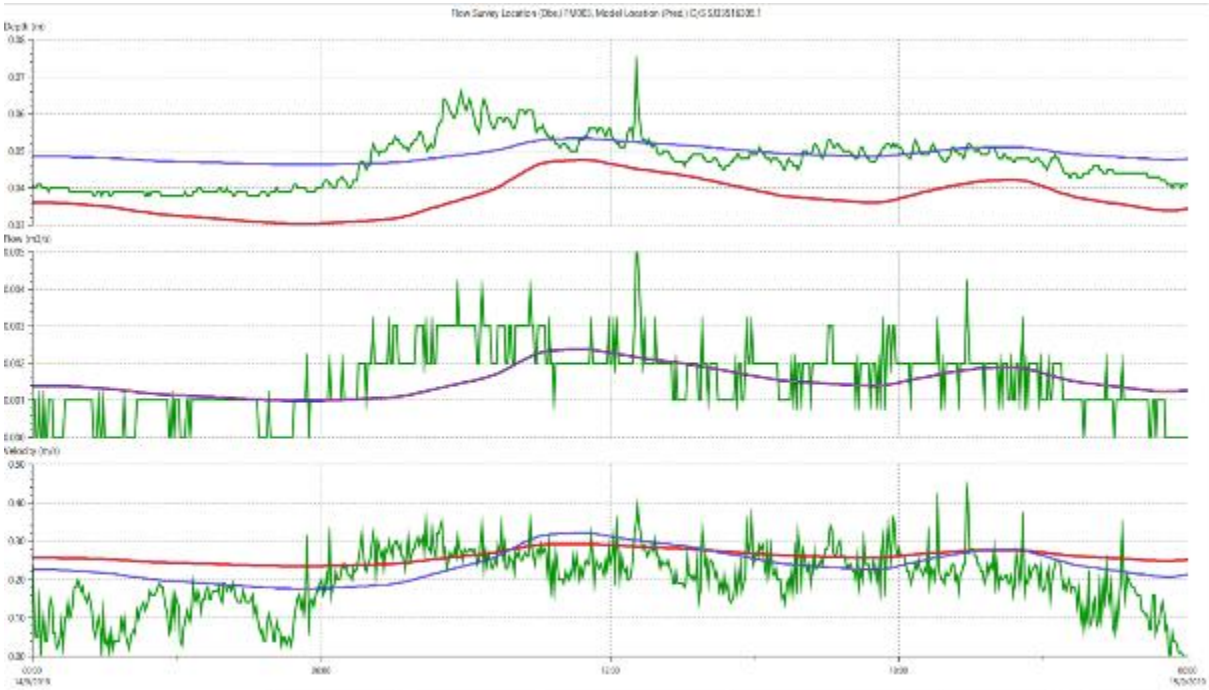
Flow Monitor Schematic

DRY WEATHER FLOW VERIFICATION

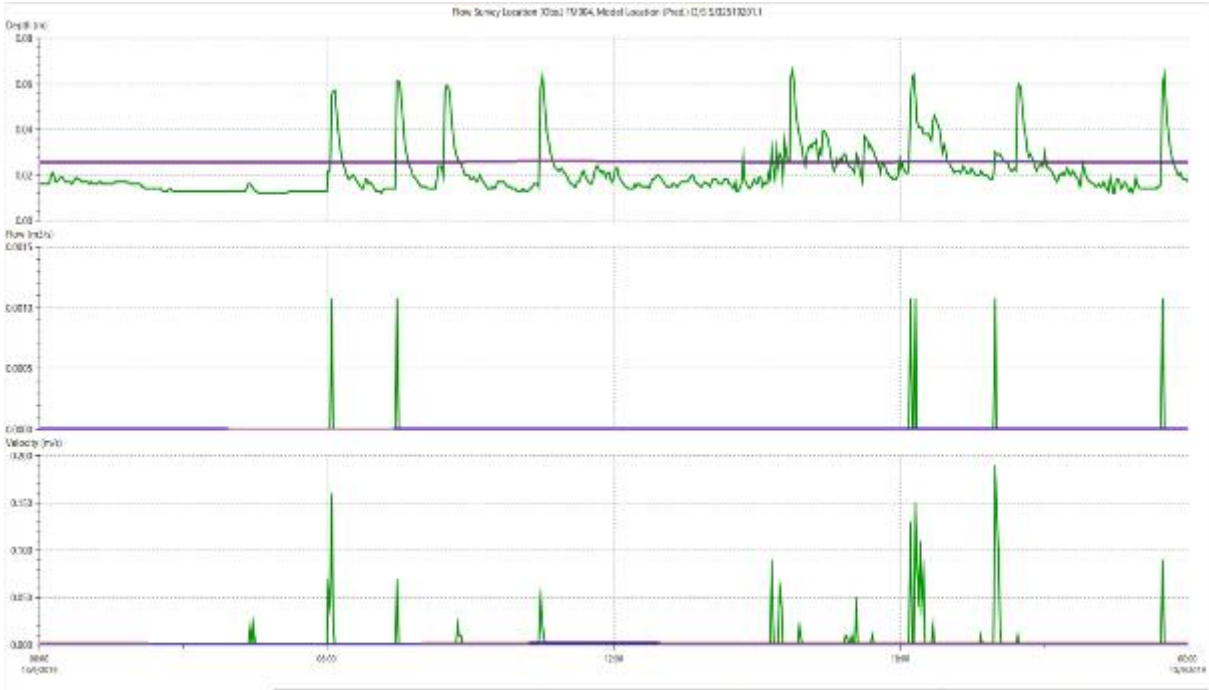
Dry Day 1



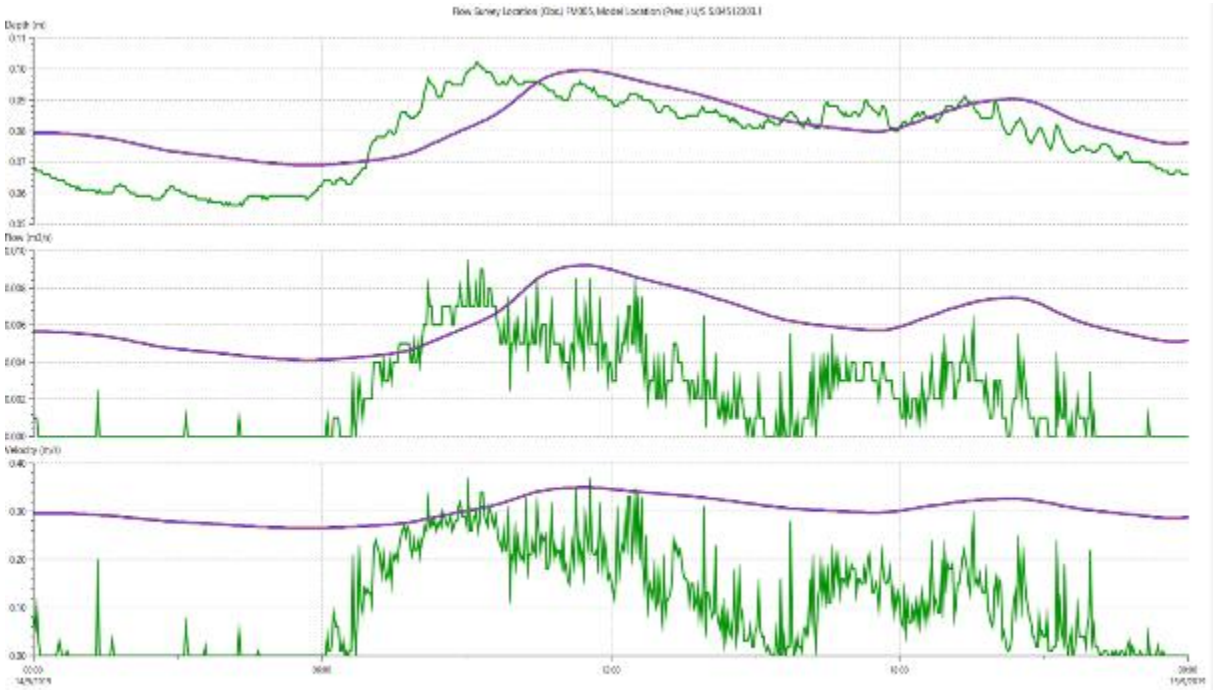




	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D01 initial->DWF	0.033	0.046	0.001	0.002	[illegible]	0.234	0.241
D01 version 25->DWF	0.048	0.053	0.001	0.002	[illegible]	0.175	0.321

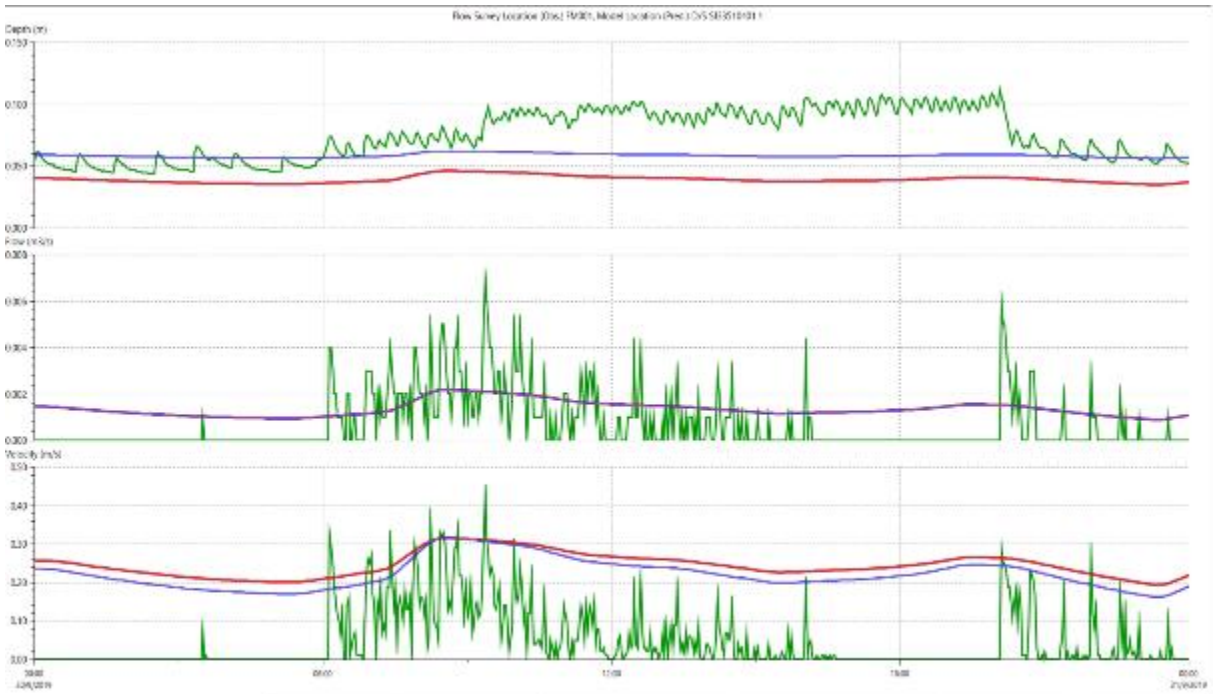


	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D01 initial->DWF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
D01 version 25->DWF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

