A417 Missing Link
TR010056

6.4 Environmental Statement
Appendix 13.11 Water Features Survey
(Part 2 of 2)

Planning Act 2008

APFP Regulation 5(2)(a)
Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

Volume 6

May 2021

Infrastructure Planning

Planning Act 2008

The Infrastructure Planning (Applications: Prescribed Forms and Procedure) Regulations 2009

A417 Missing Link

Development Consent Order 202[x]

6.4 Environmental Statement
Appendix 13.11 Water Features Survey
(Part 2 of 2)

Regulation Number:	5(2)(a)
Planning Inspectorate Scheme Reference	TR010056
Application Document Reference	6.4
Author:	A417 Missing Link

Version	Date	Status of Version
C01	May 2021	Application Submission

Water Feature Survey photos
(Part 2 of 2)

G148 _ spring at Stockwell Farm N of Watercombe Farm facing SW

G149 _ facing N outfall at Stockwell Farm culverted under A417 discharging at Watercombe Farm

G150 _ solution features at Stockwell Farm N of Watercombe Farm facing NE

G151 _ seepage face at tributary of Norman's Book facing W DS

G152 _ spring in corner of Crickley Hill Tractors facing N

G153 _ facing W rushes on escarpment slope at Court Farm blue pipe feeds into ground and likely taps flow

G154 _ minor seepage at Court Farm

G155 _ seepage at Court Farm and hill farm boundary facing S

G156 _ spring at Court Farm marked by dogs mercury

G157 _ possible spring abstraction and pump house facing S

G159 _ spring at Clerk's Patch facing S

G160 _ dry spring at Oakland Farm looking NW

G161 _ dry piped spring at Oakland Farm

G162 _ head of spring fed watercourse at Oakland Farm looking E

G163 _ spring fed watercourse seeping back to ground N of Oakland Farm looking SE US

G164 _ spring at Spring Orchard looking W

G166 _ possible abstraction point replacing old well

G167 _ dry spring collects outfall at Coldwell Bottom looking NE

G168 _ spring head that forms headwaters of Coldwell Bottom looking NW US

G169 _ Coldwell Bottom looking N

G170 _ pond on L bank of Coldwell Bottom, eastern extent looking N

G173 _ possible abstraction point

G171 _ DS of culvert looking SE

G174 _ sodden ground in location of marked spring 2

G175 _ flooded ground in depression looking S

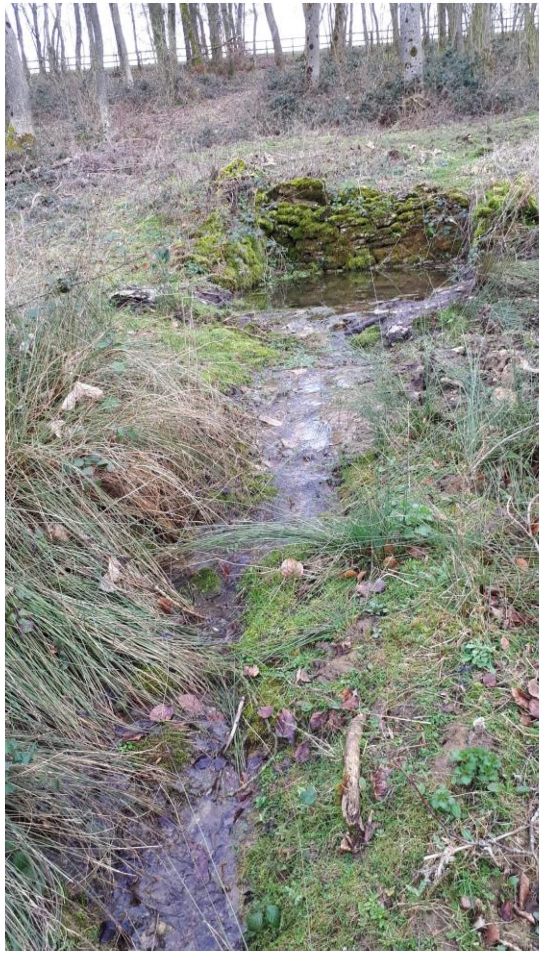
G176 _ pond at Stockwell Farm

G177 _ broken piped spring, possible overflow or land drainage from field

G178 _ dry road and field drain which flows to G142

G180a _ seepage at Rushwood Kennels looking N

G180b _ seepage at Rushwood Kennels looking N



G181 _ spring at Rushwood Kennels looking N US to pond

G182 _ rushes on slope in Barber Wood looking N

G183 _ Shab Hill dry valley looking NE

G184 _ dry valley with run-off depression at Shab Hill looking NE

G185 _ spring fed watercourse at Court Farm looking E

G186 _ spring head that feeds G185 looking N


G187 _ spring fed pond at Court Farm woodland


G188 _ spring flows downgradient of head at Court Farm woodland and seeps back to ground looking S


G189 _ re-emergence of spring flows from G188 downgradient then seeps back to ground


G190 _ staggered re-emerging spring flows exposed by collapse of ground by trees looking N

G191 _ piped spring flows downgradient of G190

G192 _ exposed pipes used for managing spring flows upper pipe is dry looking N

G193 _ downgradient of subsurface pond where water flows out looking S

G194 _ downgradient of spring flows, looking N US

G195 _ spring exposed in field looking N

G196 _ seepage upgradient of G195 looking N

G197 _ marked spring on map piped, and surrounded by dogs mercury looking NW

G198 _ possible spring in field downgradient of spring flows looking S

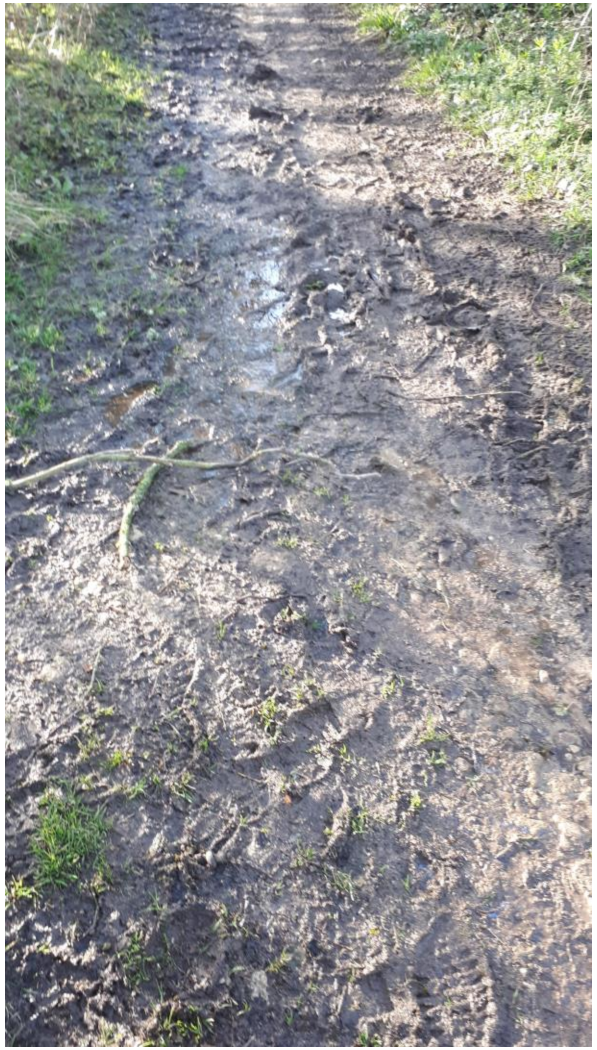
G199 _ well on side of road disused

G200 _ seepage upgradient of churn tributary on southern slope

G201 _ seepage on northern banks of churn tributary looking S

G202 _ confluence of spring flows from G159 and churn tributary looking SE

G203 _ seepage in field looking SE



G204 _ seepage on pathway upgradient of River Churn looking W

G203 _ seepage in field, noted by rushes and confirmed by landowners, looking S

G205 _ abstraction borehole on golf course grounds not used, but intended for top up

G206 _ spring and well at Fernbank looking N US

G207 _ seepage on northern slope of A417 looking SW

G208 _ spring fed watercourse looking S US

G209 _ spring looking SW US

G210 _ spring looking SW US

G211 _ spring looking SW US

G212 _ spring fed pond

G213 _ existing well and spring fed lake G177 with water present looking E

G215 _ disused borehole at Journey’s End

G214 _ spring fed watercourse at Journey's End looking SE US

G216 _ spring collects, feeding household by gravity

G217 _ spring head looking E

G218 _ spring feeding into spring fed watercourse at journey's end looking SE US

G219 _ spring at Watercombe Farm flowing to gravel catchpit looking E

G220 _ discharge point of spring flows from G219

G220 _ discharge point of spring flows from G219 looking N

G221 _ buried perforated tube draining seepage to G219 looking S

G223 _ land drainage flowing to road drains farm area and some seepage, damp with no flow looking SW DS

G222 _ spring fed watercourse piped off property at G30 looking SW DS

G224_old well, partially infilled at rose cottage

G225_upwelling of groundwater, possibly from partially infilled well

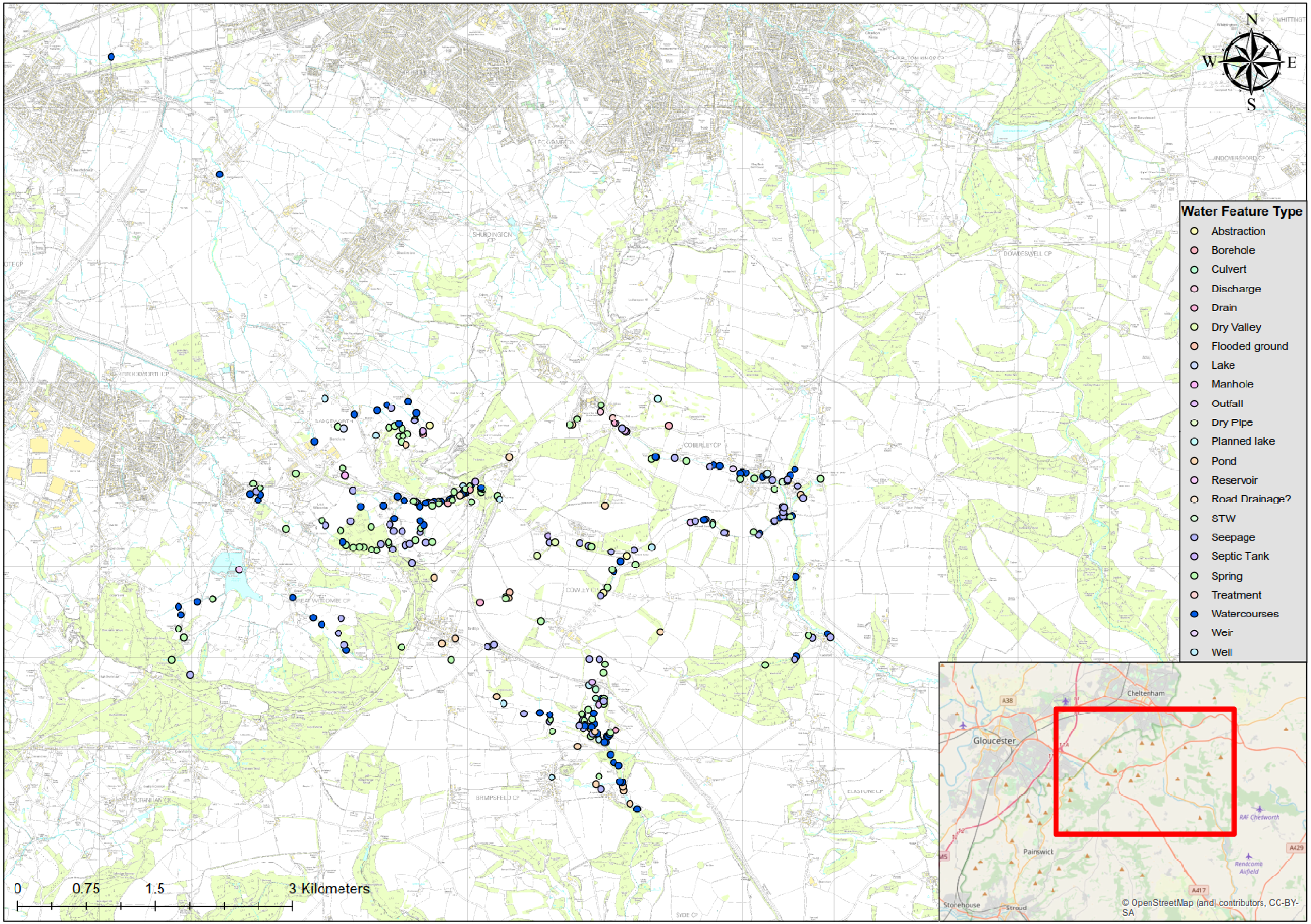
G226_area of minor seepage at rose cottage looking N

G227_dry dew pond on escarpment owner states pond rarely has water looking W

G228 _ spring flows culverted at road and flowing to drain_210319

G231 _ Head of tufa spring that feeds feature 69

Water Feature Survey Map
- all features



Notes

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

Mott MacDonald Sweco

Client

highways england

Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 1 OF 12

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size	**Date**	**Date**	**Date**	**Date**
A3	14/03/19	14/03/19	01/04/19	02/04/19

Drawing Number

HE PIN	Originator	Volume		
551505 -	MMSJV -	EWE -		
000 -	SU -	LV -		00004
Location	Type	Role		Number

Project Ref. No. 551505

Revision P01

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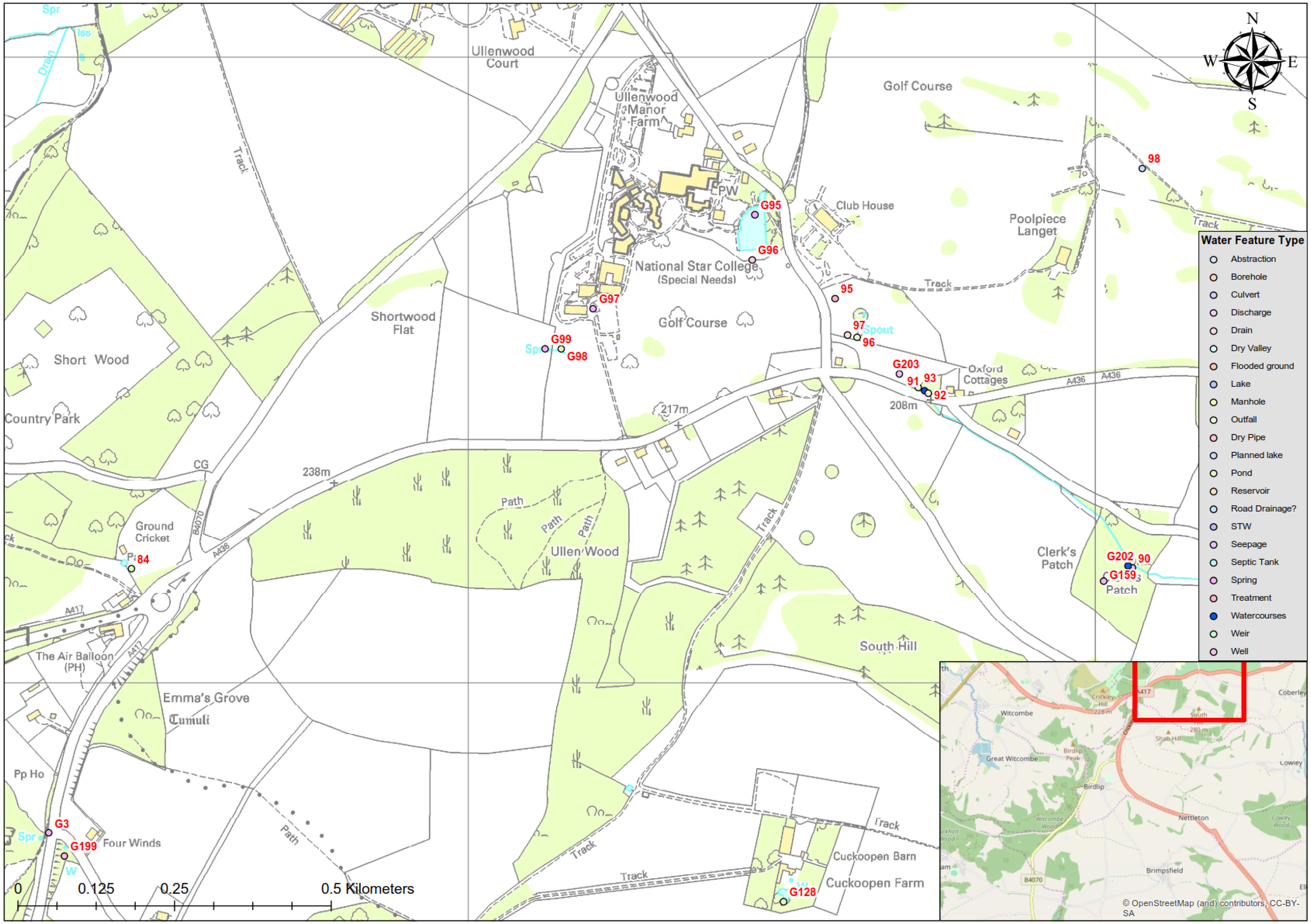

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

Mott MacDonald Sweco

Client: highways england

Drawing Status: S01

Suitability: STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY FIGURE 2 OF 12

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	KS	KS	HC	
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Project Ref. No.: 551505

