Monmouthshire County Council

Rockfield Farm, Undy

Drainage Strategy

July 2016

5th Floor Longcross Court, 47 Newport Road, Cardiff, CF24 0AD

Tel: 029 2082 9200

Email: transport.cardiff@wyg.com

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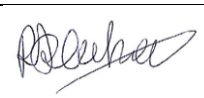
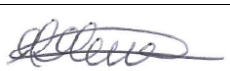
Prepared by: Paul Graham	Signed: 
Checked by: Matt Mercer	Signed: 
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1	April 2016	Draft
2	July 2016	Amended following client comments
3		
4		

Contents Page

Figures

Appendix Contents

1.0 Introduction

1.1 Brief

1.1.1 WYG have been appointed by Monmouthshire County Council to prepare a drainage strategy for a proposed mixed use development in support of an outline planning application for comprehensive development of the site and sale of the land in accordance with a master plan. The development would be a mix of residential and employment, with approximately 266 residential dwellings being constructed. The site of the development is located at land adjacent to The Elms. This Drainage Strategy has been compiled following the Welsh Government process for a Flood Consequences Assessment.

1.1.2 This report has been produced to identify, and where appropriate recommend mitigation to, any flooding issues associated with the proposed development, following the requirements of Natural Resources Wales (NRW), Monmouthshire County Council, DCWW Welsh Water and the Welsh Government. The purpose of this report is to demonstrate how the development complies with planning policy on flood risk (Technical Advice Note 15 (TAN 15) and Planning Policy Wales (PPW)), and drainage (Interim Non-Statutory Standards for Sustainable Drainage (SuDs) in Wales). The report also aims to provide a strategy to inform a masterplan and outline planning application for comprehensive development of the site with phased delivery.

1.1.3 Data has been provided by various organisations with the local authority land drainage team, sewage undertakers and NRW consulted.

1.1.4 The latest TAN 15 Development Advice Map (DAM) for the area shows the site to be within Flood Zone A – land considered to be at little or no risk of fluvial or coastal/tidal flooding. Residential developments are classified as highly vulnerable, which is permitted in Zone A and thus is considered an appropriate development. As the site is at little to no risk from fluvial flooding this report will focus on the surface water drainage strategy to ensure that flood risk is not increased downstream of the site as a result of the development.

1.1.5 The structure of this report is designed to systematically address the technical requirements for assessing flooding consequences in accordance with section A1.17 of TAN 15 – Development and Flood Risk.

2.0 Existing Conditions and Site Access

2.1 Existing Conditions

2.1.1 The site is located at land adjacent to The Elms, Undy. A site location plan is located in Figure 1 of this report.

2.1.2 The site is approximately a total size of 13.8ha and comprises undeveloped agricultural land.

2.1.3 The north of the site is bounded by the M4 and partially by the M48. To the east and west the site is bounded by agricultural land. The south of the site is bounded by residential units and in part the B4245 and allotments. The site comprises several fields with a road named 'The Elms' running through the middle of the site which leads to the access for Rockfield Farm.

2.2 Proposed Development

2.2.1 Monmouthshire County Council is developing a masterplan for the site to support an outline planning application for the site which will guide development and disposal of the site.

2.2.2 The main access to the proposed development will be from the B4245 at the south east of the Development with additional access available to parcels via The Elms.

2.3 Policy Context

2.3.1 Planning Policy Wales – Chapter 5 clearly states that flood risk is a specific material consideration in land use planning.

2.3.2 TAN 15 is the planning guidance used in Wales to assess flood risk. A requirement of TAN 15 is that developers making planning applications on sites that are potentially at risk from flooding should consult with Natural Resources Wales and produce a Flood Consequence Assessment (FCA) to support their proposals.

2.3.3 The Environment Agency's Policy and Practice for the Protection of Floodplains (1997), provides guidance to local authorities on the control of development. This guidance is also relevant in Wales.

In addition, the Welsh Assembly Government has published Development Advice Maps (DAM) which shows areas of potentially at risk from flood events.

2.3.4 This report sets out how the development compares by reference to sections 5, 6, 7 and Appendix A of TAN 15.

3.0 Requirements of the Flood Consequence Assessment

3.1 Proposed Development

3.1.1 TAN 15 – Development and Flood Risk, Appendix A1.17 sets out the requirements of a Flood Consequence Assessment.

3.1.2 The TAN 15 Appendix A1.17 guidance specifies that the report shall contain the following.

- Location Plan – see section 4 of this report and Appendix A
- Level Plan – see section 5 and Appendix A
- Details of existing flood alleviation measures – see section 6
- Access/Evacuation Routes – Section 7
- Source of flooding - see section 8
- Flood Plain – see section 9
- Structures influencing Local Hydraulics – see section 10
- Flood Probabilities - see section 11
- Cross Section of Proposed Site – see section 12
- Sewer Hydraulics – see section 13
- Flood Volume Displaced – see section 14
- Impact of Displaced water – see section 15
- Impact of Fluvial Morphology – see section 16
- Climate Change Impacts – see section 17
- Flood Defence Residual Risk Assessment – see section 18
- Summary – see section 20

3.1.3 The following sections address each of the points referring to the relevant paragraph in TAN 15, Appendix 1E, paragraph A1.17

3.1.4 The proposed on site drainage strategy is discussed in section 19 of this report.

4.0 Site Location (A1.17.1)

4.1.1 The site is located at land adjacent to The Elms. The grid reference is ST 43754 87745. Refer to Figure 1 for a location plan.

4.1.2 The site is bounded to the north by the M4 and partially by the M48, to the east and west by undeveloped agricultural land and to the south residential units.

4.1.3 The red line boundary of the site covers an area of approximately 13.8ha.

5.0 Level Plan (A1.17.2)

5.1 Site Survey

5.1.1 A topographical survey of the site has been undertaken. Details can be found in Figure 5.

5.1.2 Site levels range from 42.5m to 10.0mAOD with a general downwards slope from west to east.

6.0 Existing Alleviation Measures (A1.17.3)

6.1 Flood Mitigation

6.1.1 The TAN 15 Development Advice Map (DAM) shows that the site is wholly in Flood Zone A, which is land defined as having little no risk of fluvial flood.

6.1.2 There are flood defences approximately 2.7km away from the site, however the site is not within an area benefiting from flood defences and is not within an area at risk of coast or main river flooding.

7.0 Access/Evacuation Routes (A1.17.4)

7.1 Site Access Routes

7.1.1 The main vehicular and pedestrian access to the site will be via the B4245.

7.1.2 The TAN 15 Development Advice Map shows that the area immediately to the north of the site is classified as Zone A so access will not be affected.

7.1.3 Should the site become flooded during a flood event more extreme than the Q1000 events it would be possible to safely evacuate to the north along The Elms which leads away from the site.

8.0 Sources of Flooding (A1.17.5)

8.1 Tidal Flooding

8.1.1 The proposed development site is located 2.7km away from the coast. There is no evidence of tidal flooding at the site.

8.2 Fluvial Flooding

8.2.1 The NRW (Figure 2) indicates that the site is situated within Zone 1, which is land defined as having less than 1 in 1000 annual probability of river or sea flooding.

8.3 Pluvial Flooding

8.3.1 The NRW Risk of Surface Water Flooding Map (Figure 3) shows that the site is at very low risk of pluvial flooding. Some minor parts of the site are at high risk of surface water flooding.

8.4 Sewer Flooding

8.4.1 Refer to Section 13.

8.5 Groundwater Flooding

8.5.1 British Geology Survey (BGS) data indicates that the bedrock underlying the site is the Black Rock Limestone Subgroup – Dolostone and the Mercia Mudstone Group (Marginal Facies) – Conglomerate. There is no overlying geology to the site, see Figures 6 and 7 for further details.

8.5.2 Groundwater flooding can occur when the water table rises and emerges above the ground level. There is no evidence of groundwater flooding within the site. Borehole logs (ST48NW21) near the site held by the BGS indicate that groundwater was not detected up to 14.25mbgl at some locations.

9.0 Flood Plain (A1.17.6)

9.1 Flood Plain Extent

9.1.1 The extent of the predicted 1% and 0.1% annual probability flood plain is indicated on the NRW Flood Map. Refer to Figure 3.

9.1.2 The site is wholly situated within NRW Flood Zone 1 and thus is outside of the extreme floodplain extent for any watercourse or the Bristol Channel.

9.1.3 Natural Resources Wales have confirmed that the site is outside the maximum flood extents meaning that the chance of flooding is less than 0.1% in any given year. See Appendix A for further information.

10.0 Hydraulic Structures (A1.17.7)

10.1 Restrictions to Flow

10.1.1 There are no watercourses running through the site. The nearest main river, the Prat Reen, is approximately 650 m away from the site which is culverted at several locations, the nearest of which are the culverts under The Causeway and an unnamed road which links Church Rise to Church Road. The floodplain associated with this river is not within the boundary of the site.

11.0 Flooding Probabilities (A1.17.8)

11.1 Flood Risk

11.1.1 The NRW Flood Maps indicates that the proposed site is located within Flood Zone A, which is land defined as having less than 1 in 1000 annual probability of river or sea flooding.

11.1.2 Overland flow paths from offsite are unlikely to affect the site due to site's gradient generally falling away from the site, and the presence of highways to the north and south, which would intercept any flows. As well as this there are large attenuation basins to the north of the site which would intercept any surface run off from the M4.

12.0 Cross Sections and Finished Levels (A1.17.9)

12.1 Proposed Site Levels

12.1.1 It is recommended that minimum finished floor levels of the proposed buildings will not be lower than the existing ground levels. It is also anticipated that the development will not significantly alter ground levels. This ensures that flood risk will not increase.

13.0 Sewer Hydraulics

13.1 Sewer Flooding Reports

13.1.1 DCWW have confirmed that they hold no records of any sewer related flooding in the vicinity of the site. Correspondence with DCWW can be found in Appendix B.

13.1.2 The SFCA indicates that there is no evidence to suggest an existing problem with sewer flooding that might affect the site.

13.1.3 A strategy of foul sewer upgrade works in the vicinity of the site has been detailed by Welsh Water to ensure that the future risk of sewer flooding is not increased.

14.0 Flood Volume Displacement (A1.17.12)

14.1 Displacement of Water

14.1.1 The site is situated within Flood Zone A and as such the proposed development will not result in the displacement of water during a 1 in 100 fluvial flood event.

15.0 Impact of Displaced Water (A1.17.13)

15.1 Offsite Flooding

15.1.1 There will be no flood water displaced by the development as the site is situated outside of Flood Zone C.

16.0 Impact on Fluvial and Coastal Morphology (A.17.14)

16.1.1 As the site will continue to discharge at Greenfield rates to the watercourse, the impact on the fluvial morphology is not expected to change from current conditions.

17.0 Climate Change Impacts (A1.17.15)

17.1.1 The NRW Flood Maps do not include an allowance for climate change. Therefore it is recommended that the NRW defined Flood Zones 2 and 3 are used as a precautionary indicator. From the NRW Flood Map it can be seen that the site will remain outside of the 1 in 100 annual probability flood extent.

17.1.2 Storage estimates within MicroDrainage software allow a 40% increase in precipitation to allow for the changes in climate anticipated within the design life of the site.

18.0 Flood Defence and Residual Assessment (A1.17.16)

18.1 Flood Defence Assessment

18.1.1 As the site is within Flood Zone 1, and will remain within Flood Zone 1 flood resilience measures for the site are not required.

19.0 Drainage Strategy for the Proposed Development

19.1 Surface Water

19.1.1 The surface water drainage strategy will be delivered in accordance with prevailing local and national planning policy. Currently, the most significant factors influencing the design of the drainage strategy are the Flood and Water Management Act 2010, Monmouthshire Council's Strategic Flood Risk Assessment, the Interim Non-statutory Standards for Sustainable Drainage (SuDS) in Wales, Technical Advice Note 15 (TAN 15) and Planning Policy Wales (PPW).

19.1.2 This drainage strategy sets the guidelines for future detailed design, but more importantly, it demonstrates that a sustainable drainage solution is deliverable at this site, complying with all relevant planning and legislative criteria. The most important function of this drainage strategy is to demonstrate that the development will not increase flood risk elsewhere.

19.1.3 The method of discharge of surface water is critical to ensuring that flood risk will not be increased elsewhere. TAN 15 guidance and Building Regulations dictate the hierarchy for discharge options. In order of preference these are:

- To the ground (infiltration);
- To a surface water body;
- To a surface water sewer, highway drain or another drainage system;
- To a combined sewer;

19.1.4 A site investigation was conducted by Intégral Géotechnique in September 2015, with additional soakaway testing carried out by WYG in June 2016. There were mixed results throughout the site, meaning that infiltration drainage would be possible in some areas though not in others.

19.1.5 Infiltration rates in the south west of the site were found to be suitable for soakaways so it is proposed that areas of the site that are able to naturally drain to this location will continue to do so and infiltration devices such as pot soakaways and porous paving will be constructed to allow infiltration drainage to occur. There were also favourable infiltration rates to the north east of the site, although the suitable areas are within the M4 safeguard corridor. It is likely that the area where an infiltration device could be positioned is to be used as landscaping for the M4. In the

event of this, it is probable that an infiltration basin could be located here. As such, the current design includes an infiltration basin for the northern sections of the site. As this would serve the final phase of the development, it is anticipated that the full extents of the requirements for the M4 will be known which will allow for the infiltration basin to be constructed. If, however the M4 corridor does not allow for the placement of any such devices, it is possible that the depth of the other drainage features could be increased in order to compensate for the additional storage required.

19.1.6 Other areas of the site are not suitable for infiltration, so will be conveyed to attenuation basins located throughout the application site. Surface water will be attenuated throughout the site and discharged as per existing conditions, though with betterment offered during the more extreme rainfall events.

19.1.7 There is a culvert at the low point of the site in the south east that travels under the B4245 that allows surface water to cross under the highway where it continues to flow overland. There is also a natural overland flow route that travels through the site. It is proposed that this outfall is maintained as the point of discharge in order to mimic as closely as possible the existing drainage regime.

19.1.8 At the time of writing, a CCTV survey is being arranged in order to allow confirmation of this existing drainage regime. If the culvert is found to be unsuitable, a new culvert, matching the route could be installed under the B4245.

19.1.9 It is proposed where possible to utilise above ground conveyance features such as swales, and filter drains in order to both act as a SuDS feature and convey surface water to the final SuDS feature (soakaway or attenuation basin).

19.2 Greenfield Runoff and Volume

19.2.1 It is proposed that runoff from the site will be restricted to Greenfield rates so that risk of flooding is not increased elsewhere. As the intention is to utilise a mixed drainage regime, the amount of run-off discharging to the watercourse or sewer should be the prorated rate so that the runoff is equal to or better than current Greenfield conditions. The prorated rate for each parcel will differ, however; the total flow discharging from the south of the site should not exceed the values set out in the prorated rate below for the Q100+40%CC event.

As a large area of the site will infiltrate into the underlying ground through pot soakaways and porous paving in the south west of the site and an infiltration basin to the north east of the site, betterment from current overland flows will be provided.

19.2.2 The run off rates for the whole site have been calculated using ICP SuDS within MicroDrainage. These calculations can be seen within Appendix C and are summarised below (A Qbar rate of 4.73l/s/ha has been extrapolated using the ICP SuDS calculations):

Event Frequency	Run Off Rate (l/s) [Whole Site]	Pro-Rata Rate (l/s) [Development Parcels]
Q1	68.0	26.8
Qbar	77.3	30.5
Q30	136.3	53.7
Q100	168.6	66.5

19.3 SuDS Strategy

19.3.1 SuDs strategies could be incorporated within the proposed development; including, but not limited to:

- Swales: grassed channels used to direct and store water during storm events, these swales can also be used to provide infiltration locations should rates in the area be favourable.
- Permeable paving: used to minimise the run-off from car-parks or other potentially impermeable areas.
- Rainwater Harvesting Systems: used to collect rainwater from roof areas for non-potable uses such as gardening.
- Rain Gardens: allows surface water runoff the opportunity to infiltrate, and be used by vegetation in public spaces.

19.3.2 The proposed drainage solution would involve infiltration devices in areas where infiltration is possible, and separate attenuation areas where rates make infiltration unviable. The attenuated surface water will then discharge at 30.5l/s to the culvert under the B4245. Additional testing could be carried out in areas to be used for infiltration in order to identify the extents of the soakaway suitable area. Due to the lack of open space in the south western section of the site draining to infiltration devices, it is proposed that individual pot soakaways and porous paving are used. The Surface Water Drainage Strategy can be seen in Appendix D.

19.3.3 The latest site layout splits the site down into a number of smaller parcels and from these parcels an area of impermeable surfaces has been assumed. For the purposes of calculations to inform the drainage strategy, 60% impermeable surfaces have been estimated for residential areas and 80% estimated within the employment zone. These values would usually exceed the amount of impermeable surfaces within a detailed master plan, but provide a conservative guide to storage requirements for the site.

19.3.4 Newly published guidance confirms that the 1 in 100 year surface water runoff rate and storage for the 1 in 100 plus climate change (40%) will be suitable for the site.

19.3.5 The storage requirement information is set out below:

Parcel Name	Total Area	Percentage Impermeable	Impermeable Surface	Prorated Qbar /Infiltration Rate	Storage Estimate
A	2.13ha	60%	1.278ha	10.1l/s	1107m^3
B (Non-Soakaway)	2.29ha	60%	1.374ha	10.8l/s	1192m^3
C (Employment)	2.54ha	80%	2.032ha	$3.26x10^{-5}$ m/s	1119m^3
D	2.02ha	60%	1.212ha	9.6l/s	1049m^3

19.3.6 The required storage volume will be divided across multiple attenuation areas, as identified within the indicative drainage strategy.

19.3.7 Where possible within the site it is recommended that swales are constructed alongside highways to provide storage and manage water quality at source. The volumes of these structures can be taken away from the basins to reduce the land take from these.

19.3.8 Within the car parks in the employment area, storage within permeable paving is to be utilised as a source control attenuation measure. For the purpose of calculation an area of 4210m^2 of car park area has been used with a 350mm sub base with a void ratio of 0.3 to provide 442m^3 of attenuation.

19.4 Future Responsibility and Maintenance

19.4.1 The SuDs Approval Body (SAB) role is no longer to be designated to the LLFA as expected following government legislation from April 2015. Despite the absence of a SAB, there remain a number of options for the adoption and maintenance of the SuDS features and drainage network, including SuDs features being owned and maintained by the developer with the maintenance activities undertaken by a third party contractor.

20.0 Foul Drainage Strategy

20.1 Local Public Sewers

20.1.1 Building Regulations Approved Document H details guidance for drainage and waste disposal. It specifies that the priority hierarchy for the disposal of foul water is to;

a) A public sewer, or, where that is not reasonably practicable;

b) A private sewer communicating with a public sewer, or, where that is not reasonably practicable;

c) Either a septic tank which has an appropriate form of secondary treatment or another wastewater treatment system; or, where that is not reasonably practicable;

d) A cesspool.

20.1.2 Foul drainage will discharge to nearby public foul sewers owned and operated by DCWW. All new plots will need to be connected to the system as there are currently no dwellings or other buildings which similarly discharge to this sewer at the present moment. Following the completion of hydraulic modelling, DCWW has confirmed the sewer would not have spare capacity for the additional development.

20.1.3 Welsh Water conducted modelling for three development scenarios. The Rockfields Farm development is the scenario this FCA is concerned with, therefore scenario 2 will be focused on. Scenario 2 was to include a total development of 270 units at Rockfields Farm. The assessment found that an unacceptable level of flood detriment in the downstream network, upstream of Church Road PS would occur. Full details can be seen in the HMA produced by DCWW included in Appendix F.

20.1.4 Two solutions to the issues related to Scenario 2 have been proposed. Solution one is to create a pumped connection from the development site with a total of 80m^3 of storage (Additional storage of 34m^3 may also be required). Welsh Water has estimated that this solution would cost approximately £950k.

20.1.5 Solution 2 would involve upsizing the existing 225mm sewer and providing 48m^3 of storage (Additional storage of 34m^3 may also be required). Welsh Water has estimated that this solution would cost approximately £582k. This solution is Welsh Waters preferred solution as the gravity

solution is more sustainable and has a lower cost. For full details of the hydraulic modelling please refer to the Developer Services Hydraulic Modelling Report in Appendix B.

20.1.6 The point of connection specified by Welsh Water is higher than some of the onsite levels meaning that a gravity connection will not be possible. However, to maintain the gravity connection it is possible to connect into this same sewer where Rockfield Grove meets the B4245 which would have the same level of capacity following the specified upgrade works given that flows would move in this direction in the current situation.

21.0 Conclusion and Recommendations

21.1.1 The NRW Flood Maps show the site to be located wholly within Flood Zone 1, which is land defined as having less than 1 in 1000 annual probability of river or sea flooding.

21.1.2 The development is designed to ensure that the new residential units do not increase the risk of flooding (from any source) and are compliant with the relevant planning policy, TAN 15.

21.1.3 The preferred option to manage the surface water runoff from the proposed development will be to utilise infiltration devices where ground conditions allow, though this will depend on the availability of the M4 safeguard area. The other areas of the site will involve the attenuation of surface water and discharge at the prorated Qbar rate of 30.5l/s. In the event of infiltration not being viable in the north east area of the site, the storage capacity of the attenuation device will be increased, however, this can be achieved through the deepening of the attenuation from 450mm to 950mm and no additional land will be needed.

21.1.4 Based on the current sewer infrastructure available, the proposed development could not be supported. The foul sewer system will need to be upgraded; this will need to be done in line with the options provided by DDCW.

21.1.5 As a result of development, flood risk will not be increased elsewhere.

Figures

REV	DETAILS	DRAWN	CHECKED	DATE

PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: Site Location

WYG Transport
part of WYG group
5th Floor, Longcross Court
47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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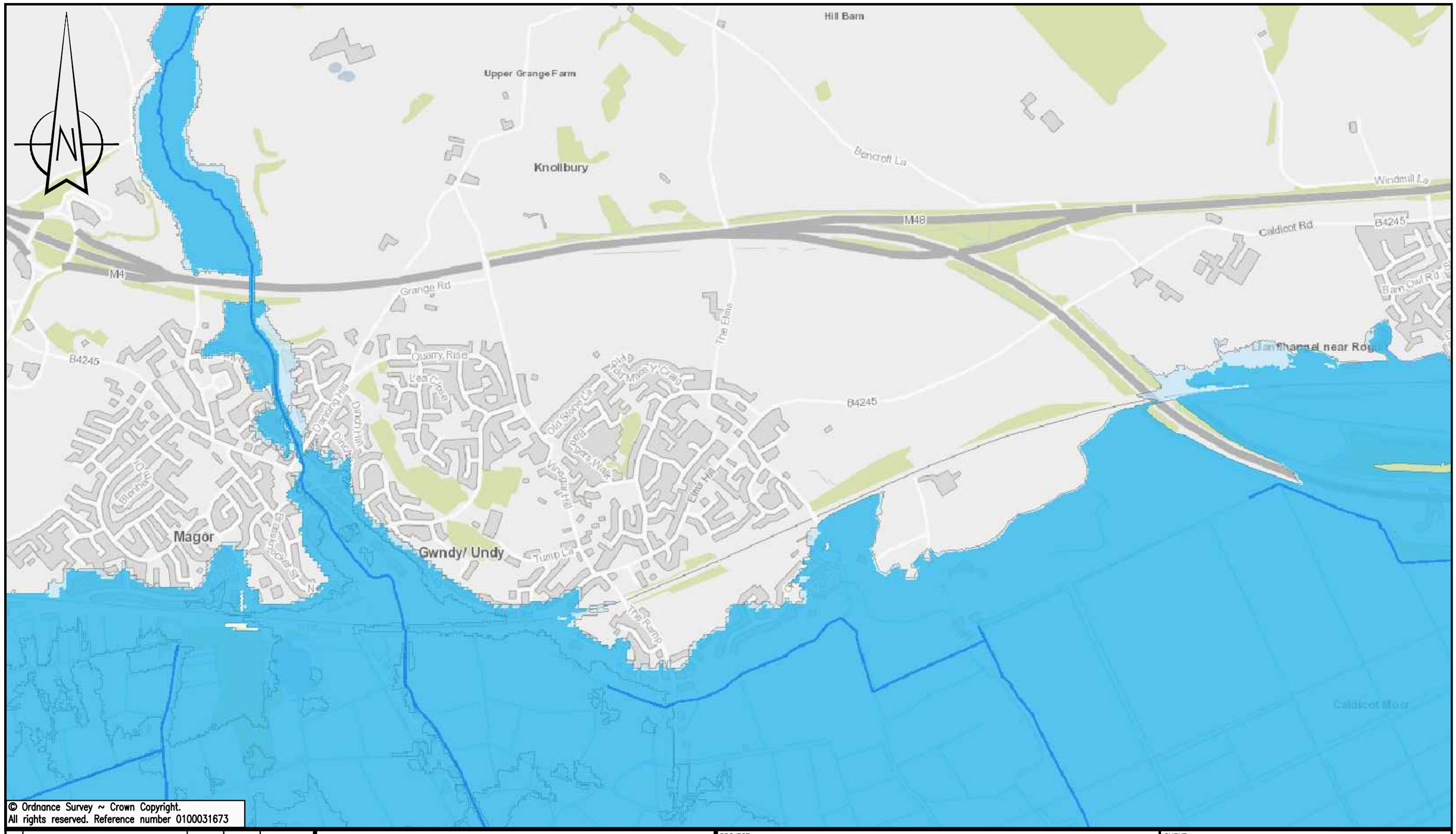