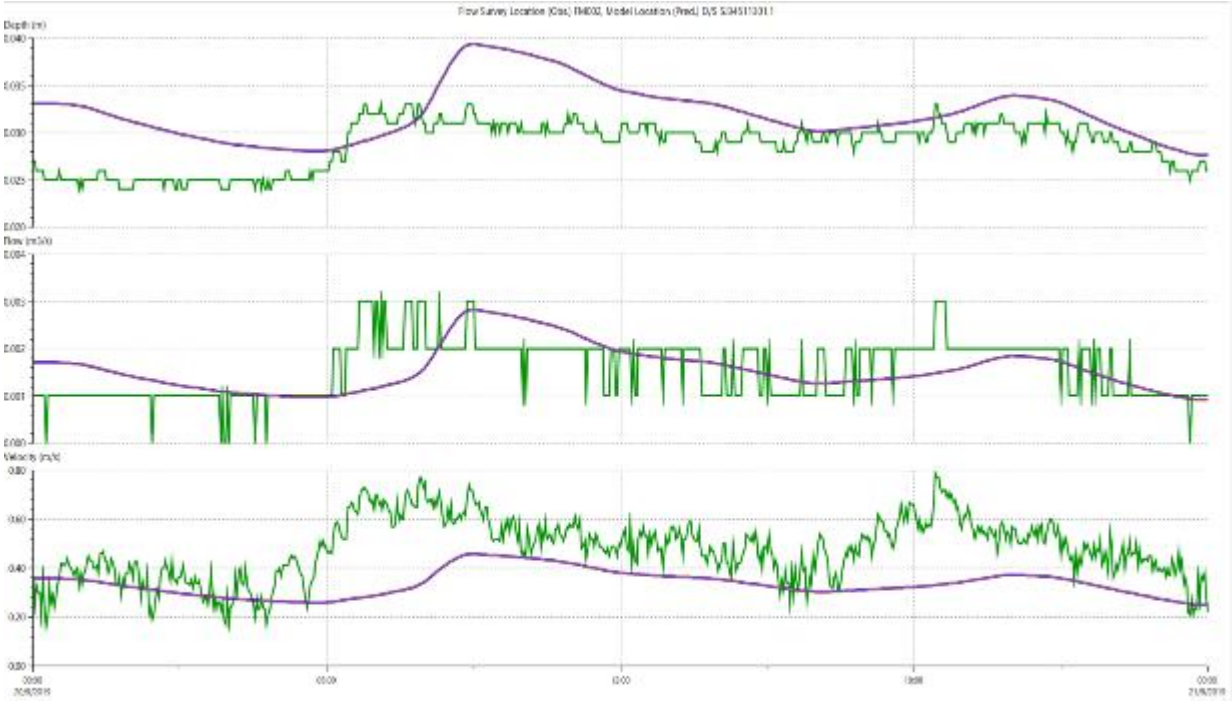


	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Observed	0.055	0.157	0.000	0.004	167.710	0.000	0.318
DO1 initial->DWF	0.069	0.130	0.004	0.009	503.008	0.295	0.358
DO1 version 2->DWF	0.067	0.130	0.004	0.009	503.008	0.286	0.358

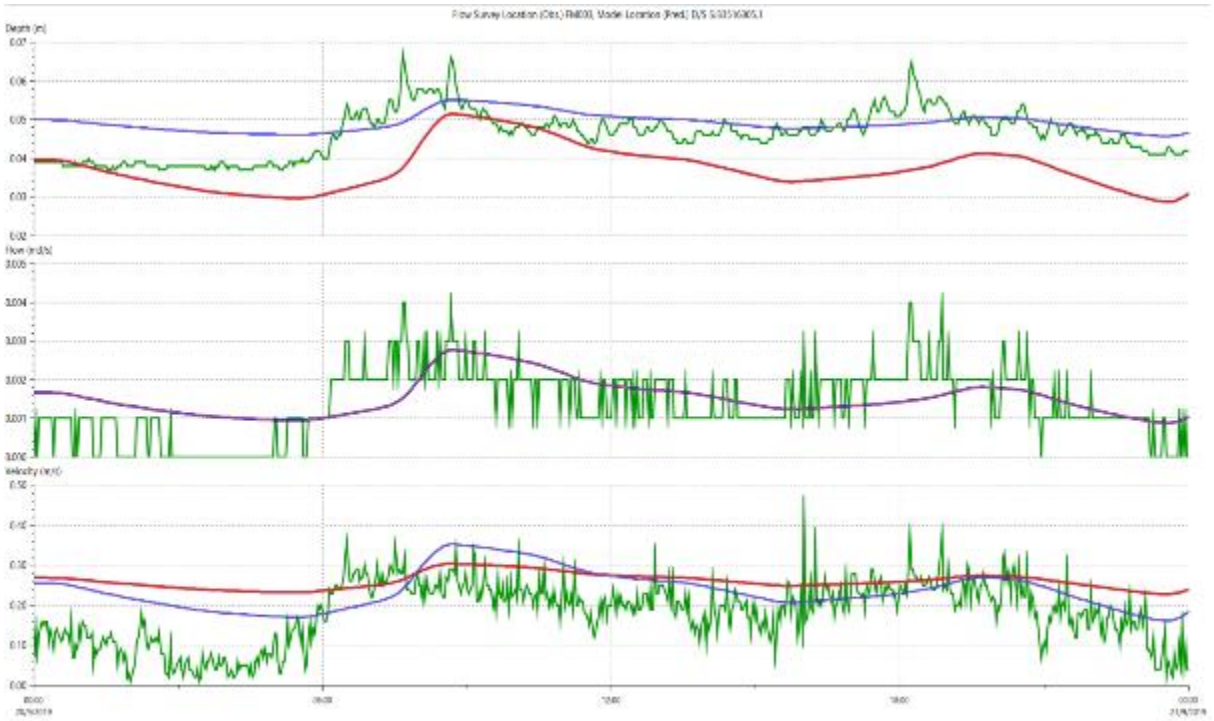
Dry Day 2



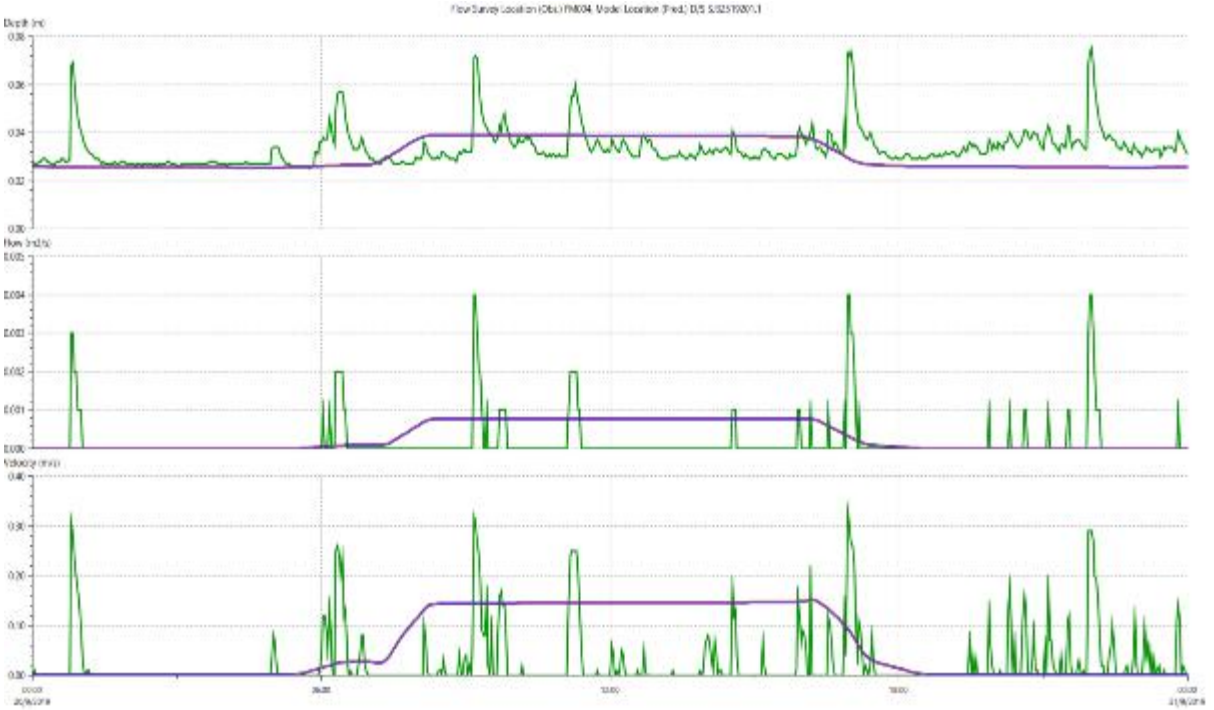
	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Observed	0.044	0.112	0.000	0.007	56.046	0.000	0.430
DO2 max->DWF	0.028	0.049	0.001	0.002	111.254	0.154	0.376
DO2 version 2->DWF	0.026	0.062	0.001	0.002	111.250	0.145	0.376



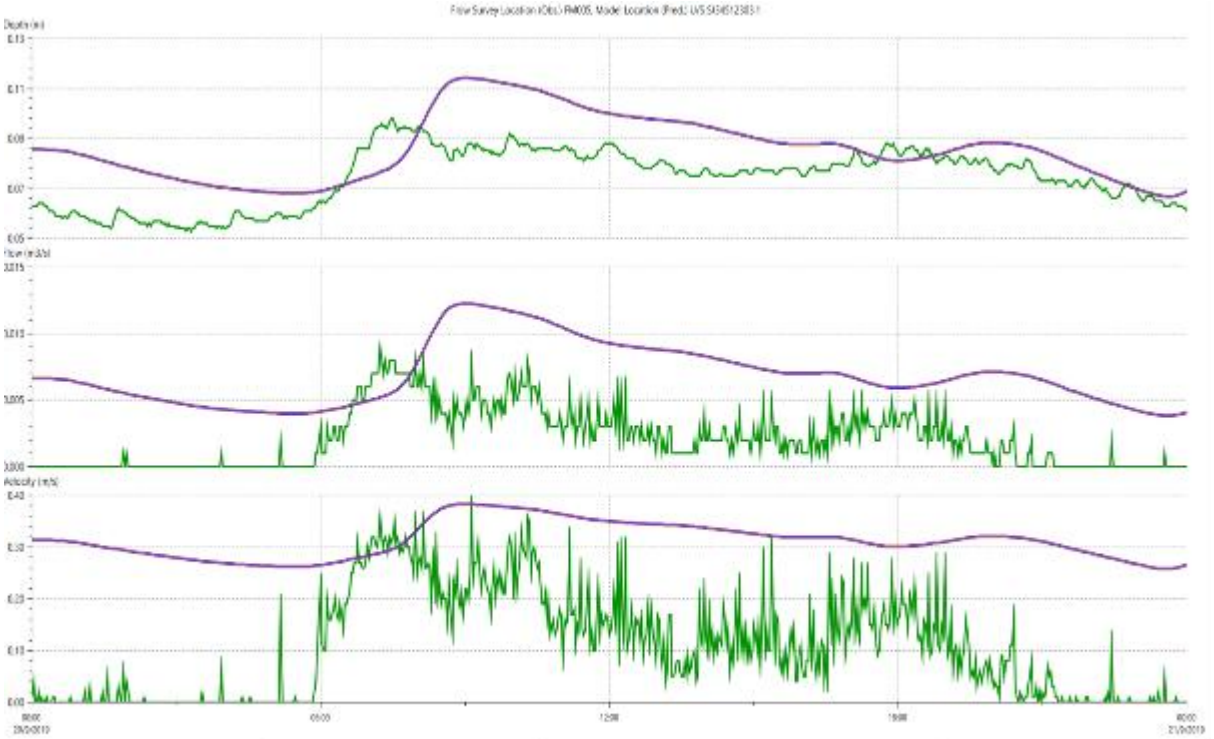
	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	0.024	0.033	0.000	0.003	134.080	0.160	0.790
DD2 mean+DWF	0.030	0.039	0.001	0.000	138.171	0.250	0.450
DD2 mean 25+DWF	0.030	0.039	0.001	0.000	138.092	0.250	0.450