Revision: P01

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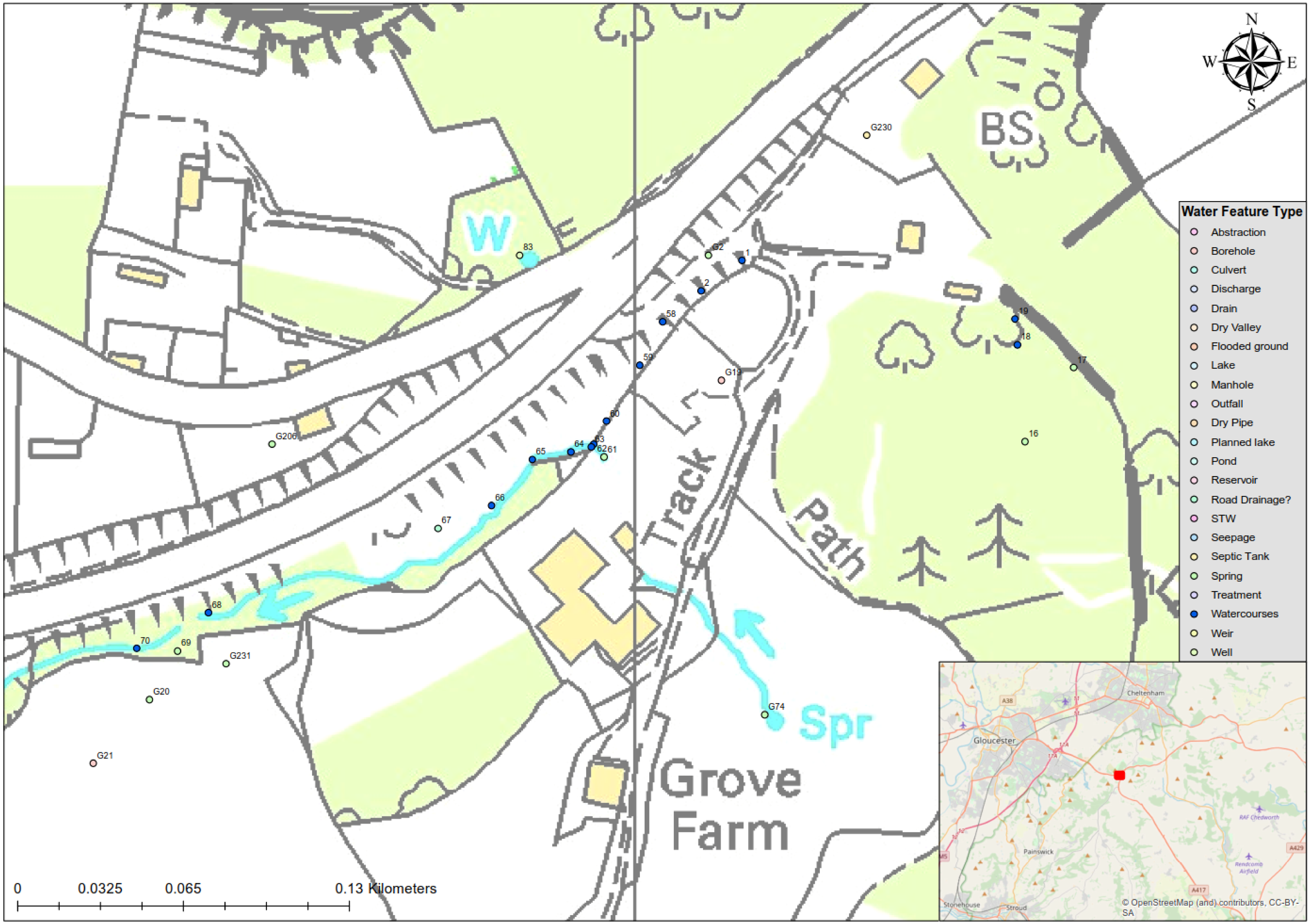

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Mott MacDonald Sweco

Client: highways england

Drawing Status: S01

Suitability: STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY FIGURE 3 OF 12

Scale	Designed	Drawn	Checked	Approved
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Drawing Number: HE PIN | Originator | Volume
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Location | Type | Role | Number

Project Ref. No. 551505

Revision P01

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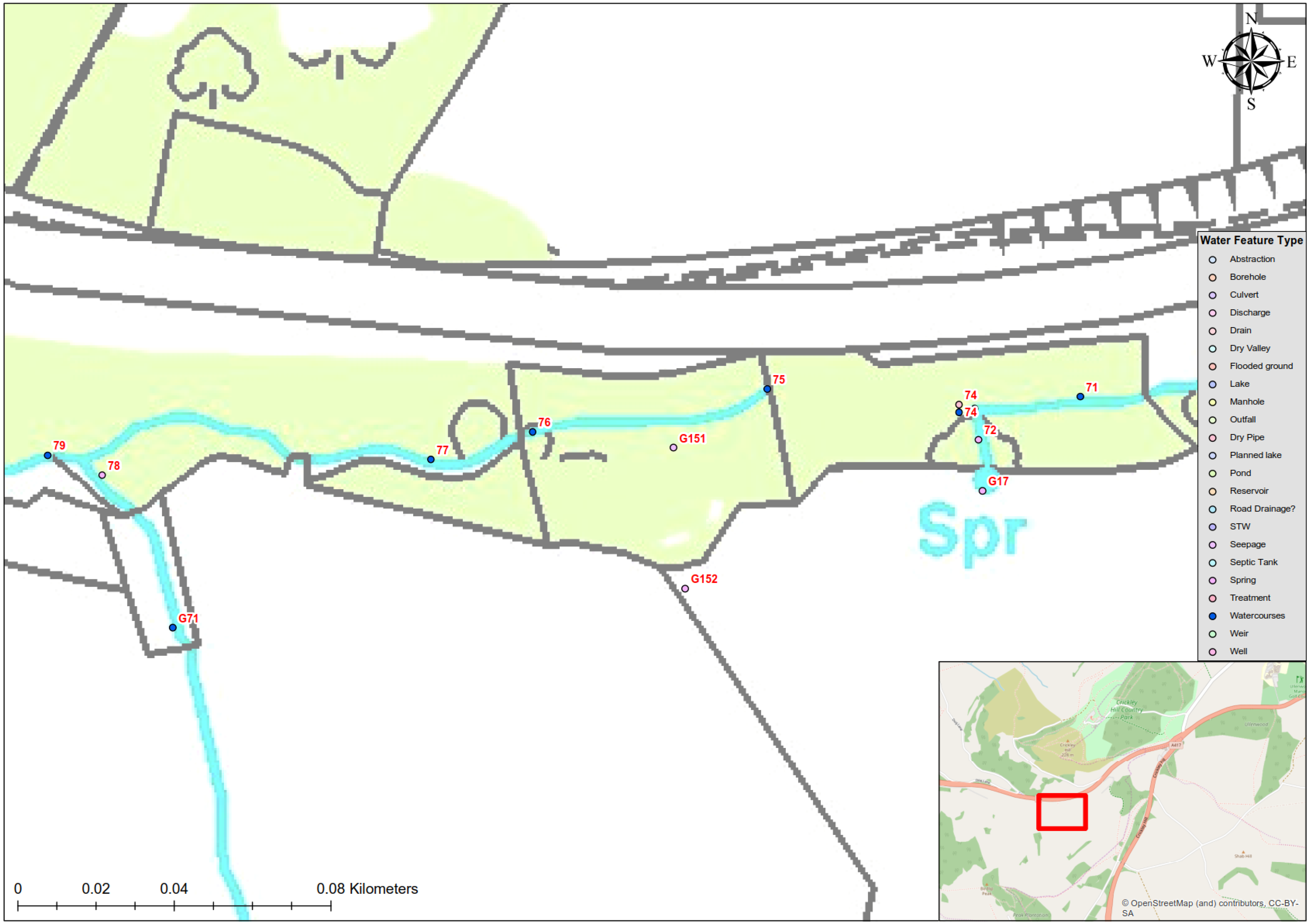

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 4 OF 12

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size	Date	Date	Date	Date
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Drawing Number
HE PIN | Originator | Volume
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Project Ref. No.
551505

Revision
P01

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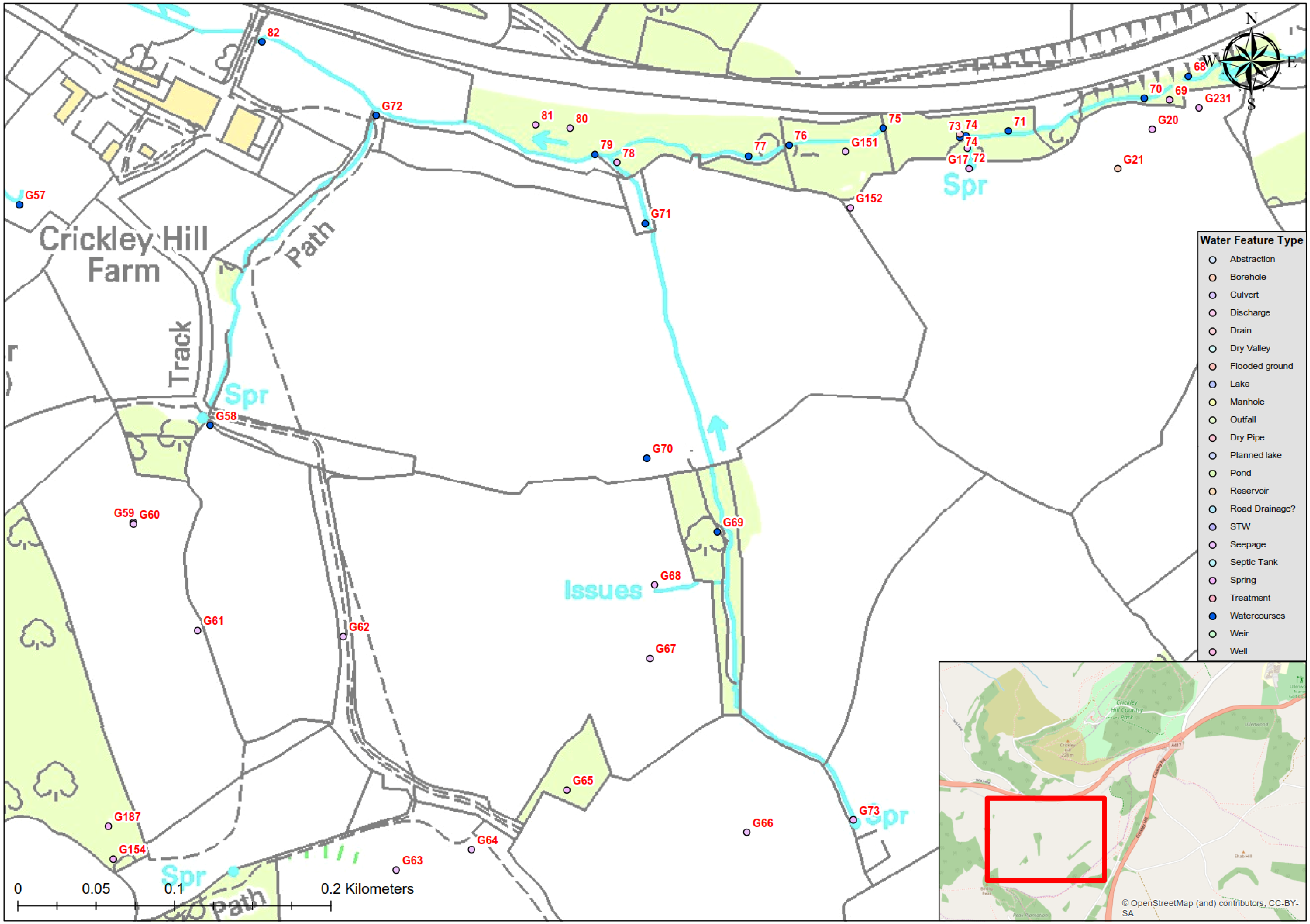

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Client

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Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 5 OF 12

Scale	Designed	Drawn	Checked	Approved
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Original Size	Date	Date	Date	Date
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Location	**Type**	**Role**	**Number**	**Revision**
000 -	SU -	LV -	00004	P01

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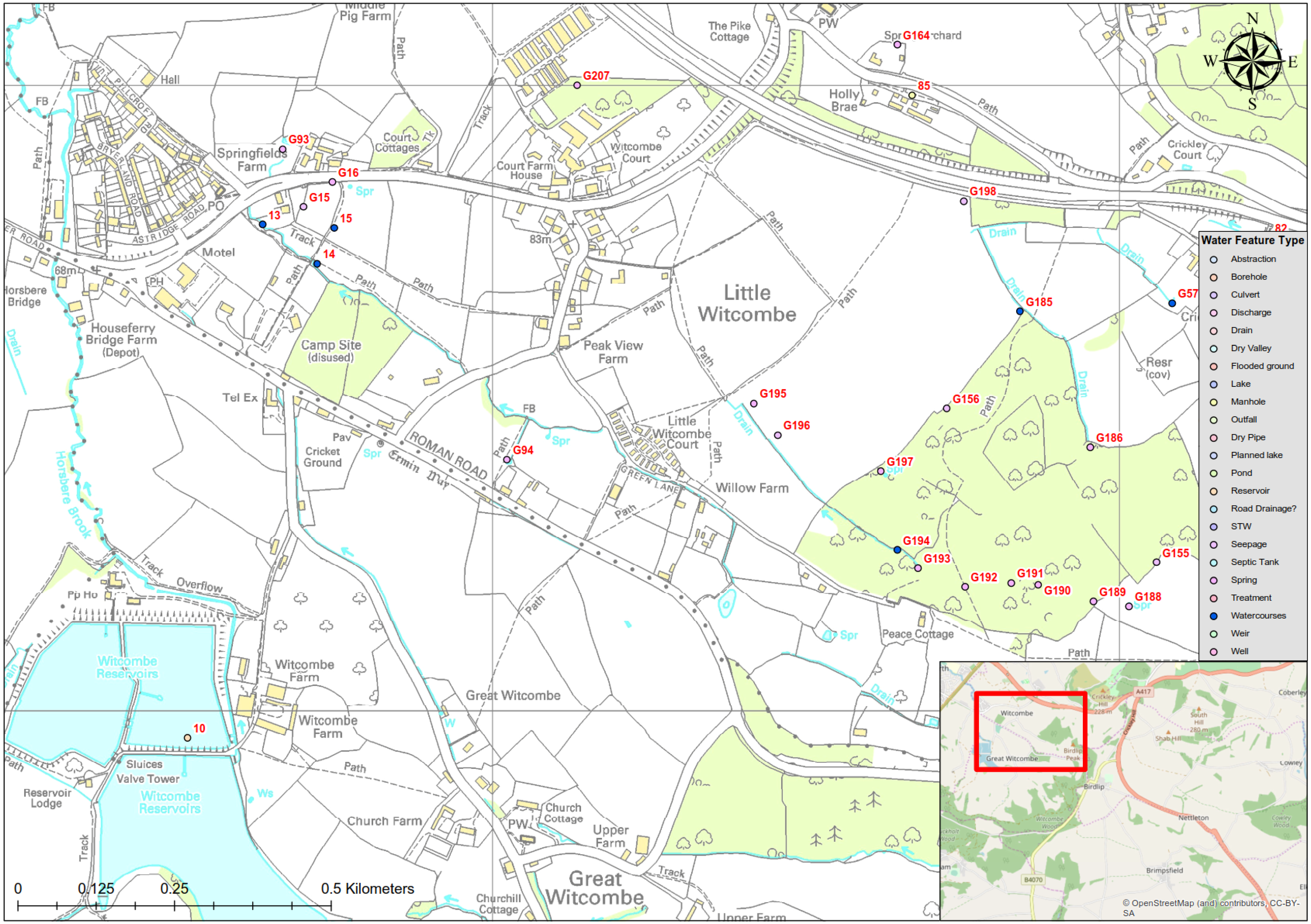

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Mott MacDonald Sweco

Client: highways england

Drawing Status	Suitability
S01	STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY FIGURE 6 OF 12

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
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Revision: P01

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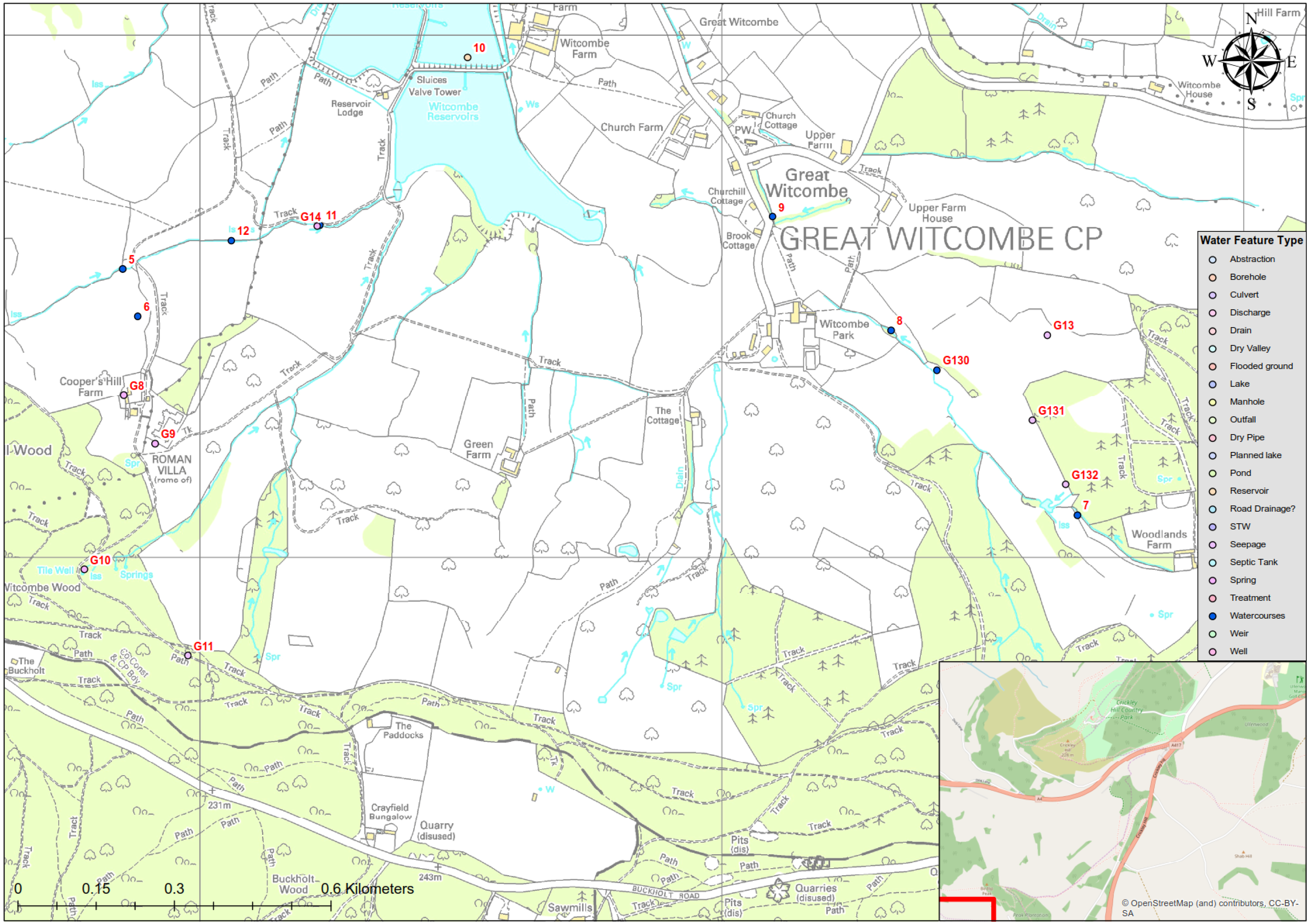

