

## 5. Risk Assessment

### 5.1. Introduction to the Groundwater Vulnerability Matrix

The information that has been obtained from the assessment outlined in previous section has been used to identify areas more vulnerable to groundwater flooding.

In order to determine the areas that may have an increased risk of groundwater flooding the factors outlined previously have been considered together within a matrix.

The factors that may increase the potential for groundwater flooding include the following:

- Superficial Deposits – The presence of sands and gravels may indicate areas more vulnerable to groundwater flooding. Therefore the percentage of sand and gravel has been considered.
- Bedrock Geology – The underlying geology can indicate on potential risk from groundwater flooding, either via low permeability deposits limiting vertical infiltration from overlying aquifers or through the presence of shallow aquifers.
- Springs – The presence of a spring may indicate where groundwater has emerged in the past and where it could potentially emerge in the future.
- Gradient – This has been considered as it is more likely that ponding will occur on land that is flat rather than land with a steep gradient.
- Historical Flooding – this indicates where flooding has occurred in the past and is considered likely to occur again.

The factors have been combined within a groundwater flooding vulnerability matrix and mapped together on a 100 m grid square map of the area in order to determine localised areas with greater potential risk. Each factor has been separated into ranges and given a scoring for each range. Some factors which are considered to have a greater influence on the potential for groundwater flooding have also been given a multiplying factor. Factors which have been considered to have a greater influence on groundwater flooding include; presence of springs; the percentage of coverage of sand and gravel (superficial); the gradient of the land; and whether historic flooding has occurred.

The overall score is separated into a range and then mapped from a low to high scoring. The methodology for the scoring, the data analysis and mapping process has been included in Appendix D.

#### 5.1.1. Summary of Prioritised List of Groundwater Flood Risk Zones

The groundwater vulnerability matrix (Drawing 5125400/BC/009) categorises the 500 m grid squares covering the area into one of five categories. The categories are based on the combined score of each 100 m grid square. The range of categories is as shown below.

- 0 – 4 – Low Risk
- 5 – 8 – Potential Risk
- 9 – 12 – Intermediate Risk
- 13 – 16 – High Risk
- 17 – 20 – Highest Risk

The range from lowest to highest risk is based on the results from the risk matrix. The lowest risk at 0-4 is the lowest value of the scoring range. The risk has then been evenly distributed based on the scoring range. Low risk areas are considered to be areas where groundwater flooding is considered unlikely. Potential risk areas are considered to have a potential for groundwater flooding due to the presence of one or two factors that may influence groundwater flooding e.g. geology, however they may also be within a steep gradient. Intermediate risk areas may have a number of factors interacting and should be considered within the planning stage specifically during the flood risk assessment stage. The areas identified as high and highest risk are areas which would either require further investigations or consideration of groundwater flooding during the planning stage.

The south of the Cotswold District is shown to be within a high level of vulnerability to groundwater flooding. This is due to the majority of factors which facilitate groundwater flooding as identified in the matrix being present within this area. For example the lower lying land to the south is shown to have areas that have a higher potential risk of groundwater flooding due to a combination of low gradient land, the presence of superficial deposits with a high percentage coverage of sands and gravels and underlying mudstones along with historic flooding.

Within Cirencester there are areas identified as high risk to groundwater flooding. There are sands and gravels present within this area and a number of springs present between the boundary of the permeable limestone and lower permeability mudstone indicating groundwater emergence is likely in this location.

The slope of the Cotswold Hills is shown to have potential risk of groundwater flooding. Although there are limited superficial deposits and the land is sloping south, the risk remains as potential due to the underlying Principal Aquifer and the presence of springs indicating groundwater emergence is a potential risk here. The areas identified as intermediate risk follow the natural valleys of the surface watercourses present which have superficial deposits and flood plains associated with them.



## 6. Conclusions and Recommendations

### 6.1. Conclusions

As the legislation relating to flood risk has highlighted groundwater flooding as an issue, the LLFA are now taking responsibility for the review of groundwater flooding. An intermediate assessment has been completed in order to assess and determine areas within the south Cotswold District which may have an increased risk or higher vulnerability to groundwater flooding and is based on the Strategic assessment of the county wide groundwater flood risk completed in October 2013.

In accordance with the SWMP Guidance<sup>2</sup> the intermediate assessment has been completed and has identified where groundwater flooding hotspots may lie. The majority of the area identified as high risk is within the southern boundary of the Cotswold District Council and therefore the mapping within this area should be utilised to inform emergency planning and to be incorporated within the SWMP and SFRA produced in the future.