	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	0.037	0.067	0.000	0.006	117.123	0.010	0.453
DD2 total+DWF	0.039	0.051	0.001	0.003	132.365	0.218	0.304
DD2 mean 25+DWF	0.040	0.052	0.001	0.003	132.253	0.192	0.302



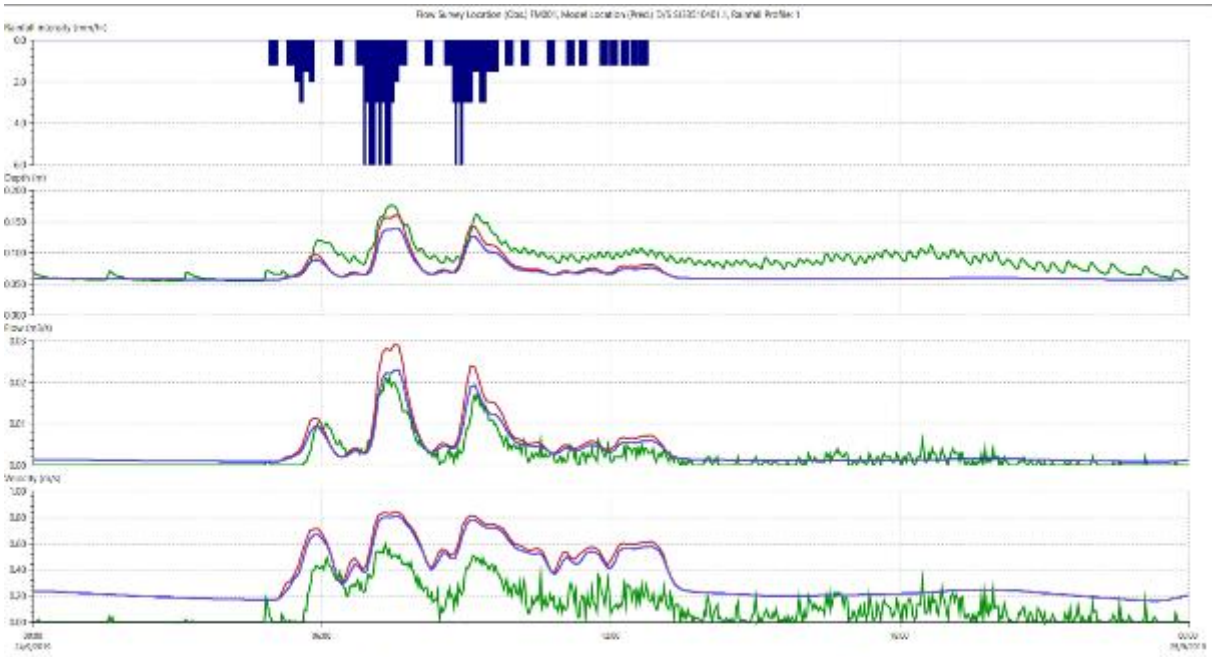
	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	0.025	0.075	0.000	0.004	12.300	0.000	0.333
DR2 initial+DWF	0.025	0.039	0.000	0.007	26.234	0.001	0.753
DR2 version 25+DWF	0.025	0.039	0.000	0.007	26.234	0.001	0.753



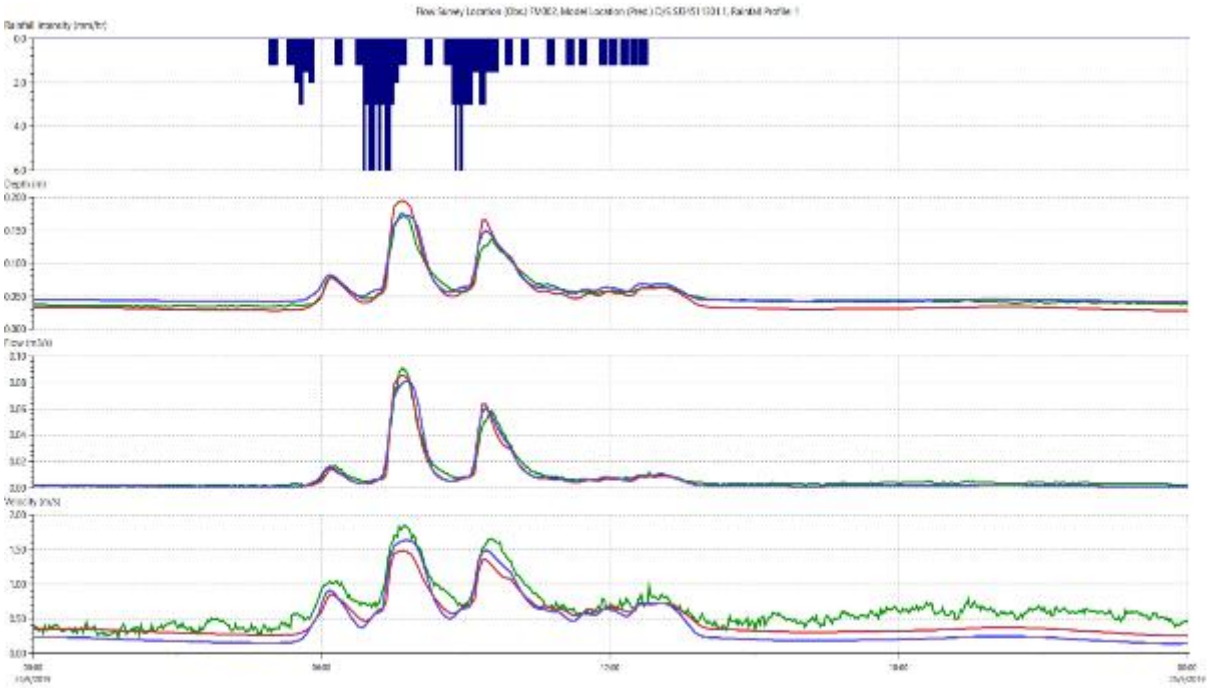
	Depth		Flow			Velocity	
	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Observed	0.053	0.098	0.000	0.005	175.560	0.000	0.380
DR2 initial+DWF	0.067	0.114	0.004	0.012	510.241	0.258	0.383
DR2 version 25+DWF	0.067	0.114	0.004	0.012	510.234	0.258	0.383