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P01	MARCH 19	DRAFT	KS	HC	MC

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Client

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Drawing Status: S01

Suitability: STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 7 OF 12

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size A3	Date 14/03/19	Date 14/03/19	Date 01/04/19	Date 02/04/19

Drawing Number

HE PIN	Originator	Volume		
551505 -	MMSJV -	EWE -		
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Location	Type	Role	Number	

Project Ref. No. 551505

Revision P01

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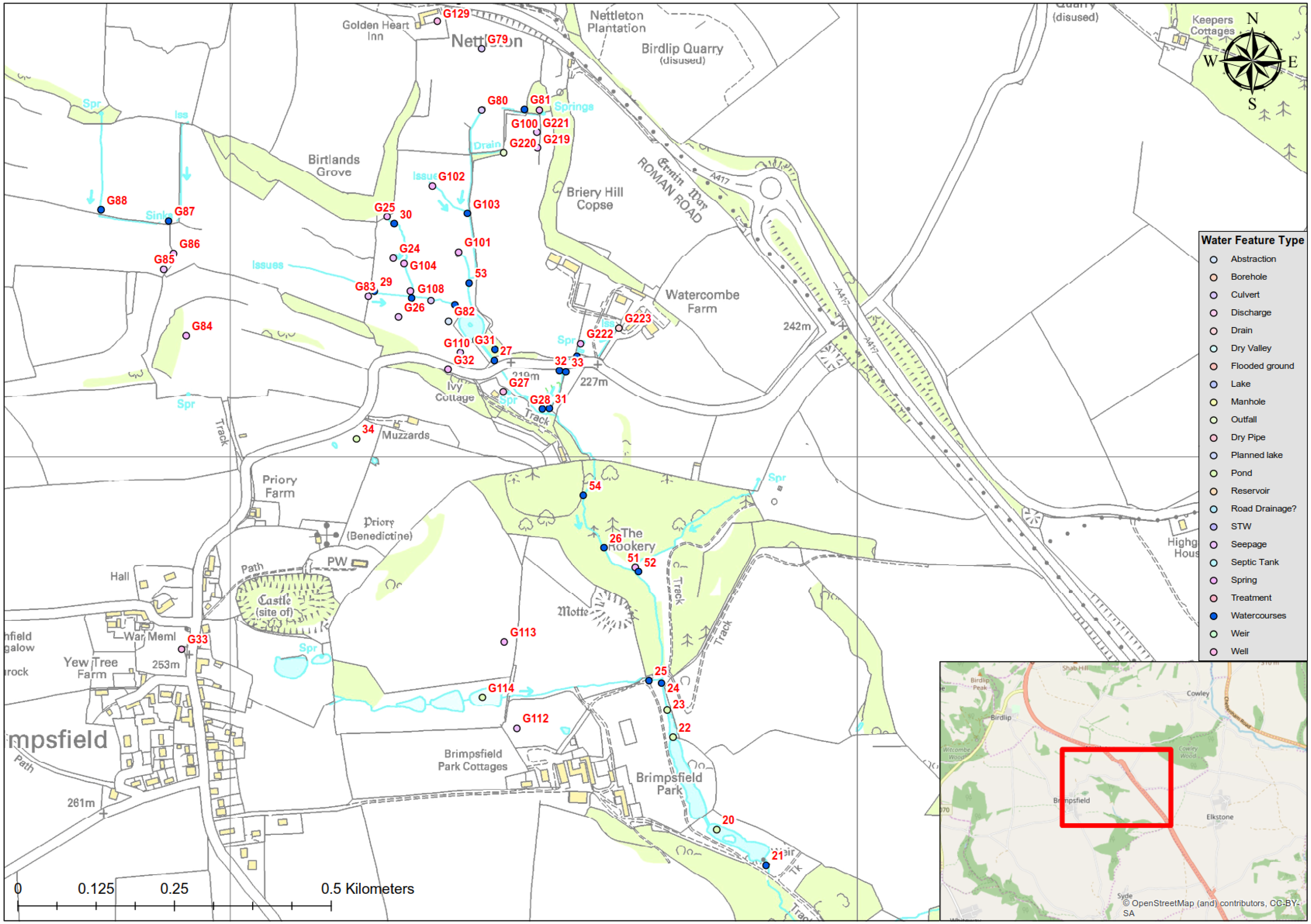

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Client: highways england

Drawing Status: S01	Suitability: STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY FIGURE 8 OF 12

Scale	Designed	Drawn	Checked	Approved
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Original Size: A3	Date: 14/03/19	Date: 14/03/19	Date: 01/04/19	Date: 02/04/19

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Project Ref. No.: 551505

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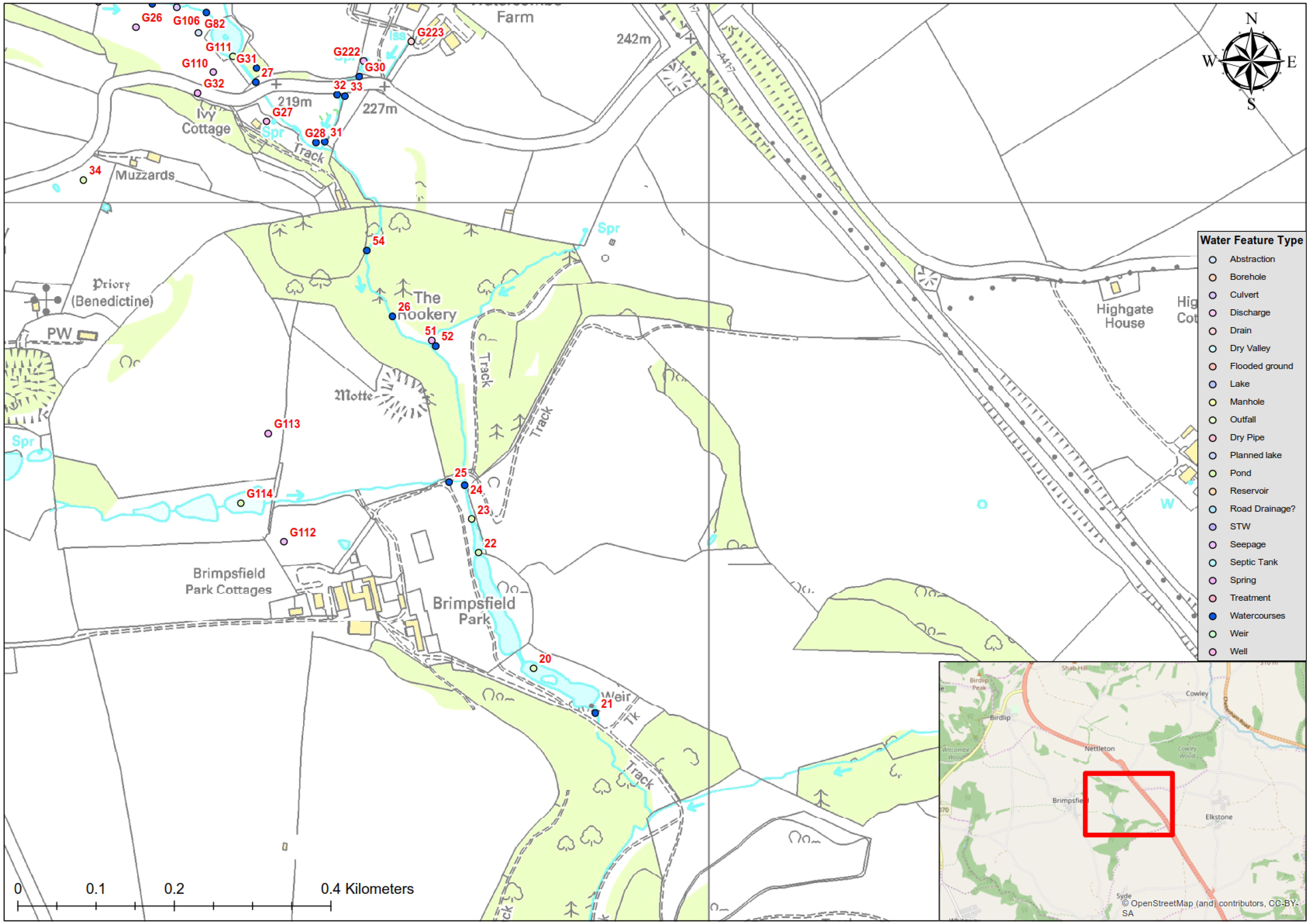

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Client: highways england

Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 9 OF 12

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size	**Date**	**Date**	**Date**	**Date**
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Drawing Number

HE PIN | Originator | Volume

551505 - MMSJV - EWE -

000 - SU - LV - 00004

Location | Type | Role | Number

Project Ref. No. 551505

Revision P01

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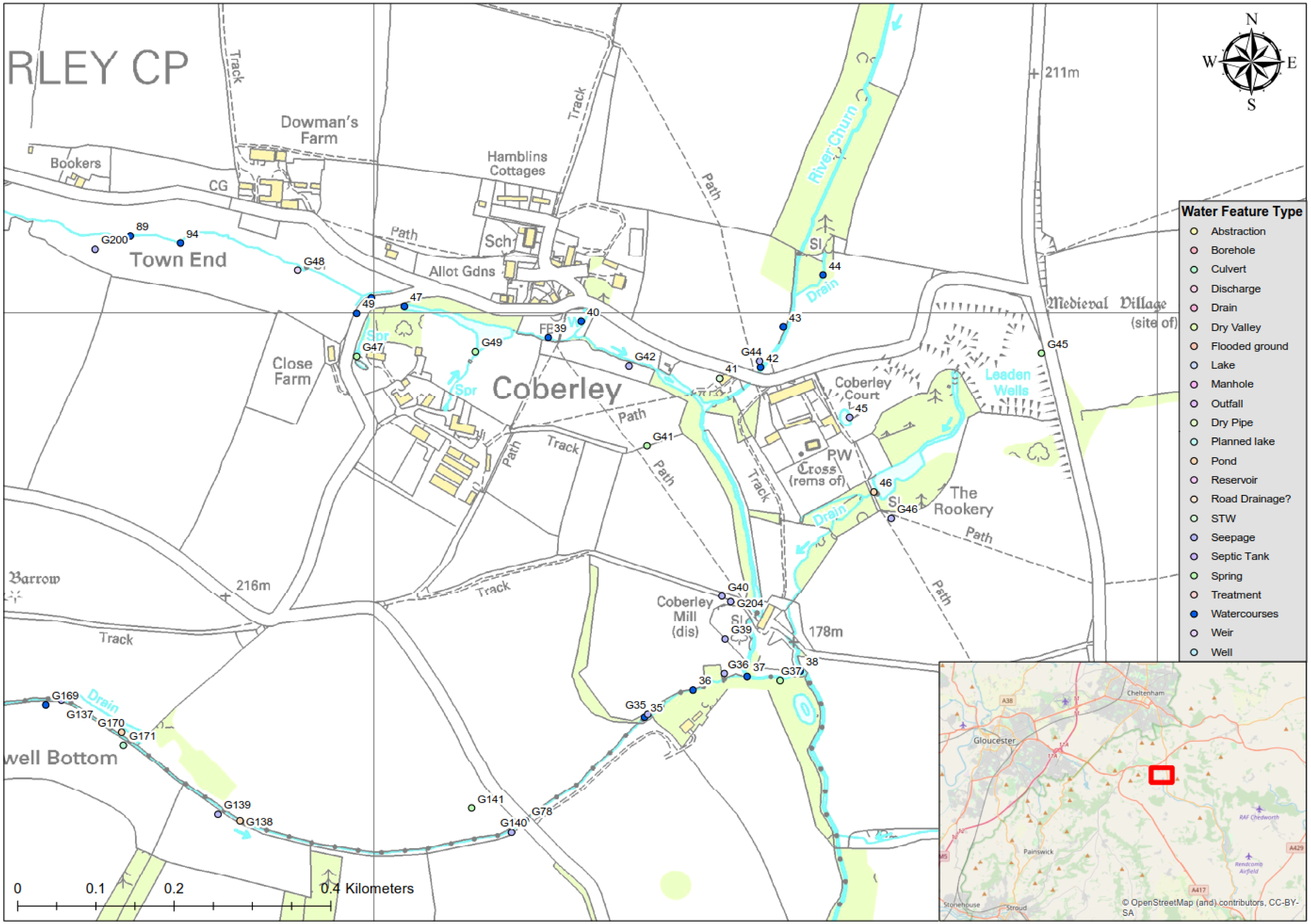

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P01	MARCH 19	DRAFT	KS	HC	MC

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Client

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Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 10 OF 12

Scale	Designed	Drawn	Checked	Approved
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Drawing Number

HE PIN | Originator | Volume

551505 - MMSJV - EWE -

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Location | Type | Role | Number

Project Ref. No. 551505

Revision P01

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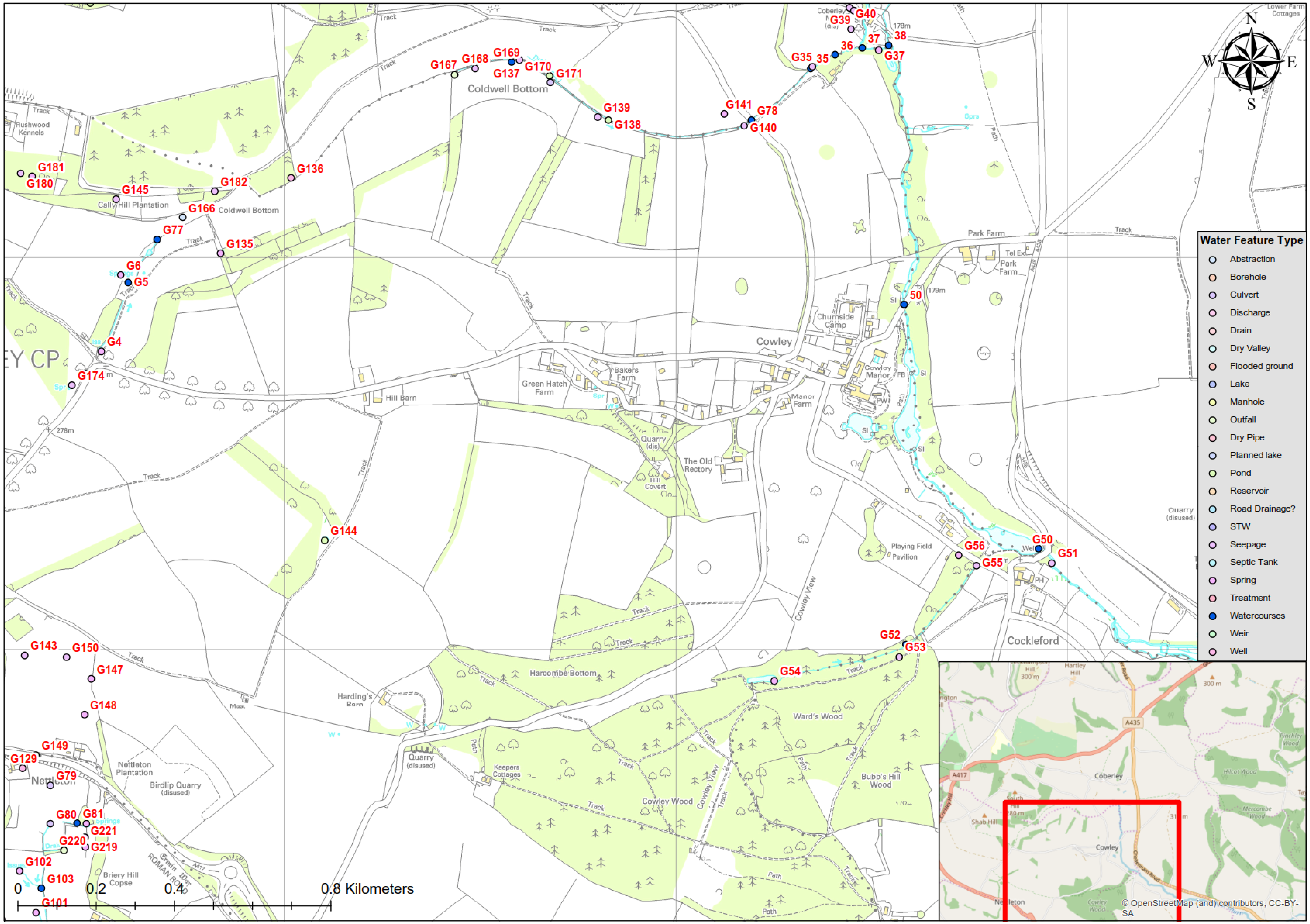

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Rev	Date	Amendment Details	Drawn	Chk'd	App'd

Mott MacDonald Sweco

Client

highways england

Drawing Status: S01

Suitability: STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY FIGURE 11 OF 12

Scale	Designed	Drawn	Checked	Approved
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Original Size A3	Date 14/03/19	Date 14/03/19	Date 01/04/19	Date 02/04/19

Drawing Number

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551505 -	MMSJV -	EWE -		
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Location	Type	Role		Number