The assessment indicates that with regard to the potential risk for groundwater flooding, the underlying geology is the most important factor to consider as it determines the groundwater storage and movement.

The potential for groundwater flooding within the south of the Cotswold District is considered to be a result of one of the following settings:

- Shallow unconsolidated sedimentary aquifers in hydraulic continuity with surface watercourses; or
- Shallow unconsolidated sedimentary aquifers particularly where underlain by low permeability strata limiting further vertical infiltration (in the south);
- Potential perched groundwater table within the Cornbrash Formation;
- Rise of typically high groundwater levels within the bedrock geology to extreme levels in response to extreme rainfall.

A combination of multiple factors was used in order to complete a groundwater vulnerability matrix for the area. The results of the matrix show that the high risk areas are generally low lying with superficial Secondary A aquifer deposits and underlain by unproductive bedrock.

The southern area of the Cotswold District has been identified as having the highest risk for groundwater flooding. The reason behind this designation is the combination of the low lying and flat land, historical flooding (2007 floods), with superficial Secondary A aquifers of 100% sands and gravels overlying unproductive bedrock. The historical flooding has heavily influenced this area as being categorised as having the highest groundwater flood risk. It is unknown as to whether this flood event was a result of groundwater flooding.

### 6.2. Recommendations

Consideration should be given to areas identified as having granular superficial deposits such as the sand and gravel deposits during the planning process and for new developments which include the provision of infiltration SuDS. The superficial deposits might appear suitable for infiltration SuDS; however additional infiltration from such systems could result in raised groundwater levels and potential for groundwater flooding.

Properties with basements or cellars within the sand and gravel deposits should be identified by Gloucestershire County Council.

#### 6.2.1. Groundwater Level Monitoring

Long term groundwater level data is required in order to fully determine the likely risk of groundwater flooding. Groundwater level data for the superficial aquifers is limited therefore; it is recommended that groundwater levels within the superficial aquifers, Northmoor Sand and Gravel Member and Somerton Radley Sand and Gravel Member, are monitored long term. Long term groundwater level monitoring would provide data to determine the suitability of infiltration SuDS. Data from this monitoring would inform the

groundwater flood risk matrix and would also provide additional benefit to the fluvial modelling in terms of considering the groundwater and surface water interactions.

Groundwater monitoring data for the bedrock aquifers should be updated with data from the Environment Agency and ground levels verified. The data available can be used in combination with flood event data and groundwater levels compared to real time flood data in order to determine the presence of trends in the groundwater level data and the timing of flood events.

Groundwater level data should be taken into consideration in potential development plans within the south of the Cotswold District where groundwater flooding may pose a risk to properties which are constructed overlying the superficial geology and where there is potential for foundations to breach confining layers and allow emergence of confined groundwater.