STORM VERIFICATION

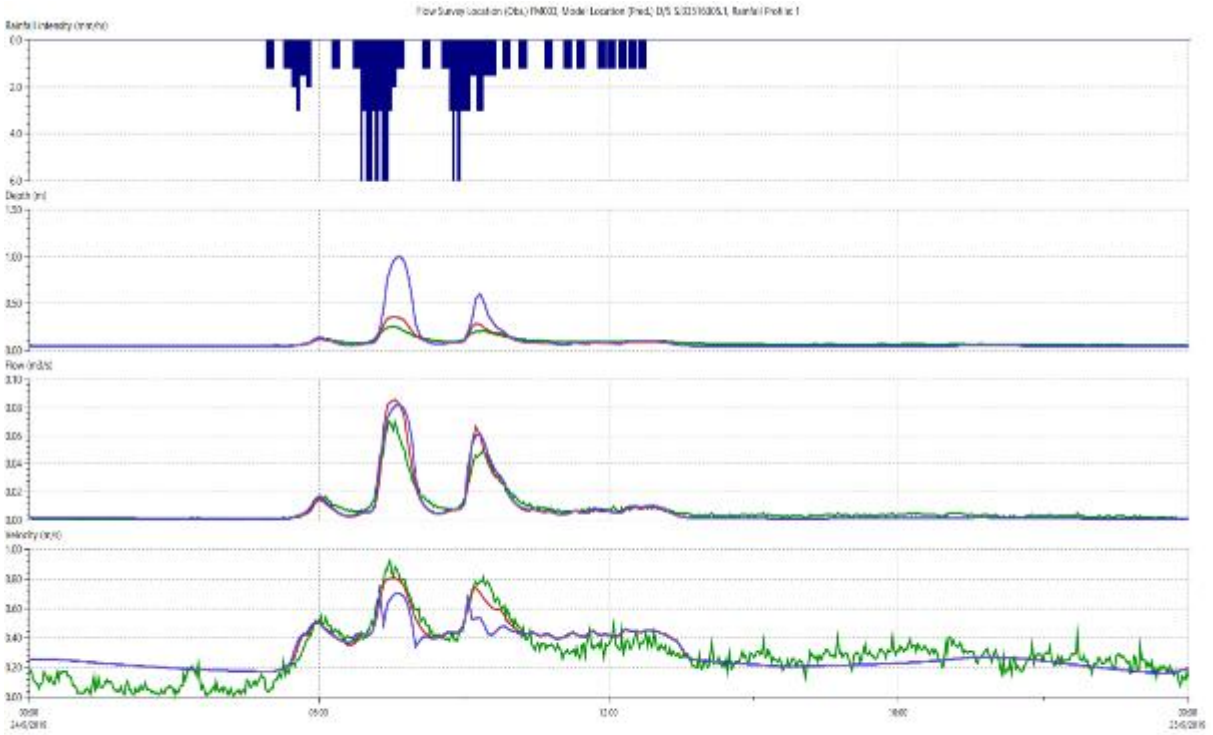
Storm A



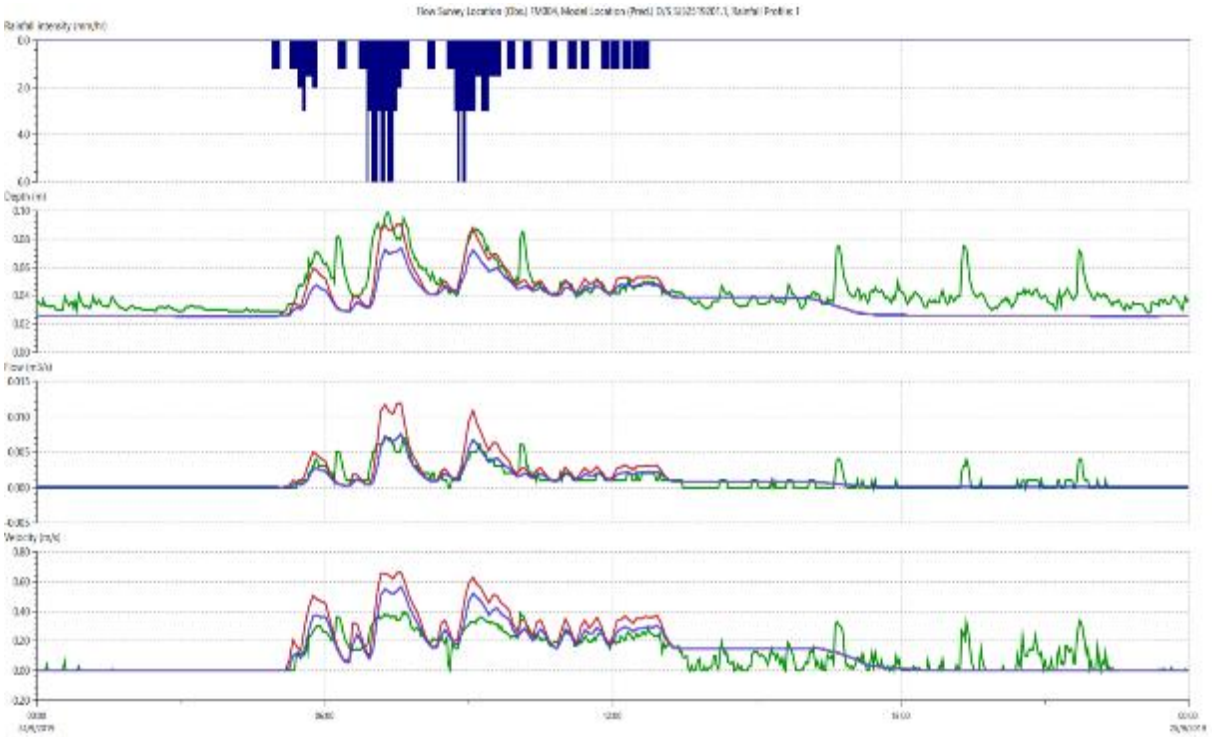
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	10.000	5.000	0.418							
Observed				0.075	0.172	0.000	0.271	141,160	0.000	0.000
Storm A initial+Storm A				0.056	0.160	0.001	0.329	375,035	0.164	0.843
Storm A final+Storm A				0.056	0.178	0.001	0.323	270,020	0.164	0.809



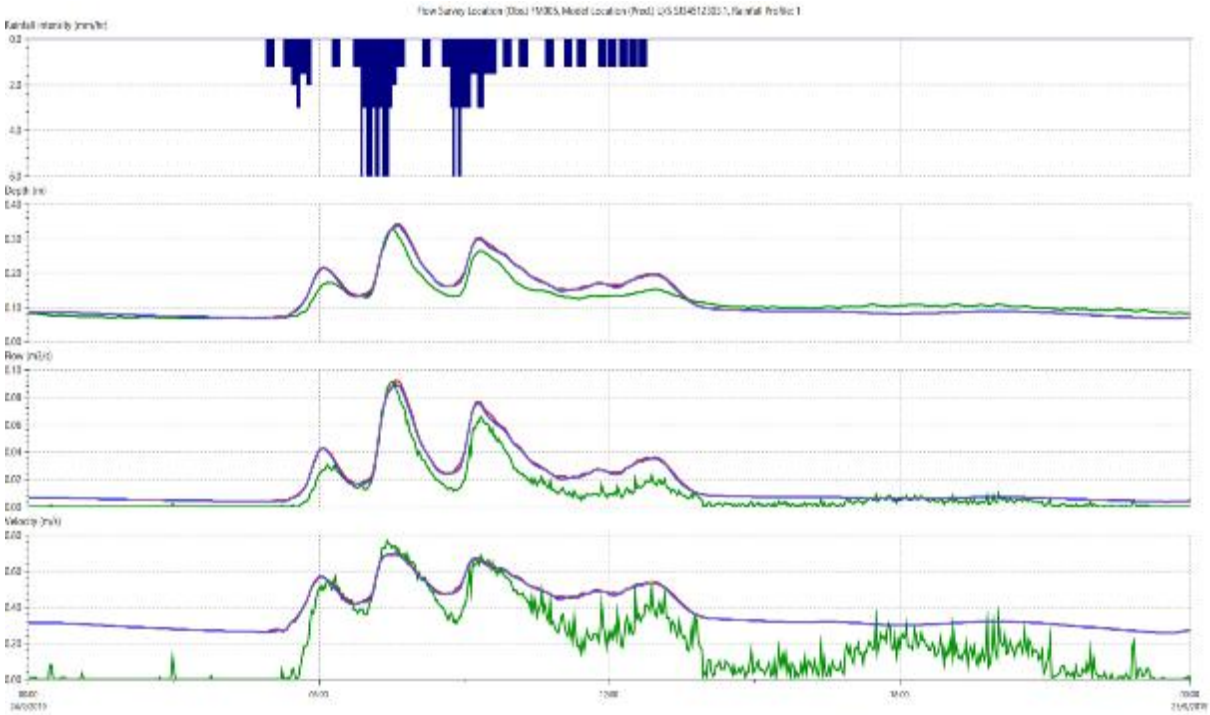
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	10.000	5.000	0.418							
Observed				0.014	0.119	0.001	0.351	617,166	0.230	1.340
Storm A initial+Storm A				0.028	0.155	0.001	0.386	564,409	0.252	1.476
Storm A final+Storm A				0.041	0.173	0.001	0.381	596,307	0.140	1.523



	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	10.300	6.000	0.416							
Observed				0.047	0.254	0.000	0.070	587.960	0.010	0.520
Storm A initial+Storm A				0.046	0.256	0.001	0.086	560.316	0.193	0.606
Storm A final+Storm A				0.046	1.003	0.001	0.082	587.446	0.193	0.734

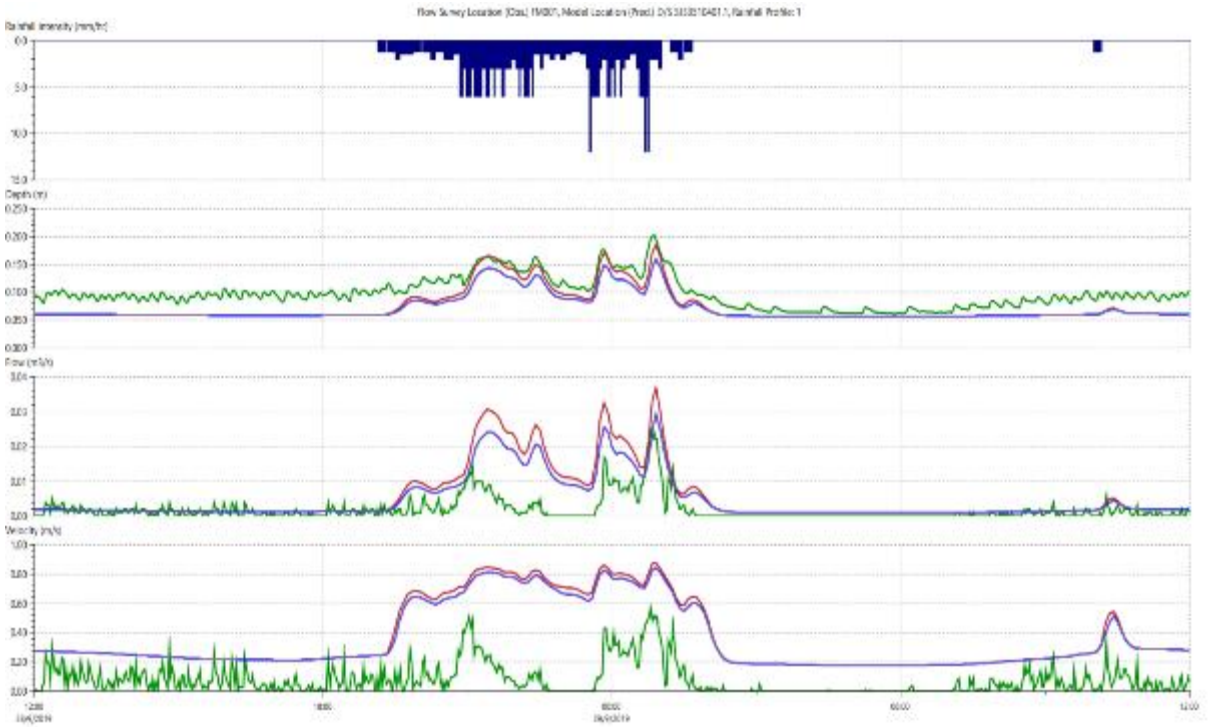


	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	10.300	6.300	0.416							
Observed				0.038	0.098	0.000	0.007	81.300	0.000	0.400
Storm A initial+Storm A				0.025	0.098	-0.000	0.012	107.199	0.000	0.865
Storm A final+Storm A				0.025	0.674	-0.000	0.008	74.823	-0.000	0.564

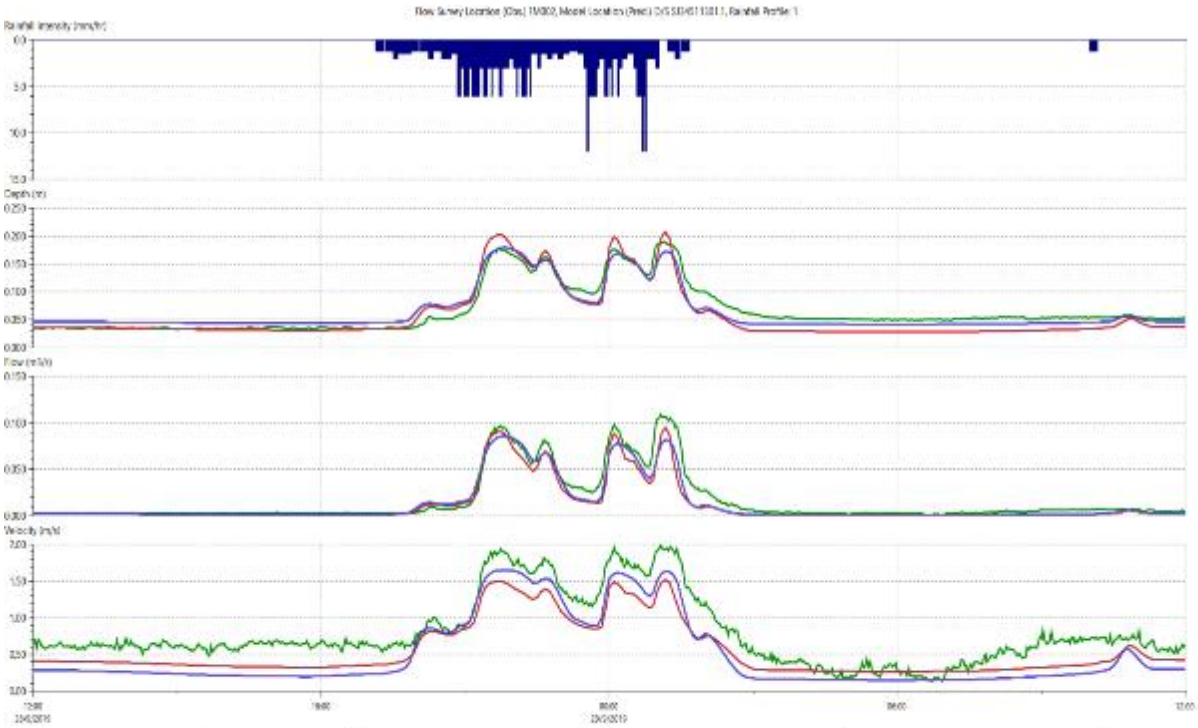


	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	10.000	6.000	0.415							
Observed				0.058	0.176	0.000	0.061	853.000	0.000	0.770
Storm A initial>Storm A				0.067	0.143	0.004	0.082	1463.085	0.259	0.700
Storm A final>Storm A				0.067	0.135	0.004	0.089	1413.082	0.259	0.695