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PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: NRW Flood Map

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part of WYG group
5th Floor, Longcross Court
47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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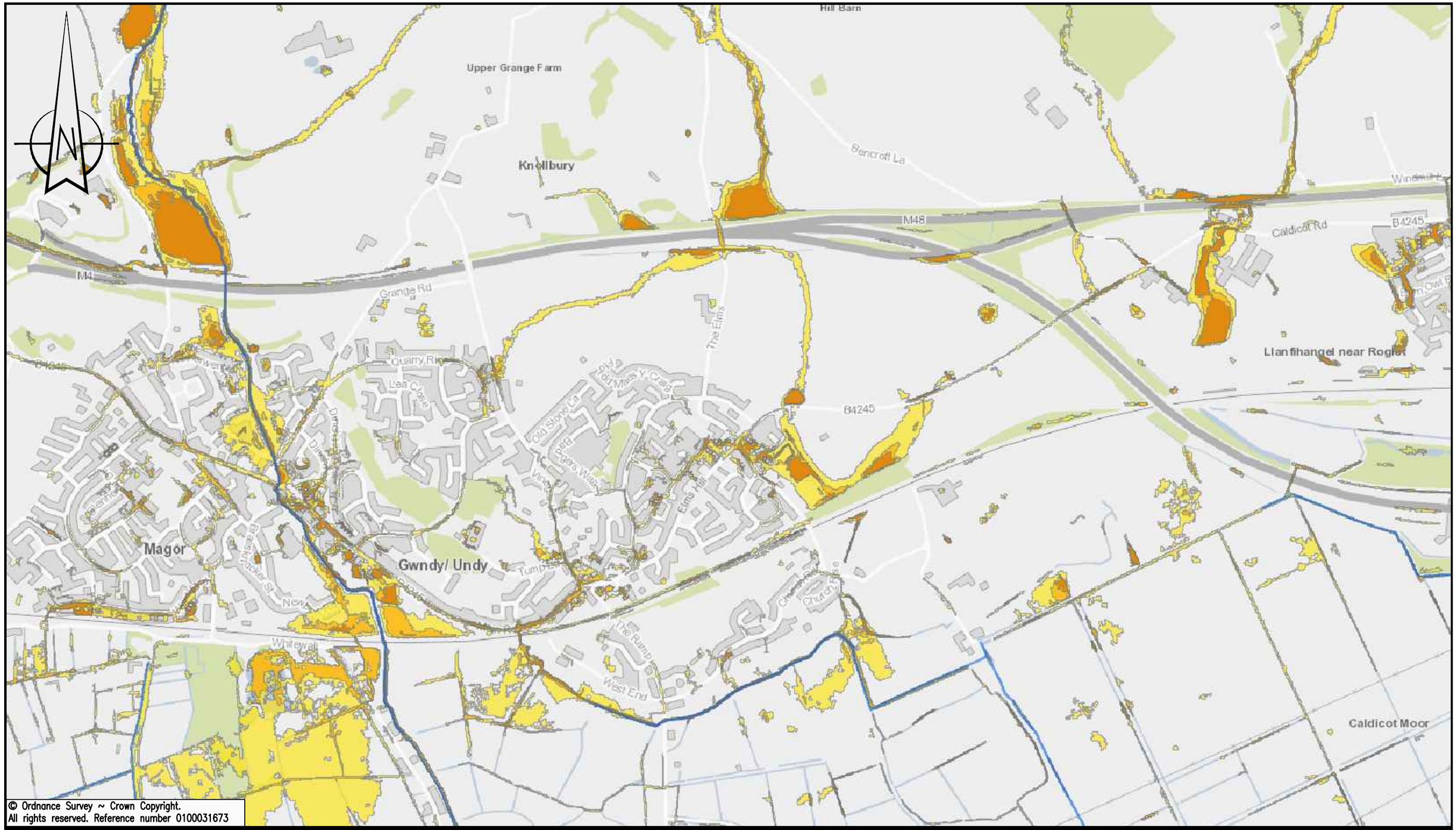

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PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: NRW Surface Water Flood Map

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part of WYG group
5th Floor, Longcross Court
47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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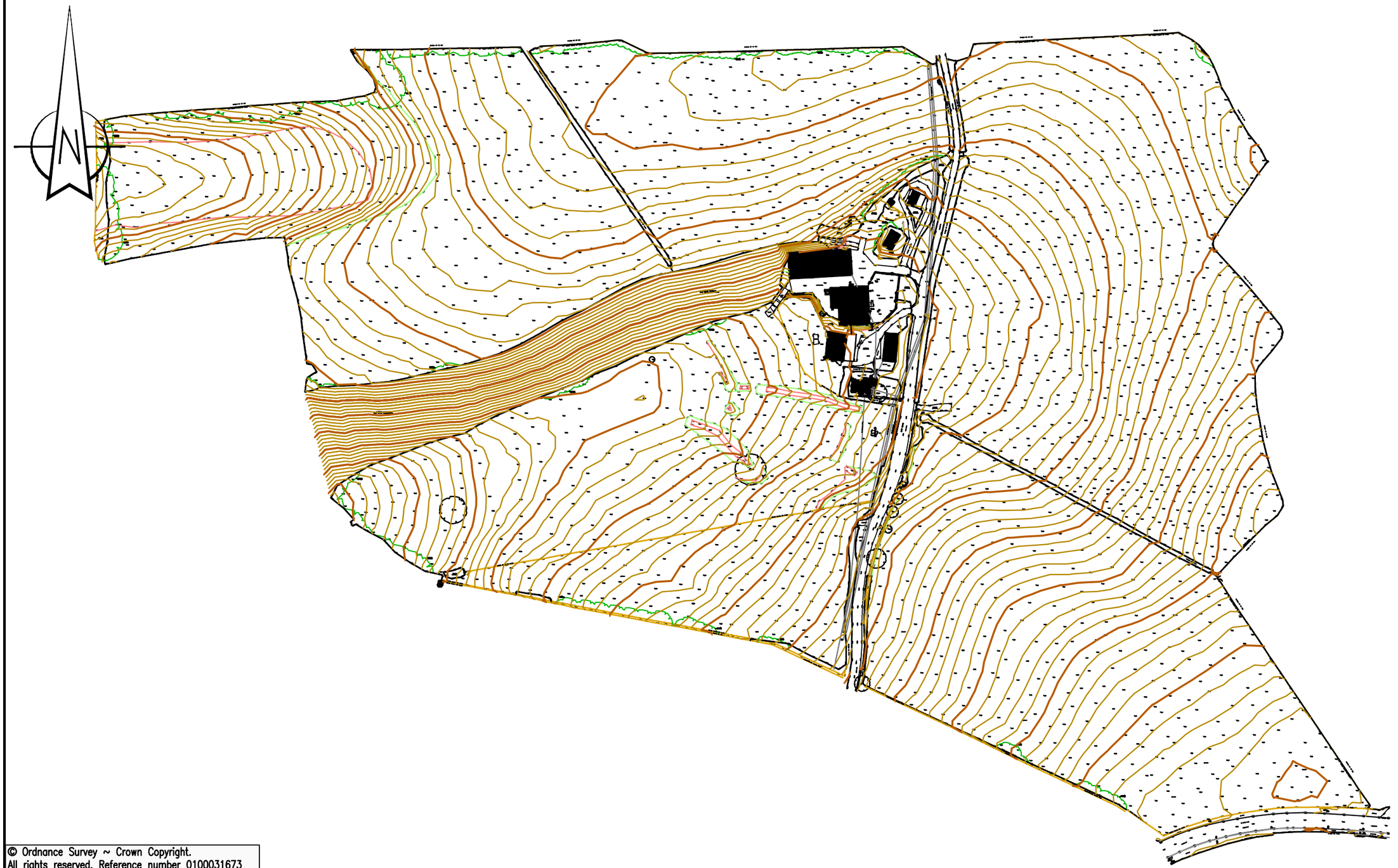

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PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: Topograpgical Survey

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part of WYG group
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47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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JJ	MM	05.04.16	1:2000	A3	Figure 5	-

GEOINDEX ONSHORE

Enter location

Data

Superficial deposits
1:50,000 scale

ADD DATA SHOW LEGEND

Map Legend

Superficial deposits 1:50,000 scale

- ALLUVIUM - CLAY, SILT, SAND AND GRAVEL
- HEAD - CLAY, SILT, SAND AND GRAVEL
- RIVER TERRACE DEPOSITS, 1 - SAND AND GRAVEL
- TIDAL FLAT DEPOSITS - CLAY AND SILT

REV	DETAILS	DRAWN	CHECKED	DATE

PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: Superficial Geology Map

WYG Transport
part of WYG group
5th Floor, Longcross Court
47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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JJ	MM	05.04.16	NTS	A3	Figure 6	-

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PROJECT: A090363 - Rockfield, Undy

CLIENT: Monmouthshire County Council

DRAWING TITLE: Bedrock Geology Map

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47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

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JJ	MM	05.04.16	NTS	A3	Figure 7	-

Appendices

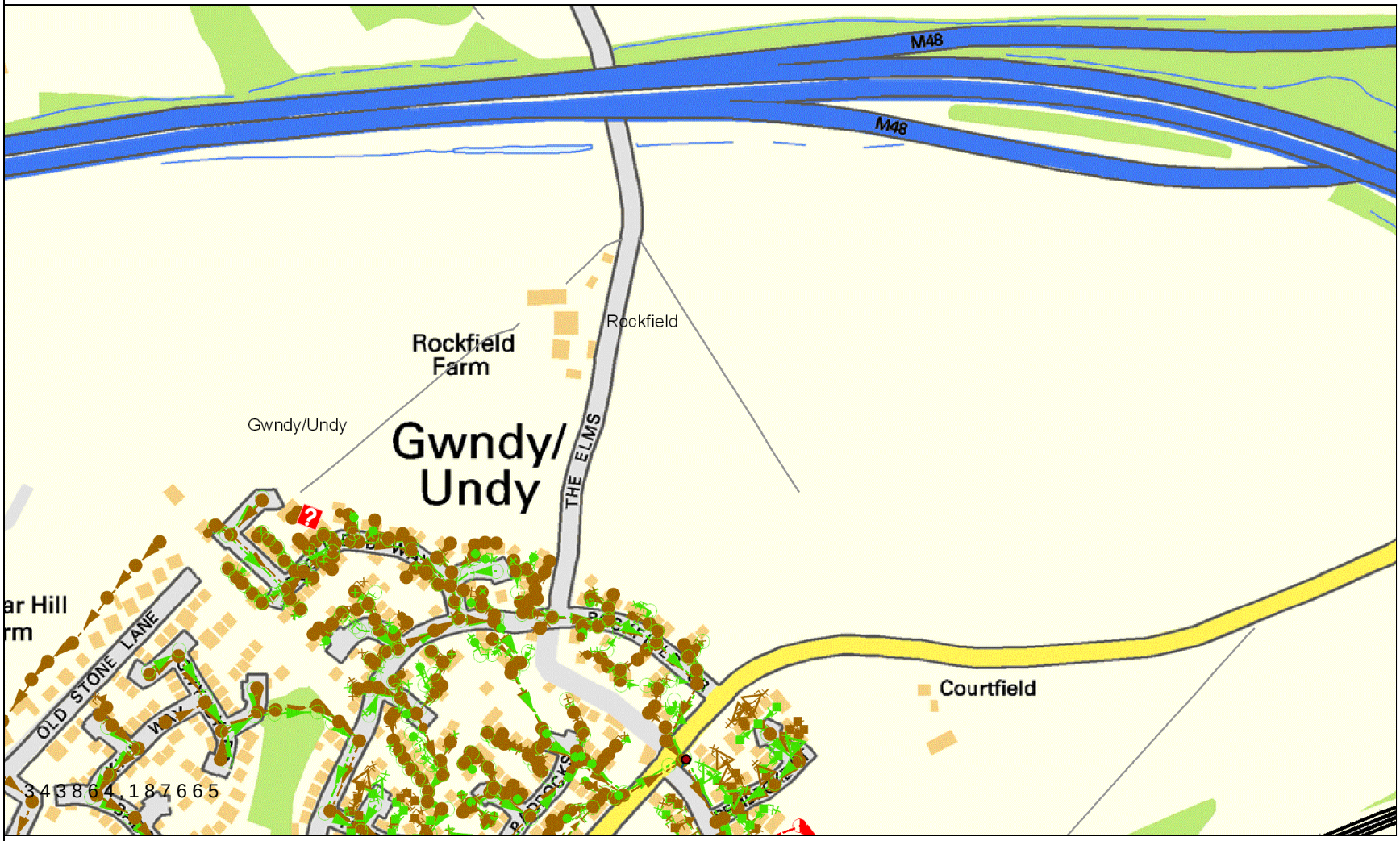
Appendix A – Sewer Records

Dŵr Cymru
Welsh Water

27/05/2016

Rockfield Farm Sewer Map

Scale: 1:5000



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

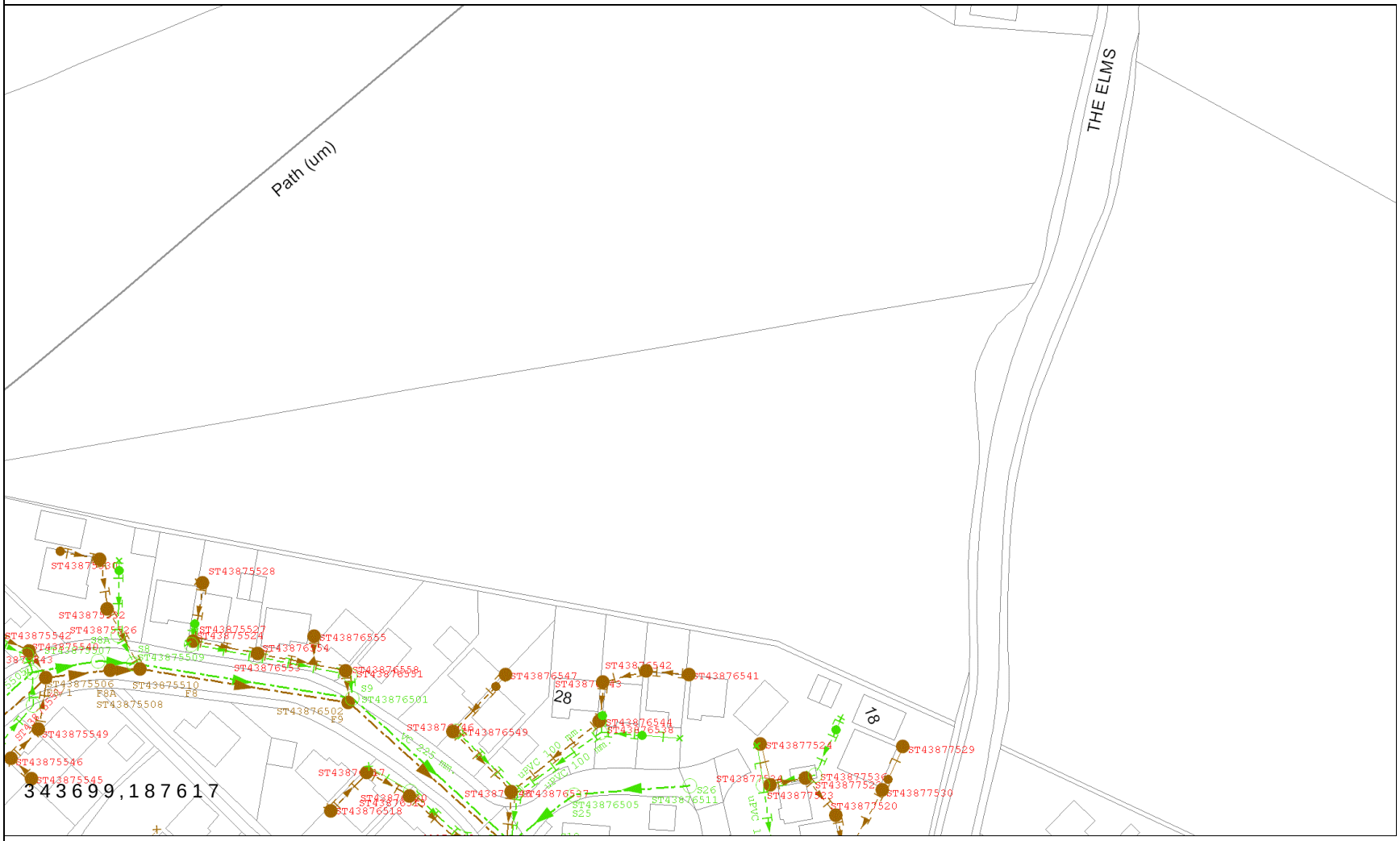
Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF) . It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Dŵr Cymru
Welsh Water

27/05/2016

Rockfield South Sewer Map

Scale: 1:1250



LEGEND

Clean Water

- Sluice Val
- Air Val, SINGLE
- Tap
- Pressure Reducing Valve
- Meter
- BULK Meter
- FH
- Cap
- Existing Main
- NON COMPANY

Sewerage External

- Foul
- Surface Water
- Combined
- Rising Main
- Private
- Treatment Works
- Pumping Station
- Special Purpose
- Unknown End
- Change, Combined Overflow
- Outfall, FOUL
- Lamp Hole, Foul
- Private Sewer Transfer
- Lateral Drain
- Inspection Chamber

EXACT LOCATION OF ALL APPARATUS TO BE DETERMINED ON SITE

Whilst every reasonable effort has been taken to correctly record the pipe material of DCWW assets, there is a possibility that in some cases pipe material (other than Asbestos Cement or Pitch Fibre) may be found to be asbestos cement (AC) or Pitch Fibre (PF) . It is therefore advisable that the possible presence of AC or PF pipes be anticipated and considered as part of any risk assessment prior to excavation

Appendix B – Correspondence

From: Davies, Mark J. (Highways) [MarkDavies2@monmouthshire.gov.uk]
Sent: 08 July 2016 15:57
To: matt.mercer; Halford, Cerys
Cc: jonathan.vining; Elaine.Williams; david.jeffery; Keyse, Nicholas; paul.graham
Subject: RE: Rockfield Farm, Undy

Matt

I have undertaken a cursory review of the submission and generally I would agree with the strategy for the management of surface water on the site due to the varying ground conditions, topography and lack of existing surface water features (drainage ditches /. Watercourses). The use of different methods of controlling surface water on a site location basis the use of pot soakaways, permeable surfaced private drives & car parks, swales etc is duly noted

However I note that the preferred option to manage the majority of the site surface water run off is to attenuate and discharge at the pro rata`d Qbar rate I do question whether a suitable means of discharge is readily available at this time. I note that you have identified a culvert under the B4245 to which the attenuated surface water run-off can be discharged, as I say I am not convinced at this time whether this culvert and more particularly the receiving drainage ditches watercourse downstream, including the existing attenuation pond adjacent to Church Road are acceptable to accommodate the designed discharge flows.

It is therefore recommended that further research and analysis is required to determine a suitable means of off site discharge to the Pratt Reen.

Regards

Mark Davies
Traffic & Development Manager
01633 644754

From: matt.mercer [mailto:matt.mercer@wyg.com]
Sent: 04 July 2016 10:32
To: Halford, Cerys <CerysHalford@monmouthshire.gov.uk>; Davies, Mark J. (Highways) <MarkDavies2@monmouthshire.gov.uk>
Cc: jonathan.vining <jonathan.vining@wyg.com>; Elaine.Williams <elaine.williams@wyg.com>; david.jeffery <david.jeffery@wyg.com>; Keyse, Nicholas <NicholasKeyse@monmouthshire.gov.uk>; paul.graham <paul.graham@wyg.com>
Subject: RE: Rockfield Farm, Undy

Hi Cerys,

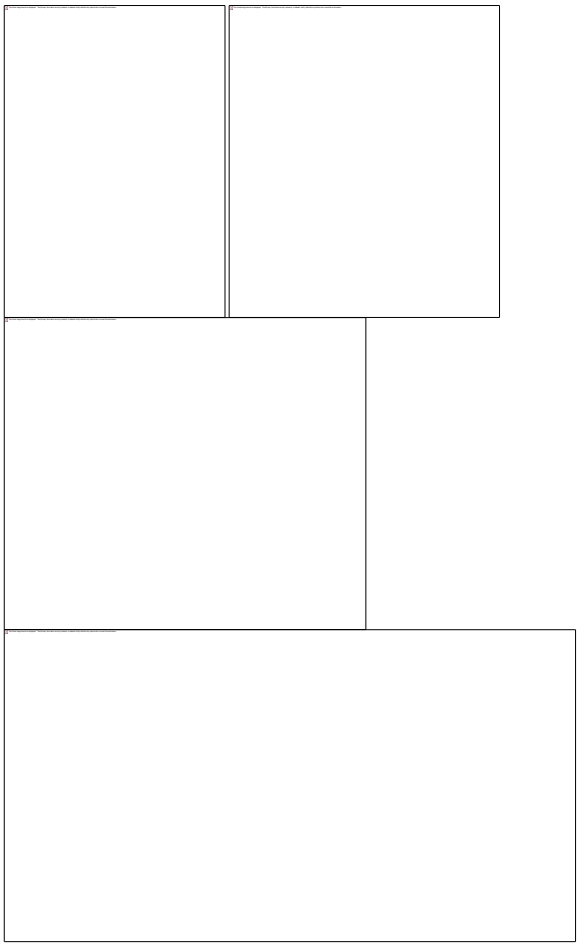
Apologies for this not making it over Friday afternoon, but please see attached the draft FCA and drainage strategy for Rockfield Farm. Any comments or queries, please give me a call/email me. **Mark**, for info I've copied you in – if you have any comments on the proposals, please let me know.

Kind regards,
Matt

Matt Mercer
Principal Engineer

WYG
5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD
Tel: +44 2920 320 753
Fax: +44 29 2045 5321

www.wyg.com



From: Halford, Cerys [mailto:CerysHalford@monmouthshire.gov.uk]
Sent: 28 June 2016 18:33
To: matt.mercer <matt.mercer@wyg.com>
Cc: jonathan.vining <jonathan.vining@wyg.com>; Elaine.Williams <elaine.williams@wyg.com>; david.jeffery <david.jeffery@wyg.com>; Keyse, Nicholas <NicholasKeyse@monmouthshire.gov.uk>;

paul.graham <paul.graham@wyg.com>
Subject: RE: Rockfield Farm, Undy

Thank you Matt for the update and info. much appreciated. Look forward to seeing the draft FCA and DS.

Regards,

Cerys

Cerys Halford MRICS
Principal Surveyor Estates
Monmouthshire County Council/Cyngor Sir Fynwy
Tel /Ffion: 01633 64 (4734)
Mobile/ Symudol: 07773478648
Email / Ebost: ceryshalford@monmouthshire.gov.uk
Website / Gwefan: www.monmouthshire.gov.uk
Follow us on Twitter / Dilynwch ni ar Twitter: www.twitter.com/monmouthshirecc

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From: matt.mercer [mailto:matt.mercer@wyg.com]
Sent: 28 June 2016 16:21
To: Halford, Cerys <CerysHalford@monmouthshire.gov.uk>
Cc: jonathan.vining <jonathan.vining@wyg.com>; Elaine.Williams <elaine.williams@wyg.com>; david.jeffery <david.jeffery@wyg.com>; Keyse, Nicholas <NicholasKeyse@monmouthshire.gov.uk>; paul.graham <paul.graham@wyg.com>
Subject: RE: Rockfield Farm, Undy

Hi Cerys,

The draft FCA has been placed on my desk today for checking, so will be with you this week. We've liaised with Elaine, David and Jonathan on the SuDS placements. I believe there are some minor tweaks being undertaken to suit our final calculations for the site.

The Employment parcel is being drained to a basin and to underground tanks/formpave – this is to minimise the above land take. It may be possible to drain the whole of the area to below ground tanks/porous paving, however this is less sustainable, and due to fairly shallow bedrock in places, could end up being quite expensive.

The residential parcels are then draining to attenuation features within the site (though an area of Parcel B will drain to infiltration features as this was the area with suitable rates). These are placed around the site in the open space to a) split up the SuDS features so as not to concentrate all surface water in one place, and b) to minise the size of the main feature at the south east corner of the site. The SuDS feature to the east of the SINC is one of a couple of intermediary features (one couldn't be placed in the middle of 'B' due to the tree conservation area around the existing tree there). Regarding the delivery – as the largest attenuation feature is in 'A' this can be constructed earliest and can then form the drainage strategy for 'A' and then as the other parcels are brought forward.