Project Ref. No. 551505

Revision P01

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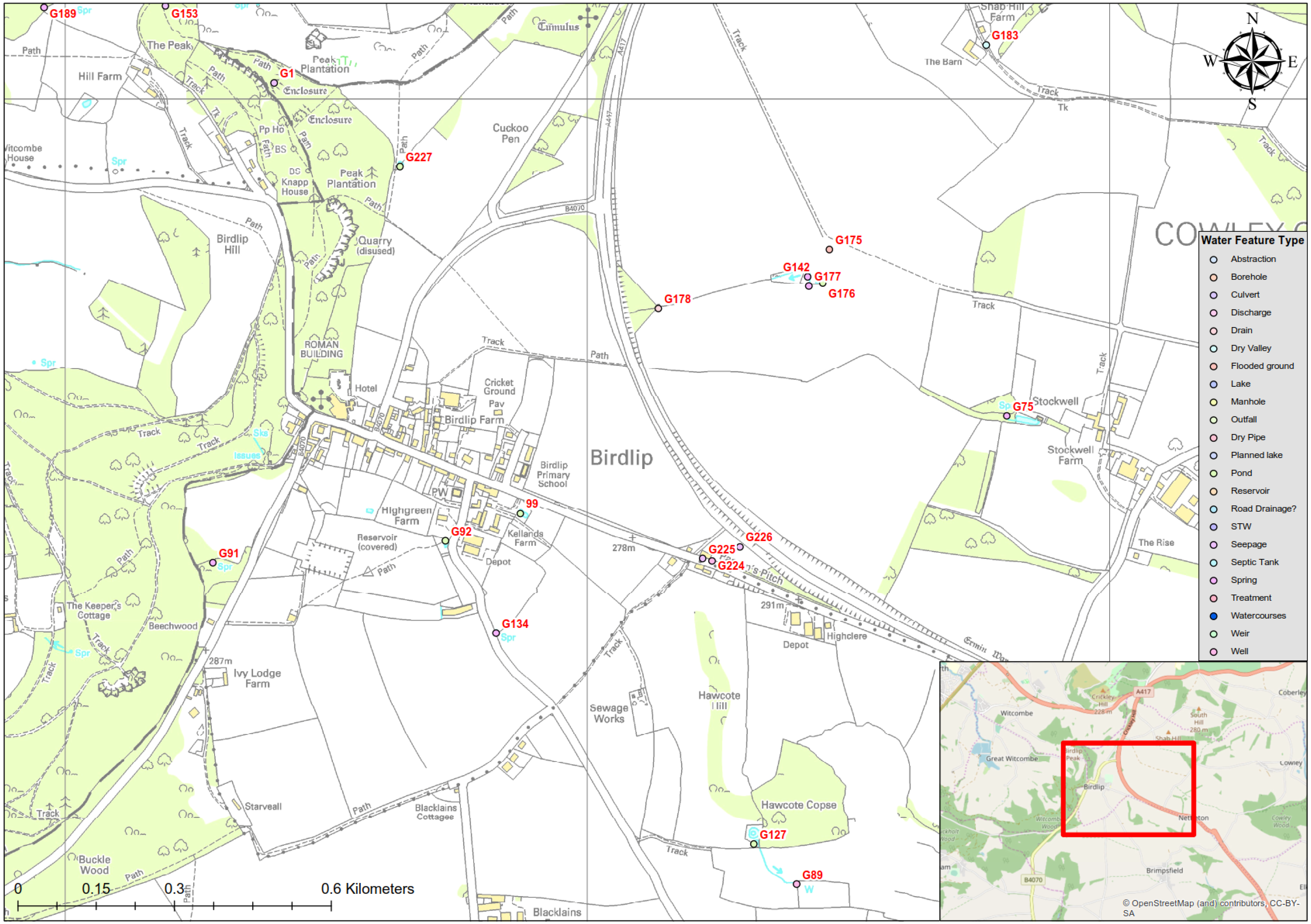

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

Mott MacDonald Sweco

Client: highways england

Drawing Status: S01 | Suitability: STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY FIGURE 13 OF 12

Scale	Designed	Drawn	Checked	Approved
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Original Size A3	Date 14/03/19	Date 14/03/19	Date 01/04/19	Date 02/04/19

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Project Ref. No. 551505

Revision P01

FILE LOCATION: F:\U4013\nonproj\Other profit centre projects\A417\Water Feature surveys\Combined Water Features Survey\GIS\AN184-MapTemplate-A1-ESRI-ArcMap.mxd

Water Feature Survey
- flow gauging technical note

Project:	A417 “Missing Link” Road Scheme		
Document title:	A417 Stream flow gauging report		
Document ref:	HE551505-MMSJV-EWE-000-SU-LV-00007	Revision:	P01.1
Author:	Karen Scott	Date:	03/04/19
Checker:	Harriet Carlyle	Date:	05/04/19
Approver:	Mark Casey	Date:	24/04/19
Authoriser:	Mark Casey	Date:	24/04/19

1 Summary

This technical note describes a spot flow gauging programme, which was undertaken as part of the Water Features Survey for the A417 Missing Link scheme. Spot flow gauging was undertaken in order to understand spring and stream flows, and surface water – groundwater interaction within the scoped area for Option 12 and 30.

Flow gauging was undertaken at 47 locations during four monitoring periods between April 2018 and March 2019, subject to land access constraints. The gauging programme confirmed that watercourses are typically fed by springs and seepages but can also lose water to the underlying aquifer(s). As flows are dependent on groundwater, many watercourses and springs became dry during the dry summer 2018 and winter 2018/2019.

It is recommended that additional flow gauging is undertaken on a monthly basis for a minimum of a year to establish a more robust baseline. This will allow a better understanding of how these watercourses react seasonally and with changing groundwater levels, and the baseline data can be used to assess any potential impacts during and after construction.

2 Introduction

This note describes a spot flow gauging programme, which was undertaken in conjunction with the Water Features Survey (WFS) for Stage 2 (Options Appraisal) of the A417 Missing Link scheme. Spot flow gauging was undertaken to understand both seasonal variations in stream flow and accretion profiles within the study area and surface water – groundwater relationships. Streams within the study area are largely spring-fed and also may lose water to the underlying aquifers.

3 Assessment

Methodology

Flow gauging was carried out at key locations within the study areas for Option 12 and 30 during WFS site visits in April 2018, July 2018, February 2019 and March 2019. Repeated gauging was undertaken where possible to understand seasonal variations in stream flow and accretion profiles.

Figure 3.1 identifies the location of flow gauging points during each of the above site visits. These were dependent on land access (be this public or private land) and as a result, it was only possible to visit some gauging locations once during the survey programme.

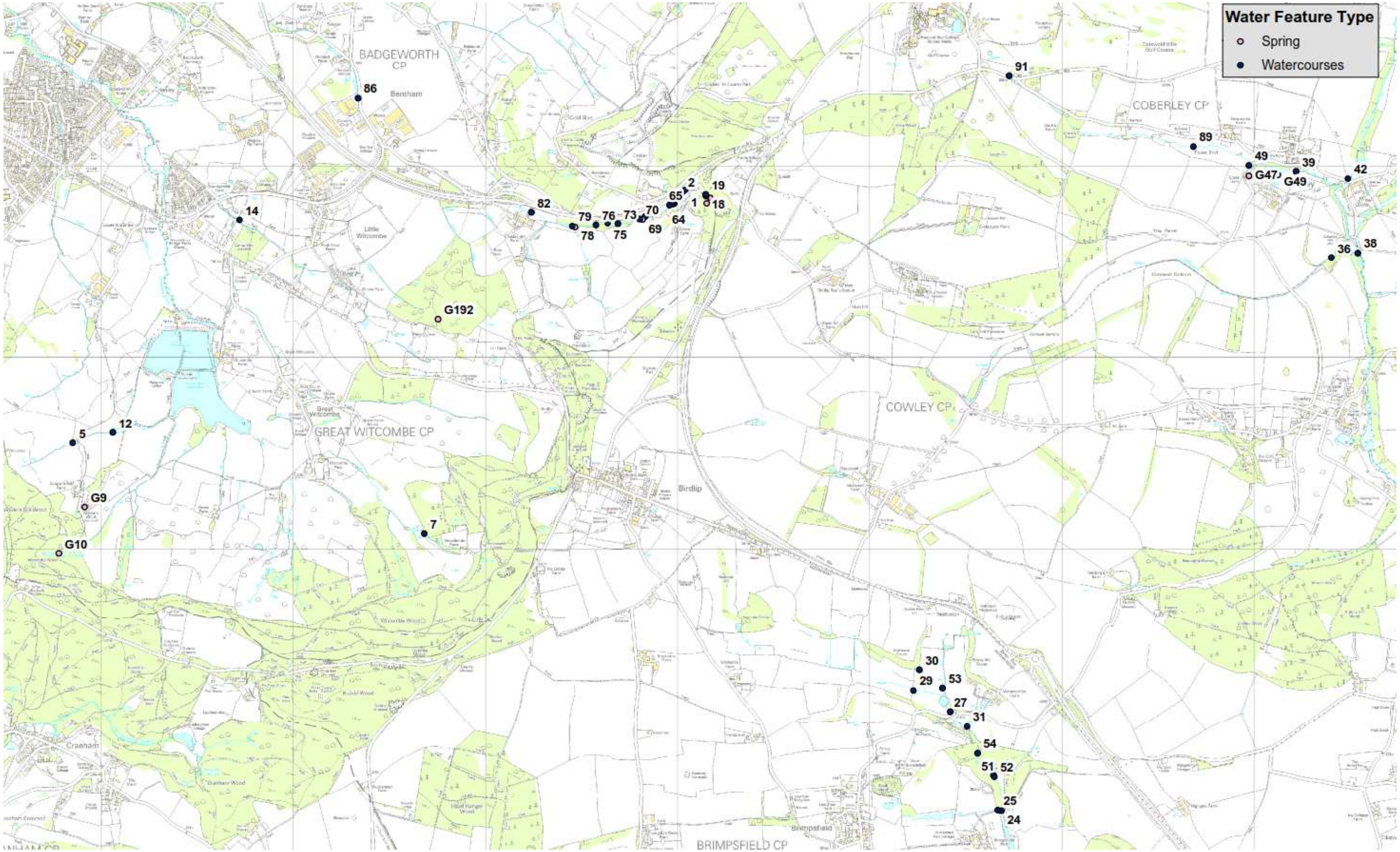


Figure 3.1 – Flow gauging locations

A Valeport model 801 Electromagnetic Open Channel flow meter was used to measure the velocity. The technique for recording velocity is described below:

1. A measuring tape was placed across the channel, taking note of the width, which is then split into equal intervals (generally 20cm apart). At each of these points, velocity recordings were taken. If the width of the channel was less than 0.5m wide, or if there were time constrains, only one measurement was taken.
2. The foot of the staff was placed on the channel bed and the water level was recorded. The flow sensor was positioned at 60% of the water depth as this typically represents the average flow velocity in the watercourse.
3. The sensor was left for 30 seconds and the flow rate was recorded. This process was repeated at each of the locations, ensuring that the sensor was always adjusted to 60% of the channel depth.
4. Flow was calculated back in the office by multiplying velocity by channel cross sectional area.

Results

In total, 47 water courses and springs were flow gauged between April 2018 and March 2019. The results are summarised in Table 3.1. Any watercourses less than 3cm deep could not be flow gauged due to the limitations of the flow meter.

Table 3.1 Stream flow (m^3/s) measurements

	Week commencing			
Gauging location reference number	**16/04/2018**	**23/07/2018**	**04/02/2019**	**18/03/2019**
1	0.0486, 0.1123	Dry	Dry	Inaccessible
2	0.1245	Dry	Dry	0.1269
5 Upstream of confluence	0.0141	Dry	0.0031	N/A
5 Downstream of confluence	0.0340	0.0053	0.0079	0.0087
7	0.0365	<3cm depth	0.0028	N/A
12	0.0083	N/A	0.0110	N/A
14	0.0086	Dry	0.0072	N/A
16	0.0266	Dry	Dry	0.0066
17	0.0168	Dry	Dry	0.0069
18	0.0155	Dry	Dry	0.0410
19	0.0219	Dry	Dry	0.0152
24 Upstream of confluence	N/A	Dry	0.0612	N/A
24 Downstream of confluence	0.0442	Dry	0.0835	N/A
25	0.0224	Dry	0.0835	N/A
27	0.0474	<3cm depth	0.0595	N/A
29	0.0173	Dry	0.0059	N/A
30	0.0104	Dry	0.0062	N/A
31	0.0080	Dry	0.0026	N/A

	Week commencing			
Gauging location reference number	**16/04/2018**	**23/07/2018**	**04/02/2019**	**18/03/2019**
36	0.0671	Dry	0.0269	0.0462
38	0.1958	0.0332	0.0350	N/A
39	0.1928	0.0425	0.0718	0.0773
42	0.5222	0.0982	0.1721	0.2083
49 Upstream of confluence	0.0560	0.0367	0.0149	N/A
49 Downstream of confluence	N/A	N/A	0.0240	0.0418
51	N/A	0.0069	0.0180	N/A
52	N/A	0.0106	0.0435	N/A
53	N/A	0.0018	0.0018	N/A
54	N/A	0.0031	0.0436	N/A
62	N/A	N/A	<3cm depth	0.0086
64	N/A	N/A	0.0057	0.0185
65	N/A	N/A	0.0057	N/A
68	N/A	N/A	0.0154	N/A
69	N/A	N/A	N/A	0.0035
70	N/A	N/A	0.0065	0.0436
73	N/A	N/A	0.0063	0.0540
75	N/A	N/A	0.0122	N/A
76	N/A	N/A	0.0150	N/A
78	N/A	N/A	0.0510	N/A
79	N/A	N/A	0.0097	N/A
82	N/A	N/A	0.0396	0.0700
86	N/A	N/A	0.0353	N/A
89	N/A	N/A	N/A	0.0595
91	N/A	N/A	N/A	0.0396
G9	0.0080	Dry	Dry	N/A
G10	N/A	N/A	0.0061	N/A
G47	N/A	N/A	N/A	0.0201
G49	N/A	N/A	N/A	0.0418
G192	N/A	N/A	N/A	0.0002

Note: NB indicates the sampling point had not been visited or was too shallow to gauge.

As a result of the dry summer of 2018, over half of the locations gauged during week commencing 23rd July 2018 were recorded as either being dry or having shallow water depth (<3cm). Some of these locations were still recorded as being dry in February 2019 and the majority of those that were flowing had a lower measured flow than in April 2018. In general, flows were greater in March 2019 than in February 2019 at locations gauged in both months.

Norman's Brook tributary accretion profile

The more comprehensive dataset for Norman's Brook tributary on Crickley Hill has been plotted as a flow accretion profile (Figure 3.2). This indicates that the springs identified at locations 18, 19 and 61 supply the headwaters of this watercourse. Locations 18 and 19 were observed to be dry during two of the four visits, which is likely to be primarily due to a reduction in groundwater levels, although flow was maintained at Location 61. Anecdotal evidence suggests that the spring at Location 61 has flowed continuously for a number of years.

The flow accretion profile indicates some flow losses, which implies that the watercourse loses to the underlying aquifer(s) in places (February 2019 sampling points 70, 79 and 82). Aquifer units are likely to consist of more permeable horizons within the landslip deposits on Crickley Hill. These overlie either the Inferior Oolite aquifer or the Lias, including the poorly permeable mudstone of the Whitby Mudstone Formation or the underlying more permeable Marlstone Rock.

Bushley Muzzard SSSI student project

With the assistance of MS2JV, University of Gloucestershire undergraduate students undertook a short hydrological and water quality study of the stream that receives water from springs and streams within Bushley Muzzard SSSI. The study was undertaken to assess baseline flow and water quality impacts due to the current road and potential impacts due to the Scheme. Part of this project involved undertaking a series of spot stream velocity measurements on four days (29 and 30 October, 6 November and 20 December 2018).

The report can be found in Appendix A.

- Location 1 is the outfall from a culvert that runs under the existing road from the land at Stockwell Farm. The culvert may also be receiving drainage from the road and the car park of the Golden Heart public house.
- Location 3 is immediately downstream of the confluence with a stream fed by a series of springs at the foot of the Great Oolite on the eastern side of the valley.
- Location 6 is an ephemeral stream fed by springs and seepages at the base of the Great Oolite.
- Location 10 is at the confluence with ephemeral streams to the west and north west, the latter fed by a spring rising from the foot of the Great Oolite within the SSSI.

As stream flows were not calculated and there are no groundwater monitoring boreholes, it is not possible to fully understand the relationship between surface water and groundwater in this valley. However, some observations can be made:

- The stream velocity measurements indicate that the stream responds strongly to rainfall. Flow at some locations where velocity measurements were more constant during the monitoring period, for example locations 2, 4 and 9, may be more dependent on springs and seepages at the foot of the Great Oolite than elsewhere.
- Although no stream flow measurements were calculated, it is likely that the stream gains and/or loses to the Inferior Oolite that BGS 1:50,000 online geological mapping suggests underlies the stream from Location 3 southwards. (https://www.bgs.ac.uk/discoveringgeology/geologyofbritain/viewer.html?src=topNav) Locations 1 and 2 appear to be underlain by the more impermeable Fuller's Earth separating the Great and Inferior Oolite.

Note that the British Geological Survey (BGS) 1:50,000 sheet 234 solid and drift map dated 1975 shows landslip deposits overlying the Inferior Oolite and Fuller's Earth within this valley. However, these are not shown on the current 1:50,000 online mapping.