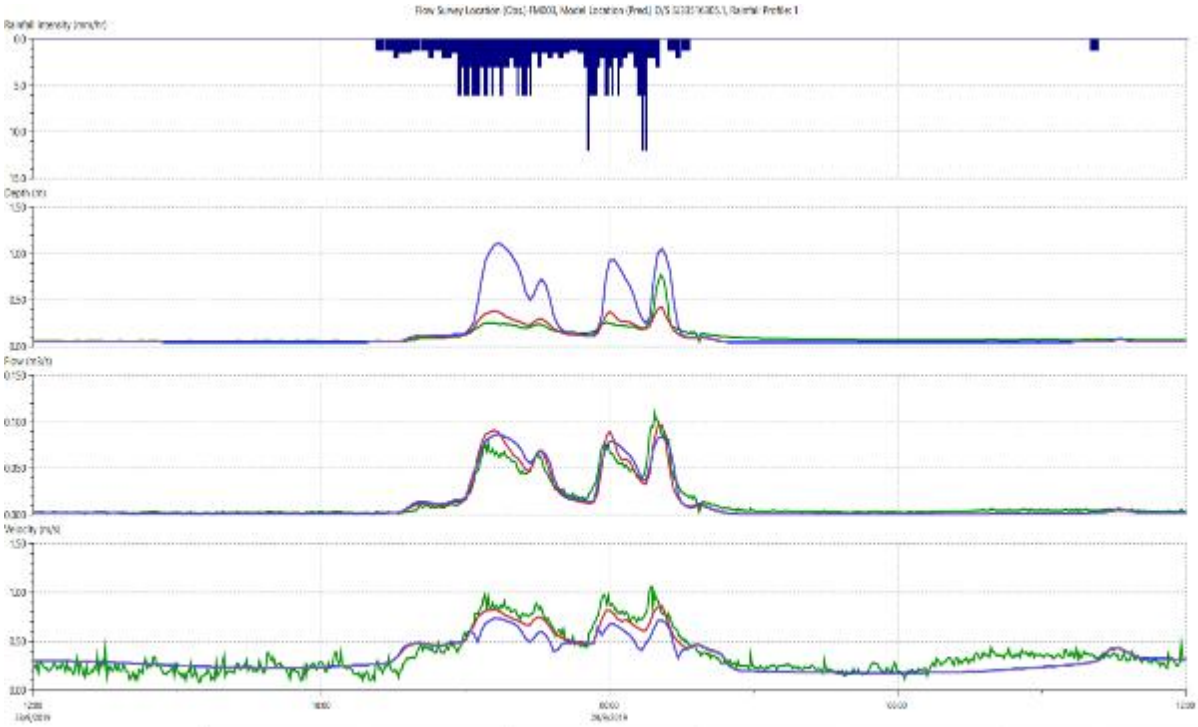
Storm B



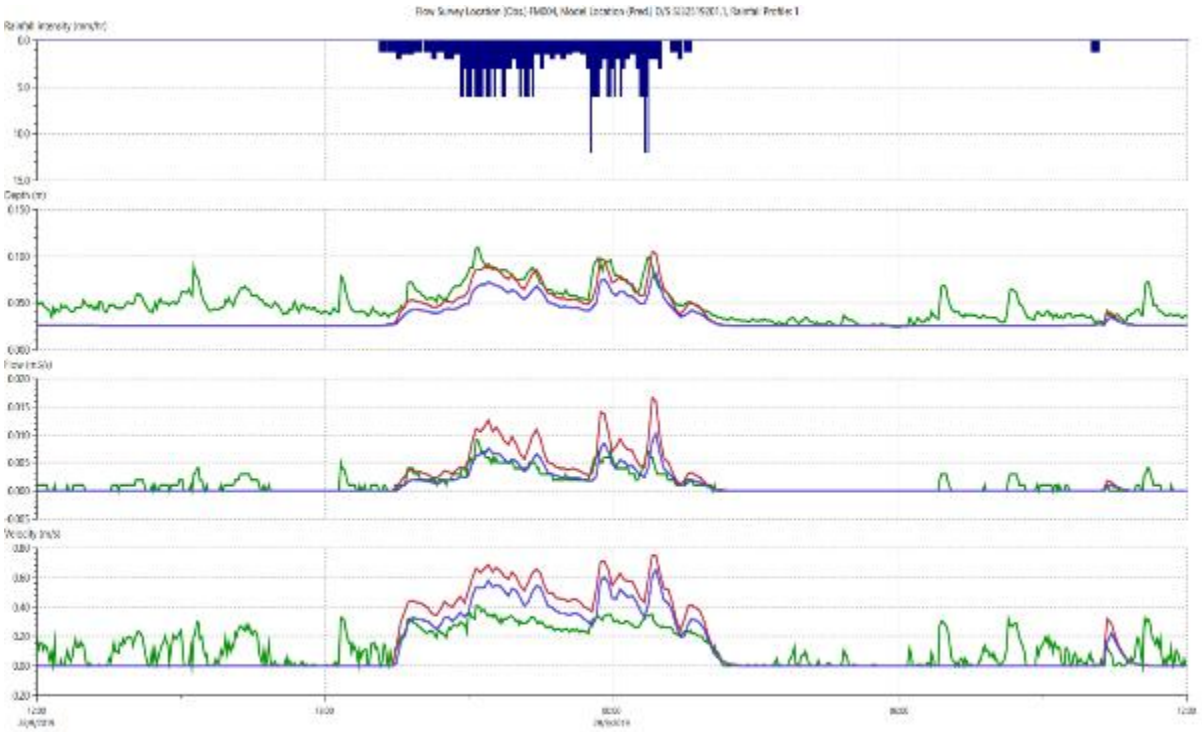
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m³/s)	Max (m³/s)	Volume (m³)	Min (m/s)	Max (m/s)
Rain	17.000	12.000	3.740							
Observed				0.051	0.202	0.000	0.125	154.020	0.000	0.573
Storm B initial>Storm B				0.057	0.188	0.001	0.157	478.486	0.314	0.819
Storm B final>Storm B				0.057	0.198	0.001	0.178	402.570	0.314	0.845



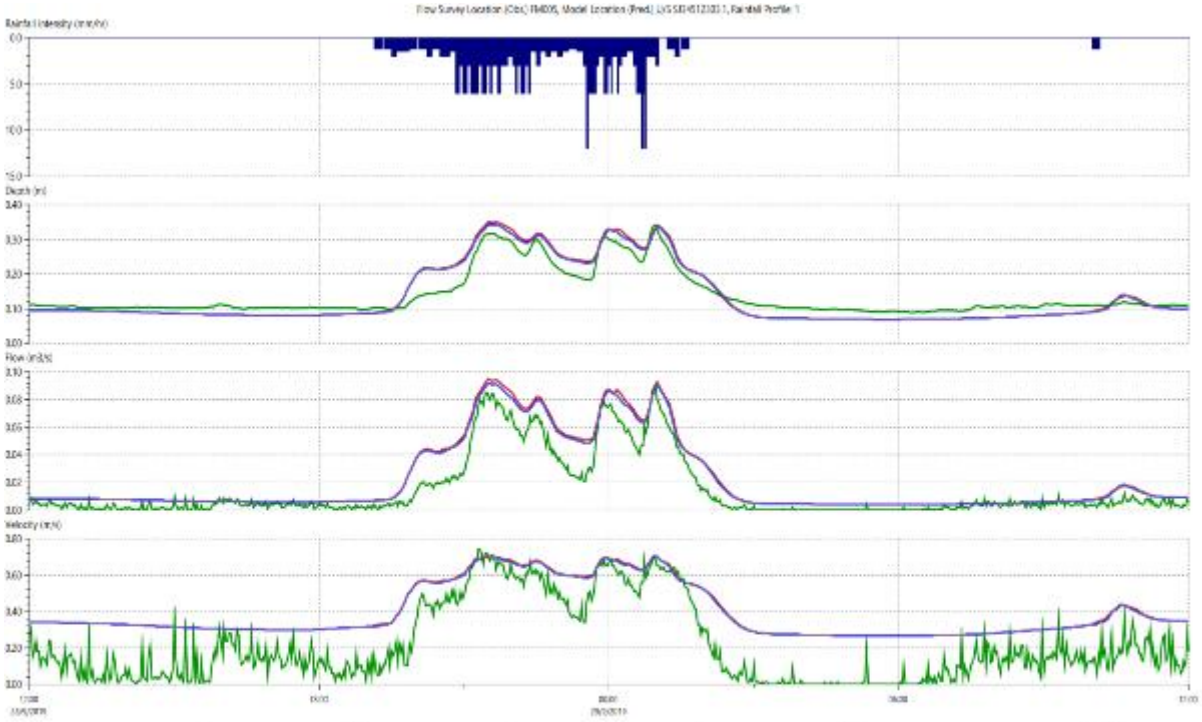
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	17.600	12.000	3.748							
Observed				0.012	0.190	0.001	0.109	1432.140	0.143	1.860
Storm II initial-Storm II				0.018	0.208	0.001	0.095	1031.024	0.065	1.517
Storm II final-Storm II				0.042	0.168	0.001	0.086	1098.926	0.153	1.648



	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	17.600	12.000	3.748							
Observed				0.050	0.776	0.001	0.109	1119.960	0.088	1.656
Storm II initial-Storm II				0.046	0.422	0.001	0.097	1016.708	0.175	0.868
Storm II final-Storm II				0.046	1.173	0.001	0.097	1080.867	0.175	2.737

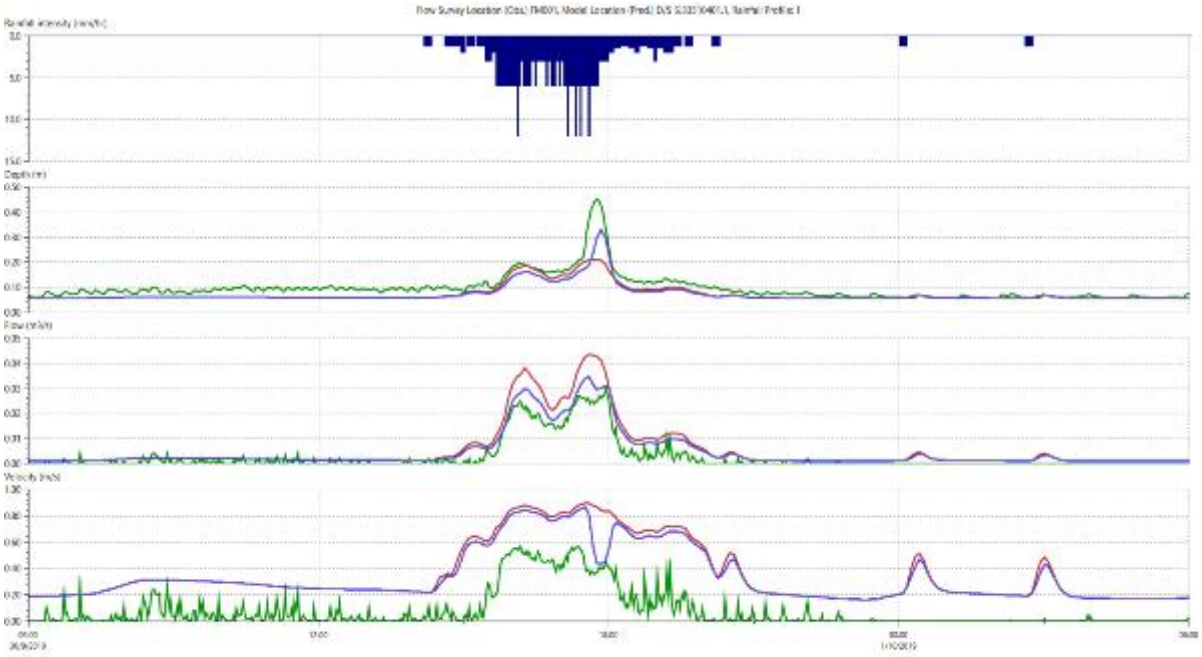


	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	17.800	12.000	3.140							
Observed				3.005	3.110	3.000	3.005	170.480	3.000	3.470
Storm II initial-Storm II				3.005	3.195	-3.000	3.017	144.985	-3.000	3.752
Storm II final-Storm II				3.005	3.092	3.000	3.010	87.432	3.000	3.651