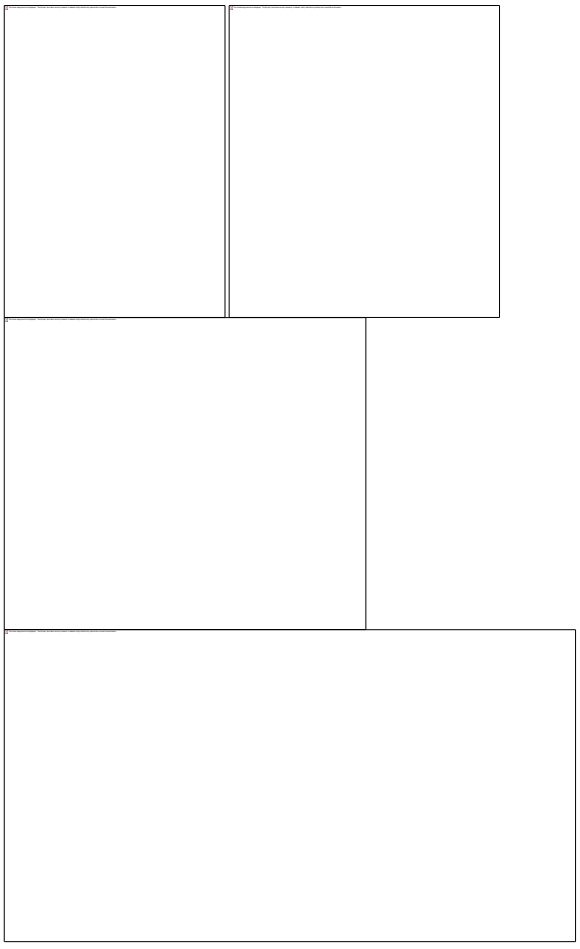
Hope this helps? As mentioned, we'll be issuing a draft FCA and DS this week – I'll also ensure that a copy of the DS is sent to Mark as soon as the drawing is ready.

Kind regards,
Matt

Matt Mercer
Principal Engineer

WYG
5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD
Tel: +44 2920 320 753
Fax: +44 29 2045 5321

www.wyg.com



From: Halford, Cerys [mailto:CerysHalford@monmouthshire.gov.uk]
Sent: 27 June 2016 14:11
To: matt.mercer <matt.mercer@wyg.com>
Cc: jonathan.vining <jonathan.vining@wyg.com>; Elaine.Williams <elaine.williams@wyg.com>; david.jeffery <david.jeffery@wyg.com>; Keyse, Nicholas <NicholasKeyse@monmouthshire.gov.uk>

Subject: RE: Rockfield Farm, Undy
Importance: High

Hi Matt,

Could you let me know how you are getting on please. I trust that you have linked up with Elaine to inform the latest design attached following the movement of the employment parcel. However not sure about what appears to be a SUDs feature in middle of the site to the right(east of the SINC . ?

Could you explain to me the outline strategy for delivery in phases i.e. how each parcel is to be drained ?

If you I and Elaine need a conference call this pm please let me know otherwise would be grateful for an update.

Thanks

Cerys

Cerys Halford MRICS
Principal Surveyor Estates
Monmouthshire County Council/Cyngor Sir Fynwy
Tel /Ffion: 01633 64 (4734)
Mobile/ Symudol: 07773478648
Email / Ebost: ceryshalford@monmouthshire.gov.uk
Website / Gwefan: www.monmouthshire.gov.uk
Follow us on Twitter / Dilynwch ni ar Twitter: www.twitter.com/monmouthshirecc

---

From: matt.mercer [mailto:matt.mercer@wyg.com]
Sent: 21 June 2016 10:57
To: Halford, Cerys <CerysHalford@monmouthshire.gov.uk>
Cc: jonathan.vining <jonathan.vining@wyg.com>
Subject: Rockfield Farm, Undy

Hi Cerys,

Just to let you know I've spoken to Mark this morning, and had a very helpful chat – the good news being that the worst case scenario of requiring a requisition doesn't look like it will be required, and we can continue utilising the existing drainage regime (discharging through a culvert at the south corner of the site).

We'll get the draft of the FCA and drainage strategy in as soon as we can. Mark also mentioned that he'd be happy to informally look over the drainage strategy to provide his thoughts prior to submission.

Thanks
Matt

Matt Mercer
Principal Engineer

WYG
5th Floor, Longcross Court, 47 Newport Road, Cardiff, CF24 0AD
Tel: +44 2920 320 753
Fax: +44 29 2045 5321

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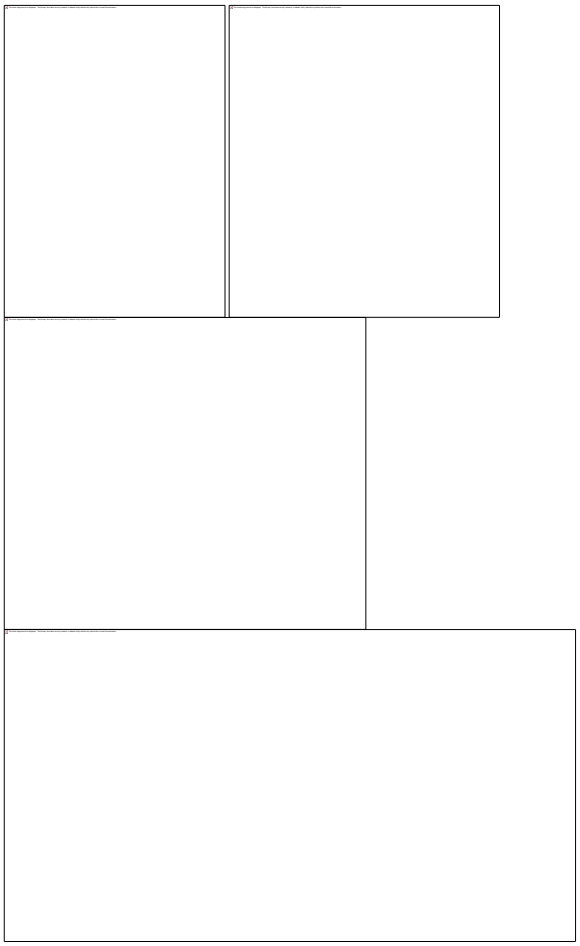

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The Council welcomes correspondence in English or Welsh or both, and will respond to you according to your preference. Corresponding in Welsh will not lead to delay.

Appendix C – Calculations

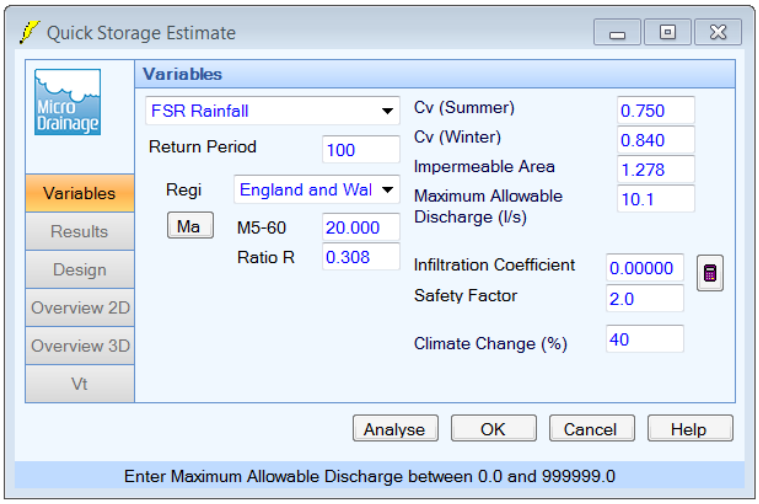
ICP SUDS Mean Annual Flood

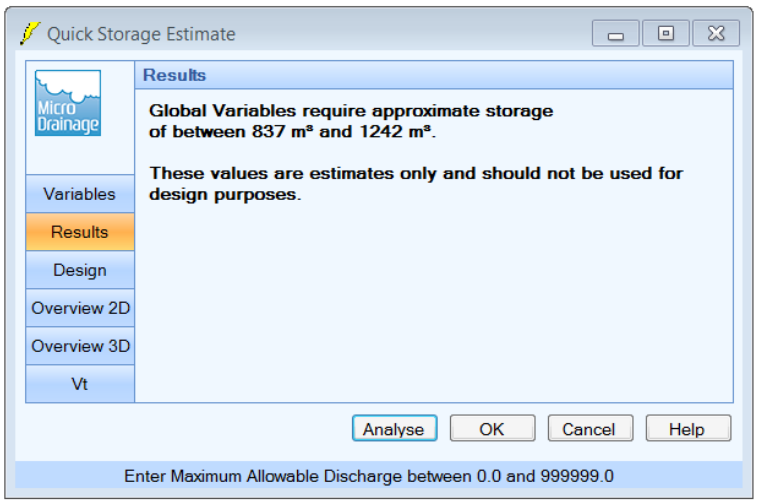
Input

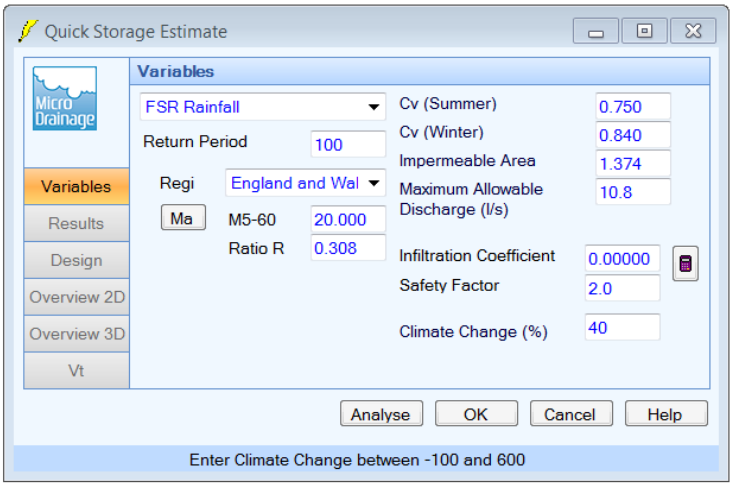
Return Period (years)	100	SAAR (mm)	928	Urban	0.000
Area (ha)	16.340	Soil	0.400	Region Number	Region 9

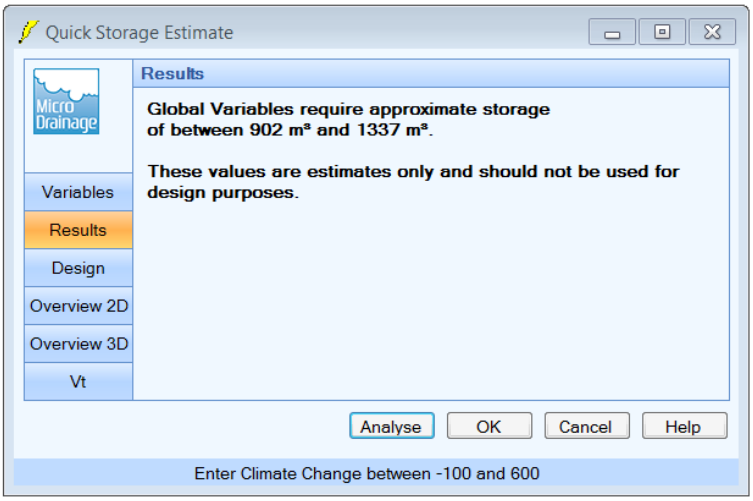
Results l/s

QBAR Rural	77.3
QBAR Urban	77.3
Q100 years	168.6
Q1 year	68.0
Q30 years	136.3
Q100 years	168.6


Quick Storage Estimate
Variables
FSR Rainfall
Return Period 100
Regi England and Wal
Ma
M5-60 20.000
Ratio R 0.308
Cv (Summer) 0.750
Cv (Winter) 0.840
Impermeable Area 1.278
Maximum Allowable Discharge (l/s) 10.1
Infiltration Coefficient 0.00000
Safety Factor 2.0
Climate Change (%) 40
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Maximum Allowable Discharge between 0.0 and 999999.0


Quick Storage Estimate
Results
Global Variables require approximate storage of between 837 m³ and 1242 m³.
These values are estimates only and should not be used for design purposes.
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Maximum Allowable Discharge between 0.0 and 999999.0


Quick Storage Estimate
Variables
FSR Rainfall
Return Period 100
Regi England and Wal
Ma
M5-60 20.000
Ratio R 0.308
Cv (Summer) 0.750
Cv (Winter) 0.840
Impermeable Area 1.374
Maximum Allowable Discharge (l/s) 10.8
Infiltration Coefficient 0.00000
Safety Factor 2.0
Climate Change (%) 40
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Climate Change between -100 and 600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Results
Global Variables require approximate storage of between 902 m³ and 1337 m³.
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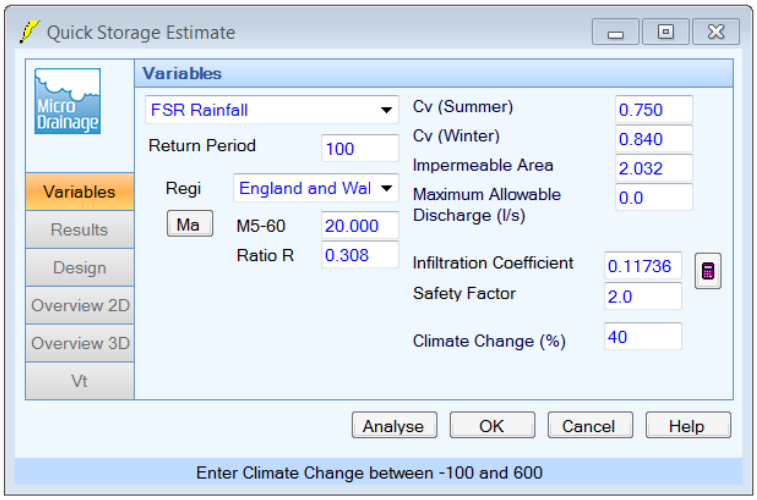
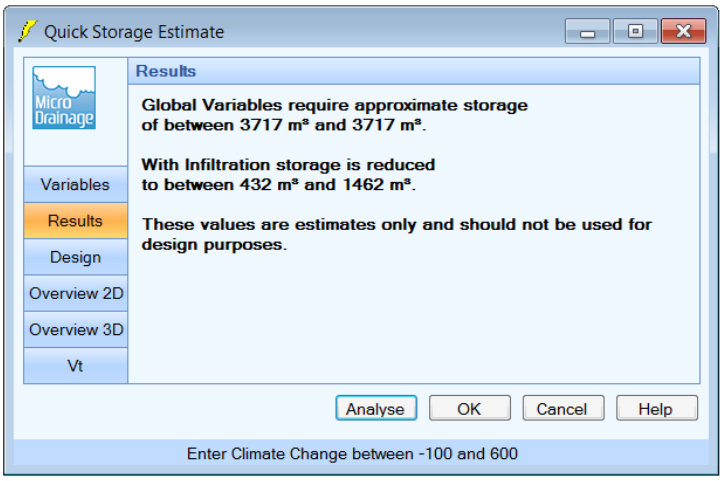
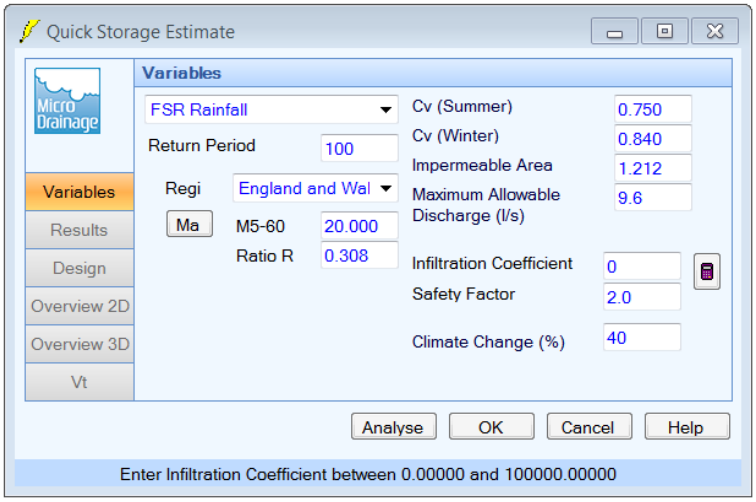
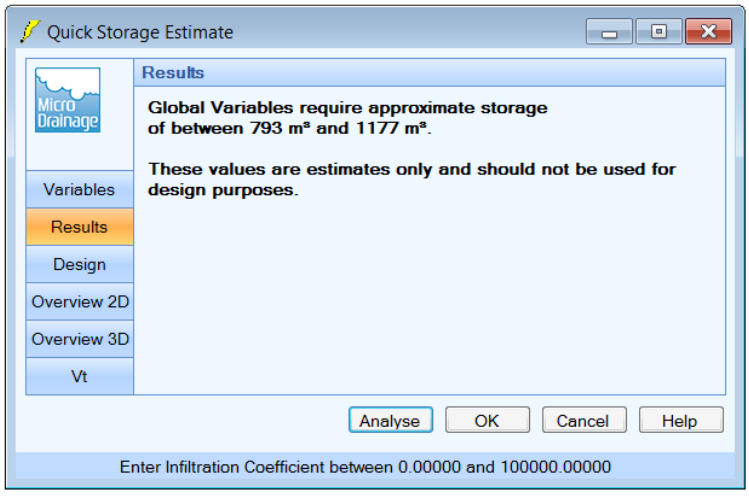
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Climate Change between -100 and 600


Quick Storage Estimate
Variables
FSR Rainfall
Return Period 100
Regi England and Wal
Ma
M5-60 20.000
Ratio R 0.308
Cv (Summer) 0.750
Cv (Winter) 0.840
Impermeable Area 2.032
Maximum Allowable Discharge (l/s) 0.0
Infiltration Coefficient 0.11736
Safety Factor 2.0
Climate Change (%) 40
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Climate Change between -100 and 600


Quick Storage Estimate
Results
Global Variables require approximate storage of between 3717 m³ and 3717 m³.
With Infiltration storage is reduced to between 432 m³ and 1462 m³.
These values are estimates only and should not be used for design purposes.
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Climate Change between -100 and 600


Quick Storage Estimate
Variables
FSR Rainfall
Return Period 100
Regi England and Wal
Ma
M5-60 20.000
Ratio R 0.308
Cv (Summer) 0.750
Cv (Winter) 0.840
Impermeable Area 1.212
Maximum Allowable Discharge (l/s) 9.6
Infiltration Coefficient 0
Safety Factor 2.0
Climate Change (%) 40
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Infiltration Coefficient between 0.00000 and 100000.00000


Quick Storage Estimate
Results
Global Variables require approximate storage of between 793 m³ and 1177 m³.
These values are estimates only and should not be used for design purposes.
Variables
Results
Design
Overview 2D
Overview 3D
Vt
Analyse
OK
Cancel
Help
Enter Infiltration Coefficient between 0.00000 and 100000.00000

Appendix D – Drainage Strategy

REV	DETAILS	DRAWN	CHECKED	DATE

PROJECT: Rockfield Farm, Undy

CLIENT: Monmouthshire CC

DRAWING TITLE: Indicative Drainage Strategy & Pond Location Plan

WYG Transport
part of WYG group
5th Floor, Longcross Court
47 Newport Road, Cardiff, CF24 0AD
t: 029 2082 9200 f: 029 2045 5321 e: transport.cardiff@wyg.com

DRAWN:	CHECKED:	DATE:	SCALES:	SHEET SIZE:	DRAWING NUMBER:	REVISION:
PG	MM	21.06.16	1:2000	A3	SK04	-

Appendix E – Photographs

Appendix F – DCWW HMA

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Welsh Water

Developer Services Hydraulic Modelling Report

Developer Services HMA – Rockfields Farm, Magor Pill WwTW

Prepared By	Date	Approved By	Date	Rev	Section(s)	Comments
Ruby John	18/01/16	Tom Boichot	24/01/16	1		Draft for comment
Paul Black	05/02/16	Tom Boichot	05/02/16	2		Final Issue
Paul Black	19/02/16	Tom Boichot	16/02/16	3		Client Issue

Dŵr Cymru
Welsh Water

Contents

Figures

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Tables

Executive Summary

- Two developments are proposed within the Magor Catchment. In total 496 residential dwellings are proposed on two adjacent sites; 270 units at Rockfields Farm and 226 units at Vinegar Hill.

- The proposed developments have been assessed using two connection points.
  - Connection Point 1 - Vinegar Hill - ST43872401 – South of the development, connecting to an existing 150mm diameter foul sewer draining to Undy Main PS.
  - Connection Point 2 - Rockfields Farm - ST43877503 - South of the development, connecting to an existing 150mm diameter foul sewer draining to Church Road PS.

- The key model build activities undertaken were:
  - Update of the model with manhole survey data.
  - Area take off using returned IAS data.
  - Inclusion of the Undy Main PS and Undy Sub PS in the model.

- The model was verified against a short term flow survey comprising three flow monitors and two rain gauges. Overall a reasonable level of DWF and Storm Verification was achieved.

- The key model build assumptions/limitations are:
  - Uncertainties surrounding the on/off levels and invert of the incoming sewer into the Undy Main PS. While it is recommended that future users of the model seek to confirm these levels, these uncertainties have negligible impact on the results of the HMA.

- The extent of storage within the Church Road PS. It is recommend that future users undertake a complete survey to establish the storage volumes at this PS.

- The hydraulic assessment was undertaken on the following scenarios:
  - *Scenario 1* - Total development of 226 units at Vinegar Hill.
  - *Scenario 2* - Total development of 270 units at Rockfields Farm.
  - *Scenario 3 - Combined total of 496 dwellings from Vinegar Hill and Rockfields Farm.*

The findings of the assessment were:

- Scenario 1 – Unacceptable level of flood detriment in the downstream network in the vicinity of Undy Sub PS.
- Scenario 2 – Unacceptable level of flood detriment in the downstream network, upstream of Church Road PS.
- Scenario 3 – Unacceptable level of flood detriment in the downstream network, at the same locations as Scenario 1 and 2, but no significant new flooding locations outside the areas previously identified.

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

Scenario 1:

- Solution 1a: £614k– Offline storage (20m^3) on Main Road, 260m sewer upsize (225mm to 300mm) upstream of Undy Main PS. *May require an additional 20m^3 emergency storage at Undy Main PS.*
- Solution 1b: £521k Sewer upsize on Main Road (180m of 300mm sewer), and 61m^3 online storage upstream of Undy Main PS (120m of 750mm). *No additional storage required.*
- Solution 2: £622k - Offline storage (20m^3) on Main Road, online storage upstream of Undy Sub PS. *May require 28m^3 storage at Undy Main PS.*
- Solution 3: £738k - Sewer upsize on Main Road (730m of 300mm sewer), 40m of pipe dualling under the railway line, and 31m^3 online storage upstream of Undy Main PS (20m of 1050mm). *No additional storage required. A lower cost (£540k) could be achieved by construction of the sewer crossing the rail line 130m to the east (Solution 3a).*

Scenario 2:

- Solution 1: £950k – Pumped connection from the development site (including 63m^3 storage) and 17m^3 online storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 16m^3 emergency storage at Church Road PS.*
- Solution 2: £582k – Upsize 71m of sewer to 225mm. Provide 48m^3 of storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 0m^3 emergency storage at Church Road PS.*

Scenario 3:

- Solution 1: £978k – Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Implement Scenario 1, Solution 2. *May require 61m^3 storage at Undy Main PS.*
- Solution 2: £1,103k – Provide any combination of Scenario 1 and Scenario 2 Solutions. *Additional storage required as a combination of the above solutions.*
- Solution 3: £1,024 - Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Increase Church Road PS pump rate to 12 l/s and upsize downstream network (225m of 300mm). *May require 61m^3 storage at Church Road PS (270m^3 if current consent is retained) and Undy Main PS.*

The preferred solution for each scenario is:

- Scenario 1 – Solution 3a – The provision of network storage upstream of Undy Main PS achieves a dual objective of flood reduction and emergency storage provision.
- Scenario 2 – Solution 2 – The gravity solution is more sustainable (lower energy usage) and lower cost.
- Scenario 3 - Solution 3 – This Solution limits buildability issues, construction of additional assets, and achieves a dual objective of flood reduction and emergency storage provision at Undy Main PS and Church Road PS. This is subject to gaining agreement from NRW to relax the existing EO consent.

Based on a review of the solution costs and feedback from DCWW Operations, it is recommended that both developments are constructed with independent drainage and the preferred independent solutions delivered. This will allow both developments to drain to the existing system via gravity. Therefore, no new pumping stations are required which will increase DCWWs operating costs. A review of the costs of the preferred solutions for each scenario indicates that the preferred solutions for Scenarios 1 and 2 are more cost effective than the preferred solution for Scenario 3.

Introduction

1.1 Appointment

On 12th June 2015 Atkins were appointed by Dŵr Cymru Welsh Water (DCWW) under the Sustainable Drainage and Hydraulic Modelling Support (Waste Network) Framework, to undertake a Hydraulic Model Assessment (HMA) for a proposed development consisting of 496 dwellings at two adjacent sites in Magor; Vinegar Hill and Rockfields Farm.

Dŵr Cymru Welsh Water (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 Rockfields Farm development.