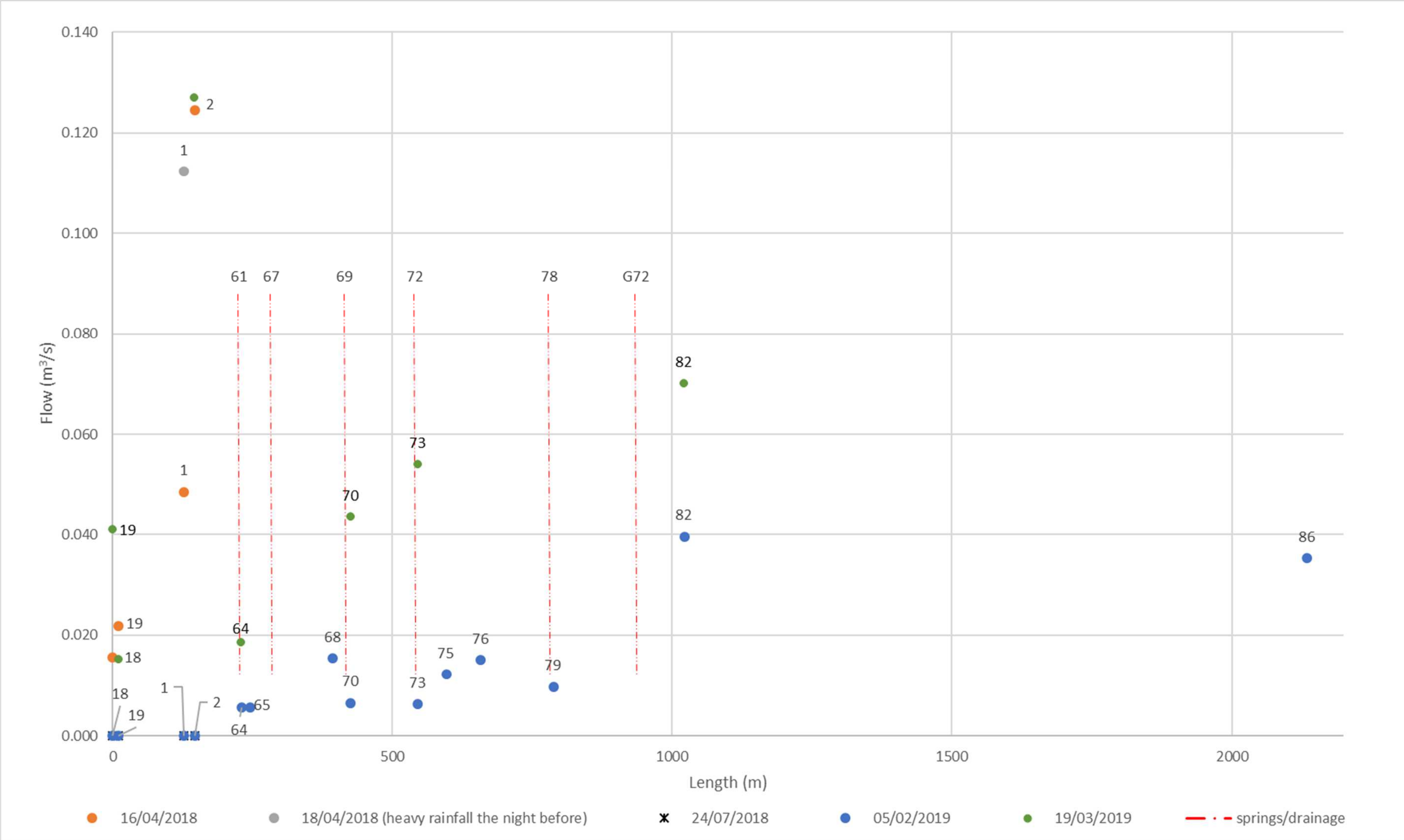


Figure 3.2 – Flow accretion profile of Norman's Brook tributary.

4 Conclusion

A spot flow gauging programme was undertaken in conjunction with the WFS to help understand seasonal variations in stream flow and surface water – groundwater relationships. Flow gauging was undertaken during four site visits between April 2018 and March 2019.

The data provides a good indication of how the watercourses and springs within the study area of the Scheme react to seasonal recharge and changes in groundwater levels.

Over half of the gauged locations were recorded as either being dry or having shallow water depth during the dry summer of 2018. The subsequent dry winter also appears to have impacted flows, with some locations recorded as remaining dry or having lower flows in February 2019.

The flow accretion profile of Norman's Brook tributary (Crickley Hill) indicates that the headwaters of this watercourse are supplied by springs. One spring (Location 61) flows continually although others can become dry. The stream gains and loses water to the underlying aquifer(s) as it flows down Crickley Hill.

5 Recommendations

In order to obtain a more robust dataset, it is recommended further flow gauging is undertaken on a monthly basis for a minimum of a year. This will allow a better understanding of how these watercourses react seasonally and with changing groundwater levels, and the baseline data can be used to assess any potential impacts during and after construction.

Appendix A

A417 'Missing Link' results: Bushley Muzzard hydrological survey.

Jodie Threadingham-Wasley

Acknowledgments: Charlie Bex, Lloyd Carr, Layla Mabrouk and James Rush.

Figure 0.1: Bushley Muzzard, Nettleton Bottom, 2018.

UNIVERSITY OF GLOUCESTERSHIRE
at Cheltenham and Gloucester

SWECO

Contents

1. Main findings 3
2. Introduction 3
3. The site 4
4. Methodology 6
   4.1. Field method 6
   4.2. Water quality 6
5. Results and data analysis 7
   5.1. Site conditions 7
   5.2. pH 7
   5.3. Conductivity 8
   5.4. Flow rate 11
   5.5. Ammonia 12
   5.6. Phosphates and nitrates 12
6. Conclusions and recommendations 14
7. Appendix 1: Day 1 photos 15
8. Appendix 2: Day 4 photos 16
9. Appendix 3: pH chart 18
10. Appendix 4: 3D image draping 19
11. References 20

1. Main Findings

- River is healthy under current conditions
- High precipitation influences higher concentrations of phosphates and nitrates (water nutrients)
- High precipitation does not correlate to influxes of ammonia into the stream
- The pH of the stream meets the standardised water quality baseline recommendations
- Conductivity in the stream is high
- The stream relies on precipitation as the primary inflow.
- Lack of visual aquatic invertebrates may suggest low dissolved oxygen (DO) within the water
- Repeat investigations required.

2. Introduction

This project centred on the need to re-route part of the A417 through an area termed the 'Missing-Link' (Highways England (2018). The problem is the single carriageway that runs from the Cowley roundabout to the Brockworth bypass, as shown in figure 2, which is notorious for its high levels of accidents, pollution and traffic congestion (Highways England (2018). In attempt to resolve the situation, Option 12 of 30 (see figure 2) has been inferred (Highways England, 2018). The development of Option 12 will change the upstream geology ultimately impacting upon the hydrology of the site.

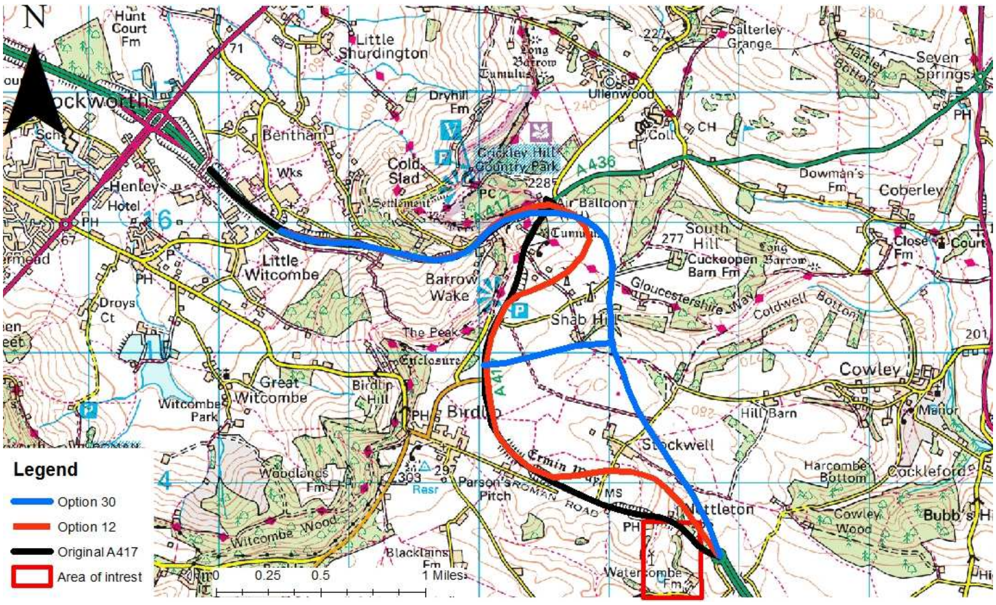


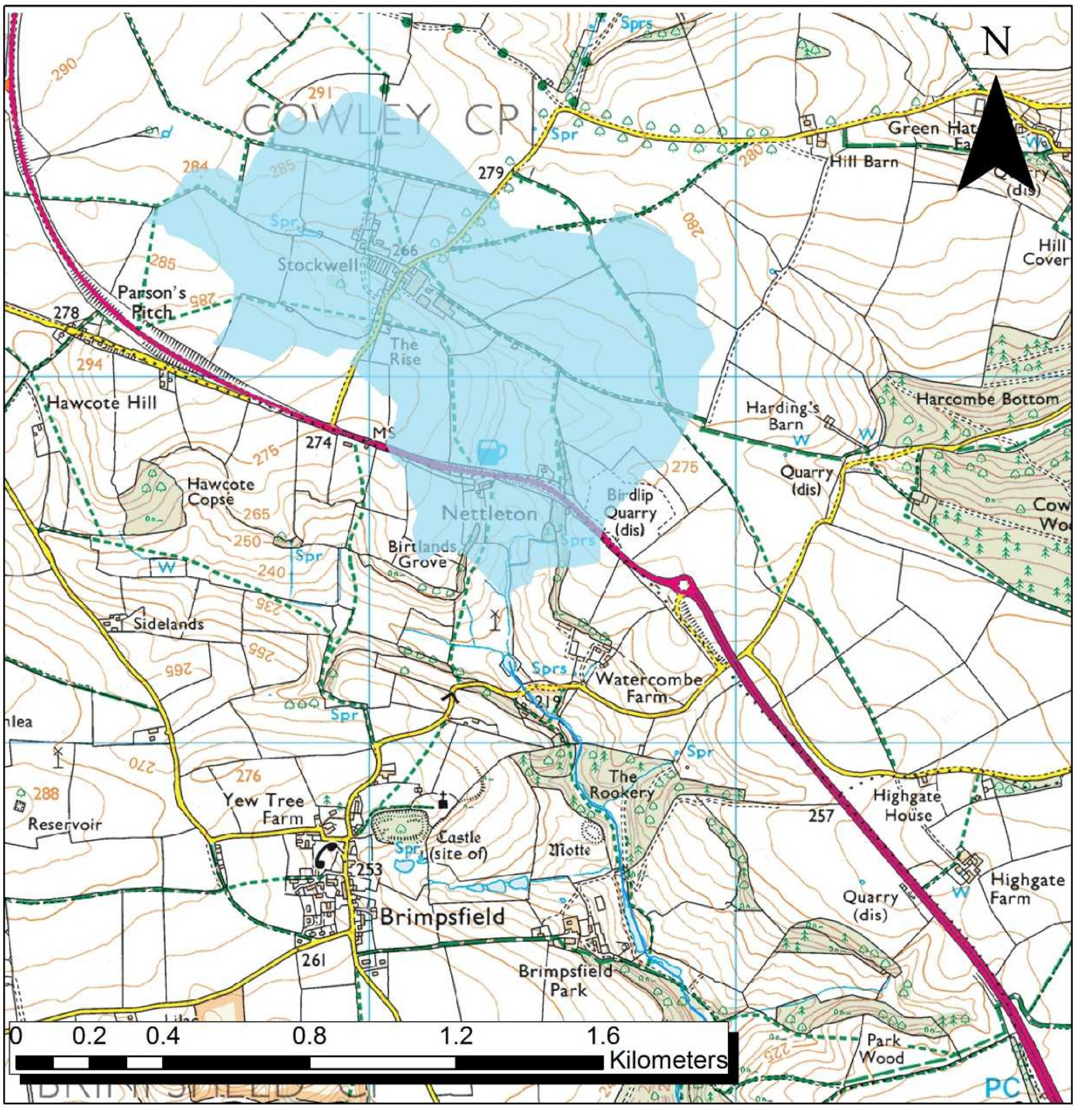
Figure 0.2: Option 12 in correlation to the original A417 route. The area outlined in red is Bushley Muzzard, the site of interest.

This project therefore aimed to examine and assess the hydrological impacts imposed upon the water course in Bushley Muzzard from road development and associated environmental changes. Data regarding flow rate and measures of water quality (ammonia, phosphates and nitrates) was collected allowing for analysis of hydrological base levels.

3. The site

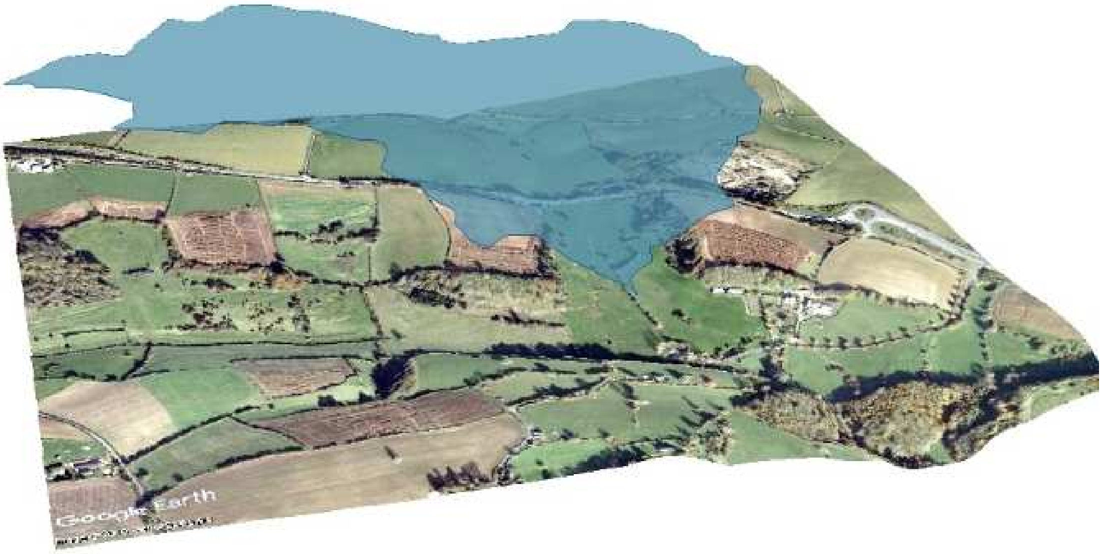
The site of interest was Bushley Muzzard, Nettleton Bottom, Gloucestershire (51°49'08.73"N 2°04'58.73"W) (see figure 3), a SSSI located within the River Frome catchment characterised by its marshland and stream ecology. See figure 4 and 5 for watershed location.

Figure 0.3: Bushley Muzzard with 10 sample sites located onto the stream. Created through ArcMap. It is of note to say that these sample sites do not accurately represent the distance between each location.



1:25 000 Scale Colour Raster [TIFF geospatial data], Scale 1:25000, Tiles: so91_clipped, Updated: 17 May 2018, Ordnance Survey (GB), Using: EDINA Digimap Ordnance Survey Service, <https://digimap.edina.ac.uk>, Downloaded: 2018-11-08 14:28:39.034. OS MasterMap® Topography Layer [FileGeoDatabase geospatial data], Scale 1:1250, Tiles: GB, Updated: 11 July 2018, Ordnance Survey (GB), Using: EDINA Digimap Ordnance Survey Service, <https://digimap.edina.ac.uk>, Downloaded: 2018-11-08 14:28:39.034

Figure 0.4: Watershed of Bushley Muzzard, created through ArcGIS.



PROFILE DTM [TIFF geospatial data], Scale 1:25000, Tiles: SO91SW and SO91SE Updated: July 2018, Ordnance Survey (GB), Using: EDINA Digimap Ordnance Survey Service, Downloaded: 23rd January 2019

Figure 0.5: 3D image drape of the watershed of Bushley Muzzard. Created using ArcScene.

4. Methodology

This survey required both field methods and lab methods for water quality data acquisition and analysis

4.1. **Field method**:

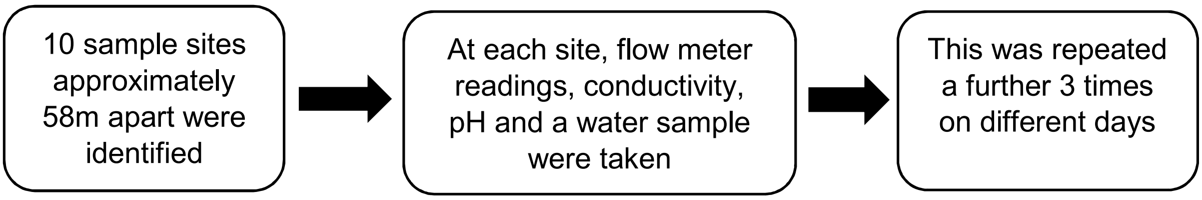


Figure 6: Flow chart of the field methodology.

4.2. **Water quality:**

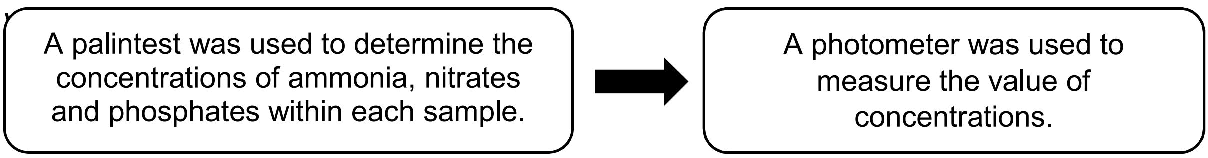


Figure 7: Flow chart explaining the method used to conduct water quality tests.

5. Results and Data analysis
5.1. Site conditions

Table 2: Site conditions of Bushley Muzzard on the date of surveying.

Day	Date	Conditions
1	29/10/2018	Sunny and dry
2	30/10/2018	Sunny and dry. Light rain overnight
3	06/11/2018	Dry, partly sunny. Potential overnight rain
4	20/12/2018	Very wet ground. Heavy rain during the week.