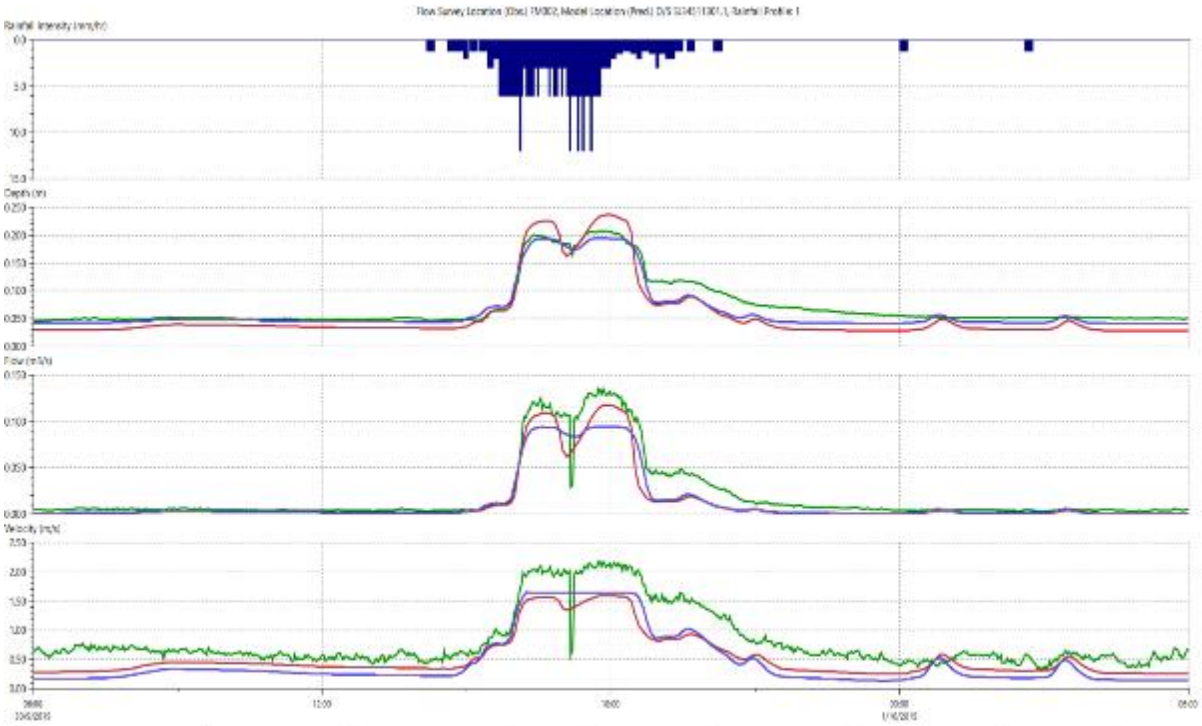


	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	17.800	12.000	3.140							
Observed				3.085	3.341	3.000	3.088	1,221.420	3.000	3.740
Storm II initial-Storm II				3.086	3.251	3.004	3.096	1,020.136	3.266	3.787
Storm II final-Storm II				3.086	3.343	3.004	3.092	1,081.515	3.266	3.701

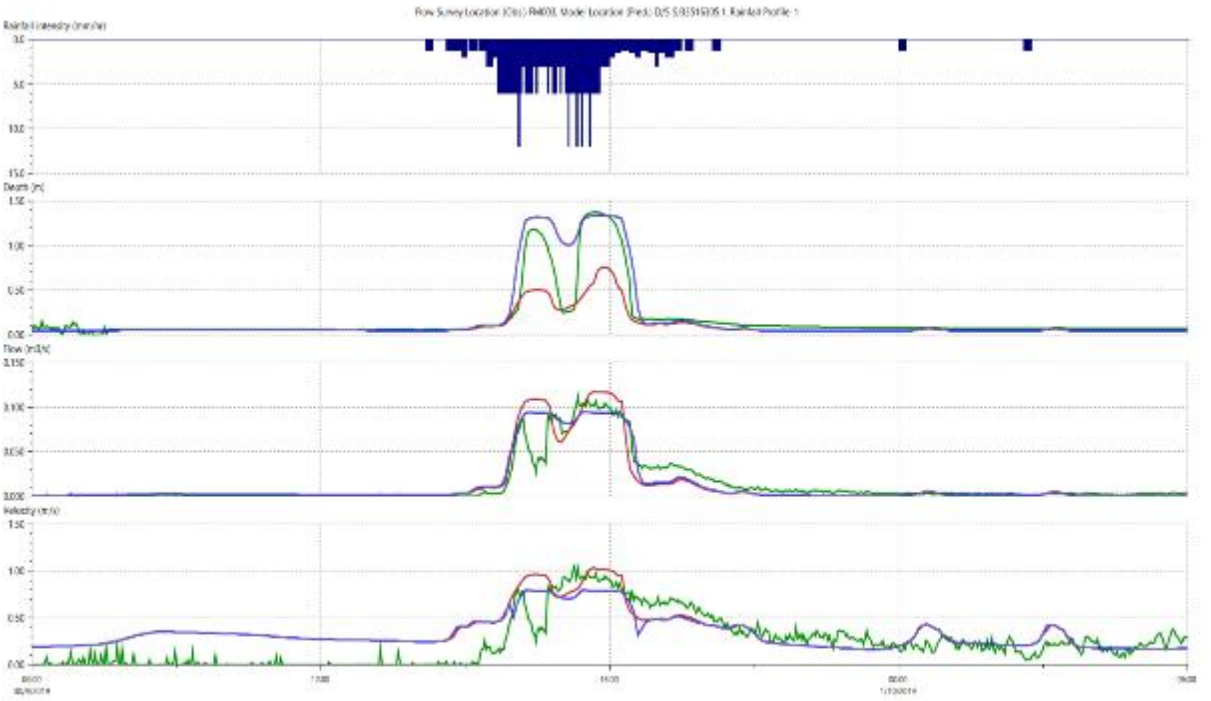
Storm C



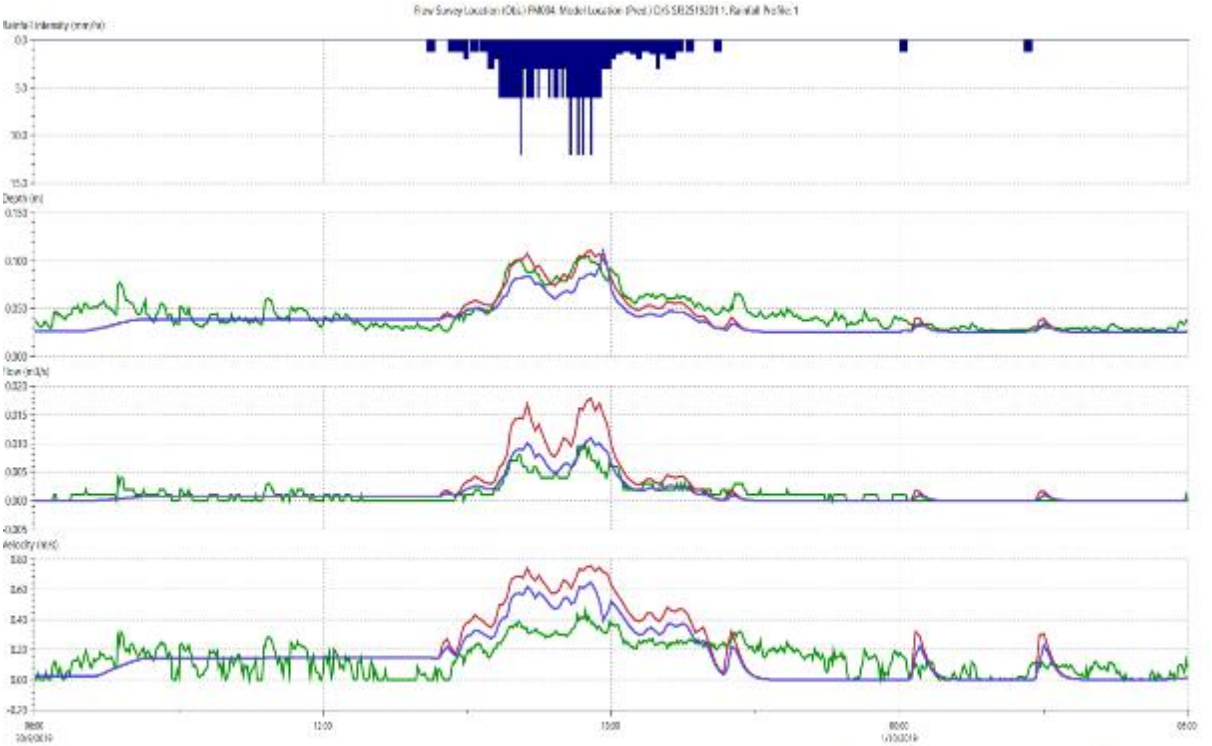
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
	17.000	12.000	0.743							
Rain										
Observed				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Storm C Initial-Storm C				0.056	0.210	0.001	0.044	470.969	0.194	0.698
Storm C final-Storm C				[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]