1.2 Development Site

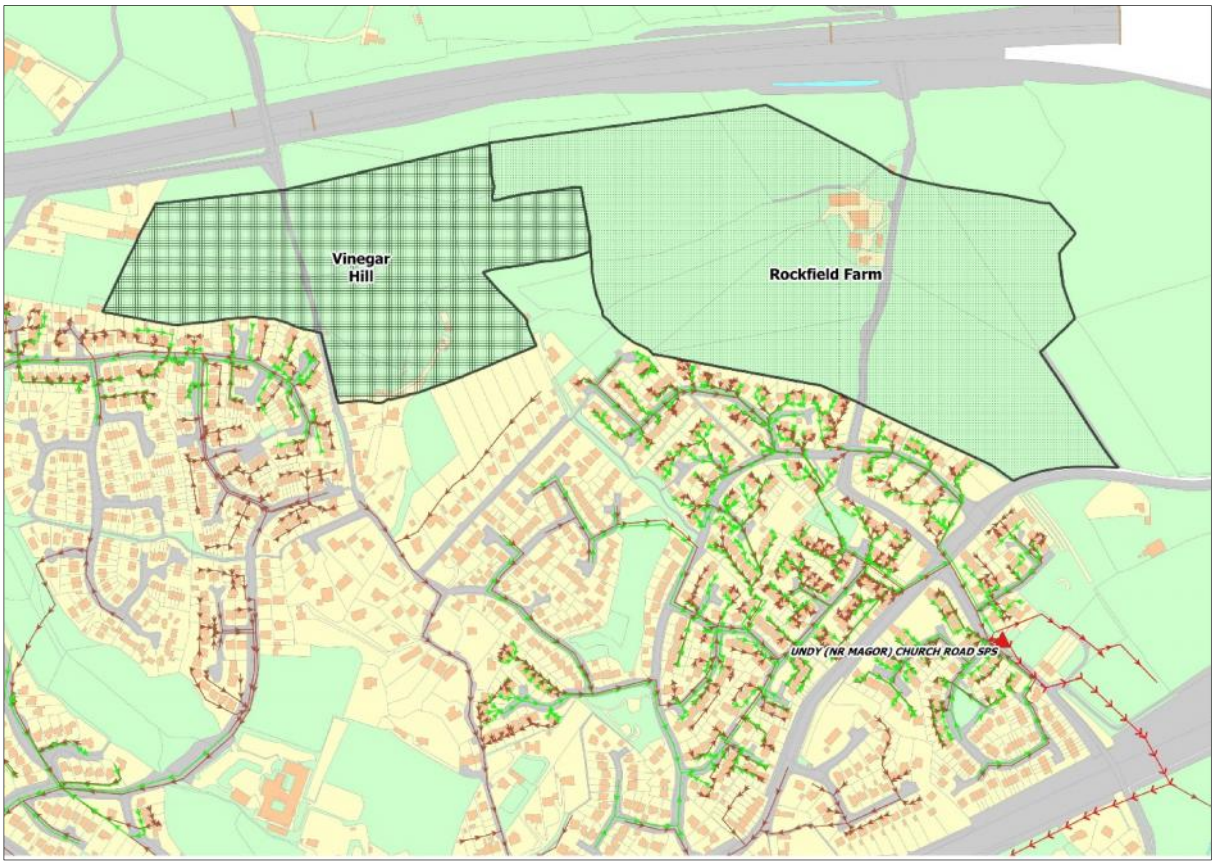


Figure 1 – Proposed Development Site

- Size – Vinegar Hill – 7.75 ha

  Rockfields Farm – 13.55 ha
- Location – Vinegar Hill and Rockfields Farm, Magor, Newport
- Topography – The development is located to the north–east of Magor. A desktop review has identified two possible connection points, at Vinegar Hill and Rockfields Farm (Elms Hill). A review of the existing LiDAR data indicated that a gravity connection was unfeasible to connect the Vinegar Hill development due to the land being at a lower level than the receiving foul network, and as such a pumped connection has been assumed. It is possible to connect the Rockfields Farm development by gravity to the foul network draining to the Church Road Pumping Station (PS)
- Previous/Current Usage – Greenfield site
- Proposed Usage – Development consisting of 496 residential dwellings on two adjacent sites; 270 units at Rockfields Farm and 226 units at Vinegar Hill
- Sewerage Details – No sewerage details have been supplied by the developer and as such an outline estimate has been made based on the DCWW specifications
- Connection Type – Vinegar Hill – Pumped; Rockfields Farm – Gravity
- Phasing – The development has been assessed as three separate scenarios:

  Scenario 1 - Total development of 226 units at Vinegar Hill

  Scenario 2 – Total development of 270 units at Rockfields Farm

  Scenario 3 – Combined total of 496 dwellings from Vinegar Hill and Rockfields Farm

1.3 Background Information

The proposed development is within the Magor Catchment which drains to the Nash Wastewater Treatment Works (WwTW) - 30996.

The Magor model provided by DCWW for the Sustainable Drainage Plan (SDP) study did not contain the sewer network draining to the Undy Main PS. This was added into the model using the DCWW GIS as part of the SDP study. No verification was undertaken in the study area for the SDP, due to the low risks present within the catchment. The majority of the sewers in this area are small diameter (150/225mm).

As part of this HMA it was proposed to undertake surveys within the catchment to improve the model and increase confidence in the predictions for areas likely to be affected by the development site. A flow survey comprising of three Flow Monitors (FMs) and two Rain Gauges (RGs) was undertaken from 18/08/2015 to 20/10/2015, along with surveys of Church Road PS and Undy (Sub) PS. Survey data of Undy Main PS from the Arup South East Coastal (SEC) study was also used. The model was then updated appropriately. For further details refer to Section 3.

2 Land Usage

The proposed development consists of 496 residential dwelling on two adjacent sites in Magor; 270 units at Rockfields Farm and 226 units at Vinegar Hill. A location plan has been provided but no details of the development master plan are available. For the purpose of the HMA, it is assumed to be of high density housing with an occupancy rate of 2.5 persons per property.

Land Use surfaces for the development have been defined as per the DCWW MBV Specification.

		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	226	2.5	565
		Total	565

Table 1 - Proposed Domestic Development Contribution – Scenario 1

		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	270	2.5	675
		Total	675

Table 2 - Proposed Domestic Development Contribution – Scenario 2

		Domestic Populations	
Type	Number of Units	Bedrooms (per House Type)	Number of Residents
Housing	226	2.5	565
Housing	270	2.5	675
		Total	1240

Table 3 - Proposed Domestic Development Contribution – Scenario 3

2.1 Proposed Connection Details

The following connection points have been proposed by DCWW as stated in *055 - Rockfields Farm, Magor HMA - Issue*:

Scenario 1: Vinegar Hill - ST43872401 – South of the development, connecting to an existing 150mm diameter foul sewer draining to Undy Main PS.

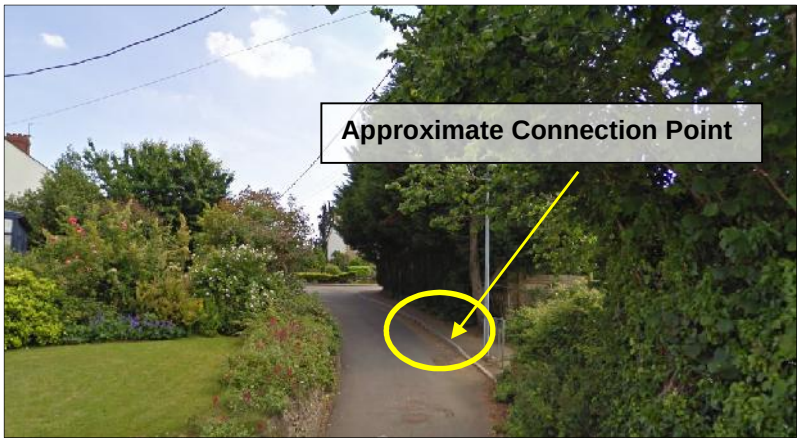


Figure 2 – Scenario 1: Vinegar Hill

Scenario 2: Rockfields Farm- ST43877503, South of the development, connecting to an existing 150mm diameter foul sewer draining to Church Road PS.

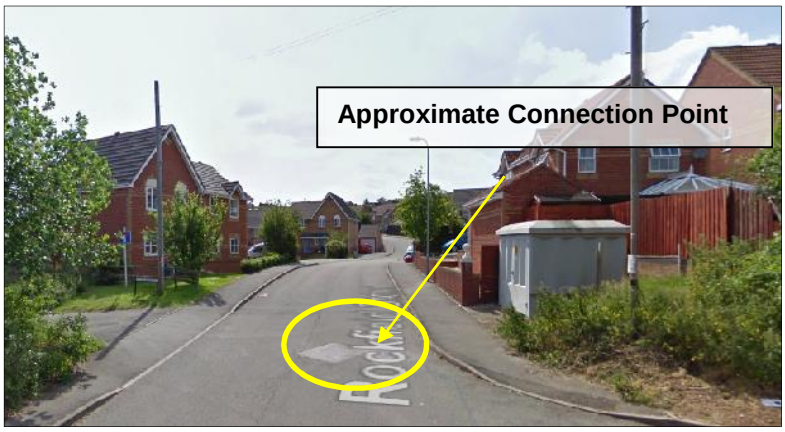


Figure 3 – Scenario 2: Rockfields Farm

Based on the development details provided and a desktop assessment, a pumped connection would be required for the Vinegar Hill development, while the Rockfields Farm development can be drained by gravity, see Figure 4 below for details.

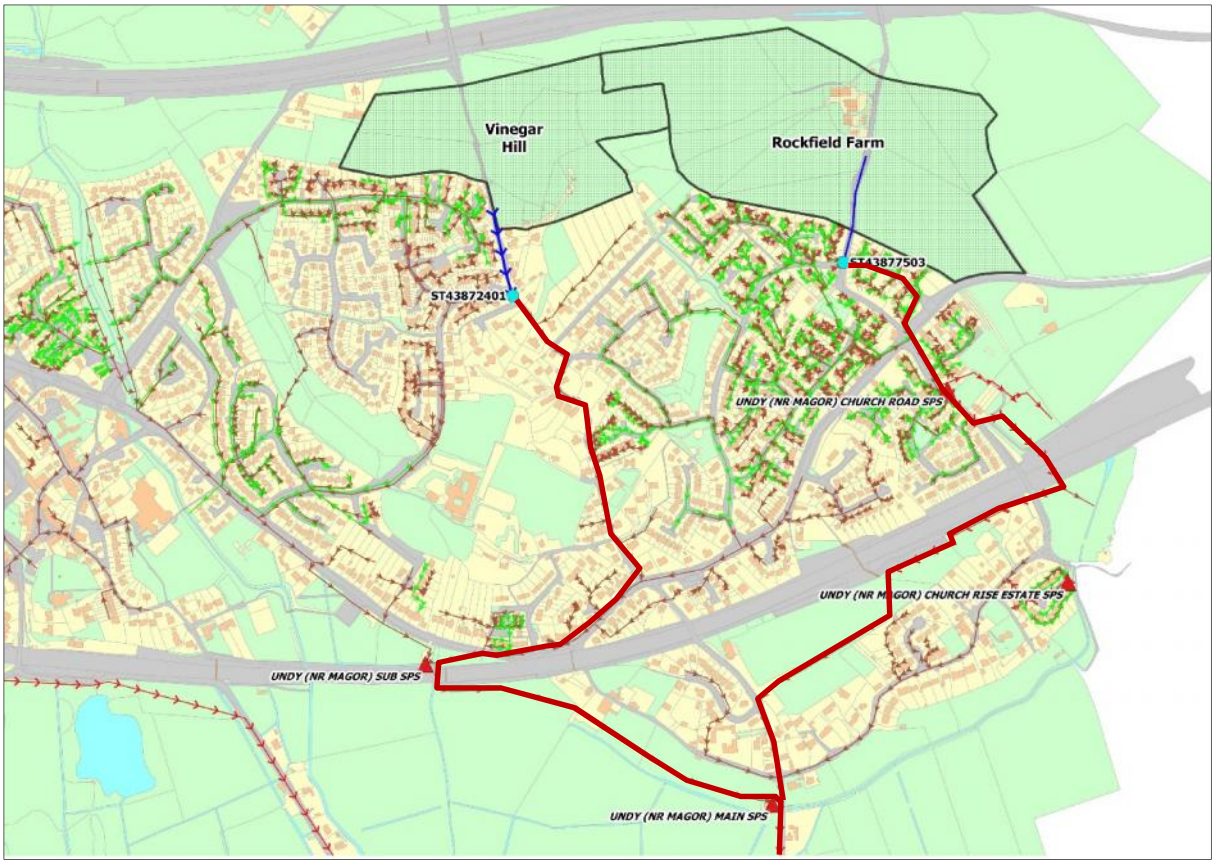


Figure 4 - Development Site Overview Plan – Including Connection Point(s)

3 Developed System Modelling

3.1 Model Build / Enhancement

The proposed development is within the Nash WwTW catchment. The model database "30996-F-Magor_DAP_Model.iwt" was used for the study, this was created as part of the AMP5 DCWW Sustainable Drainage Plan (SDP) for the Magor Pill sub catchment.

A review of the SDP model indicated that the representation of the key assets, e.g. Church Road PS, lacked sufficient detail to progress the HMA. It was also noted that the Undy Main PS and Undy Sub PS were not represented. The area draining to the Undy Main PS was modelled as draining to a dummy outfall and as such surveys were proposed to improve the model network. The model was updated based on the results of the ancillary survey, Impermeable Area Survey (IAS) and historic survey information obtained from Arup for the Undy Main PS.

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

- Existing DCWW Geographical Information Systems (GIS)
- Historic Survey Data
- DCWW Telemetry Data
- PS Survey
- Manhole Survey
- Impermeable Area Survey (IAS)

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 10 manholes was commissioned to supplement the existing DCWW GIS data. Manhole survey cards for seven of these were returned as the survey contractor was unable to locate ST43861801 (rising main discharge point of Undy Sub PS), ST43866601 (d/s of FM01) and ST43865600 (d/s of FM01). The survey of manhole ST43866703 was not completed due to a gas alarm.

This survey data was identified with the InfoWorks flag "SD" and notes included within the model.

3.1.2 Impermeable Area Survey

An IAS survey was undertaken due to concerns that small pipe sizes throughout the catchment would give poor flow monitoring sites. Twelve discreet areas were identified and proposed for survey. The impermeable area survey indicates that runoff from impermeable surfaces are predominantly drained by the surface water system and that the DCWW GIS data was on the whole representative of actual connectivity.

3.1.3 PS Surveys

The Church Road and Undy Sub PSs were surveyed as part of the HMA. It was proposed to survey both assets and undertake drop tests to establish the current pump performance. However, Undy Sub PS could not be drop tested as the inlet pipe was too low within the wet well to allow the drop test to be calculated. The surveyor used a flow pulse monitor to establish a snap shot of the discharge rates and pump performance. The Church Road PS was drop tested to calculate pump performance. The results of the survey have been summarised in section 3.1.4.

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

3.1.4 Ancillary Modelling

A review of the DCWW GIS database has highlighted the following assets that may be impacted on by the developments:

- Church Road Undy PS (33699) and overflow;
- Magor Sub PS (31427);
- Undy Main PS (31426);
- Magor SWK PS (71389) and overflow.

Church Road Undy PS CSO – Asset ID 33699. Two pumps operating on a duty/standby regime are modelled as a single pump with a discharge rate of 10 l/s. A 100mm diameter rising main discharges flow into the downstream network at ST43868901.

Construction drawings were available for the PS, including diameters, inverts, overflow and flow control devices (150mm diameter gate valve on the incoming pipe). Additional storage was identified adjacent to the wet well, in the form of a large diameter (750mm) pipe, however the survey contractor was unable to locate the upstream end. Consent AN00231401 states that a minimum of 26.5 hours storage capacity shall be available based on the design dry weather flow. No further detail was available as to the design flow to make a suitable assumption of the storage constructed, and as such an estimate of approximately 41m^3 was made based on the available telemetry depth data at the site. The survey stated that this pipe is heavily silted and greased.

There is an Emergency Overflow (EO) pipe in the wet well connecting to the adjacent storm system at ST43878303. The survey contractor could not access this manhole and it is unclear if there is a flap/non return valve at this connection point to prevent surface water flows entering the wet well.

Magor Sub PS – Asset ID 31427. Two pumps operating on a duty/assist regime, modelled with the pump rate of 13 l/s and 12 l/s respectively based on survey data. The 150mm diameter rising main discharges into manhole ST43861801. Construction drawing were available for the asset including diameters, inverts and flow control devices.

The survey reports that the operator stated that there is no overflow but there is a 300mm diameter pipe at a very high level in the wet well, which connects to the rising main discharge point, essentially acting as a gravity bifurcation in the event of pump failure. This manhole was

identified for survey. However, there it could not be accessed as the area is very close to the rail track and heavily overgrown.

Undy Main PS – Asset ID 31426. The asset has three pumps operating on a Duty/Assist/Standby regime. The duty pump is set to a discharge rate of 36 l/s and the assist is set to 12 l/s based on drop test results. The pump on/off levels could not be confirmed as there was not enough flow to the PS during the survey period to undertake the drop down tests. A 150mm diameter rising main discharges flow at ST43846902 (Magor Works).

Historic survey information indicated that the invert of the incoming pipe is at the chamber floor level of the wet well (see Figure 5 below). There is no overflow/outfall in the PS and the Hydro-Brake flow control has been removed. The survey indicated that there is evidence of heavy surcharging in the wet well.

Figure 5 – Undy Main PS wet well and incoming sewer

3.1.5 Summary of Model Build / Enhancement Activities

The model build activities undertaken were:

- Update of the model with manhole survey.
- Area take-off using returned IAS data.
- Inclusion of the Undy Main PS and Undy Sub PS in the model.

3.2 Verification

A short term flow survey was carried out, comprising of three FMs, and two RGs located within the Nash WwTW catchment. Two flow monitors (FM01 and FM02) were installed in each of the two incoming sewers at the Undy Main PS. FM03 was installed in the 150mm sewer in Church Road (upstream of the Church Road PS).

The locations of the FMs and RGs are shown in Figure 6.

The flow survey began on 18/08/2015 and was terminated on 20/10/2015, a total duration of 63 days.

The performance of the system was initially verified for Dry Weather Flows (DWFs) 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 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	ST43864701	545931.1	225	18/08/2015	21/10/2015
FM02	ST43866600	545911.1	225	18/08/2015	21/10/2015
FM03	ST43878302(uncharted manhole)FM installed in the incoming sewer at this manhole	1053206.1	150	18/08/2015	21/10/2015

Table 4 – Flow & Depth Monitor Location Details

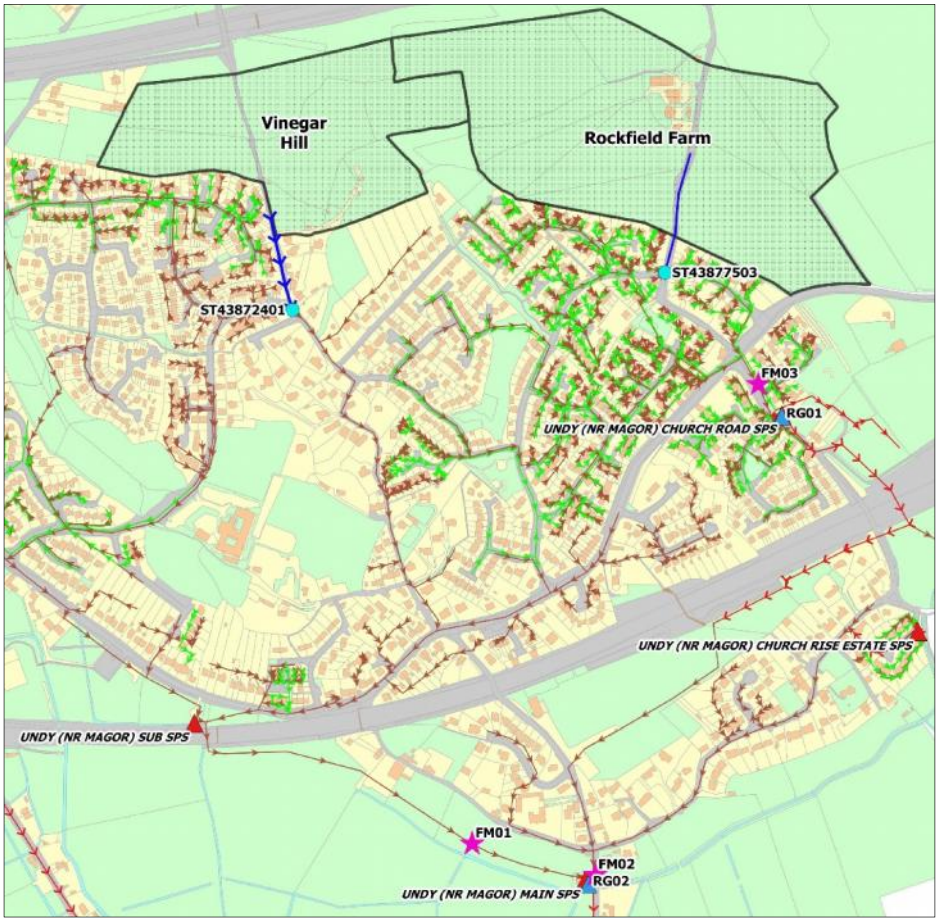


Figure 6 – Flow, Depth & Rain gauge Monitor Location Plan

3.2.1 Dry Weather Flow Verification

Two WaPUG compliant dry days were selected for the DWF verification:

- Dry Day 1 – 00:00 11/10/2015 to 00:00 12/10/2015
- Dry Day 2 – 00:00 12/10/2015 to 00:00 13/10/2015

FM01

The initial model showed a reasonable match against observed peak flow. However, the model over predicted depth and flow. Base flow of 3.18 l/s was removed from subcatchments upstream of FM01 to reduce the over prediction in flow and volume.

Overall a reasonable level of DWF verification was achieved at this location.

FM02

The initial model over predicted flow, volume and depth. Base flow of 0.63 l/s was removed from subcatchments upstream of FM02. No changes could be justified to replicate observed depth, as levels were based on PS and manhole survey information. A sensitivity test was conducted by altering the switch/on off levels at the d/s PS. However, this was found to negatively impact the verification at FM01.

A low level of DWF verification was achieved at this location as a result of poor data.

FM03

The initial model over predicted flow and depth when compared with the observed data. Base flow of 2.18 l/s was removed from subcatchments upstream of FM03. This led to a good correlation with observed data for both the dry days.

Overall a reasonable level of DWF verification has been achieved for FM03.

3.2.2 Storm Flow Verification

Three storm events were selected for storm flow verification. These are detailed in Table 5 below.

Event	Date	Weekday	Start Time	End Time	Duration (hrs.)	Peak Intensity (mm/hr.)
A	23/08/2015	Sunday	04:20	11:24	7:04	24
B	05/10/2015	Monday	20:46	22:10	01:24	30
C	06/10/2015	Tuesday	09:12	09:42	00:30	72

Table 5 – Flow Survey Storm Events

FM01

Initial plots indicated a greater observed storm response than predicted. Impermeable area of 0.992 ha was added upstream of the PS to partially replicate the depths for Event 1. Any further increase in contributing area would result in significant over prediction for Event 3. A good correlation of observed and predicted hydrographs is seen for Events 2 and 3.

A reasonable level of storm verification has been achieved for this location.

FM02

Initial plots indicated that the model slightly over predicted flow and over predicted depth. The impermeable area upstream of the monitor was subsequently reduced from 0.446 ha to 0.223 ha. However, the model continues to over predict depth for all the events. This is considered most likely to be attributed to the current on/off arrangements at the Undy Main PS. However, this could not be confirmed. Therefore, no changes have been made.

A reasonable level of storm verification has been achieved at this site.

FM03

Initial plots showed a reasonable level of verification. The area upstream of FM03 is served by a separate system, which was confirmed by the observed data. A small contributing area of 0.03 ha has been added immediately upstream of FM03 to replicate a small storm response seen in observed flow hydrographs.

A reasonable level of storm verification has been achieved at this site.

3.3 Historical Verification

A review of DCWWs flood incident database 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 is one property located upstream of Undy Sub PS and three properties upstream of Church Road PS known to be at risk of hydraulic flooding. These are identified in Table 6.

Property Address	Status	Scheme Type
Main Road, Undy	Active	OF (1:10)
Pembroke Court, Undy	Active	OF (1:20+)
The Paddocks, Undy	Active	DG5 (1:20+)
The Paddocks, Undy	Active	DG5 (1:20+)

Table 6 – Flooding Summary

Confirmed Flooding

Main Road, Undy (OF 1:10)
This property is located upstream of Undy Sub PS. The model predicts flooding in the vicinity of this DFL property (ST42879007) for a 10 year return period storm event. The relative ground level of the flooding manhole flagged #A (Asset Data) was lower than the surrounding nodes and thus the ground level was updated with LiDAR data.

Pembroke Court, Undy (OF 1:20), The Paddocks, Undy DG5 (1:20+)

These properties are located immediately upstream of the Church Road PS. The model does not predict flooding at this location for up to 30 year design storm, as the network is confirmed as separate. However, the model predicts surcharge and backing up from the PS for a 2 year design storm.

Unconfirmed Flooding

Millfield Park
The model predicts flooding in the vicinity of Millfield Park. The ground level at manhole ST42876440 was inferred from the Lidar data. It is likely that the model is over predicting flooding and surcharge. However, no further changes could be justified to reduce the flooding at this location.

Dancing Hill
The model predicts flooding in the vicinity of manhole ST42877201. A flood volume of less than $5m^3$ is predicted for a 10 year return period event. The manhole is located on a highway, and it is likely that flooding would drain through the highway drainage system and hence not be reported.

Elms Hill
The model predicts flooding on Elms Hill Road which is parallel to the railway line. It is possible that the manholes are flooding. The predicted flood volume is less than $5m^3$ for a 30 year return period event.

The model predicted flood volumes and locations after Historical Verification for 2, 5, 10, 20 and 30 year return periods are shown in Table 7 and Figure 7.