5.2. pH

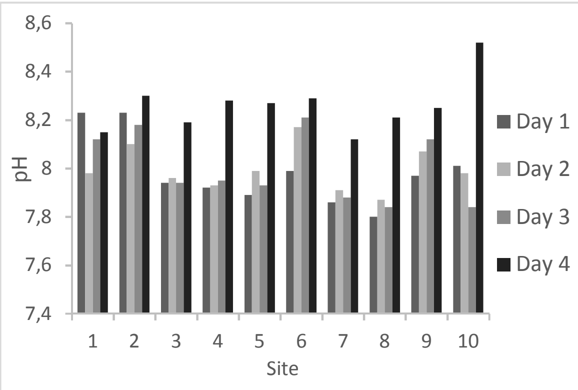


Figure 8: The pH level within each of the 10 sample sites over 4 days, Bushley Muzzard.

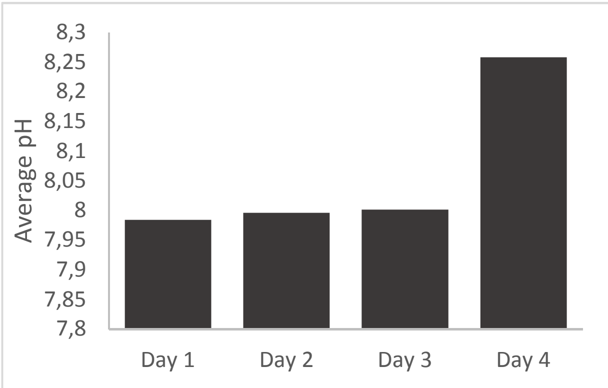


Figure 9: Average pH of the stream across 4 days, Bushley Muzzard.

Results here show that the total values average a pH reading of 8.06 determining a slightly alkaline stream according to the pH scale (appendix 3). In general, the pH during days 1-3 over the 10 sites showed little variance between readings, potentially owing to climatic similarities. Site 1 however on day 1 reflected a higher pH reading as to what was expected considering general result patterns. pH readings on day 4, following heavy rain during the week, recorded the highest values over all sites excluding site 1. Site 6 collectively showed higher values compared to the other sites-potentially due to its differing environmental conditions. Refer to appendix 1 and 2 for site photos.

Bushley Muzzard's marshland characteristics are accommodate anaerobic conditions which may justify the pH level. Because pH and alkalinity are related, it can be assumed that because the stream is just above neutral, its alkalinity is also acting at medium efficiency where it would be able to resist changes in pH that may result from development such as acid rain or other polluting factors. A beneficiary in terms of road development is that the pH ranges at levels that won't damage or corrode any pipes or systems used to redirect the water course. This is specific to Option 12 which will see the removal of Fuller's Earth Formation and Great Oolite approximately 0.25 miles upstream of the site. As the new road would cut through the aquifer, a culvert would have to be constructed under the road as to not obstruct the waterway or cause subsequent subsiding into the softer material beneath.

5.3. Conductivity

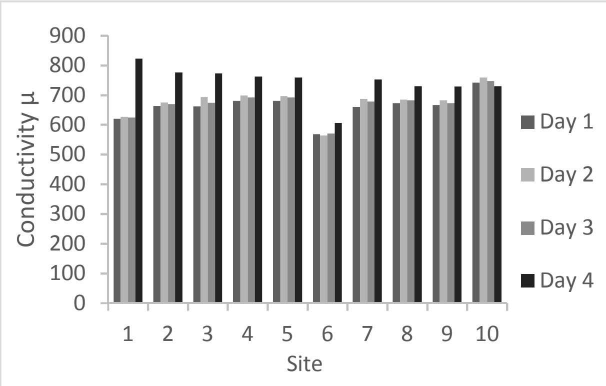


Figure 10: Conductivity within each of the 10 sample site over 4 days, Bushley Muzzard.

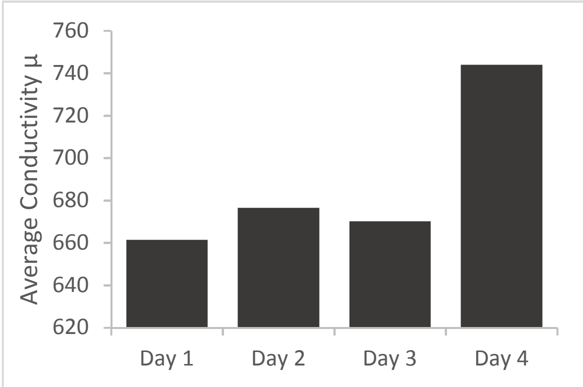


Figure 11: Average conductivity of the stream across the 4 days, Bushley Muzzard.

Although high, the relatively stable values indicate that currently there is minimal change within the water system (during low precipitation) which can ideally be used as a baseline measurement for future conductivity tests for during and post development. Site 6 was the obvious anomaly where conductivity was lower than the other sites. This is potentially reasoned by the site, as seen in appendix 2, being slightly off of the water course and more vegetated than the comparable sites. Further research into the organic content of the site is necessary.

Across each of the 10 sites and 4 days, conductivity appears to have a relatively high level value with an average conductivity of 687.98 µ. For a freshwater stream, conductivity should range between 150 µS/ µS/cm and 500 µS/cm to support aquatic life (Behar, 1997). Immediately, a high value suggest that the stream relies on precipitation as the main input. This can be seen when comparing day 1 photos in appendix 1 to day 4 photos in appendix 2. This value could be influenced by the on-site geology the stream runs through. Forming part of the geological heterogeneity (Eaton, 2006) of Bushley Muzzard is largely Salperton Limestone Formation (part of the Inferior Oolie group) (Gloucestershire Geology Trust, 2016) sequentially bordered by Fuller's Earth Formation and Great Oolite aquifers (See figure 12). Fuller's Earth (mudstone) is an extremely weak bluish grey mudstone with low permeability and has varying levels of thickness throughout the layer (Gloucestershire County Council, 2017). The discontinuity of Fuller's Earth affects the quantity of groundwater storage and thus aquifer productivity in different localities. At Bushley Muzzard, the layer is thick and therefore supports greater water storage. Great Oolite (limestone) also has low intergranular permeability and is present around the site. This geological layer is generally classed as a highly responsive aquifer with large variations according to climatic conditions due to its high transmissivity and low stativity (British Geological Survey, 2018). At this site, transmissivity is high even though the permeability is low due to water being able to drain through the extensive faulting seen within the geology (British Geological Survey, 2018) (see figure 13).

Clay materials contain inorganic dissolved salts (chloride, sodium, magnesium, sulphate, calcium and potassium) that ionise when they are washed into the water. As fuller's earth is expected to be removed during development exposing Salperton Limestone Formation as the ground layer, ground water storage, hydraulic conductivity, and flow (Eaton, 2006) are likely to be affected. Water by precipitation may find different routes through cracks, joints, fissures and pores (British Geological Survey, 2018) diverging some water from reaching the stream. For a precipitation dependant stream, development may adversely affect water content and see higher conductivity due to a reduction in inorganic dissolved salts within the limestone.

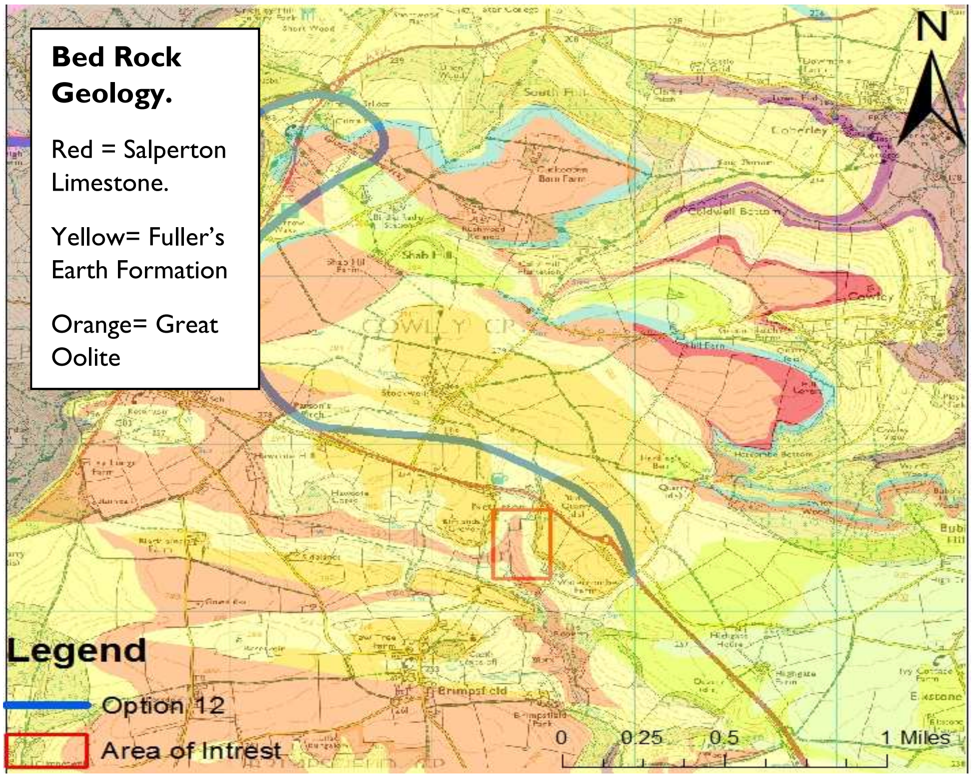


Figure 12: The geology of Bushley Muzzard. Geology data sourced from Digimaps and mapped using ArcMap

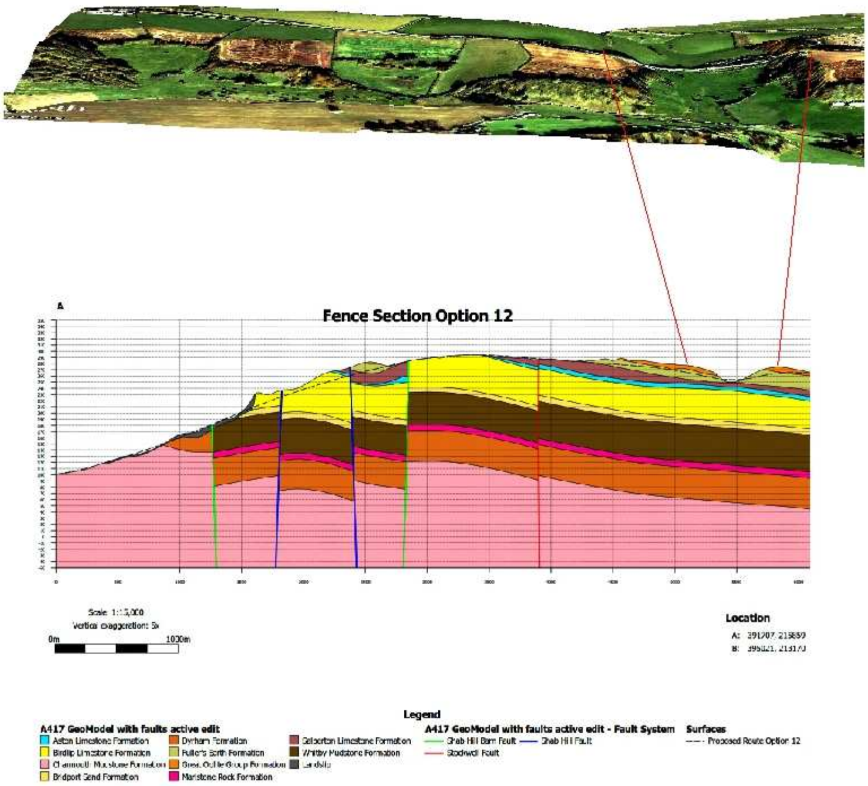


Figure 13: Geology fence of the A417 combined with the 3D model created using ArcScene. (Geology source after an internal source within Sweco, 2018).

5.4. Flow rate m/s

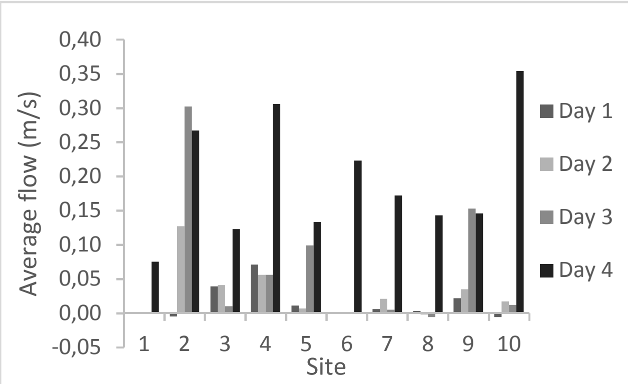


Figure 14: Average flow readings across each of the 10 sample sites over 4 days, Bushley Muzzard.

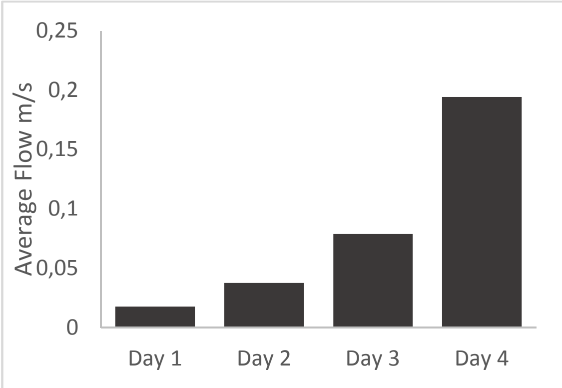


Figure 15: Average flow of the stream across 4 days, Bushley Muzzard.

Considering the stream is dependent on precipitation, the flow rates in this survey can be associated to a dry period during days 1-3. Day 4 showed the largest flow rates resulting from precipitation the week prior. Site 4 maintained a relatively constant flow rate around the 0.05 m/s mark rate during the dry spell which was higher than the majority of neighbouring sites. Low flow conditions do not support much oxygenation within the water and so typically have a low dissolved oxygen (DO) concentration. Algae species typically inhabit low flowing freshwater streams containing large amounts of phosphorus and nitrogen. Linking the low flow rates of Bushley Muzzard to the presence of the dominating phosphate minerals in the stream, it is possible that this watercourse supports vast prokaryote life (see site 7 appendix 2 for aquatic vegetation extent) and therefore potential eutrophication. As the algae dies and undergoes decomposition, a process of Carbonaceous Biochemical Oxygen Demand (CBOD) occurs where dissolved oxygen is consumed, leaving little remaining for other aquatic life (Minnesota Pollution Control Agency, 2009).

Flow rates of this stream have the potential to be affected by the re-routing developments. Excavation would expose Salperton Limestone Formation as the ground layer which will in turn affect the heterogeneity of the site. Lithology, grain size, mineralogy and porosity will change resulting in variations in ground water storage, hydraulic conductivity, movement of water through the ground surface and flow (Eaton, 2006). Salperton Limestone is not very porous and so water may find different routes through cracks, joints, fissures and pores (British Geological Survey, 2018) diverging some water from reaching the stream. This sort of perturbation in the stream's characteristics may negatively affect the SSSI's uncommon floral species such as star sedge, the scarce yellow sedge, flat sedge, marsh arrowgrass, water mint, meadowsweet marsh orchid and the hybrid marsh orchids; *D. fuchsii x incarnate* and *D. fuchsii x pratermissa* (Natural England, 2018). It may also have implications amongst the sedimentology of the stream owing to a change in sedimentary transportation systems within the hydrology. As Bushley Muzzard lies within the River Frome's catchment, this may alter the chemistry and water quality of the river Frome as well as affecting its aquatic ecosystems (NIWA, 2016).

5.5. Ammonia

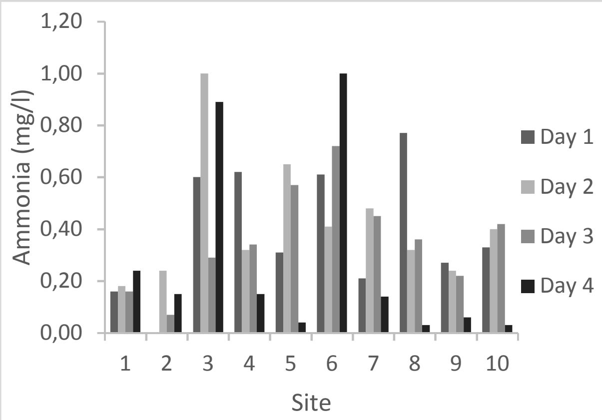


Figure 16: Ammonia concentration with each of the 10 sample sites of 4 days, Bushley Muzzard.

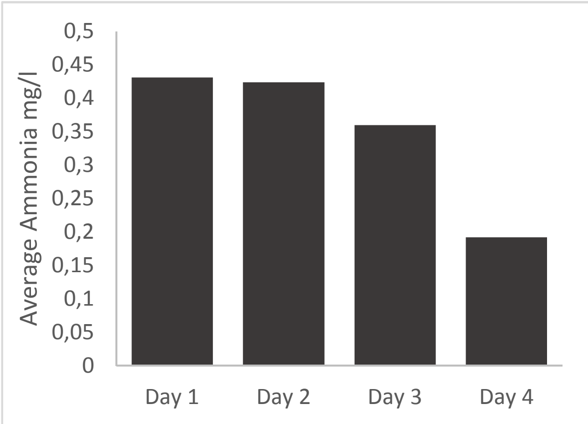


Figure 17: Average concentration of ammonia of the stream across 4 days, Bushley Muzzard.

Ammonia is likely to have entered the stream at Bushley Muzzard through animal waste (cattle) and potentially through agricultural fertilisers as the site is rurally situated. In 2016, variations to a pig farm 4.4km away were undertaken to increase environmental responsibility (Environment Agency, 2016). Whilst it was concluded that the pig farm probably wouldn't affect the SSSI, under new road layout and development, there is the possibility that ammonia from this farm may enter Bushley Muzzard, especially if groundwater is affected. Surface waters can contain up to 12 mg/l (WHO, 2003) which is very high. Levels exceeding 0.1 mg/l (Oram, 2014), which is what the majority of the sites excelled, begin to affect the stream ecology. Ammonia largely affects aquatic invertebrates where high concentrations will either prevent species from inhabiting that site or will increase the mortality of those that do. Site 6 produced the highest quantities of ammonia and it should be of note that on day 4 the results concluded a score of >1 mg/l. Site 6 presented a boggy habitat which can act as an ammonia sink- without conducting an EcIA it is difficult to suggest what species this concentration will impact.