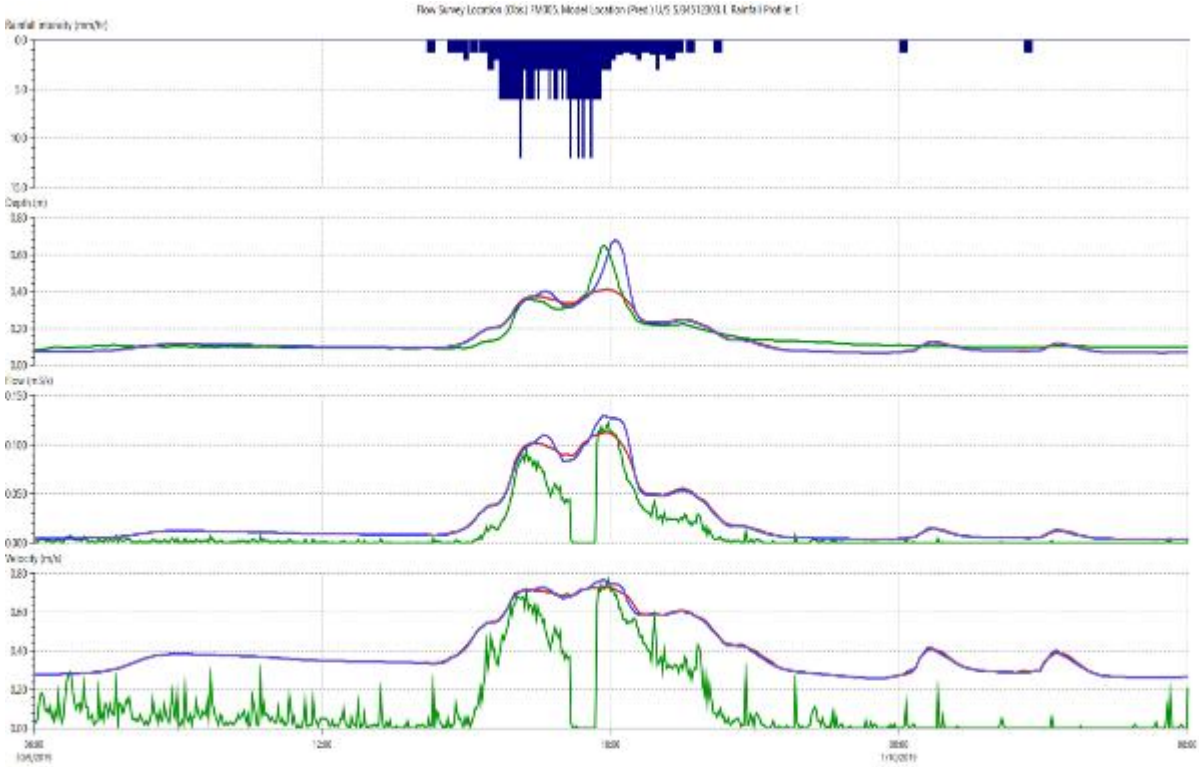
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
	17.000	12.000	0.743							
Rain										
Observed				0.048	0.208	0.003	0.135	1707.730	0.320	2.103
Storm C Initial-Storm C				0.038	0.237	0.001	0.116	1164.419	0.252	1.598
Storm C final-Storm C				0.041	0.194	0.001	0.095	1102.256	0.140	1.653



Run	Rainfall Depth (mm)	Rainfall Peak (mm/hr)	Rainfall Average (mm/hr)	Depth Min (m)	Depth Max (m)	Flow Min (m3/s)	Flow Max (m3/s)	Flow Volume (m3)	Velocity Min (m/s)	Velocity Max (m/s)
	17.600	12.000	0.140							
Observed				0.000	1.174	0.000	0.117	1040.080	0.000	1.072
Storm C Initial+Storm C				0.045	0.780	0.001	0.117	1131.157	0.103	1.010
Storm C Final+Storm C				0.045	1.107	0.001	0.264	1089.172	0.103	0.792



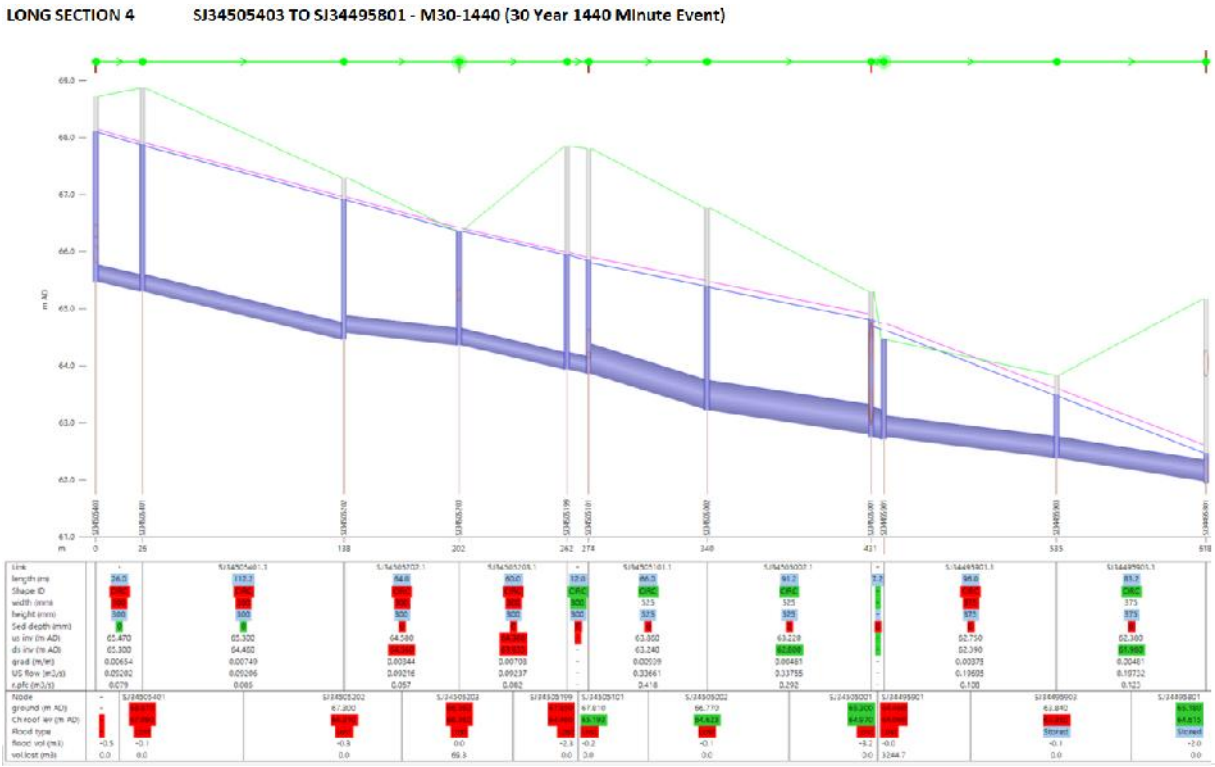
Run	Rainfall Depth (mm)	Rainfall Peak (mm/hr)	Rainfall Average (mm/hr)	Depth Min (m)	Depth Max (m)	Flow Min (m3/s)	Flow Max (m3/s)	Flow Volume (m3)	Velocity Min (m/s)	Velocity Max (m/s)
	17.600	12.000	0.140							
Observed				0.025	0.105	0.000	0.010	105.323	0.000	0.403
Storm C Initial+Storm C				0.025	0.193	-0.000	0.018	1.108e3	-0.001	0.257
Storm C Final+Storm C				0.025	0.193	-0.000	0.011	115.305	-0.001	0.645



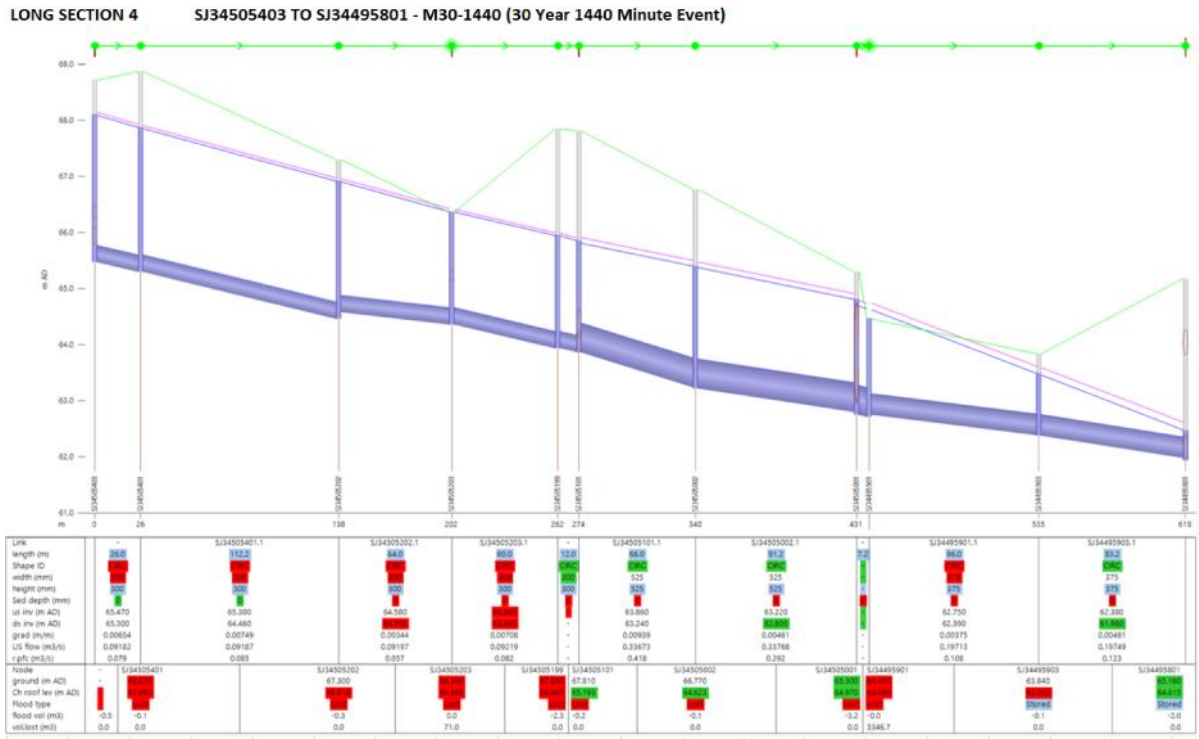
	Rainfall			Depth		Flow			Velocity	
	Depth (mm)	Peak (mm/hr)	Average (mm/hr)	Min (m)	Max (m)	Min (m3/s)	Max (m3/s)	Volume (m3)	Min (m/s)	Max (m/s)
Rain	17.600	12.000	0.743							
Observed				0.261	0.848	0.000	0.122	843.366	0.000	0.770
Storm C Initial>Storm C				0.067	0.411	0.004	0.113	1888.682	0.259	0.729
Storm C Final>Storm C				0.067	0.878	0.004	0.133	1928.570	0.259	0.761