		Design Storm				
		30 Year	20 year	10 Year	5 Year	2 Year
Manhole ID	Road Name	Flooding Volume m^3				
ST43862902	Elms Hill	1	0.3	-	-	-
ST43863904	Elms Hill	0.3	0.1	-	-	-
ST43863903	Elms Hill	2.8	1.4	-	-	-
ST43863902	Elms Hill	2.1	0.6	-	-	-
ST43863907	Elms Hill	0.3	-	-	-	-
ST42877201	Dancing Hill	13.8	10.2	4.9	0.9	
ST42877100	Main Road	0.8	0.1	-	-	-
ST42877102	Main Road	32.8	24.7	12.8	5.2	-
ST42879006	Main Road	4.9	2.5	0.3	-	-
ST42879007	Main Road	24.5	19.9	11.7	4.08	0.97
ST42876440	Millfield park	5.8	3.1	0.1	-	-
ST42878103	Pennyfarthing lane	4.2	2.68	0.30	-	-

Table 7 – Flood volume comparison of unconfirmed flooding

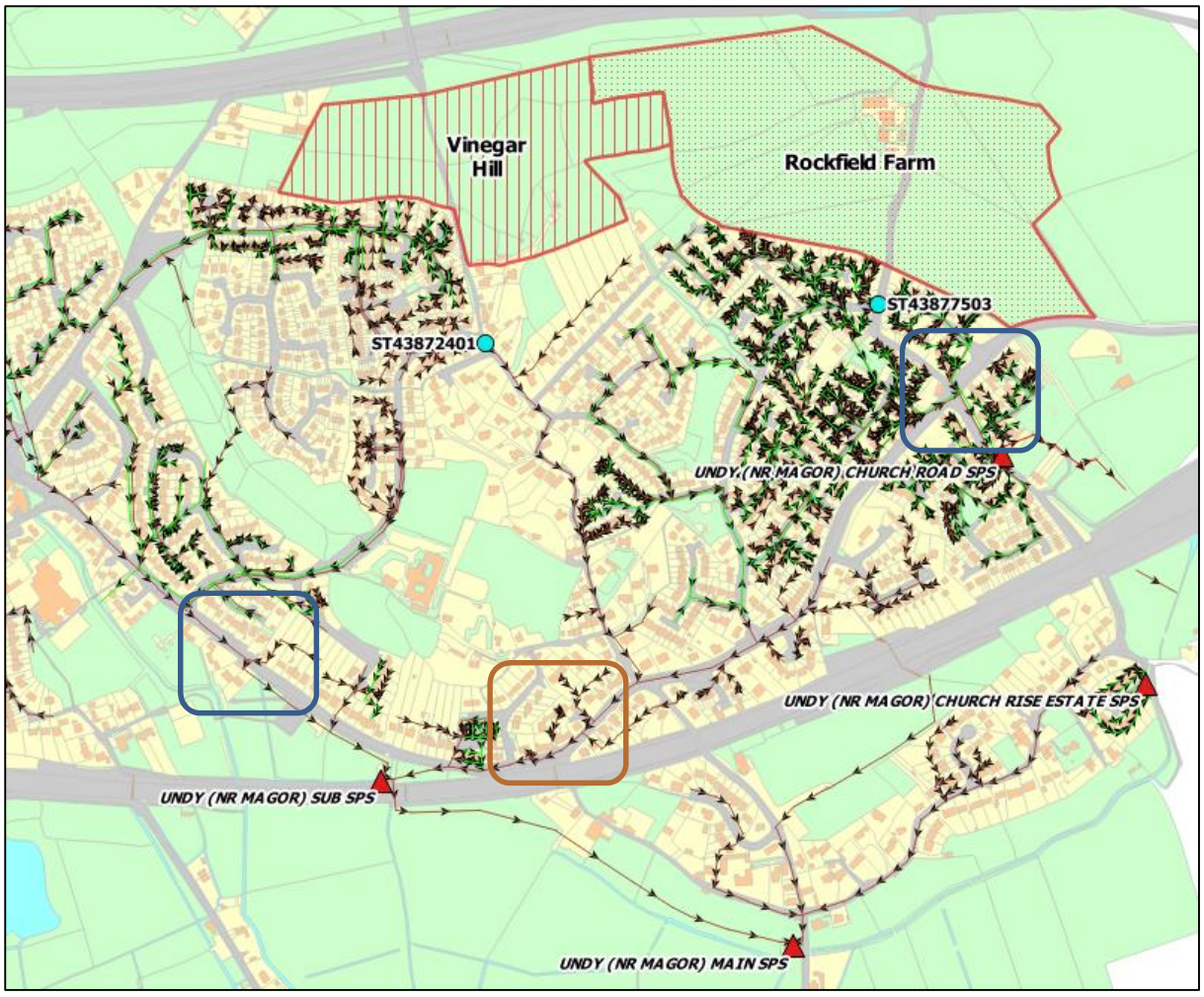


Figure 7 – Confirmed (Blue) and Unconfirmed (Orange) Flooding Locations

3.4 Verification Summary

3.4.1 DWF Verification

Overall a reasonable level of DWF verification was achieved at all flow monitor locations. However, future users should seek to confirm the pump switch on and off levels and wet well chamber floor level at Undy Main PS.

3.4.2 Storm Verification

Overall a reasonable level of storm verification was achieved at all flow monitor locations.

There is a reasonable level of confidence in the model for the areas upstream of Undy Main PS.

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 A.

3.5 Model Assumptions & Limitations

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

The on/off levels at the Undy Main PS could not be surveyed as there was not enough flow to the PS. The survey also indicated that the invert of the incoming sewer is the same as the wet well floor level and is modelled as such. It is recommended that future users of the model seek to confirm these levels.

The survey of the Church Road PS indicated the presence of a storage section in the wet well which could not be surveyed. The consent AN00231401 (1995) states that a minimum of 26.5 hours storage capacity shall be available based on the design dry weather flow. A complete survey would be required to establish the storage volumes at this PS. The model includes an assumed storage volume of 41m^3 at this PS.

There is believed to be an interaction between the foul and surface water system at Church Road PS, as seen in the telemetry data. It is recommended that a flap valve is installed to prevent future ingress from the surface water system.

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

Since the full extent of the storage volume available in the Church Road PS is not confirmed due to the limitation of the survey, solutions which propose storage at the Church Road PS may under or over-estimate required storage volumes.

A large number of levels within the catchment are inferred or based on historic GIS data. There is a low level of confidence in this data, which may have an impact on model predictions, particularly when assessing detriment at flooding nodes.

4 Development System Analysis

4.1 Dry Weather Flow

The DWF for the residential properties has been calculated separately and for total development as shown below.

The Development phasing has been proposed as follows.

- Scenario 1 –Vinegar Hill Development
- Scenario 2 – Rockfields Farm Development.
- Scenario 3 (Total) - Vinegar Hill and Rockfields Farm Development

Scenario 1: Vinegar Hill Development

Parameter	Value	Comment
Population – P	565	226 properties
Per Capita Return to Sewer Flow Rate – G	180 l//h/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/h/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.118 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	1.18 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	1.30 l/s	
DWF Peak Hydraulic Assessment Multiplier	2	DWF Peaking factor for flooding level of performance investigation.

Table 8 – HMA - DWF Parameters – Scenario 1 (Vinegar Hill Development)

Scenario 2: Rockfields Farm Development

Parameter	Value	Comment
Population – P	675	270 properties.
Per Capita Return to Sewer Flow Rate – G	180 l//h/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/h/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.141 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	1.41 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	1.55 l/s	
DWF Peak Hydraulic Assessment Multiplier	2	DWF Peaking factor for flooding level of performance investigation.

Table 9 – HMA - DWF Parameters – Scenario 2 (Rockfields Farm Development)

Scenario 3: Vinegar Hill and Rockfields Farm Development

Parameter	Value	Comment
Population - P	1240	496 properties
Per Capita Return to Sewer Flow Rate – G	180 l//h/day	The wastewater profile used for the HMA has a per capita return to sewer flow of 180 l/h/day. This figure is a standard design figure adopted by DCWW for new developments.
Infiltration	0.26 l/s	10% DWF (PG) assumed
Total DWF Calculations		
P * G	2.58 l/s	Population multiplied by the per capita return to sewer flow rate.
Total DWF	2.84 l/s	
DWF Peak Hydraulic Assessment Multiplier	1 and 2	DWF Peaking factor for flooding level of performance investigation.

Table 10 – HMA - DWF Parameters – Scenario 3 (Vinegar Hill and Rockfields Farm Development)

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.

The development master plan was not provided hence a high density housing rate has been applied on the impermeable area as specified in the DCWW HMA Specifications.

Scenario 1: Vinegar Hill Development

- Net Residential Area – 7.75 ha
- Total Impermeable Area – 7.75 x 0.7 = 5.425 ha
- An even distribution of Road and Roof areas was assumed (2.7125 ha road and 2.7125 ha roof)
- 2% of total road area and 2% of total roof area applied:
- Road Area = 2.7125 ha x 0.02 = 0.0542 ha
- Roof Area = 2.7125 ha x 0.02 = 0.0542 ha

Scenario 2: Rockfields Farm Development

- Net Residential Area – 13.55 ha
- Total Impermeable Area – 13.55 x 0.7 = 9.485 ha
- An even distribution of Road and Roof areas was assumed (4.74 ha road and 4.74 ha roof)
- 2% of total road area and 2% of total roof area applied:
- Road Area = 4.74 ha x 0.02 = 0.0948 ha
- Roof Area = 4.74 ha x 0.02 = 0.0948 ha

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
5.425	2.7125	0.0542	2.7125	0.0542

Table 11 - Development Impermeable Areas – Scenario 1 (Vinegar Hill)

Total Impermeable Area (ha)	Total Road Area (ha)	2% Road Area (ha)	Total Roof Area (ha)	2% Roof Area (ha)
9.485	4.74	0.0948	4.74	0.0948

Table 12 - Development Impermeable Areas – Scenario 2 (Rock Field Farm)

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 as they represented the 'worst case' scenario. It has been found that most flooding incidents occur during the 960 minute storm duration for Scenario 1, 2 and 3. Model predicted flood volumes vary with the duration of event and therefore all storm durations have been assessed to highlight the worst case scenario.

Flooding is predicted at a number of locations downstream of the proposed discharge locations of both the Vinegar Hill and Rock field farm development. The flooding is caused by a localised hydraulic incapacity of 150/225mm sewers and is affected by the development flows.

5.1.1 Scenario 1 – Vinegar Hill Development

This scenario assesses the impact of the Vinegar Hill development connecting to ST43872401 for the development of 226 units.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
545881	ST43862902	240	0	6.5	6.5	New
545884	ST43863904	240	0	3	3	New
545885	ST43863903	240	0	8.1	8.1	New
545886	ST43863902	120	0.2	6.9	6.7	3350
545892	ST43863907	60	0	2.6	2.6	New
742921	ST42877102	720	0.1	6.9	6.8	6800
742925	ST42879006	720	2.7	13.1	10.4	385
742926	ST42879007	960	0.4	30	29.6	7400

Table 13 – Hydraulic Assessment Results – Scenario 1

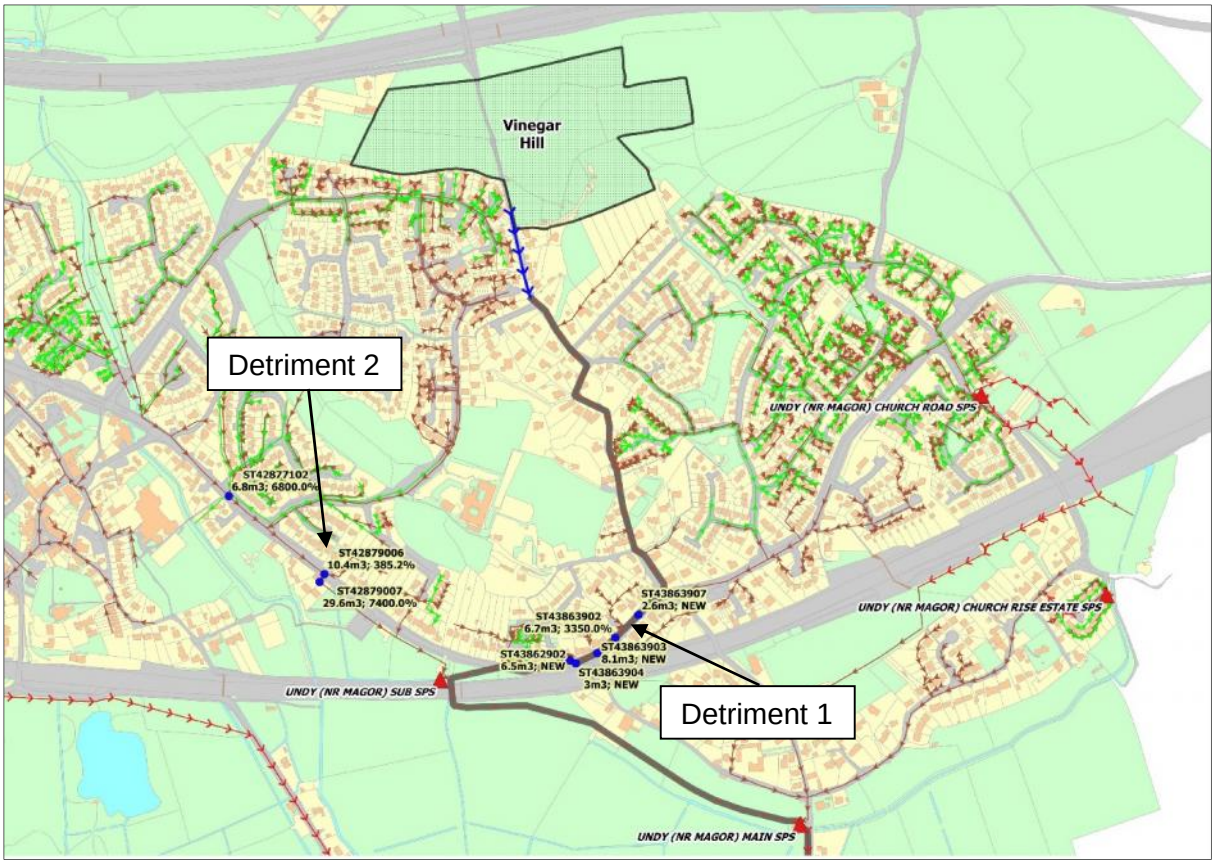


Figure 8 – Model Predicted Flooding Location Plan – Vinegar Hill (Scenario 1)

New flooding is predicted at manholes ST43862902, ST43863904, ST43863903 and ST43863907 with the addition of the Vinegar Hill development. The flooding occurs as a result of sewer incapacity where the gradient reduces after a steep fall.

Flood detriment is also predicted at manholes ST42877102, ST42879006 and ST42879007 located upstream of the Undy Sub PS. This is due to flows backing up through the high level overflow bypass arrangement into the pumping station wet well. The surcharge is caused by sewer incapacity which is exacerbated by the increased downstream depth caused by the development. These manhole are in the vicinity of the Main Road, Undy DFL property.

5.1.2 Scenario 2 – Rockfields Farm Development

This scenario assesses the impact of the Rockfields Farm development consisting of 270 units connecting to ST43877503.

Model Node ID	Manhole ID	Critical Duration (min)	Flood Volume (m^3)		Flooding Detriment	
			Existing	Developed	Absolute (m^3)	Percentage (%)
1053205	ST43878304	360	0	19.6	19.6	New
2034830	ST43878402	60	0	10.9	10.9	New
2034831	ST43878403	30	0	2.5	2.5	New
545886	ST43863902	120	0.2	1.5	1.3	650
742896	ST42877201	480	1.2	9	7.8	650
742921	ST42877102	720	0.1	20	19.9	19900
742925	ST42879006	960	0	2.5	2.5	New
742926	ST42879007	960	0.4	19.8	19.4	4850
742967	ST42876440	240	0	1.6	1.6	New
748445	ST42878103	90	0.5	2.9	2.4	480

Table 14 – Hydraulic Assessment Results – Scenario 2

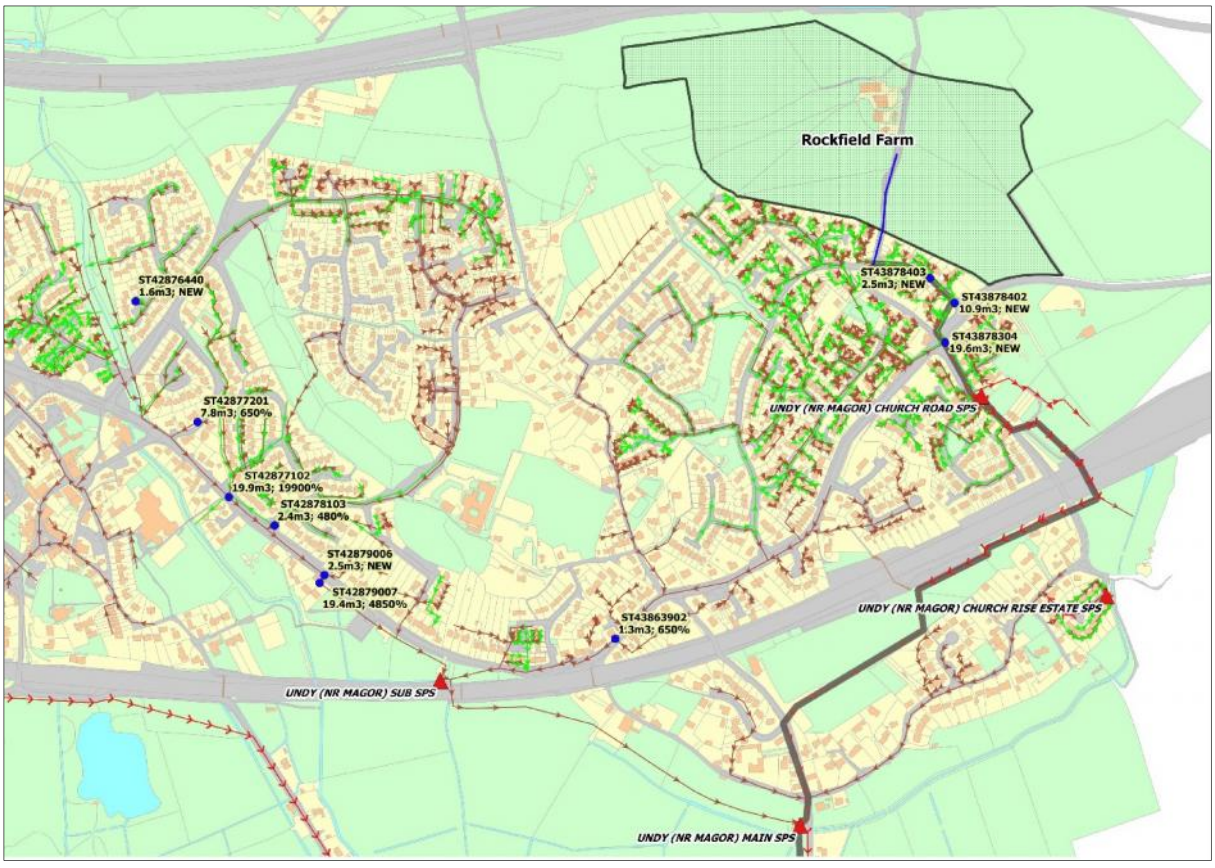


Figure 9 – Model Predicted Flooding Location Plan – Rockfields Farm (Scenario 2)

Significant new flooding is predicted at manholes ST43878304, ST43878402, and ST43878403, which are located upstream of Church Road PS in the vicinity of The Paddocks and Pembroke Court, Undy DFL properties. This flooding is primarily due to the incapacity of 150mm sewers that are unable to pass forward the additional peak flow from the development, where there is change in gradient in the network.

The pump states and pump run time flow from Church Road PS increase with the addition of development flow, increasing the top water level in the Undy Main PS and the 225mm sewers in Main Road. This increases flooding upstream of Undy Sub PS, in the vicinity of the DFL property.

5.1.3 Scenario 3 – Vinegar Hill and Rockfields Farm Development

This scenario assesses the combined impact of the development at Vinegar Hill and Rockfields Farm, connecting to ST43872401 and ST43877503 for the total development of 496 units (226 units at Vinegar Hill and 270 units at Rockfields Farm).

Model Node ID	Manhole ID	Critical Duration	Flood Volume (m^3)		Flooding Detriment	
		(min)	Existing	Developed	Absolute (m^3)	Percentage (%)
1053205	ST43878304	240	0	22	22	New
2034830	ST43878402	60	0	11.5	11.5	New
2034831	ST43878403	30	0	2.5	2.5	New
545881	ST43862902	240	0	6.8	6.8	New
545884	ST43863904	240	0	3.2	3.2	New
545885	ST43863903	240	0	8.2	8.2	New
545886	ST43863902	120	0.2	6.9	6.7	33500
545892	ST43863907	60	0	2.6	2.6	New
742921	ST42877102	720	0.1	6.9	6.8	6800
742925	ST42879006	720	2.7	13	10.3	381
742926	ST42879007	960	0.4	29.6	29.2	7300

Table 15 – Hydraulic Assessment Results – Scenario 3

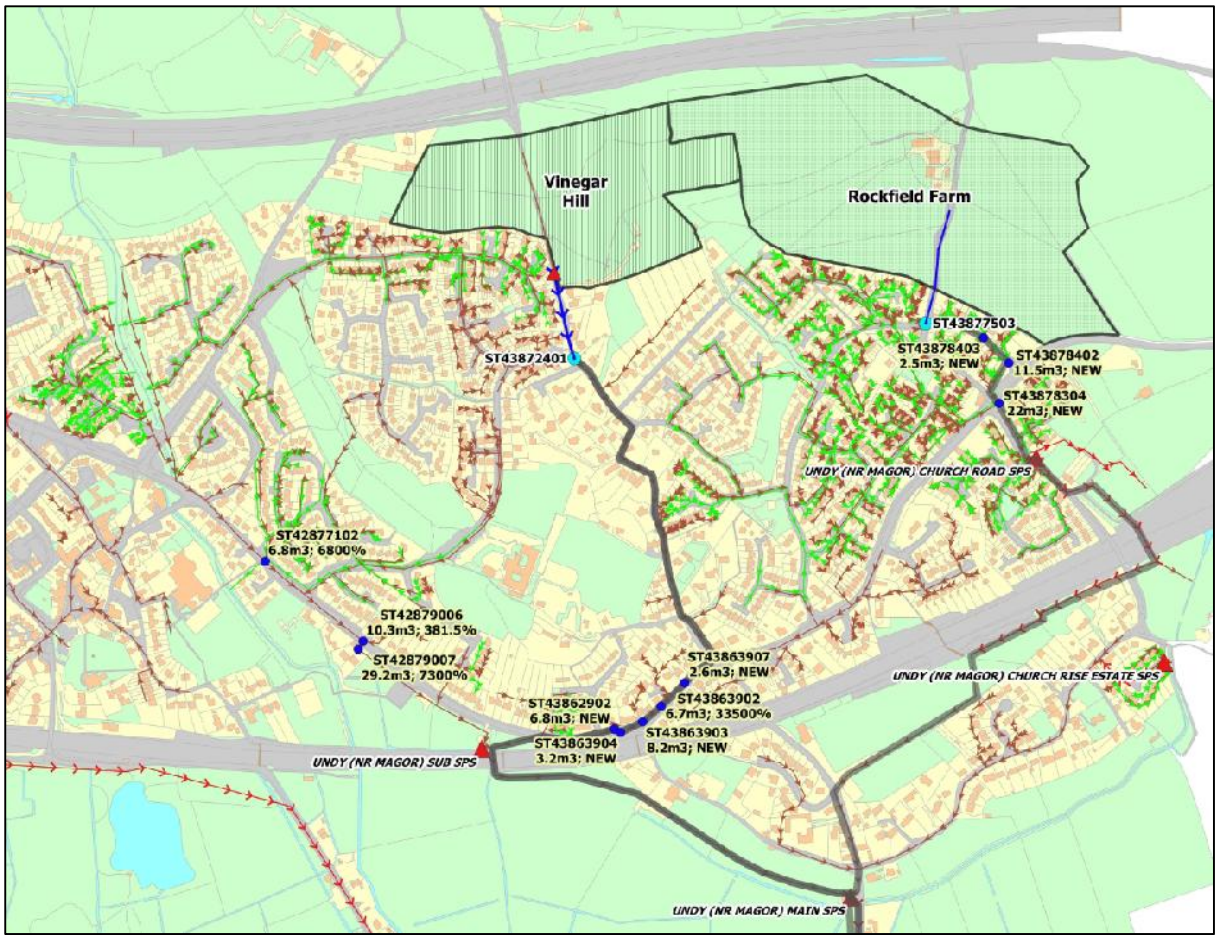


Figure 10 – Model Predicted Flooding Location Plan – Scenario 3

Significant flooding is predicted at the same locations as Scenarios 1and 2. A total flooding detriment of 110m^3 is predicted within the study area.

5.2 CSO Assessment

Spill volume analysis of the overflow was carried out using a rainfall dataset named Magor TSR rainfall. This was sourced from the AMP5 SDP model database for the Magor Catchment.

A summary of the analysis is shown in Table below.

CSO Name	Spill Frequency							
	Existing		Scenario 1, 2 and 3		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 (%)
Church Road EO	0	0	0	0	0	0	0	0

Table 16 – EO/CSO assessment at Church Road PS

The Emergency overflow at the Church Road PS is not predicted to spill for a typical year rainfall. No telemetry spill information is available at this asset.