**Appendices**



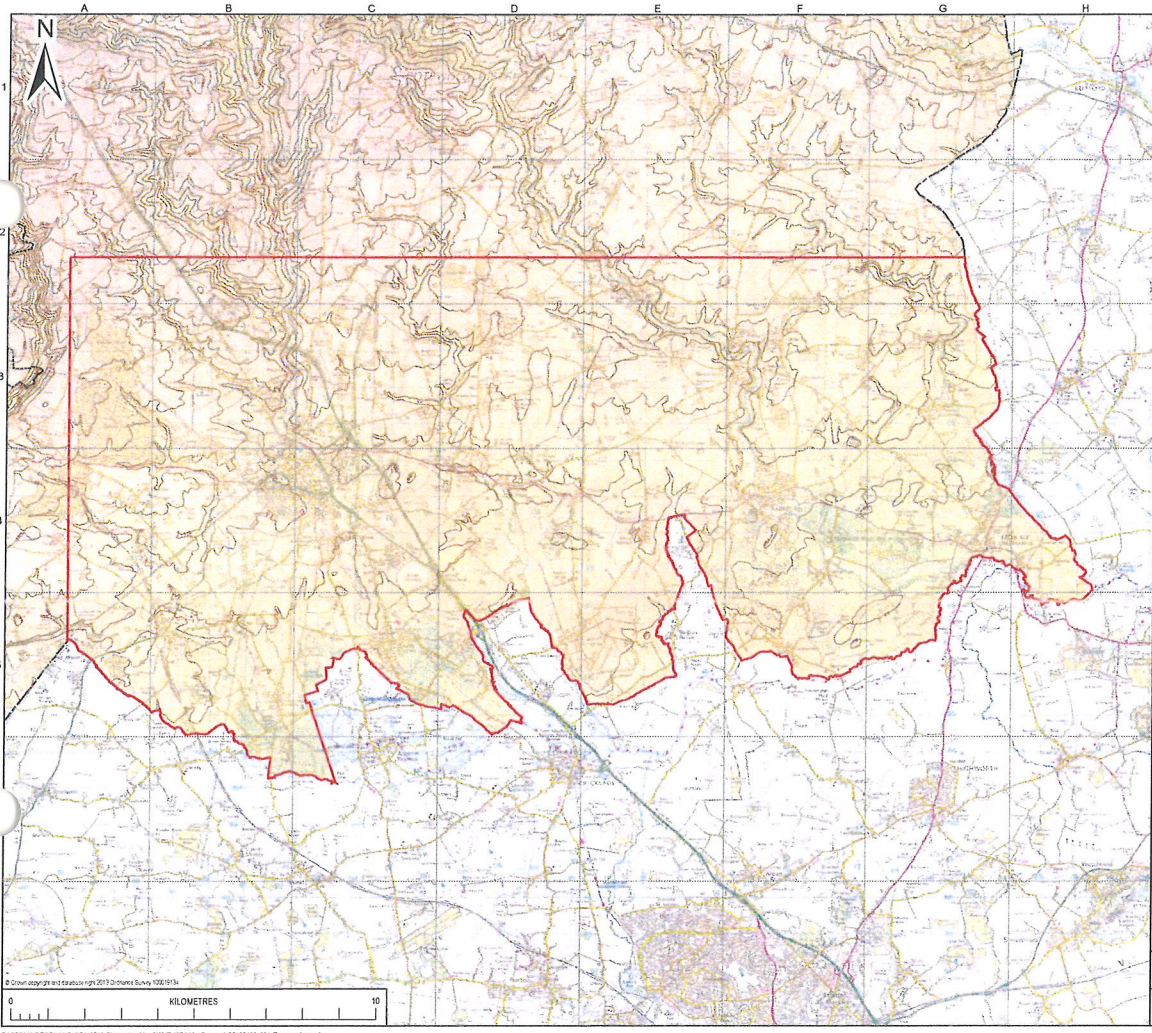
# Appendix A. Data List

**Table A-1 List of Supplied Data**

Source of Data	Data Supplied	Data Coverage
Gloucestershire County Council	1:25,000 OS Raster Maps	Countywide
Gloucestershire County Council	1:50,000 OS Raster Maps	Countywide
Gloucestershire County Council	1:250,000 OS Raster Maps	Countywide
Gloucestershire County Council	Bedrock Geology 1:50,000	Countywide
Gloucestershire County Council	Superficial Geology 1:50,000	Countywide
Gloucestershire County Council	Source Protection Zones	Countywide
Gloucestershire County Council	Aquifer Designations (Superficial)	Countywide
Gloucestershire County Council	Aquifer Designations (Bedrock)	Countywide
Gloucestershire County Council	Surface Watercourse Mapping	Countywide
Environment Agency	Groundwater Level Data	Cotswold District Council

# Appendix B. Drawings





**ATKINS**

**NOTES**  
1. DO NOT SCALE FROM THIS DRAWING.

**KEY**

- Study area
- County boundary
- District boundary

**Elevation (m)**

- > 250
- 200
- 150
- 100
- 50
- 0.142

0	Client Issue	KA	20-03-14	JC	AB	PT
01	Client Review	KA	20-03-14	JC	AB	PT
A	Internal Review	KA	24-03-14	JC	AB	PT
REV	DESCRIPTION	BY	DATE	CHKD	REVA	AUTH