5.6. Phosphates and nitrates

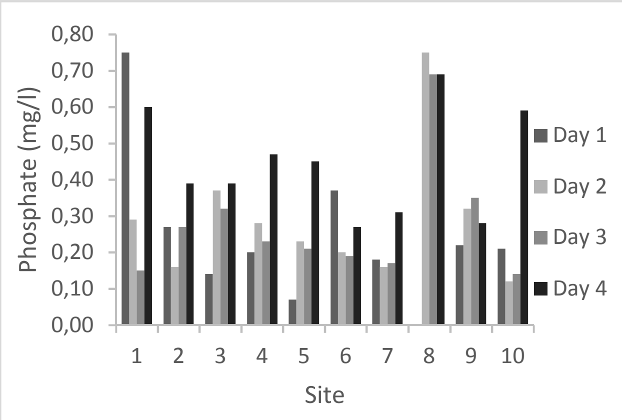


Figure 18: Phosphate concentration within each of the 10 sample sites over 4 days, Bushley Muzzard.

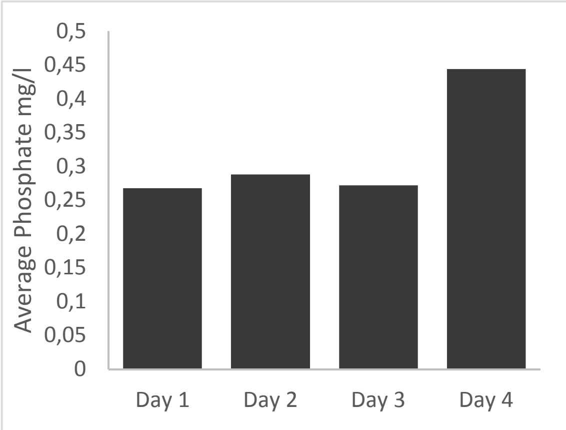


Figure 19: Average concentration of phosphate within the stream across 4 days, Bushley Muzzard.

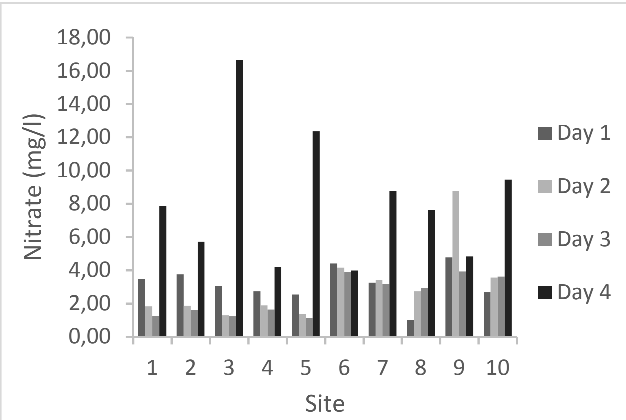


Figure 20: Nitrate concentration within each of the 10 sample sites over 4 days, Bushley Muzzard.

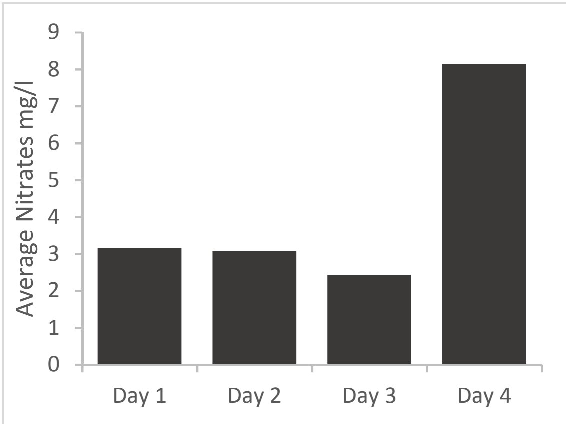


Figure 21: Average concentration of nitrates within the stream across 4 days, Bushley Muzzard.

Both nitrates and phosphates contributes to the nutritional value of a water body. Bushley Muzzard contains phosphates values below 1 mg/l which limits the impacts of high nutrients on the river's ecosystem. However, all sites have an average concentration below 0.05 mg/l which does decrease the likeliness that the river will be affected (Behar, 1997). Site 8 contained the most phosphate with an average level of 0.32 mg/l. Data suggests that rainfall directly constitutes to a large proportion of nutrients through nitrogen and phosphorus that enters fresh water systems. Expectedly, day 4 yielded on most occasions the highest concentrations concluding correct assumptions regarding high precipitation.

Considering that the A417 is one of the most polluted areas (Cotswold District Council, 2018), the significantly higher levels of nitrates found in the stream wouldn't be unexplainable. Base line nitrate concentrations for a fresh water stream can range from less than 1 mg/l to 10 mg/l (Behar, 1997) where 10 mg/l will harm the aquatic environment. Sites 1-5 on the dry spell days 1-3 showed moderate levels of nitrates healthy for a fresh water stream. Sites 6-10 produced higher concentrations of nitrates potentially due to the easier accessibility to cattle at these sites, therefore potentially higher concentrations of animal waste in these areas. During day 4 after high precipitation, nitrate levels were expectedly higher hence causing high nutrient content within the stream. On average over all 4 days, nitrate content was above 1 mg/l which suggests that Bushley Muzzard is a eutrophic stream promoting algae growth and oxygen depletion through decay. As it cannot be determined what aquatic invertebrate inhabit this site and thus cannot suggest what impact the re-routing of the A417 will have upon these, it is suggested that an EcIA survey is carried out along with during and post development surveys to monitor hydrological and ecological impacts.

6. Conclusions and recommendations

Results from this hydrological survey conclude that the status of Bushley Muzzard is currently healthy. The system supports little aquatic invertebrate ecology but supports conditions that accommodates many marine plant species. The relatively neutral pH of the water correlates to the standardised hydrological water quality measures and is what was expected of the water course. Similarly, the current stable conductivity results suggest that there is minimal change within the stream, however this is likely to be affected by the removal of Fuller’s Earth. It can be concluded that this stream relies on precipitation as the main influx of water, and given this parameter, water quality measures of phosphate and nitrate seemingly increases as precipitation increases. This in turn results in higher nutritional fluxes during times of high inflow. In relation to the re-routing of the A417 there is potential that the hydrology of the stream will change, albeit because of a slight redirection of the water course through changes in geology and therefore adjustment of water quality variables or because of variations of water inflows due to urbanisation. Given the uncertainty of the extent of change or affect, it is necessary that repeat investigations using the same methods both during and post development are implemented to fully understand what significance the re-routing, if any, will have upon the SSSI, Bushley Muzzard.

7. Appendix 1: Site photos (Day 1)

Figure 22: Stream conditions at site 1, day 1, Bushley Muzzard.

Figure 23: Stream conditions at site 6, day 1, Bushley Muzzard.

Figure 24: Stream conditions at site 10, day 1, Bushley Muzzard.

8. Appendix 2: Day 4 site photos

Figure 25: Stream conditions at site 1, day 4, Bushley Muzzard

Figure 26: Stream conditions at site 2, day 4, Bushley Muzzard. There was a slight waterfall.

Figure 27: Stream conditions at site 3, day 4, Bushley Muzzard

Figure 28: Rock formation constructed by running water. Found at site 5, Bushley Muzzard

Figure 29: Stream conditions at site 6, day 4, Bushley Muzzard.

Figure 30: Stream conditions at site 7, day 4, Bushley Muzzard. It is of note that the stream showed a bluish colour to it.

Figure 31: Stream conditions at site 8, day 4, Bushley Muzzard. It is of note that the stream showed a bluish colour to it.

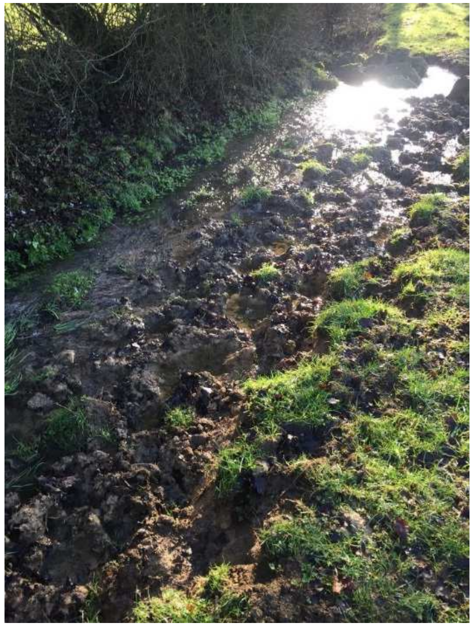


Figure 32: Stream conditions at site 9, day 4, Bushley Muzzard

Figure 33: Stream conditions at site 10, day 4, Bushley Muzzard

9. Appendix 3

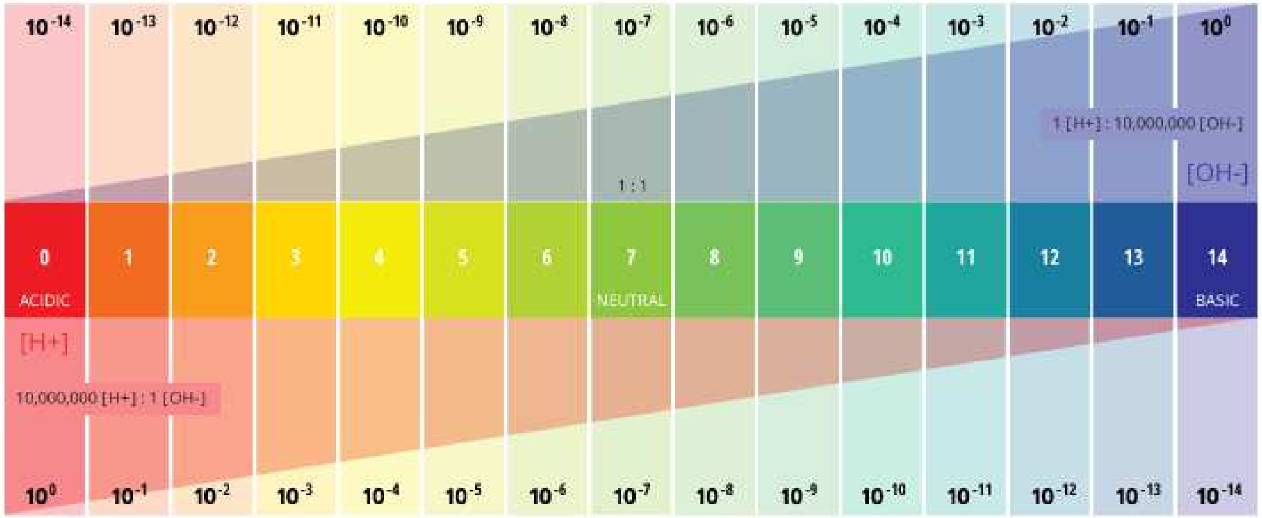


Figure 34: The logarithmic scale of pH. (Source after: Fondriest environmental inc., 2016).

10. Appendix 4: 3D image draping.

PROFILE DTM [TIFF geospatial data], Scale 1:25000, Tiles: SO91SW and SO91SE Updated: July 2018, Ordnance Survey (GB), Using: EDINA Digimap Ordnance Survey Service, Downloaded: 23rd January 2019

Figure 35: 3D image drape of Bushley Muzzard. Image created using ArcScene, 2018.

11. References

Behar, S. (1997) *Base flow vs. storm flow.* Available at: http://fosc.org/WQData/WQParameters.htm (Accessed: 21st January 2019).

British Geological Survey. (2018) *Properties of the Great Oolite and Inferior Oolite aquifers.* Available at: https://www.bgs.ac.uk/research/groundwater/waterResources/thames/limestones.html (Accessed: 2nd December 2018).

Cotswold District Council. (2018) *2018 air quality annual status report (ASR) for Cotswold District Council.* Cirencester, Gloucestershire: Cotswold District Council.

Eaton, T.T. (2006) 'On the importance of geological heterogeneity for flow simulation', *Sedimentary Geology,* 184(2006), pp. 187-201.

Environment Agency. (2016) *Environment Agency permitting decisions.* Available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/497218/Application_Substantial_Variation-_Decision_Document.pdf (Accessed: 22nd January 2019).

FONDRIEST ENVIRONMENTAL INC. (2016) *pH of water.* Available at: https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/ (Accessed: 18th January 2019).

Gloucestershire County Council. (2017) *Ground investigation report: Prison Copse Wall, Northleach.* Available at: https://www.gloucestershire.gov.uk/media/17568/2017-07-28-prison-copse-wall-northleach-gir.pdf (Accessed: 3rd December 2018).

Gloucestershire Geology Trust. (2016) *Cotswolds geology.* Available at: http://www.glosgeotrust.org.uk/cots_geology.shtml (Accessed: 21st November 2018).

Highways England (2018) *A417 Missing Link.* Available at: https://highwaysengland.citizenspace.com/he/a417-missing-link/supporting_documents/A417%20Exhibition%20Boards.pdf. (Accessed: 16th October 2018).

Minnesota Pollution Control Agency. (2009) *Low dissolved oxygen in water: causes, impacts on aquatic life-an overview.* Available at: https://www.pca.state.mn.us/sites/default/files/wq-iw3-24.pdf (Accessed: 19th January 2019).

Natural England. (2018) *Bushley Muzzard.* Available at: https://designatedsites.naturalengland.org.uk/PDFsForWeb/Citation/1003794.pdf (Accessed: 20th November 2018).

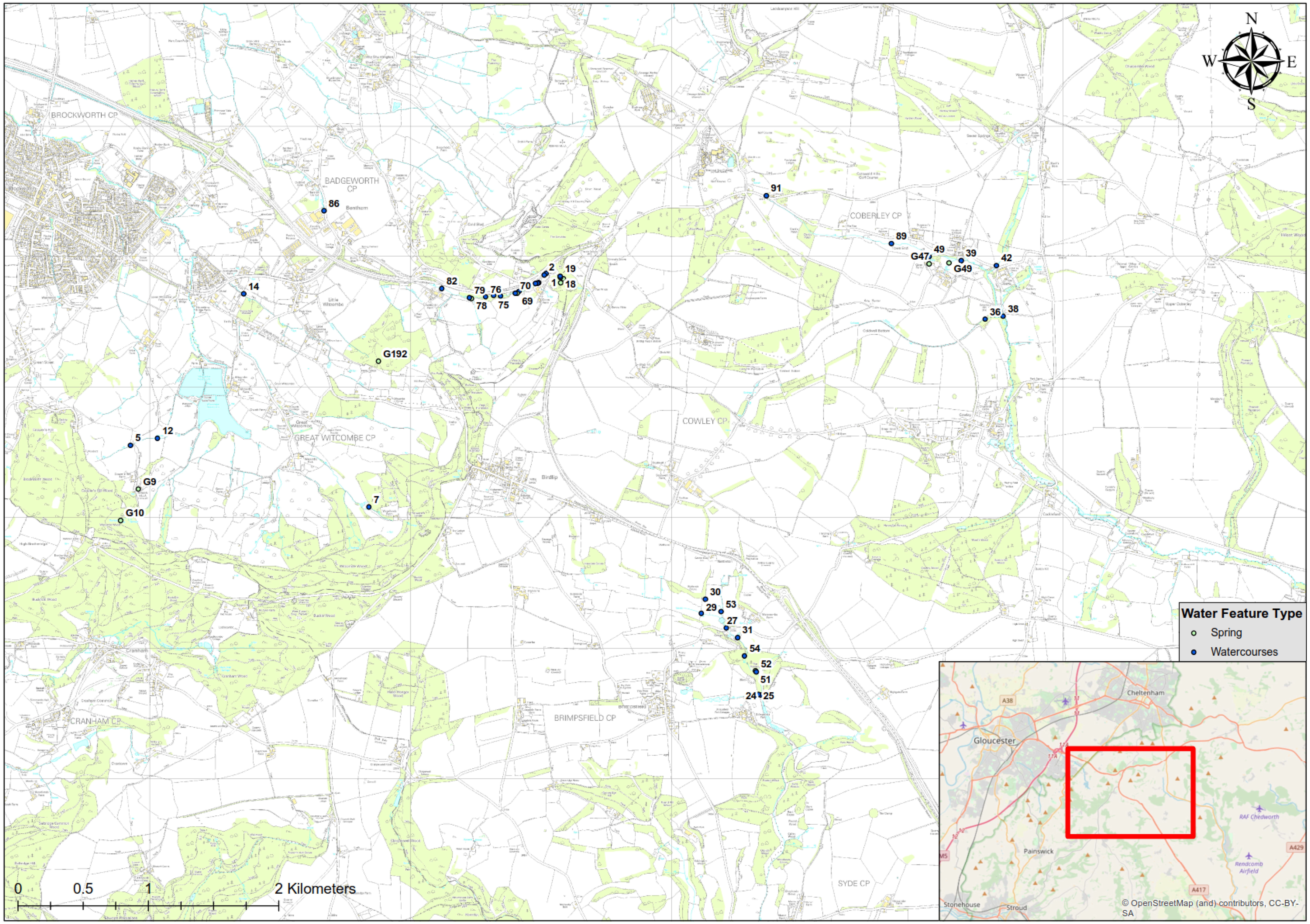
NIWA. (2016) *Sediment: When soils erode, sediments are washed into waterways.* Available at: https://www.niwa.co.nz/our-science/freshwater/tools/kaitiaki_tools/impacts/sediment (Accessed: 7th December 2018).

Oram, B. (2014) *Ammonia in groundwater, runoff, surface water, lakes and streams.* Available at: https://www.water-research.net/index.php/ammonia-in-groundwater-runoff-and-streams (Accessed: 21st January 2019).

WHO. (2003) *Ammonia in drinking water. Background document for development of WHO guideline for drinking-water quality.* Geneva, Switzerland: World Health Organisation.