5.3 PS Assessment

The impact of development flows has also been assessed at Undy Sub PS, Church Road PS and Undy Main PS in relation to operational performance including number of pump starts, pump run-times and pump volumes. The assessment also determines the impact on emergency storage requirements.

The normal requirement for emergency storage is for 2 hours of storage at 3DWF. A review of consent AN00231401, linked to the Church Road PS, states that a minimum of 26.5 hours storage capacity shall be available based on the design DWF. However, the consent does not state the value of design dry weather flow considered.

The current modelled DWF of 2.77 l/s, generates a storage requirement of 264m^3 at Church Road, for the base line scenario. Addition of the Rockfields farm development flows would require approximately 147m^3 of additional storage at the Church Road PS if Natural Resource Wales (NRW) insists on retaining the existing consent.

It is recommended that this is confirmed with NRW prior to selection of any option at this location, as agreement to limit emergency storage to provision of 2 hours of storage at 3DWF would reduce the additional storage requirement to 33m^3.

Storage calculations are presented in Tables 17, 18 and 19.

	Consent Storage time (hrs)	Storage (consent at DWF) m^3
Existing	26.5	264.26
Scenario 2	26.5	412.128
Scenario 3	26.5	412.128

Table 17 – PS Assessment Emergency Storage: Church Road PS

Church Road PS	3DWF	Pump Rate	Storage (2hrs @ 3DWF)	Pump Rate Acceptable	Storage Acceptable	Storage calculated as available in the modelled network
Existing	8.31 l/s	-	60m^3	Yes	No	40.73 m^3
Scenario 1	8.31 l/s	-	60 m^3	Yes	No	40.73 m^3
Scenario 2	12.96 l/s	-	93 m^3	No	No	40.73 m^3
Scenario 3	12.96 l/s	-	93 m^3	No	No	40.73 m^3

Table 18 – PS Assessment Emergency Storage: Church Road PS

Undy Main PS	3DWF	Pump Rate	Storage (2hrs @ 3DWF)	Pump Rate Acceptable	Storage Acceptable	Storage calculated as available in the modelled network
Existing	26.4 l/s	-	190m^3	Yes	No	97.98 m^3
Scenario 1	30.3 l/s	-	218m^3	Yes	No	97.98 m^3
Scenario 2	31.08 l/s	-	224m^3	Yes	No	97.98 m^3
Scenario 3	34.98 ls/	-	251m^3	Yes	No	97.98 m^3

Table 19 – PS Assessment Emergency Storage – Undy Main PS

Table 20 summarises the additional emergency storage requirement at affected assets. Please note that Church Road PS volumes are estimated based on the assumption 2 hours at 3DWF would be sufficient. Should NRW insist on the current discharge conditions remaining these volumes would increase to 147m^3 (Scenario 2) and 147/270m^3 (Scenario 3).

PS Name	Additional Storage Required (m^3)		
	Scenario 1	**Scenario 2**	**Scenario 3**
Undy Sub	No additional Storage required	No additional Storage required	No additional Storage required
Church Road	No additional Storage required	34	34/61
Undy Main	28	34	61

Table 20 – Additional Storage Requirements

Pump performance results are presented in Table 21 to 26.

PS Name	Existing		Developed		Run Time Difference		Run Volume Difference	
	Run Time (minutes)	Run Volume (m^3)	Run Time (minutes)	Run Volume (m^3)	Absolute (minutes)	Percentage (%)	Absolute (m^3)	Percentage (%)
Undy Sub	455	359.32	445	354.48	-10	-2%	-4.84	-1%
Church Road	390	238.56	390	238.36	0	0%	-0.2	0%
Undy Main	340	803.1	375	864.27	35	10%	61.17	8%

Table 21 – PS Assessment – Runtime & Volume – Scenario 1

A reduction in run time and run volume is predicted at the Undy Sub PS for the developed scenario. This is attributed to the high level bypass at the pumping station. A volume of approximately 0.6m^3 backs up and spills into the wet well through this bypass arrangement for the base line scenario design dry day, while approximately 0.4m^3 bypasses the pumps through this arrangement for the development scenario.

PS Name	Existing		Developed		Run Time Difference		Run Volume Difference	
	Run Time (minutes)	Run Volume (m^3)	Run Time (minutes)	Run Volume (m^3)	Absolute (minutes)	Percentage (%)	Absolute (m^3)	Percentage (%)
Undy Sub	455	359.32	440	351.94	-15	-3%	-7.38	-2%
Church Road	390	238.56	555	343.45	165	42%	104.89	44%
Undy Main	340	803.1	415	962.84	75	22%	159.74	20%

Table 22 – PS Assessment – Runtime & Volume – Scenario 2

PS Name	Existing		Developed		Run Time Difference		Run Volume Difference	
	Run Time (minutes)	Run Volume (m^3)	Run Time (minutes)	Run Volume (m^3)	Absolute (minutes)	Percentage (%)	Absolute (m^3)	Percentage (%)
Undy Sub	455	359.32	440	351.94	-15	-3%	-7.38	-2%
Church Road	390	238.56	555	343.45	165	42%	104.89	44%
Undy Main	340	803.1	415	962.84	75	22%	159.74	20%

Table 23 – PS Assessment – Runtime & Volume – Scenario 3

The following assessment compares the predicted number of starts per hour for the existing system with the number for the developed system.

PS Name	Existing Pump Starts (per hour)		Scenario 1 Pump Starts (per hour)	
	Dry Day 1	Dry Day 2	Dry Day 1	Dry Day 2
Undy Sub	8	8	8	8
Church Road	8	7	7	7
Undy Main	6	6	6	7

Table 24 – PS Assessment – Number of Pump Starts – Scenario 1

PS Name	Existing Pump Starts (per hour)		Scenario 2 Pump Starts (per hour)	
	Dry Day 1	Dry Day 2	Dry Day 1	Dry Day 2
Undy Sub	8	8	8	8
Church Road	8	7	8	10
Undy Main	6	6	6	6

Table 25 – PS Assessment – Number of Pump Starts – Scenario 2

PS Name	Existing Pump Starts (per hour)		Scenario 3Pump Starts (per hour)	
	Dry Day 1	Dry Day 2	Dry Day 1	Dry Day 2
Undy Sub	8	8	8	8
Church Road	8	7	9	10
Undy Main	6	6	8	6

Table 26 – PS Assessment – Number of Pump Starts – Scenario 3

Addition of development results in an increase in pump starts for Scenario 2 and Scenario 3 at the Church Road and Undy Main PS. However, this is well with the acceptable limits of 15 starts per hour.

5.4 Flows Arriving at Magor SWK PS WwTW

Using the annual time series 'typical year', it was calculated that 305,030 m^3 of flow arrives at the Magor SWK PS. With the new development at Vinegar Hill, this figure increases to 312,192 m^3. This corresponds to an increase of 7,161m^3 or 2%. With the new development at Rockfields Farm, this figure increases to 314,694 m^3. This corresponds to an increase of 9,664 m^3 or 3%. For Scenario 3 the flows arriving at the Magor SWK PS increases to 322,196 m^3. This corresponds to an increase of 17,166 m^3 or 5.6 %.

5.5 Network Performance Assessment Summary

Scenario 1: Vinegar Hill

Flooding Summary: The addition of development flows results in significant flooding detriment and would require solutions to alleviate flooding.

PS Summary: The development at Vinegar Hill would increase flows to the Undy Sub PS and Undy Main PS. Additional storage would be required to provide a theoretical 2 hours emergency storage.

Scenario 2: Rockfields Farm

Flooding Summary: The addition of development flows results in significant flooding detriment and would require solutions to alleviate flooding.

PS Summary: The development at Rockfields Farm would increase flows to the Church Road PS and Undy Main PS. Additional storage would be required to provide a theoretical 2 hours emergency storage.

The Church Road consent AN00231401 states that a minimum of 26.5 hours storage capacity shall be available based on the design dry weather flow. If the NRW maintain the consent restrictions at Church Road PS, an additional 147m^3 of storage would be required if the Rockfields Farm development is to be connected.

Scenario 3: Vinegar Hill and Rockfields Farm

Flooding Summary: The addition of development flows results in significant flooding detriment and would require solutions to alleviate flooding.

PS Summary: The developments at Vinegar Hill and Rockfields Farm would increase flow to the Church Road PS and Undy Main PS. Additional storage would be required to provide a theoretical 2 hours emergency storage.

As with Scenario 2, the discharge consent at Church Road would impact on the storage required at this asset. There are also significant increases in run time and volume of Church Road PS (42%, 44%) and Undy Main (22% and 20%).

6 Solution Development

The hydraulic assessment has indicated that the addition of 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 been developed for the scenarios with the developments discharging individually to their respective connection points as well as for the combined scenario.

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. It should be noted that land to the south of the railway line is designated SSSI and as such any work undertaken in this location would require a consent application through NRW.

Scenario	Solution	Development	Drainage System	Connection Points	Solution at Network Location				
					Network (Main Road)	Undy Main PS	Undy Sub PS	Church Road PS	Development Sites
1	1a	Vinegar Hill	Gravity	ST43872401	Offline Storage	Sewer Upsize and Additional Emergency Storage	-	-	-
	1b	Vinegar Hill	Gravity	ST43872402	Sewer Upsize	Online Storage	-	-	-
	2	Vinegar Hill	Gravity	ST43872403	Offline Storage	Additional Emergency Storage	Online Storage	-	-
	3	Vinegar Hill	Gravity	ST43872404	Sewer Upsize	Online Storage	-	-	-
	3a	Vinegar Hill	Gravity	ST43872405	Sewer Upsize	Online Storage	-	-	-
2	1	Rockfields Farm	Pumped	ST43877503	-	Additional Emergency Storage	-	Online Storage and Additional Emergency Storage	-
	2	Rockfields Farm	Gravity	ST43877504	-	Additional Emergency Storage	-	Sewer Upsize and Online Storage	-
3	1	Both	Pumped (Single Station at 2DWF)	ST43872401	Offline Storage	Additional Emergency Storage	Online Storage	-	Additional Storage
	2	Both	Pumped and Pumped/Gravity	ST43872401 and ST43877504	Sewer Upsize	Online Storage and Additional Emergency Storage	-	Sewer Upsize and Online Storage	-
	3	Both	Pumped (Single Station at 2DWF)	ST43877504	-	Additional Emergency Storage	-	Increase Pump Rate, Downstream Network Reinforcement and Additional Emergency Storage	Additional Storage

Table 27 – Solution Matrix

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. These were:

1. Surface Water Removal: The system is predominantly separate. Limited storm response was evident during flow survey but these are most likely to be individual properties which would significantly increase costs and uncertainties of any solution presented.
2. Online storage only upstream of Undy Main: Discounted due to detriment remaining at manholes East of the Undy Sub PS
3. Pumping the flow to a new connection point at ST43871401: The model still predicts flooding and requires 167m of 750mm sewer online storage (approximately 74 m^3 storage) upstream of Undy Sub PS. Even with this storage, there is still detriment at ST42877201 (16.2 m^3) and ST42876440 (8 m^3).
4. Reducing the pump rate for Scenario 1 to 2DWF was considered, and ruled out as this falls below a minimum practical pump rate of 5 l/s.

6.2 Scenario 1

6.2.1 Solution 1a; Offline storage and sewer upsize

6.2.1.1 Description

This solution addresses Scenario 1 development flows utilising Connection Point 1 (ST43872401). It requires provision of offline storage of 20m^3 in the vicinity of ST43863907 (Main Road) to remove flooding detriment, and upsize of approximately 260m of 225mm sewer to 300mm along the greenfield area, parallel to West End Road.

The solution elements are as follows:

- Construction of 20m^3 of offline storage;
- Reconstruct manhole ST43863907 to accommodate overflow arrangement to offline storage;
- Associated PS to return flows to the system;
- Upsize 260m of 225mm sewers between manholes ST43863800 and ST43865600 to 300mm;
- Reconstruct 3 no. 1200mm manholes to accommodate new 300mm sewers;
- Construct 20m^3 emergency storage at Undy Main PS.

6.2.1.2 Notional Design Solution

The solution seeks to reduce surcharge in sewers in the vicinity of Undy Sub PS by removing hydraulic restrictions in the network immediately upstream of Undy Main PS. An additional 20m^3 offline storage is also required at manhole ST43863907 to reduce localised incapacity/flooding.

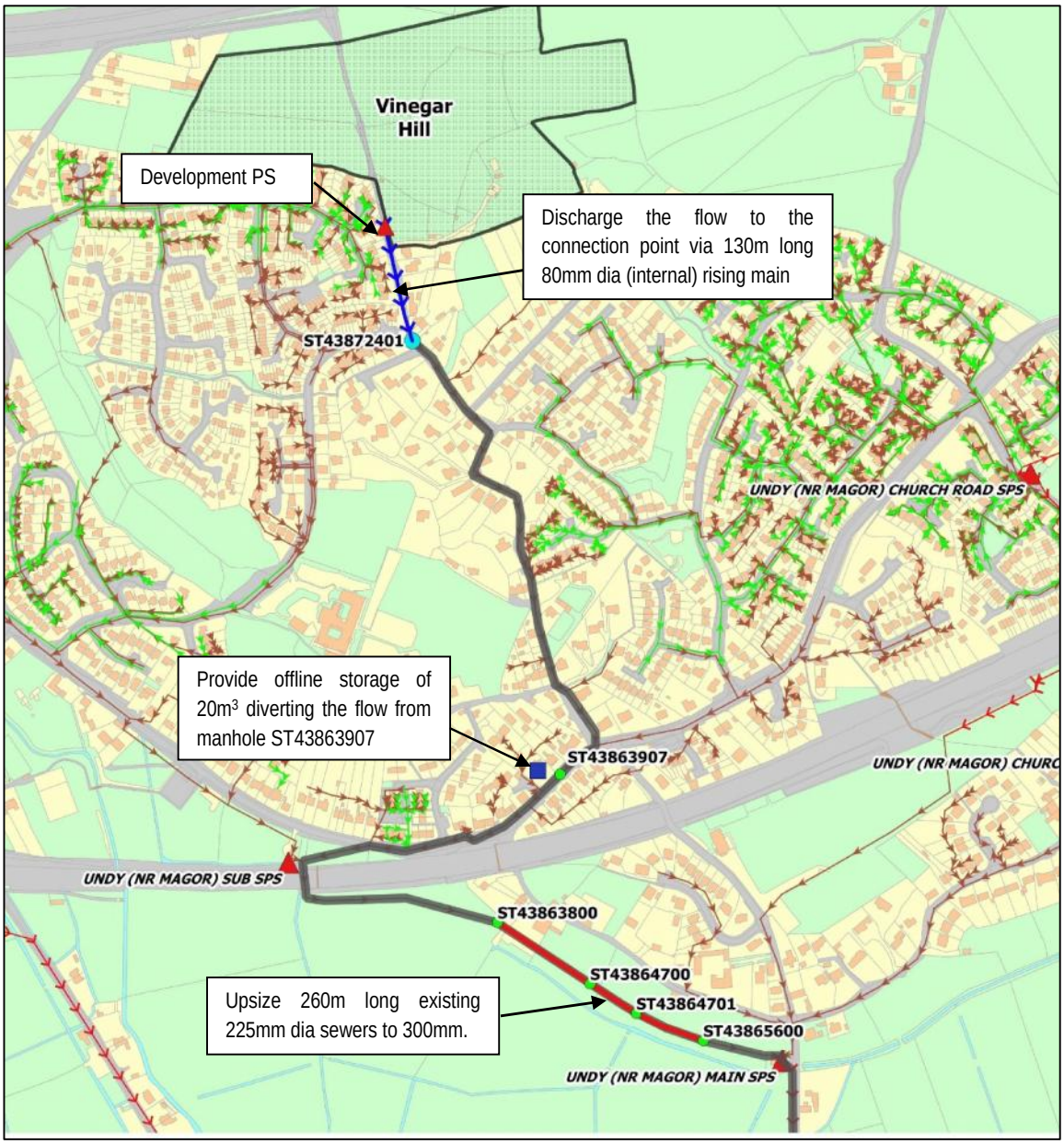


Figure 11 – Scenario 1: Solution 1a

6.2.1.3 Solution Assessment

The solution addresses flood detriment in the vicinity of the existing DFL properties upstream of Undy Sub PS and in the vicinity of Main Road.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 1a Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
742896	ST42877201	15	2.2	2.3	0.1	4.54
742921	ST42877102	15	7.7	7.8	0.1	1.3
742967	ST42876440	15	2.9	3.1	0.2	6.9

Table 28 – Scenario 1: Solution 1a Flooding Detriment Analysis

Table 27 shows that there is some residual detriment within the network, however this is relatively minor (<1m^3), and is considered acceptable.

6.2.1.4 Solution Considerations

The offline storage is proposed to alleviate the flooding detriment in the vicinity of Main Road. The precise location of storage would be dependent on detailed surveys of the sewer levels in this location.

It has been noted that this is the main road through Magor, and as such significant disruption may occur.

Alternative storage locations were investigated. However, there are constraints as a result of topography and the railway line located immediately to the south of the proposed storage location.

No detailed assessments of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended these are investigated further at the design stage.

The solution would increase DCWW Operational expenditure (maintaining return pumps/cleaning storage).

6.2.2 Solution 1b: Online storage and sewer upsize

6.2.2.1 Description

This solution addresses Scenario 1 development flows utilising Connection Point 1 (ST43872401).

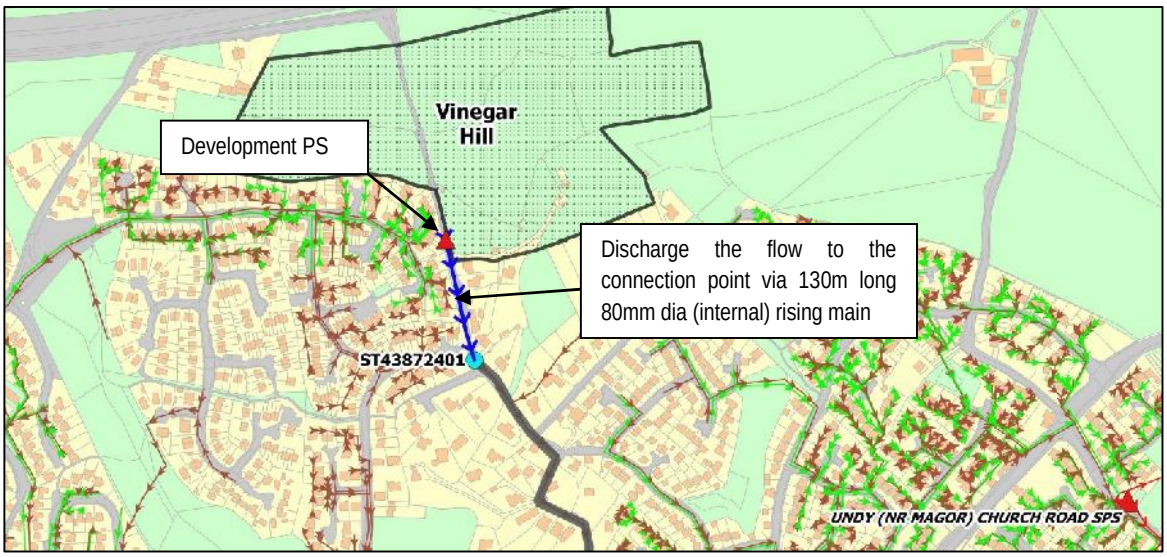
It requires upsize of 180m of 150mm diameter sewer to 300mm along Main Road and the addition of online storage through the upsize of 120m of 225mm diameter sewer to 750mm upstream of Undy Main PS.

The solution elements are as follows:

- Upsize and regrade 180m of existing 150mm diameter sewers to 300mm between manholes ST43862902 and ST43861801;
- Provide online storage through upsize of 120m of existing 150mm diameter sewers to 750mm between manholes ST43863800 and ST43864700;
- Reconstruct/re-bench 6 no. 1200mm diameter manholes to accommodate the new 300mm sewers;
- Reconstruct 2 no. 1800mm diameter manholes to accommodate the new 750mm sewer.

6.2.2.2 Notional Design Solution

The solution seeks to reduce flood detriment by increasing pass forward flow along Main Road. This initially caused downstream flood detriment. However, increased online storage in the network upstream of Undy Main PS – also required to address flooding in the vicinity of Undy Sub PS- addresses this.



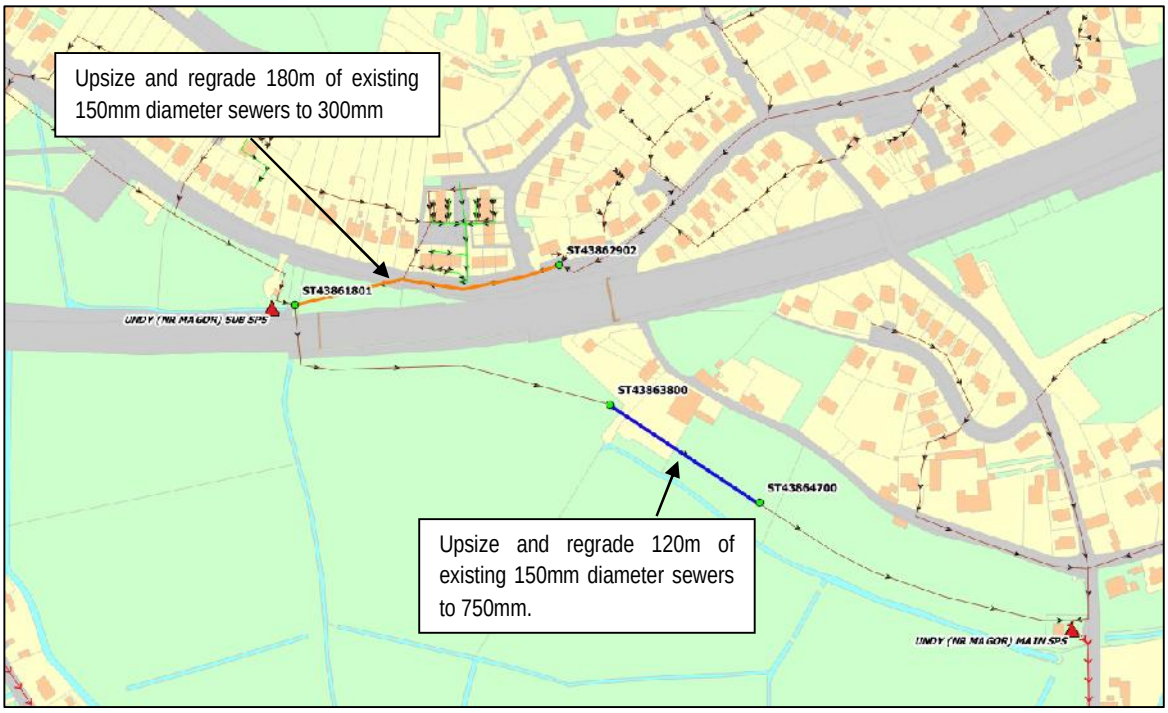


Figure 12 – Scenario 1: Solution 1b

6.2.2.3 Solution Assessment

This solution proposes to resolve detriment by providing a combination of online storage and sewer upsize along Main Road. A minor residual detriment (<1m^3) is observed in manholes on Elms Hill/Main Rd.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 1b Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545892	ST43863907	60	0	0.5	0.5	New
742896	ST42877201	15	2.2	2.3	0.1	4.5
742921	ST42877102	60	22.9	23.7	0.8	3.5
742926	ST42879007	960	0.4	1.8	1.4	350.0
742967	ST42876440	15	2.8	3	0.2	7.1
748445	ST42878103	15	2.4	2.6	0.2	8.3
748566	ST43874055	30	0	0.4	0.4	New
748567	ST43874002	30	0	0.1	0.1	New

Table 29 – Scenario 1: Solution 1b Flooding Detriment Analysis

6.2.2.4 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

Additional site investigation would be required to assess the feasibility of upsizing the existing 150mm diameter sewer to 300mm along Main Road.

Online storage is proposed in green field land to the south of the main rail line, upstream of Undy Main PS. Construction here should be feasible.

Sewer levels at this point have been regraded to maintain suitable cover. Detailed investigation of ground condition would be required to ensure suitability.

A flow control on the downstream end of the storage may be required. However, at present the modelled reduction in diameter from 750mm to 225mm limits flow sufficiently.

6.2.3 Solution 2 – Offline Storage and online storage

6.2.3.1 Description

This solution addresses Scenario 1 development flows utilising Connection Point 1 (ST43872401).

It comprises provision of offline storage of 20m^3 in the vicinity of ST43863907 (Main Road) and online storage upstream of Undy Sub PS.

This solution elements are as follows:

- Construction of 20m^3 of offline storage at ST43863907;
- Reconstruct manhole to accommodate high level overflow to the offline storage;
- Associated pumping station to return flows to the system;
- Online storage of approximately 61m^3 by providing 138m of 750mm tank sewer between manhole reference ST42869901 and a new connection to Undy Sub PS;
- Construct 2 no. 1800mm diameter manholes as part of the tank storage;
- Construct 28m^3 emergency storage at Undy Main PS.

6.2.3.2 Notional Design Solution

There is reported and model predicted flooding downstream of the connection point. The solution proposes to provide offline storage to remove predicted flood detriment in the vicinity of Main Road and online storage upstream of Undy Sub PS, to address reported and model predicted flooding.