Appendix D – Hydraulic Assessment Results & Long Sections

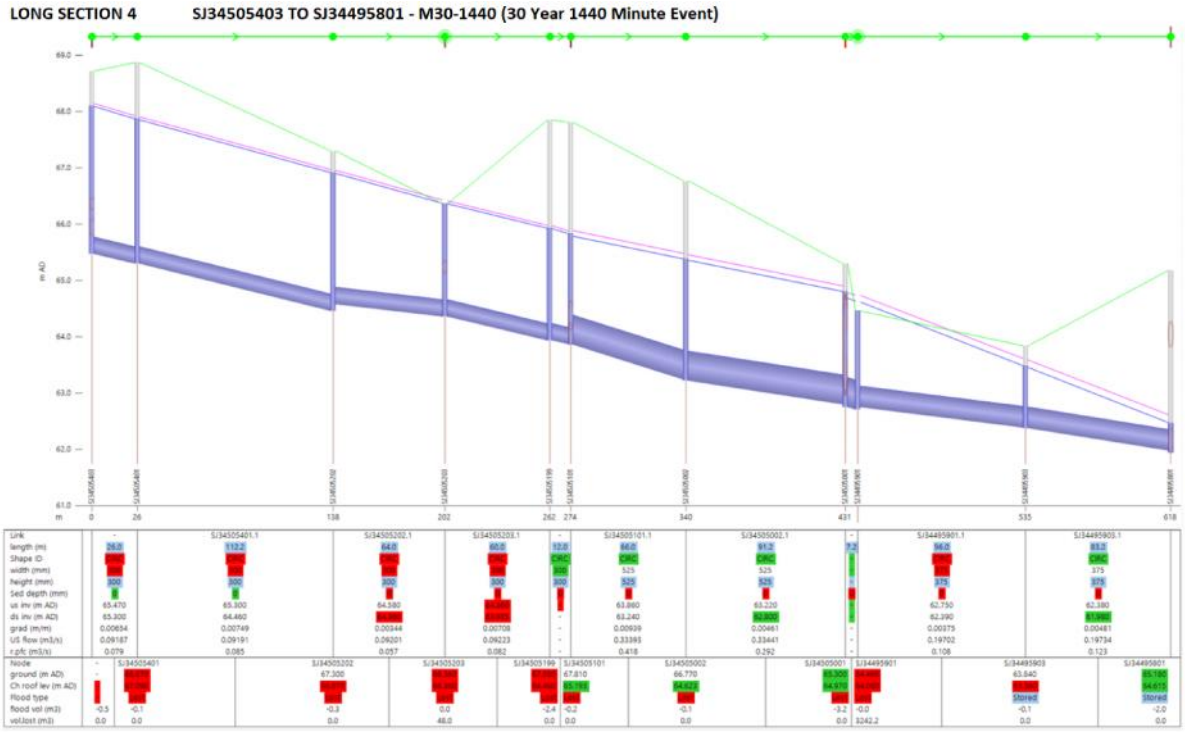
Baseline



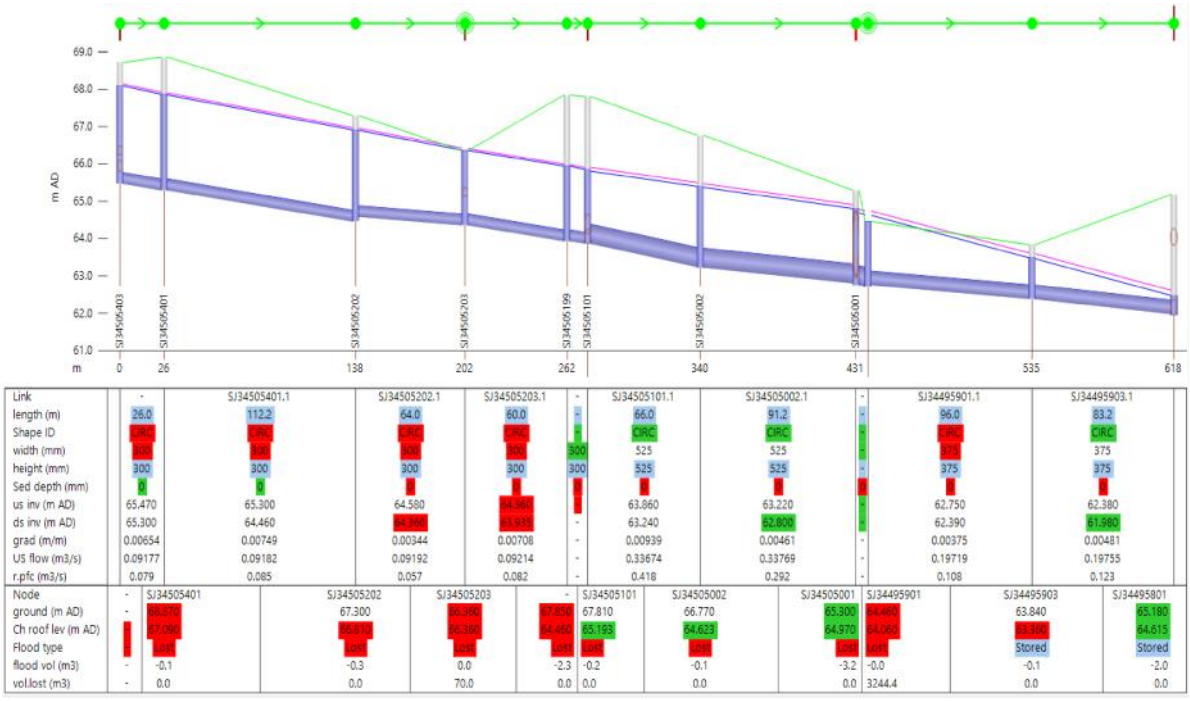
Phase 5



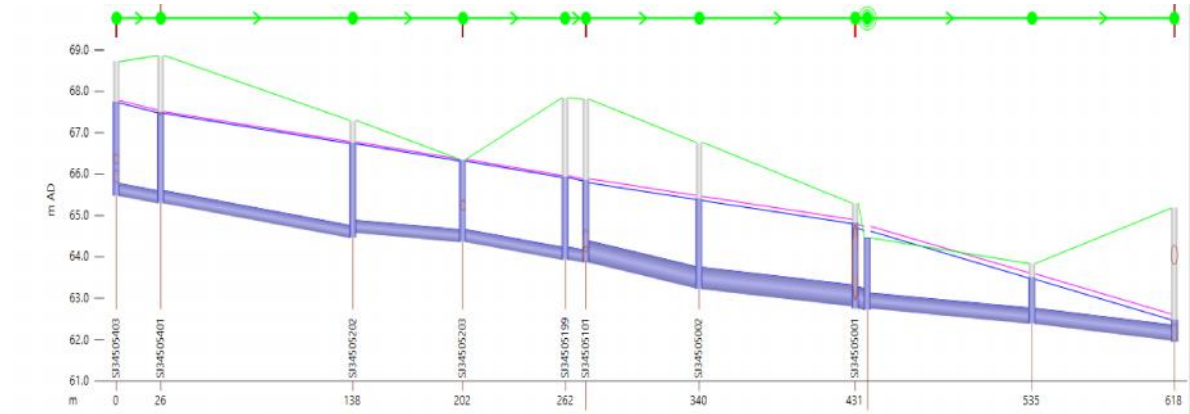
Solution 1



Solution 2



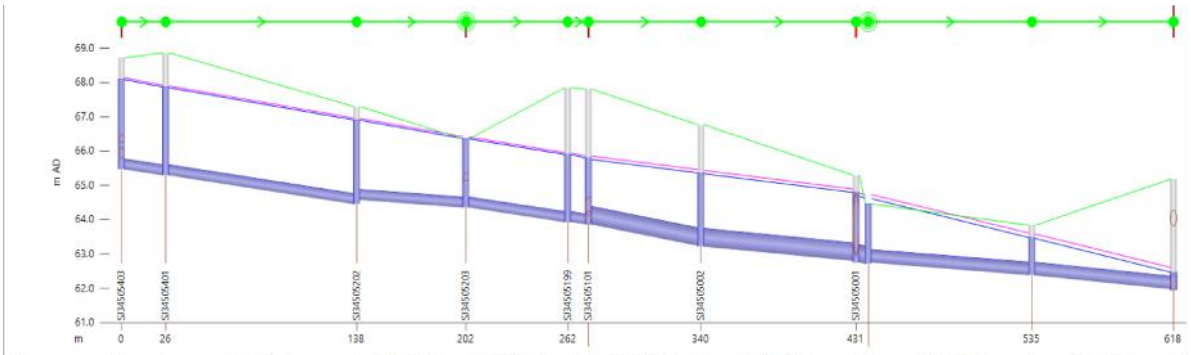
Solution 3



Link	-	SJ34505401.1	SJ34505202.1	SJ34505203.1	-	SJ34505101.1	SJ34505002.1	-	SJ34495901.1	SJ34495903.1
length (m)	26.0	112.2	64.0	60.0	-	66.0	91.2	-	96.0	83.2
Shape ID	CIRC	CIRC	CIRC	CIRC	-	CIRC	CIRC	-	CIRC	CIRC
width (mm)	300	300	300	300	300	525	525	-	375	375
height (mm)	300	300	300	300	300	525	525	-	375	375
Sed depth (mm)	0	0	-	-	-	-	-	-	-	-
us inv (m AD)	65.470	65.300	64.580	64.360	-	63.860	63.220	-	62.750	62.380
ds inv (m AD)	65.300	64.460	64.360	63.935	-	63.240	62.800	-	62.390	61.980
grad (m/m)	0.00654	0.00749	0.00344	0.00708	-	0.00939	0.00461	-	0.00375	0.00481
US flow (m3/s)	0.09283	0.09144	0.09154	0.09177	-	0.33431	0.33525	-	0.19693	0.19728
r.pfc (m3/s)	0.079	0.085	0.057	0.082	-	0.418	0.292	-	0.108	0.123

Node	-	SJ34505401	SJ34505202	SJ34505203	-	SJ34505101	SJ34505002	SJ34505001	SJ34495901	SJ34495903	SJ34495801
ground (m AD)	-	68.870	67.300	66.360	67.854	67.810	66.770	65.300	64.460	63.840	65.180
Ch roof lev (m AD)	-	67.096	66.810	66.360	64.464	65.193	64.623	64.970	64.060	63.380	64.615
Flood type	-	Lost	Lost	Lost	Lost	Lost	Lost	Lost	Lost	Stored	Stored
flood vol (m3)	-	-0.1	-0.5	-0.0	-2.4	-0.2	-0.1	-3.2	-0.0	-0.1	-2.0
vol.lost (m3)	-	0.0	0.0	0.0	0.0	0.0	0.0	0.0	3244.1	0.0	0.0

Solution 4



Link	-	SJ34505401.1	SJ34505202.1	SJ34505203.1	-	SJ34505101.1	SJ34505002.1	-	SJ34495901.1	SJ34495903.1
length (m)	26.0	112.2	64.0	60.0	-	66.0	91.2	-	96.0	83.2
Shape ID	CIRC	CIRC	CIRC	CIRC	-	CIRC	CIRC	-	CIRC	CIRC
width (mm)	300	300	300	300	300	525	525	-	375	375
height (mm)	300	300	300	300	300	525	525	-	375	375
Sed depth (mm)	0	0	-	-	-	-	-	-	-	-
us inv (m AD)	65.470	65.300	64.580	64.360	-	63.860	63.220	-	62.750	62.380
ds inv (m AD)	65.300	64.460	64.360	63.935	-	63.240	62.800	-	62.390	61.980
grad (m/m)	0.00654	0.00749	0.00344	0.00708	-	0.00939	0.00461	-	0.00375	0.00481
US flow (m3/s)	0.09182	0.09186	0.09196	0.09218	-	0.33003	0.33098	-	0.19706	0.19741
r.pfc (m3/s)	0.079	0.085	0.057	0.082	-	0.418	0.292	-	0.108	0.123

Node	-	SJ34505401	SJ34505202	SJ34505203	-	SJ34505101	SJ34505002	SJ34505001	SJ34495901	SJ34495903	SJ34495801
ground (m AD)	-	68.870	67.300	66.360	67.854	67.810	66.770	65.300	64.460	63.840	65.180
Ch roof lev (m AD)	-	67.096	66.810	66.360	64.464	65.193	64.623	64.970	64.060	63.380	64.615
Flood type	-	Lost	Lost	Lost	Lost	Lost	Lost	Lost	Lost	Stored	Stored
flood vol (m3)	-	-0.1	-0.3	0.0	-2.4	-0.2	-0.2	-3.3	-0.0	-0.1	-2.0
vol.lost (m3)	-	0.0	0.0	28.8	0.0	0.0	0.0	0.0	3242.6	0.0	0.0

Appendix E – Formula A Calculation Spreadsheet