Water Feature Survey
Gauged Locations

Notes



Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

Mott MacDonald Sweco

Client

highways england

Drawing Status: S01

Suitability: STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY GUAGED LOCATIONS
1 of 5

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size	Date	Date	Date	Date
A3	14/03/19	14/03/19	01/04/19	02/04/19

Drawing Number

HE PIN | Originator | Volume
551505 - MMSJV - EWE -

000 - SU - LV - 00005
Location | Type | Role | Number

Project Ref. No. 551505

Revision P01

FILE LOCATION: F:\U4013\nonproj\Other profit centre projects\A417\Water Feature surveys\Combined Water Features Survey\GIS\IAN184-MapTemplate-A1-ESRI-ArcMap.mxd

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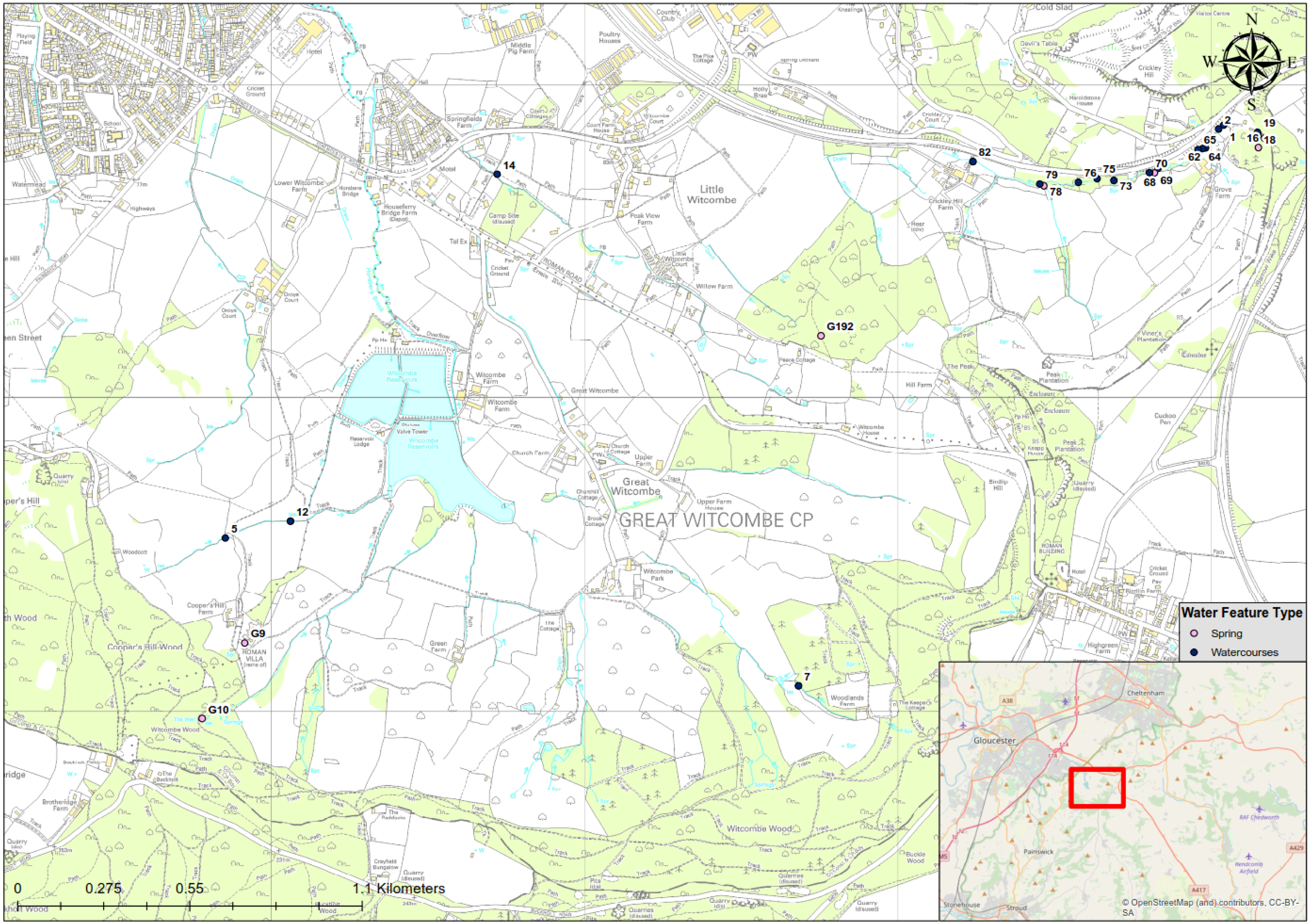

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Project Title
A417 MISSING LINK - PCF STAGE 2

Drawing Title
WATER FEATURE SURVEY GUAGED LOCATIONS
2 of 5

Scale	Designed	Drawn	Checked	Approved
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Drawing Number
HE PIN | Originator | Volume
551505 - MMSJV - EWE -
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Location | Type | Role | Number

Project Ref. No. 551505
Revision P01

FILE LOCATION: F:\U4013\nonproj\Other profit centre projects\A417\Water Feature surveys\Combined Water Features Survey\GIS\AN184-MapTemplate-A1-ESRI-ArcMap.mxd

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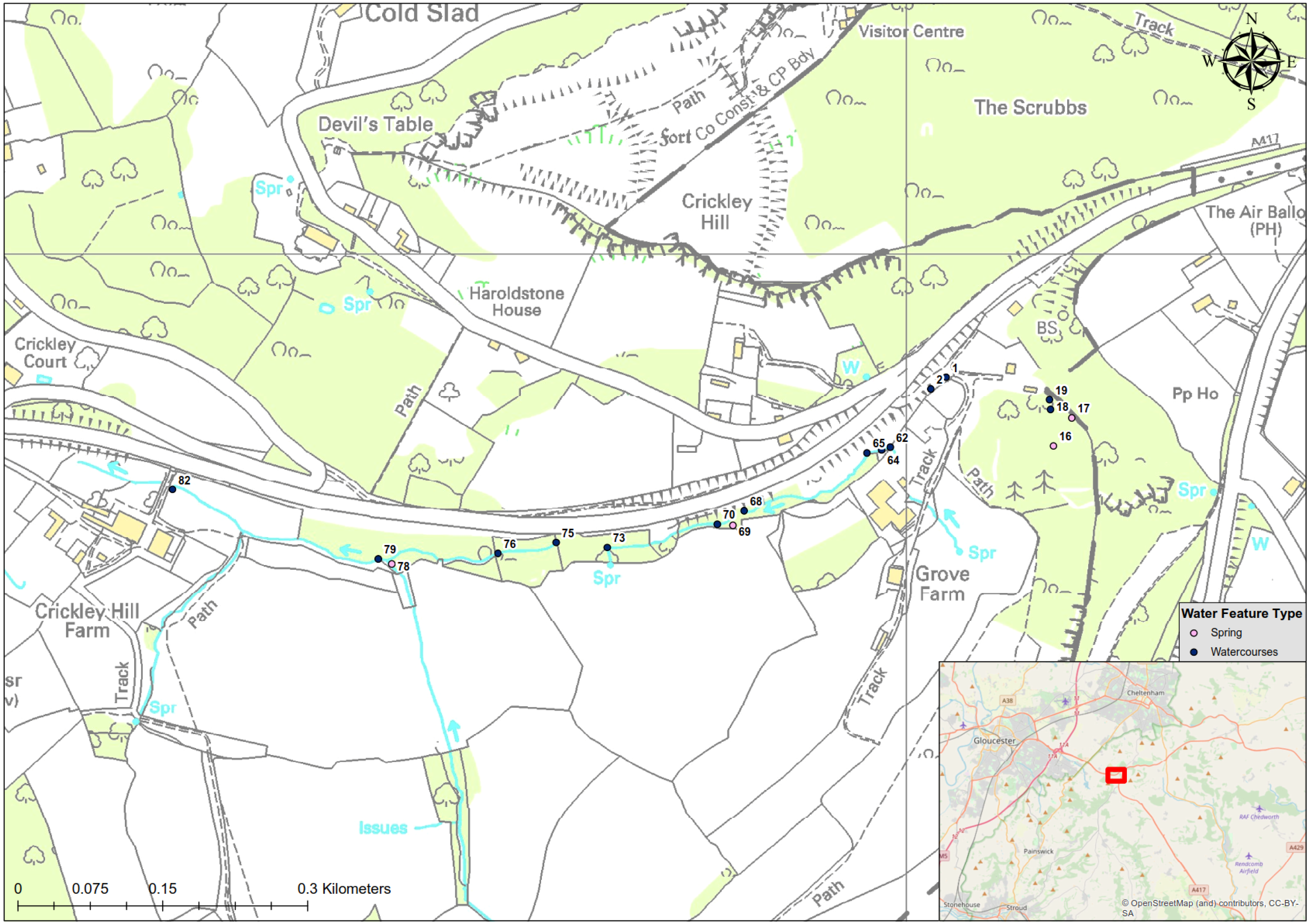

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Drawing Status: S01	Suitability: STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY GUAGED LOCATIONS
3 of 5

Scale	Designed	Drawn	Checked	Approved
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Drawing Number

HE PIN | Originator | Volume

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000 - SU - LV - 00005

Location | Type | Role | Number

Project Ref. No.: 551505

Revision: P01

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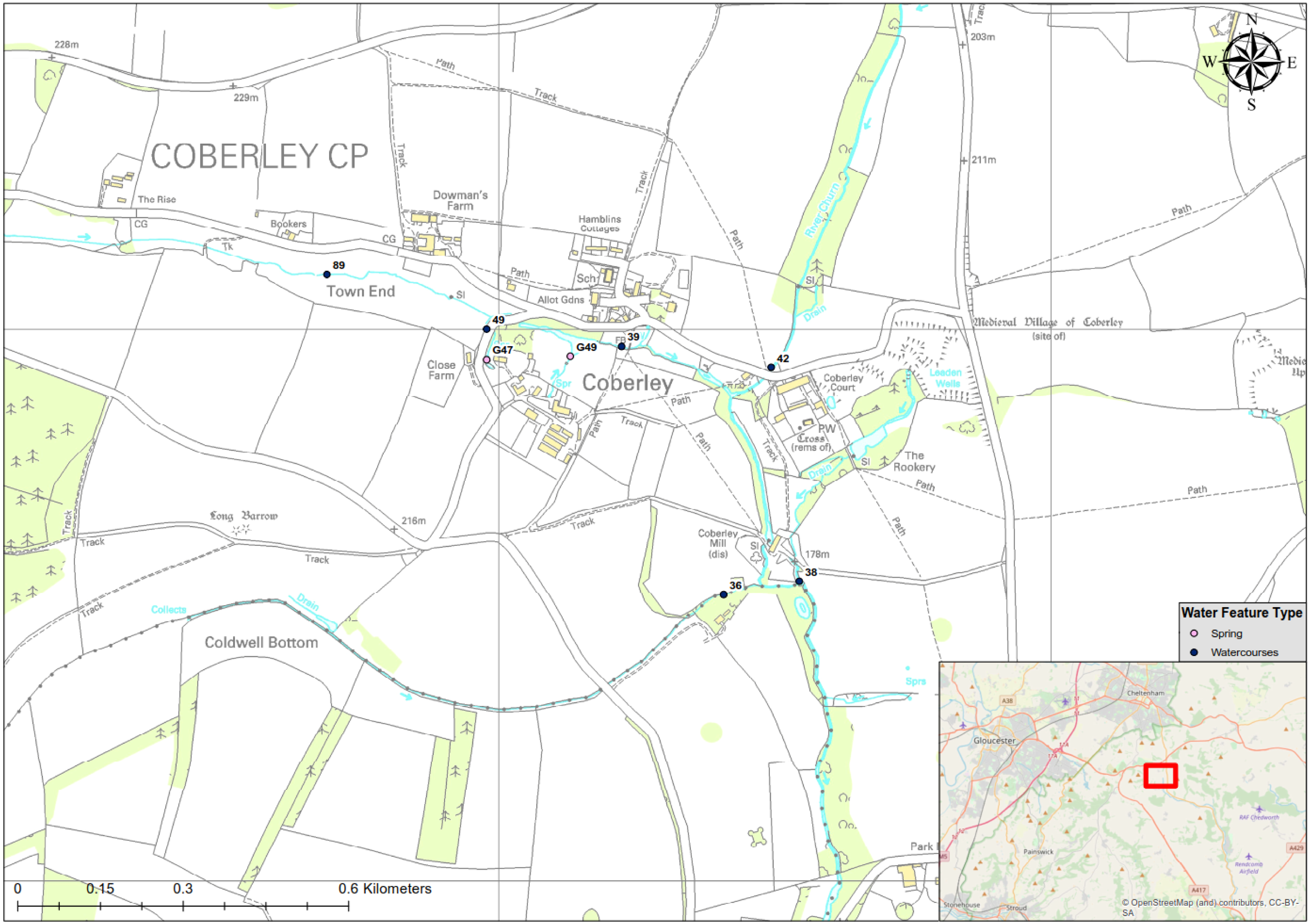

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Suitability: STATUS

Project Title: A417 MISSING LINK - PCF STAGE 2

Drawing Title: WATER FEATURE SURVEY GUAGED LOCATIONS 4 of 5

Scale	Designed	Drawn	Checked	Approved
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Drawing Number: HE PIN 551505 - Originator MMSJV - Volume EWE - Location 000 - Type SU - Role LV - Number 00005

Project Ref. No. 551505

Revision P01

FILE LOCATION: F:\U4013\nonproj\Other profit centre projects\A417\Water Feature surveys\Combined Water Features Survey\GIS\AN184-MapTemplate-A1-ESRI-ArcMap.mxd

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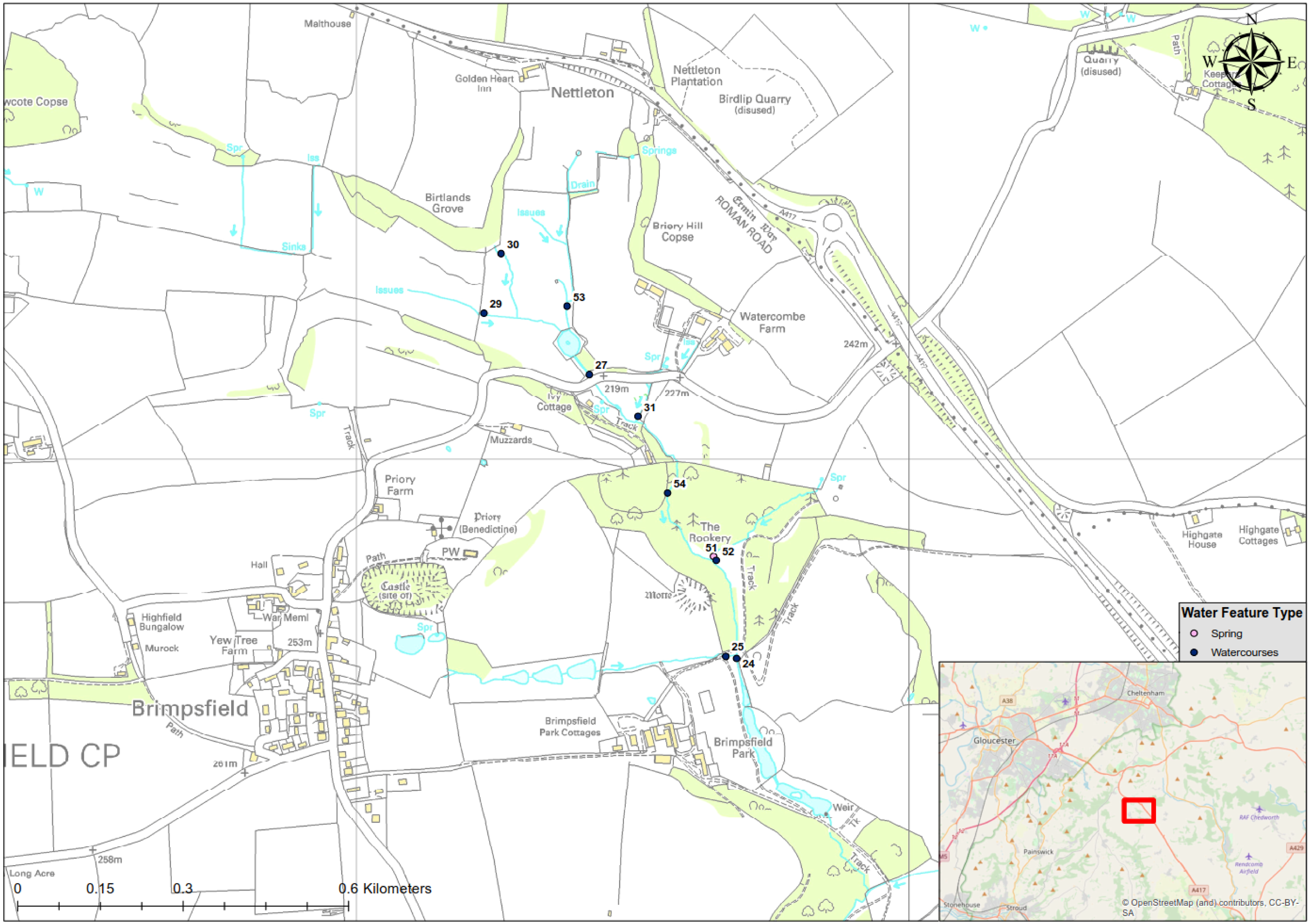

Rev	Date	Amendment Details	Drawn	Chk'd	App'd
P01	MARCH 19	DRAFT	KS	HC	MC

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Drawing Status	Suitability
S01	STATUS

Project Title

A417 MISSING LINK - PCF STAGE 2

Drawing Title

WATER FEATURE SURVEY GUAGED LOCATIONS
5 of 5

Scale	Designed	Drawn	Checked	Approved
	KS	KS	HC	MC
Original Size A3	Date 14/03/19	Date 14/03/19	Date 01/04/19	Date 02/04/19

Drawing Number
HE PIN | Originator | Volume
551505 - MMSJV - EWE -
000 - SU - LV - 00005
Location | Type | Role | Number

Project Ref. No. 551505

Revision P01

FILE LOCATION: F:\U4013\nonproj\Other profit centre projects\A417\Water Feature surveys\Combined Water Features Survey\GIS\IAN184-MapTemplate-A1-ESRI-ArcMap.mxd