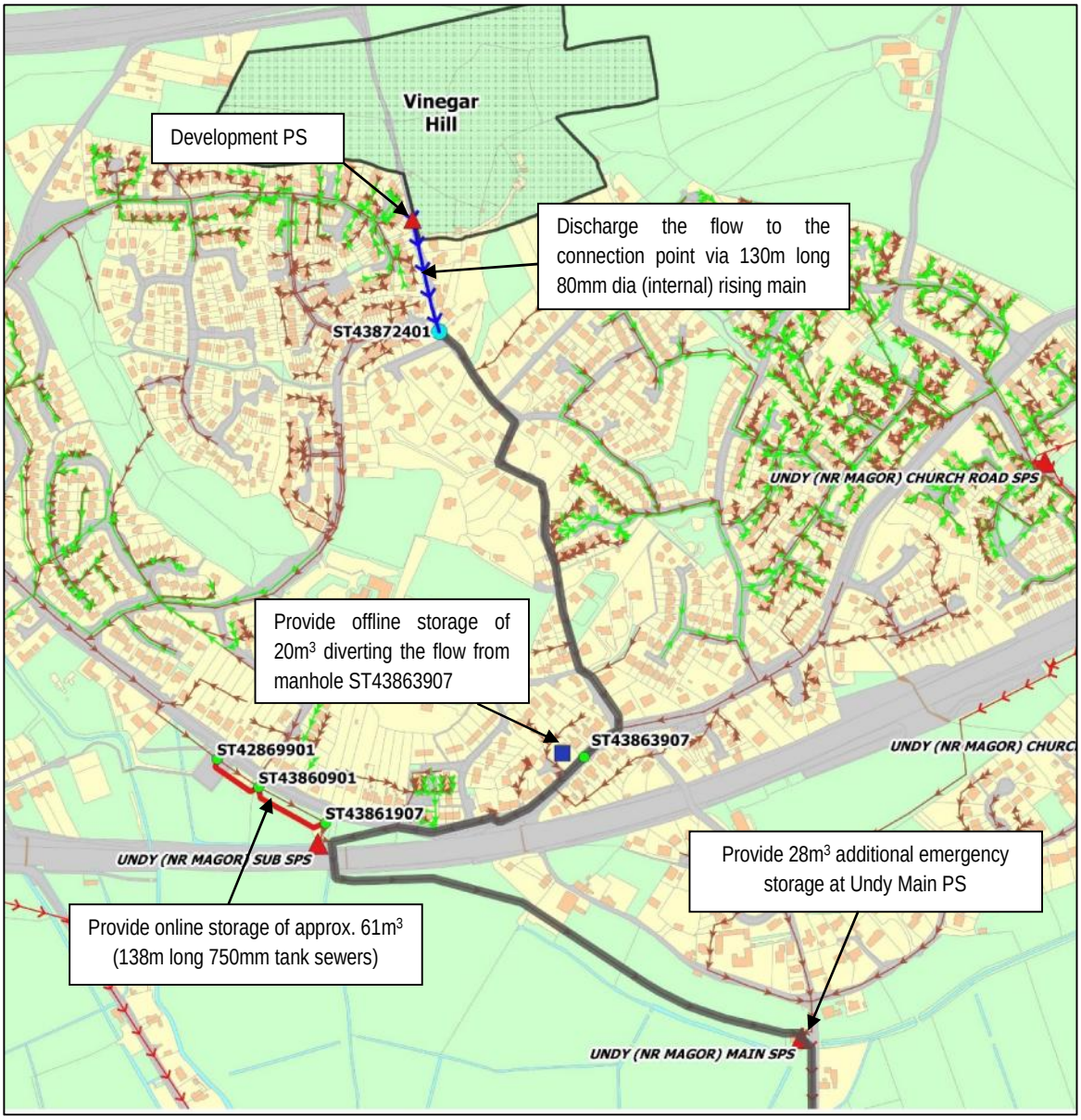


Figure 13 – Scenario 1: Solution 2

6.2.3.3 Solution Assessment

This solution proposes to resolve detriment by providing offline storage on Main Road and online storage in the vicinity of Undy Sub PS.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 2 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545881	ST43862902	480	0	0.2	0.2	New
545924	ST43861803	480	0	0.1	0.1	New
742967	ST42876440	15	2.8	3.1	0.3	10.7
748445	748445	15	2.4	2.7	0.3	12.5

Table 30 – Scenario 1: Solution 2 Flooding Detriment Analysis

Table 29 shows that the solution provides no significant flooding detriment (>1m^3) when compared to the existing baseline network.

6.2.3.4 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

Online storage is proposed in open land adjacent to Main Road, and it is assumed that land can be purchased at this location. It has been noted that this is the main road through Magor, and as such significant disruption may occur. Alternative storage locations were investigated. However, there are constraints as a result of topography and the railway line located immediately to the south of the proposed storage location.

The proposed storage upstream of Undy Main PS falls within green space, and as such is considered to have limited buildability issues.

The solution relies on the existence of the high level bifurcation at Undy Sub PS linking the two networks and the downstream arrangement of this should be confirmed prior to any detailed design being undertaken.

6.2.4 Solution 3; Sewer upsize

6.2.4.1 Description

This solution addresses Scenario 1 development flows utilising Connection Point 1 (ST43872401). It requires upsize of approximately 730m of 225mm sewer to 300mm along the Main Road and downstream to Undy Main PS. The solution also includes provision of a 300mm dualled crossing under the railway line and 20m of 1050mm tank sewer providing emergency storage for Undy Main PS.

The solution elements are as follows:

- Upsize 730m of 225mm sewers to 300mm between manholes ST43863904 and ST43866601 to 300mm;
- Upsize 20m of 225mm sewers to 1050mm between manholes ST43866601 and Undy Main PS and construct 2 no. 1800mm diameter manholes;
- Rebench 16 no. 1200mm manholes to accommodate new 300mm sewers;
- Constructed 40m of 300mm sewer (directional drill) crossing under the railway line, including construction of 2 No 1200mm diameter manholes.

6.2.4.2 Notional Design Solution

The solution seeks to reduce surcharge in sewers in the vicinity of Undy Sub PS by conveying additional flow to Undy Main PS.

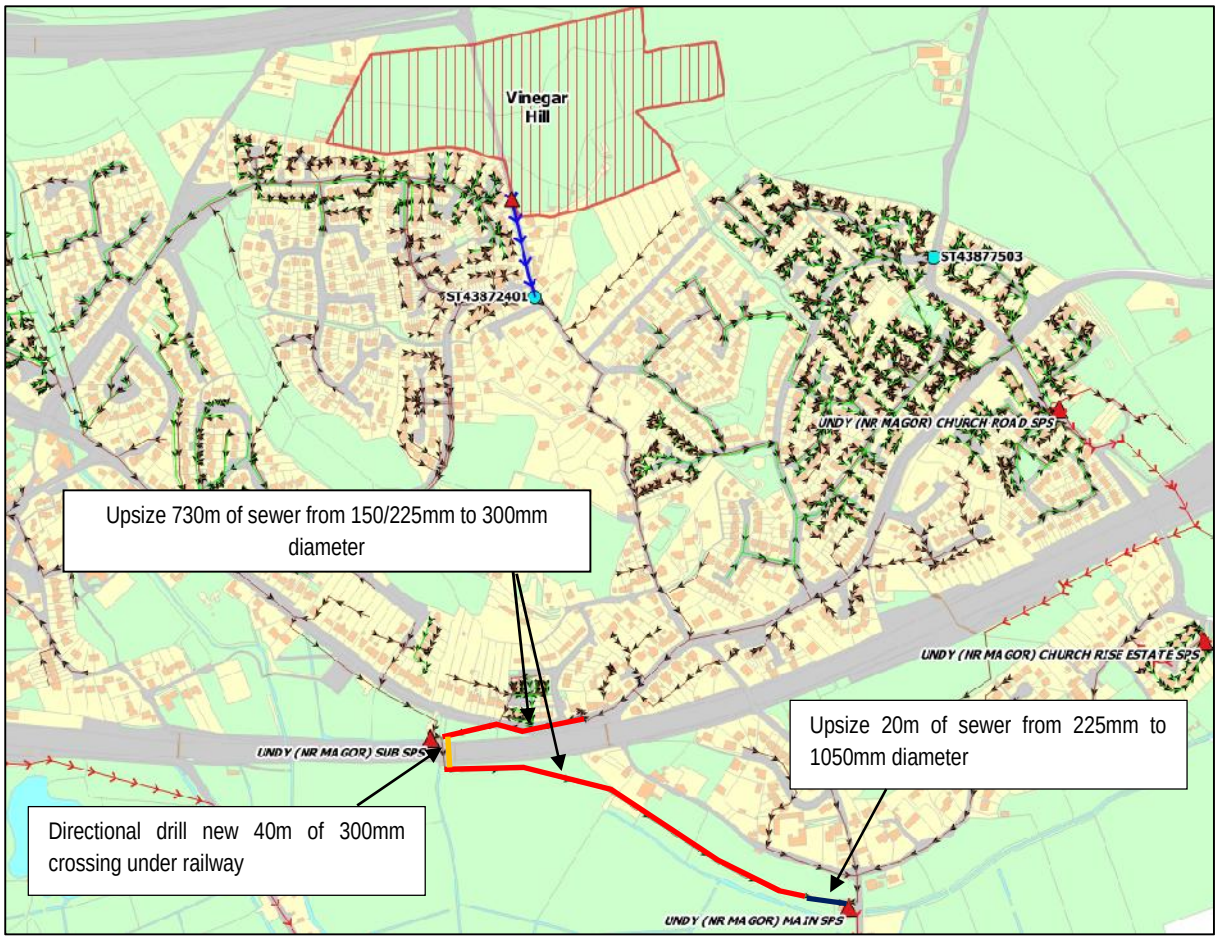


Figure 14 – Scenario 1: Solution 3

A further sub solution (3a), crossing the railway line 130m to the east was also considered, see Figure 15 for details. This provides a potential saving of £198k on the cost of Solution 3. There are potential issues regarding the feasibility of crossing the rail line at this easterly location, given the position on Main Road and the anticipated size of drill pit that would be required.

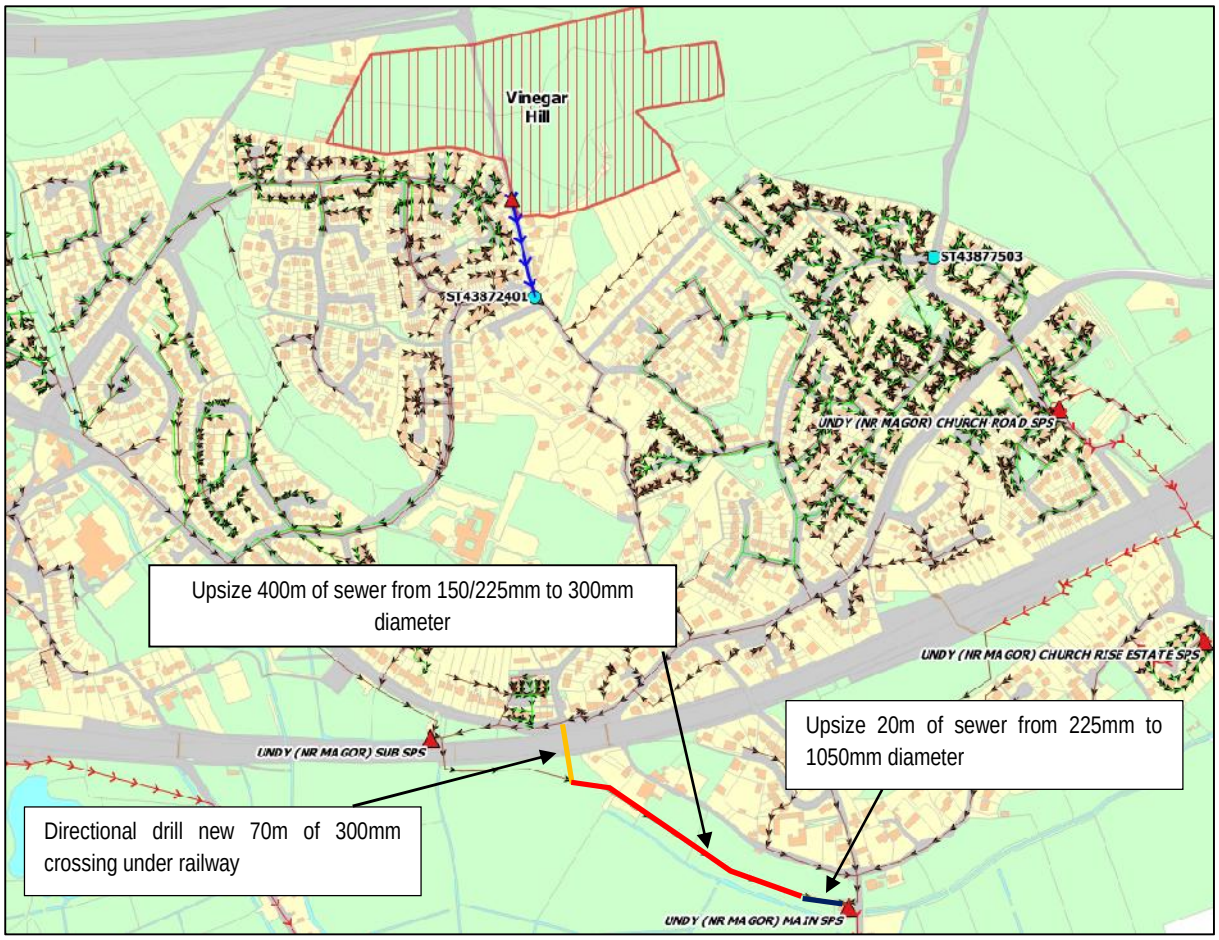


Figure 15 – Scenario 1: Solution 3

6.2.4.1 Solution Assessment

The solution addresses flood detriment in the vicinity of the existing DFL properties upstream of Undy Sub PS and in the vicinity of Main Road.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 3 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545892	ST43863907	60	0	0.2	0.2	New
742896	ST42877201	15	2.2	2.3	0.1	4.5
742921	ST42877102	60	22.9	23.5	0.6	2.6
742967	ST42876440	15	2.8	3	0.2	7.1
748445	ST42878103	15	2.4	2.6	0.2	8.3
748566	ST43874055	30	0	0.4	0.4	New
748567	ST43874002	30	0	0.1	0.1	New
545892	ST43863907	60	0	0.2	0.2	New

Table 31 – Scenario 1: Solution 3 Flooding Detriment Analysis

Table 30 shows that there is some residual detriment within the network, however this is relatively minor (<1m^3) and is considered to be acceptable.

6.2.4.2 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

It has been noted that this is the main road through Magor, and as such significant disruption may occur.

Dualling the crossing under the railway line provides improved network resilience but would require significant liaison with Network Rail.

The space required to directional drill the crossing for Solution 3A may be difficult to achieve without road closure, which would cause significant disruption.

Solution 3a has significant buildability issues and as such may not be feasible to construct.

Additional emergency storage at Undy Main PS has been included within the solution (provided by increased network storage) and no additional storage is required beyond this.

6.3 Scenario 2

6.3.1 Solution 1; Pumped flows from Rockfields Farm and online storage

6.3.1.1 Description

This solution addresses Scenario 2 development flows utilising Connection Point 2 (ST43877503).

The solution proposes to limit peak flows from the development by storing at site and pumping flow to the foul network upstream of Church Road PS at a maximum rate of 5 l/s (>3 DWF as this is the minimum recommended pump rate). There is minor flooding detriment noted due to the pumped connection. A maximum spill detriment of approximately 17m^3 from the EO is noted for the 30year design event. This can be offset by providing additional storage immediately upstream of the PS.

- Construct a PS within the Rockfields Farm development site with a maximum discharge capacity of 5 l/s;
- Construct approximately 60m of 80mm diameter rising main to discharge to connection point ST43877503;
- Provide a 15 m length of 1200mm diameter storage at the Church Road PS (approx.17 m^3);
- Construct 34m^3 emergency storage at Undy Main PS and 16m^3 at Church Road PS.

6.3.1.2 Notional Design Solution

There is model predicted and reported flooding downstream of the connection point.

The solution proposes to limit discharge from the development via a pumped connection, which addresses the flood detriment. The predicted EO spill is addressed through provision of additional storage at Church Road PS.

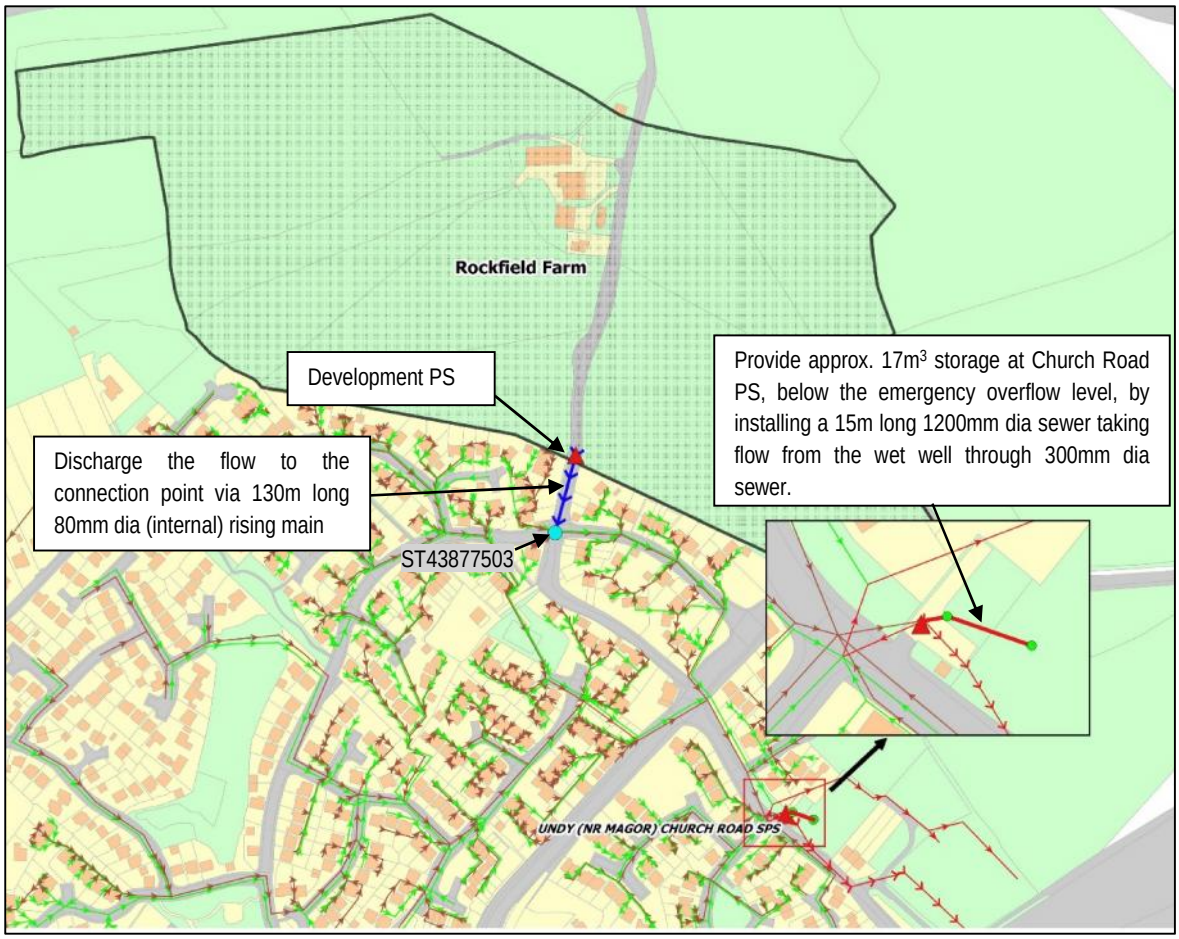


Figure 16 – Scenario 2: Solution 1

6.3.1.3 Solution Assessment

The solution proposes to resolve detriment by restricting peak flows from the Rockfields Farm development by providing a pumped connection operating at a maximum discharge rate of 5 l/s. Additional storage is required to offset the detriment of this on the Church Road EO.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 1 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545881	ST43862902	120	1.1	1.2	0.1	9.09
742921	ST42877102	240	34.8	35.2	0.4	1.15
742925	ST42879006	240	5.9	6.8	0.9	15.25
742926	ST42879007	240	26.2	27.9	1.7	6.49
742967	ST42876440	60	6.2	6.3	0.1	1.61
748445	ST42878103	30	4	4.2	0.2	5.00

Table 32 – Scenario 2: Solution 1 Flooding Detriment Analysis

6.3.1.4 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

An online storage has been proposed to offset the spill detriment predicted for 30 year design period event.

Provision of the PS at the development site would be an additional cost to the developer. However, to consider the worst case scenario to DCWW, this has been costed as part of the solution.

The current volume of additional storage available in the wet well could not be confirmed. It has been assumed that the current discharge consent for the EO could be challenged and thus the additional storage proposed would be sufficient to offset storm discharge and impacts on emergency storage.

6.3.2 Solution 2; Upsize and online storage gravity connection

6.3.2.1 Description

This solution addresses Scenario 2 development flows utilising Connection Point 2 (ST43877503).

It consists of upsize of the 150mm receiving sewer to 225mm to pass forward additional flow to the Church Road PS. This results in a maximum spill detriment of approximately 50 m^3 for a 30 year design storm, so additional online storage is also required.

- Upsize 71 m of 150mm sewer between manholes ST43878402 and ST43878304 to 225mm and regrade sewer;
- Reconstruct three manhole chambers to receive the 225mm new sewers;
- Provide approximately 48m^3 of storage by providing 89 m length of 825mm diameter online storage;
- Reconstruct 3 no. 1800mm manholes to accommodate connection in new storage pipes;
- Construct 34m^3 emergency storage at Undy Main PS.

6.3.2.2 Notional Design Solution

There is reported and model predicted flooding downstream of the connection point.

The solution proposes to upsize the 150mm diameter sewer downstream of the connection point to remove local hydraulic incapacity, and provide online storage to address detriment on EO spills caused by the upsize.

There is a minor increase in predicted flooding in the vicinity of Undy Sub PS, which is not addressed by this solution.

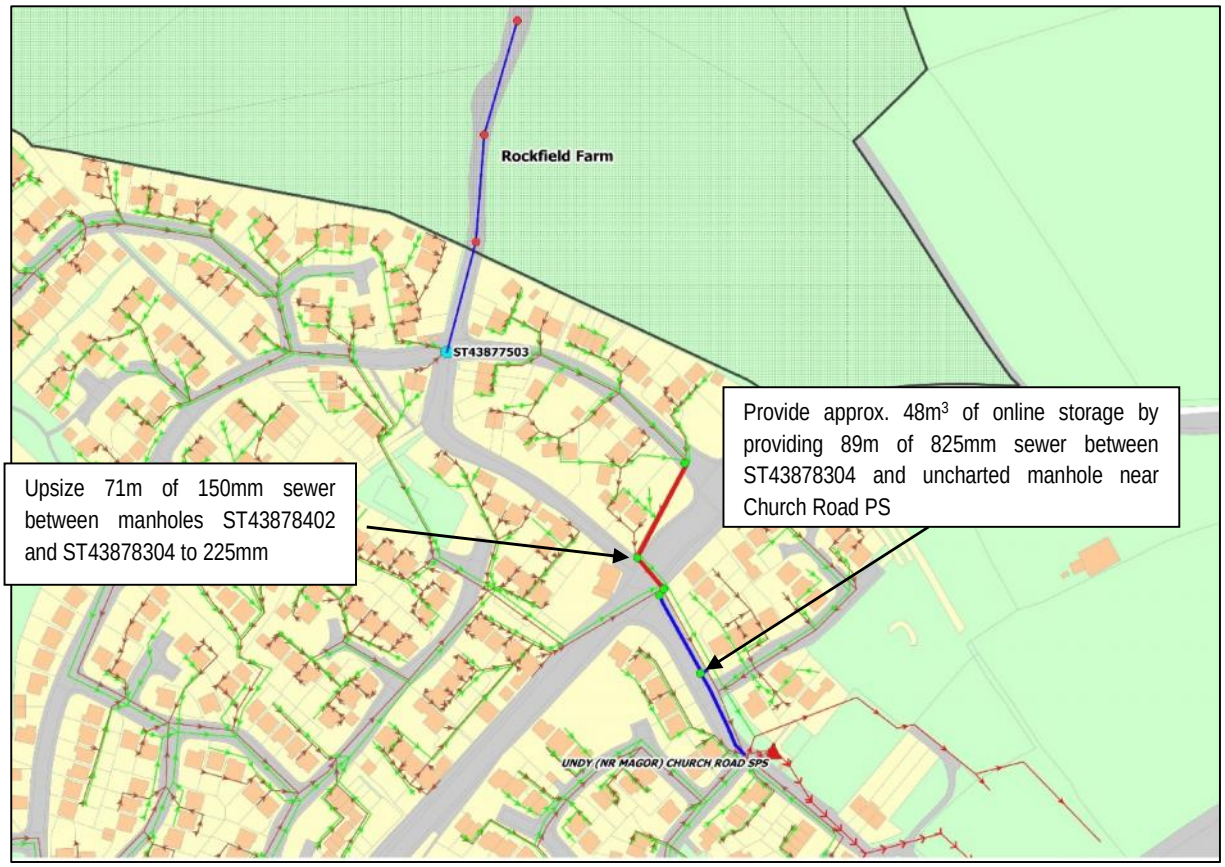


Figure 17 – Scenario 2: Solution 2

6.3.2.3 Solution Assessment

This solution proposes to resolve detriment by upsizing sewers upstream of Church Road PS and providing online storage at Church Road PS.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 2 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545881	ST43862902	120	1.1	1.2	0.1	9.09
742896	ST42877201	15	2.2	2.3	0.1	4.55
742921	ST42877102	240	34.8	35.2	0.4	1.15
742925	ST42879006	240	5.9	6.8	0.9	15.25
742926	ST42879007	240	26.2	27.9	1.7	6.49
742967	ST42876440	60	6.2	6.3	0.1	1.61
748445	ST42878103	30	4	4.2	0.2	5.00

Table 33 – Scenario 2: Solution 2 Flooding Detriment Analysis

6.3.2.4 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

The construction location is a quiet residential area and there would be a significant impact on residents. The sewer layout indicated that construction may be required through a private residential garden and agreement from the landowner would be required.

The storage tanks are proposed to be constructed within the road. However, there is a reasonable amount of space in the verge and some optimisation on the storage layout would be possible.

Some residual detriment is still predicted upstream of Undy Sub PS, due to the increase in Top Water Level (TWL) at Undy Main. This is linked to the increase in pumped flow arriving from Church Road PS. This has not been deemed significant, and could be managed by optimisation of the pumps at Church Road PS, through a minor reduction in pump rate.

6.4 Scenario 3

6.4.1 Solution 1; Combine flows from both development sites and pump forward to connection point ST43872401

6.4.1.1 Description

This solution addresses Scenario 3 development flows utilising Connection Point 1 (ST43872401).

It combines flows from both developments sites at the Vinegar Hill pumping station and restricts pass forward flows to 2DWF. A similar set of solutions to Scenario 1 can then be considered to address detriment from both sites.

The solution elements are as follows:

- Construct 200m^3 storage at the Vinegar Hill PS to store flows from both sites with 2DWF pass forward;
- Construct 20m^3 offline storage at manhole ST43863907;
- Reconstruct manhole ST43863907 to accommodate high level overflow to the offline storage;
- Online storage of approximately 61m^3 through provision of a 750mm tank sewer between manhole ST42869901 and ST43861907;
- Construct 61m^3 emergency storage at Undy Main PS.

In addition to the above, there will be a requirement to pass flows from the Rockfields Farm site to the Vinegar Hill site. We assume that this would require:

- Construction of a PS at a suitable location within the Rockfields farm development site, with a maximum discharge capacity of 5 l/s, to pump the flow from Rockfields Farm development to Vinegar Hill.
- Construction of approximately 590m (assumed) of 80mm diameter rising main to discharge to the Vinegar Hill PS.

6.4.1.2 Notional Design Solution

There is reported and model predicted flooding downstream of the connection point.

Minimum pump / pass forward flows from Scenario 1 and Scenario 2 are both 5 l/s, which is based on minimum feasible pump sizes. 2DWF for each of these sites falls significantly below this rate, so combining the two sites into one connection point leads to a minimal increase in pump rate – an increase of 1 l/s to 6 l/s. The solutions proposed during scenario 1, require minor increases to deal with this additional flow as the majority of the additional storage is provided on the development site.

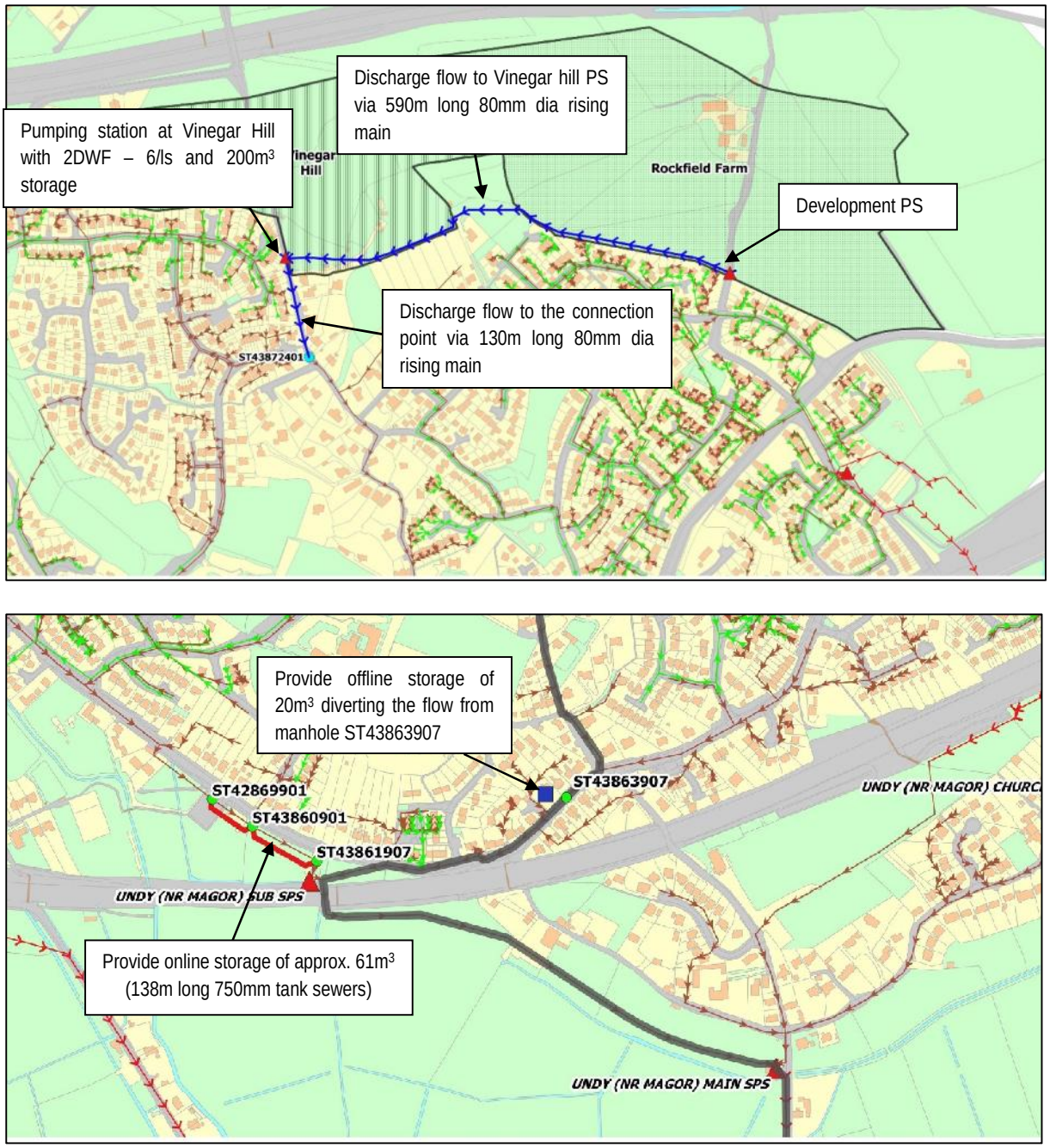


Figure 18 – Scenario 3: Solution 1

6.4.1.3 Solution Assessment

This solution proposes to resolve detriment by providing offline storage on Main Road and online storage in the vicinity of Undy Sub PS.

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 1 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545881	ST43862902	480	0	0.7	0.7	New
545924	ST43861803	480	0	0.2	0.2	New
742967	ST42876440	15	2.8	2.9	0.1	3.6
748445	748445	15	2.4	2.6	0.2	8.3

Table 34 – Scenario 3 Solution 1 Flooding Detriment Analysis

6.4.1.4 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

An online storage has been proposed to offset the spill detriment predicted for 30 year design period event.

The solution is reliant on both developers agreeing to the proposed connection point, and there would be significant legal requirements in order to satisfy the planning process. This is a major risk to both developments, but particularly to Rockfields Farm.

Further consideration would need to be given to the potential to optimise the drainage from both sites to provide an efficient solution. An assessment of the LiDAR data indicates that it may be possible to gravitate to a central PS.

6.4.2 Solution 2; Combination of Scenario 1 and Scenario 2: Offline and Online Storage + Sewer Upsize

6.4.2.1 Description

This solution addresses Scenario 3 development flows utilising Connection Point 1 and Connection Point 2.

It comprises a combination of Solution 1b from Scenario 1 and Solution 2 from Scenario 2.

The solution elements are as follows:

- Upsize and regrade 180m of existing 150mm diameter sewer to 300mm diameter between manholes ST43862902 and ST43861801;
- Provide online storage through upsize of 120m of existing 150mm diameter sewers to 750mm between manholes ST43863800 and ST43864700;
- Reconstruct/re-bench 6 no. 1200mm diameter manholes to accommodate new 300mm sewers;
- Reconstruct 2 no. 1800mm diameter manholes to accommodate new 750mm sewer;
- Upsize 71 m of 150mm sewer between manholes ST43878402 and ST43878304 to 225mm and regrade sewer;
- Reconstruct three manhole chambers to receive the 225mm new sewers;
- Provide approximately 48m^3 of storage by providing 89 m length of 825mm diameter online storage;
- Reconstruct 3 no. 1800mm manholes to accommodate the connection of the new storage pipes.

6.4.2.2 Notional Design Solution

The solution proposes to address detriment through a combination of solutions identified for alleviating detriment as part of the Scenario 1 (Solution 1b) and Scenario 2 (Solution 2) assessment. For further details refer to Sections 6.2.3.2 and 6.3.2.2.

6.4.2.3 Solution Assessment

This solution proposes to resolve detriment by providing offline storage on Main Road and online storage (120m of 750mm sewer) in the vicinity of Undy Main PS (Scenario 1) combined with upsize and online storage in the vicinity of Church Road PS (Scenario 2).

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 2 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
545881	ST43862902	480	0	0.4	0.4	New
545924	ST43861803	480	0	0.5	0.5	New

Table 35 – Scenario 3: Solution 2 Flooding Detriment Analysis

6.4.2.4 Solution Considerations

Assessment has shown that the increase in flow upstream of Church Road PS has a limited impact on the downstream network. As such, there is limited scope/justification for developing combined solutions as part of Scenario 3, unless an alternative/combined discharge point is considered.

The benefit of combining Scenario 1 Solution 1b and Scenario 2 Solution 2, is that the additional emergency storage required at Undy Main PS is achieved through the storage provision in Solution 1b, optimising overall storage requirements.

See solution consideration under Scenario 1 and 2 for further details.

6.4.3 Solution 3; Combine flows from both development sites and pump forward to connection point ST43877503

This solution addresses Scenario 3 development flows utilising Connection Point 2 (ST43877503).

It combines flows from both developments sites at the Rockfields Farm pumping station and restricts pass forward flows to 2DWF.

The solution elements are as follows:

- Construct 200m^3 storage at the Vinegar Hill PS to store flows from both sites with 2DWF pass forward;
- Increase Church Road PS pump capacity from 10l/s to 12l/s and construct 61m^3 of additional emergency storage (270m^3 if the existing consent requirement is retained);
- Upsize 225m of 150mm diameter sewer to 300mm between ST43868901 (rising main discharge point) and ST43866801;
- Online storage of approximately 61m^3 through provision of a 900mm tank sewer between manhole ST4286380 and ST43864700.

In addition to the above, there will be a requirement to pass flows from the Vinegar Hill site to the Rockfields Farm site. We assume that this would require:

- Construction of a PS at a suitable location within the Vinegar Hill development site, with a maximum discharge capacity of 5 l/s, to pump the flow from Vinegar Hill to Rockfields Farm;
- Construction of approximately 590m (assumed) of 80mm diameter rising main to discharge to the Vinegar Hill PS.

6.4.3.1 Notional Design Solution

There is reported and model predicted flooding downstream of the connection point.

Minimum pump / pass forward flows from Scenario 1 and Scenario 2 are both 5 l/s, which is based on minimum feasible pump sizes. 2DWF for each of these sites falls significantly below this rate, so combining the two sites into one connection point leads to a minimal increase in pump rate – an increase of 1 l/s to 6 l/s. This solution provides the majority of the storage required to offset detriment on the development site. However, additional upsizing is also required on the network downstream of the Church Road rising main discharge point.

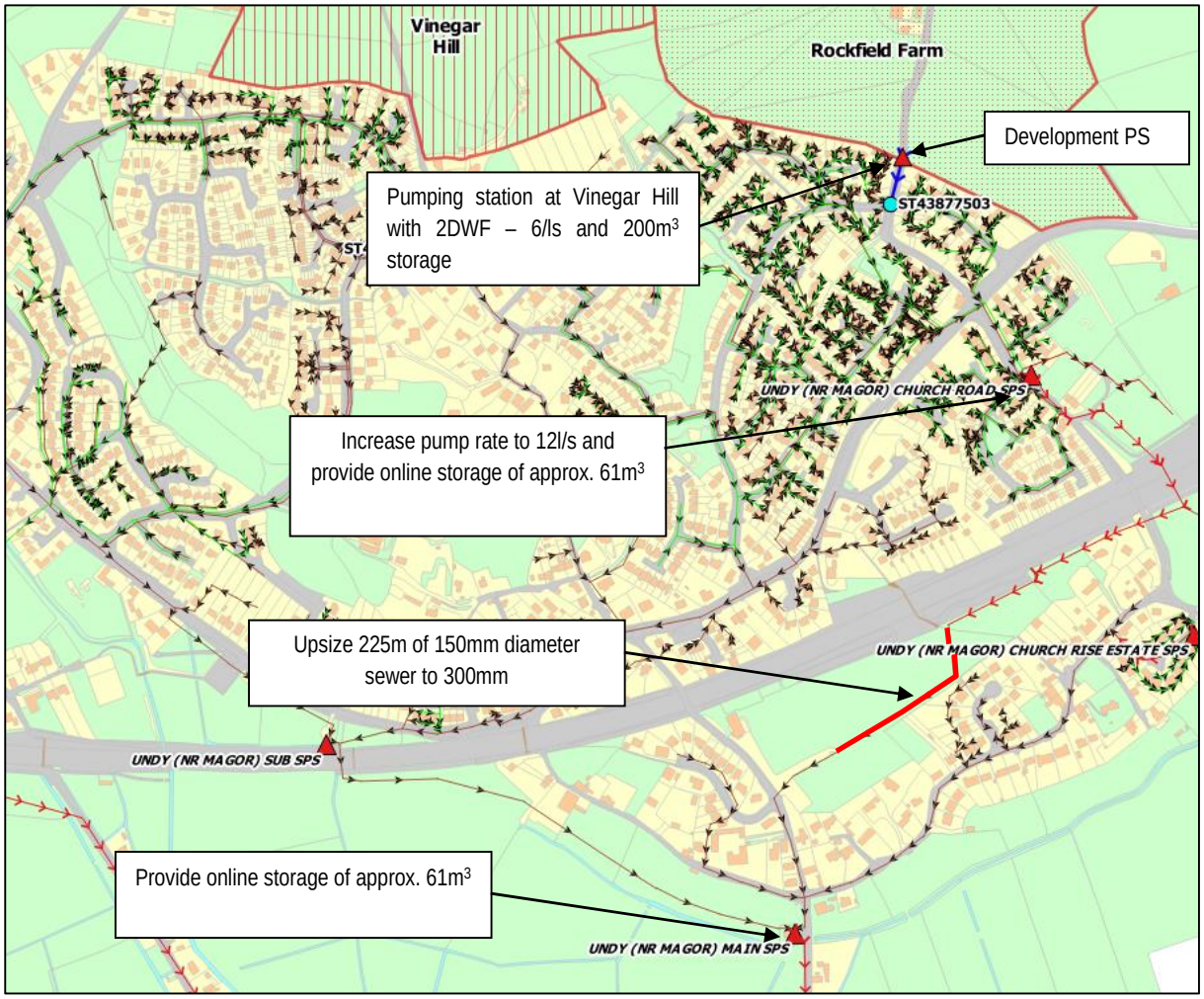


Figure 19 – Scenario 3: Solution 3

6.4.3.1 Solution Assessment

This solution proposes to resolve detriment by providing increased pass forward flow from Church Road PS and upsizing part of the downstream network. Additional emergency storage is required at both Church Road PS (61m³ or 270m³ if the existing consent requirement is retained), and Undy Main PS (61m³).

Model Node ID	Manhole ID	Critical Duration Summer (min)	Existing Flood Volume (m^3)	Solution 3 Flood Volume (m^3)	Flooding Detriment Absolute (m^3)	Flooding Detriment Percentage (%)
742896	ST42877201	15	2.2	2.3	0.1	4.5
742921	ST42877102	60	22.9	23.6	0.7	3.1
742967	ST42876440	15	2.8	3	0.2	7.1
748445	ST42878103	15	2.4	2.8	0.4	16.7

Table 36 – Scenario 3: Solution 3 Flooding Detriment Analysis

6.4.3.2 Solution Considerations

No assessment of potential clashes with infrastructure assets i.e. gas and electricity, has been undertaken at this point. It is recommended that these are investigated further at the design stage.

An online storage tank has been proposed to offset the spill detriment predicted for a 30 year design period event.

The solution is reliant on both developers agreeing to the proposed connection point, and there would be significant legal requirements in order to satisfy the planning process. This is a major risk to both developments, but particularly to Rockfields Farm.

Further consideration would need to be given to the potential to optimise the drainage from both sites to provide an efficient solution. An assessment of the LiDAR data indicates that it may be possible to gravitate to a central PS.

The solution assumes that NRW will accept a challenge to the current discharge consent at Church Road PS and that the rising main has sufficient capacity to accept increased flow rates.

6.5 Solution Summary

The solutions can be summarised as:

Scenario 1:

- Solution 1a – Offline storage (20m^3) on Main Road, 260m sewer upsize (225mm to 300mm) upstream of Undy Main PS. *May require an additional 20m^3 emergency storage at Undy Main PS.*
- Solution 1b – Sewer upsize on Main Road (180m of 300mm sewer), and 61m^3 online storage upstream of Undy Main PS (120m of 750mm). *No additional storage required.*
- Solution 2 - Offline storage (20m^3) on Main Road, online storage upstream of Undy Sub PS. *May require 28m^3 storage at Undy Main PS*
- Solution 3 – Sewer upsize on Main Road (730m of 300mm sewer), 40m of pipe dualling under the railway line, and 31m^3 online storage upstream of Undy Main PS (20m of 750mm). *No additional storage required. Potential additional saving of £198k by construction of dualled sewer 130m to the east.*

Scenario 2:

- Solution 1 – Pumped connection from the development site (including 63m^3 storage) and 17m^3 Online storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 16m^3 emergency storage at Church Road PS.*
- Solution 2 – Upsize 71m of sewer to 225mm. Provide 48m^3 of storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 0m^3 emergency storage at Church Road PS.*
  **Note both solutions assume that 2 hrs at 3DWF emergency storage would be sufficient at Church Road PS and there may be an additional storage requirement based on the current consent information.*

Scenario 3:

- Solution 1 – Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Implement Scenario 1, Solution 2. *May require 61m^3 storage at Undy Main PS*
- Solution 2 – Provide any combination of Scenario 1 and Scenario 2 Solutions. *Additional storage required as a combination of the above solutions.*
- Solution 3 – Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Increase Church Road PS pump rate to 12 l/s and upsize downstream network (225m of 300mm). *May require 61m^3 storage at Church Road PS and Undy Main PS*
  **As per scenario 2 there may be an additional storage requirement at Church Road PS.*

7 Solution Costs

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

Scenario	Solution	Emergency Storage Cost	Cost excluding Emergency Storage	Total Cost
Scenario 1	Solution1a	£112k	£502k	£614k
	Solution1b	£0	£521k	£521k
	Solution2	£125k	£497k	£622k
	Solution 3	£0	£738k	£738k
	Solution 3a	£0	£540k	£540k
Scenario 2	Solution1	£134k + £288k	£662k	£950k or £796k
	Solution2	£134k + £239k	£343k	£477k or £582k
Scenario 3	Solution 1	£179k	£799k+	£978k
	Solution 2	£0 + £239k* or £0*	£864k	£864k or £1,103k
	Solution 3	(£179k or £514) + £179k	£666k+	£1,024k or £1,359k

Table 37 - Solution Costs

+ Please note that costs for Scenario 3; Solution 1 and 3 are liable for significant change based on any changes to the development drainage layouts. It has been assumed that drainage at both sites can be reconfigured to drain the internal sites at no additional cost.
*The difference in costs relates to whether emergency storage is calculated in line with consent, or using standard values.

8 Conclusions & Recommendations

- Two developments are proposed within the Magor Catchment. In total 496 residential dwellings are proposed on two adjacent sites; 270 units at Rockfields Farm and 226 units at Vinegar Hill.

- The proposed developments have been assessed using two connection points.
  - Connection Point 1 - Vinegar Hill - ST43872401 – South of the development, connecting to an existing 150mm diameter foul sewer draining to Undy Main PS.
  - Connection Point 2 - Rockfields Farm - ST43877503 - South of the development, connecting to an existing 150mm diameter foul sewer draining to Church Road PS.

- The key model build activities undertaken were:
  - Update of the model with manhole survey data.
  - Area take off using returned IAS data.
  - Inclusion of the Undy Main PS and Undy Sub PS in the model.

- The model was verified against a short term flow survey comprising three FMs and two RGs. Overall a reasonable level of DWF and Storm Verification was achieved.

- The key model build assumptions/limitations are:
  - Uncertainties surrounding the on/off levels and invert of the incoming sewer into the Undy Main PS. While it is recommended that future users of the model seek to confirm these levels, these uncertainties have negligible impact on the results of the HMA.

- The extent of storage within the Church Road PS. It is recommend that future users undertake a complete survey to establish the storage volumes at this PS.

- The hydraulic assessment was undertaken on the following scenarios:
  - *Scenario 1* - Total development of 226 units at Vinegar Hill.
  - *Scenario 2* - Total development of 270 units at Rockfields Farm.
  - *Scenario 3 - Combined total of 496 dwellings from Vinegar Hill and Rockfields Farm.*

The findings of the assessment were:

  - Scenario 1 – Unacceptable level of flood detriment in the downstream network in the vicinity of Undy Sub PS.
  - Scenario 2 – Unacceptable level of flood detriment in the downstream network, upstream of Church Road PS.
  - Scenario 3 – Unacceptable level of flood detriment in the downstream network, at the same locations as Scenario 1 and 2, but no significant new flooding locations outside the areas previously identified.

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

Scenario 1:

- Solution 1a: £614k– Offline storage (20m^3) on Main Road, 260m sewer upsize (225mm to 300mm) upstream of Undy Main PS. *May require an additional 20m^3 emergency storage at Undy Main PS.*
- Solution 1b: £521k Sewer upsize on Main Road (180m of 300mm sewer), and 61m^3 online storage upstream of Undy Main PS (120m of 750mm). *No additional storage required.*
- Solution 2: £622k - Offline storage (20m^3) on Main Road, online storage upstream of Undy Sub PS. *May require 28m^3 storage at Undy Main PS.*
- Solution 3a/3: £540k to £738k - Sewer upsize on Main Road (730m of 300mm sewer), 40m of pipe dualling under the railway line, and 31m^3 online storage upstream of Undy Main PS (20m of 1050mm). *No additional storage required. The lower cost (£540k) could be achieved by construction of the sewer crossing the rail line 130m to the east.*

Scenario 2:

- Solution 1: £950k – Pumped connection from the development site (including 63m^3 storage) and 17m^3 online storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 16m^3 emergency storage at Church Road PS.*
- Solution 2: £582k – Upsize 71m of sewer to 225mm. Provide 48m^3 of storage at Church Road PS. *May require an additional 34m^3 emergency storage at Undy Main PS and 0m^3 emergency storage at Church Road PS.*

Scenario 3:

- Solution 1: £978k – Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Implement Scenario 1, Solution 2. *May require 61m^3 storage at Undy Main PS.*
- Solution 2: £1,103k – Provide any combination of Scenario 1 and Scenario 2 Solutions. *Additional storage required as a combination of the above solutions.*
- Solution 3: £1,024 - Drain both development sites into one PS. Limit pass forward flow to 2DWF. Provide 150m^3 additional storage to offset the reduction in pass forward flow. Increase Church Road PS pump rate to 12 l/s and upsize downstream network (225m of 300mm). *May require 61m^3 storage at Church Road PS (270m^3 if current consent is retained) and Undy Main PS.*

The preferred solution for each scenario is:

- Scenario 1 – Solution 3a – The provision of network storage upstream of Undy Main PS achieves a dual objective of flood reduction and emergency storage provision.
- Scenario 2 – Solution 2 – The gravity solution is more sustainable (lower energy usage) and lower cost.
- Scenario 3 - Solution 3 – This option limits buildability issues, construction of additional assets, and achieves a dual objective of flood reduction and emergency storage provision at Undy Main PS and Church Road PS. This is subject to gaining agreement from NRW to relax the existing EO consent.

Based on a review of the solution costs and feedback from DCWW Operations, it is recommended that both developments are constructed with independent drainage and the preferred independent solutions delivered. This will allow both developments to drain to the existing system via gravity. Therefore, no new pumping stations are required which will increase DCWWs operating costs. A review of the costs of the preferred solutions for each scenario indicates that the preferred solutions for Scenarios 1 and 2 are more cost effective than the preferred solution for Scenario 3.