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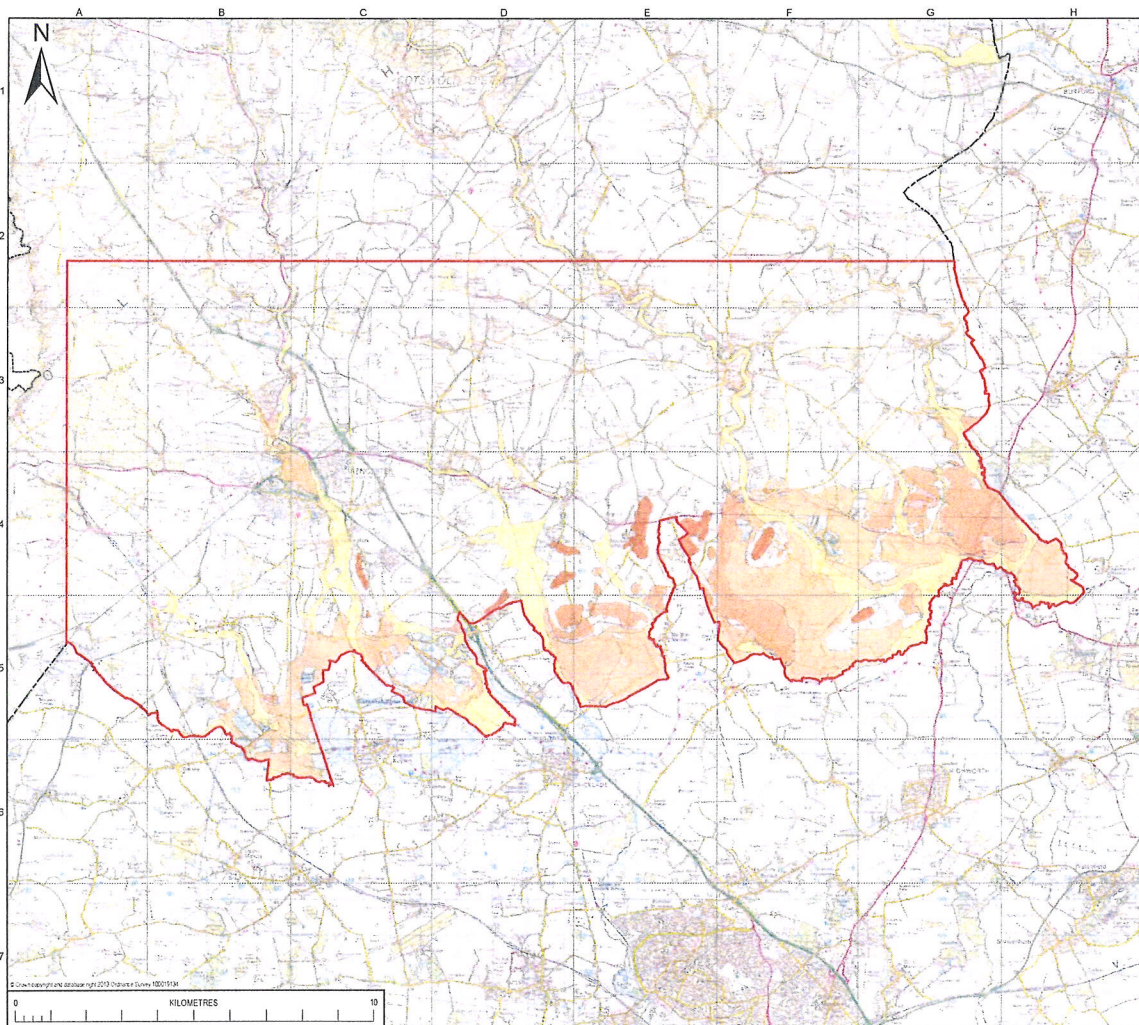
**PROJECT**  
GLOUCESTERSHIRE GROUNDWATER  
MANAGEMENT PLAN

**TITLE**  
TOPOGRAPHY  
COTSWOLD

SCALE	PROJ CODE	PREPARED BY	DATE	REVISED BY	DATE	CHECKED BY
1:100,000	AS	KA	04-03-14	JC	04-03-14	AB
	08BMA	04-03-14	04-03-14	04-03-14	04-03-14	04-03-14
Project No:	5125400/COTS/001					0

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**ATKINS**

**NOTES**  
1 DO NOT SCALE FROM THIS DRAWING

**KEY**

- Study area
- County boundary
- District boundary
- Alluvium 1
- Harbour gravel member
- Head
- Northmoor sand and gravel member
- Northmoor sand and gravel member, lower facies
- Northmoor sand and gravel member, upper facies
- Peat
- River terrace deposits, 1
- Sand and gravel of uncertain age and origin
- Summertown-rady sand and gravel member
- Tufa
- Waverley sand and gravel member

0	Client Issue	KA	20-03-14	JC	AB	PT
1	Client Review	KA	06-03-14	JC	AB	PT
A	Internal Review	KA	04-03-14	JC	AB	PT
REV	REVISED/DATE	BY	DATE	CHK'D	REV'D	APP'D

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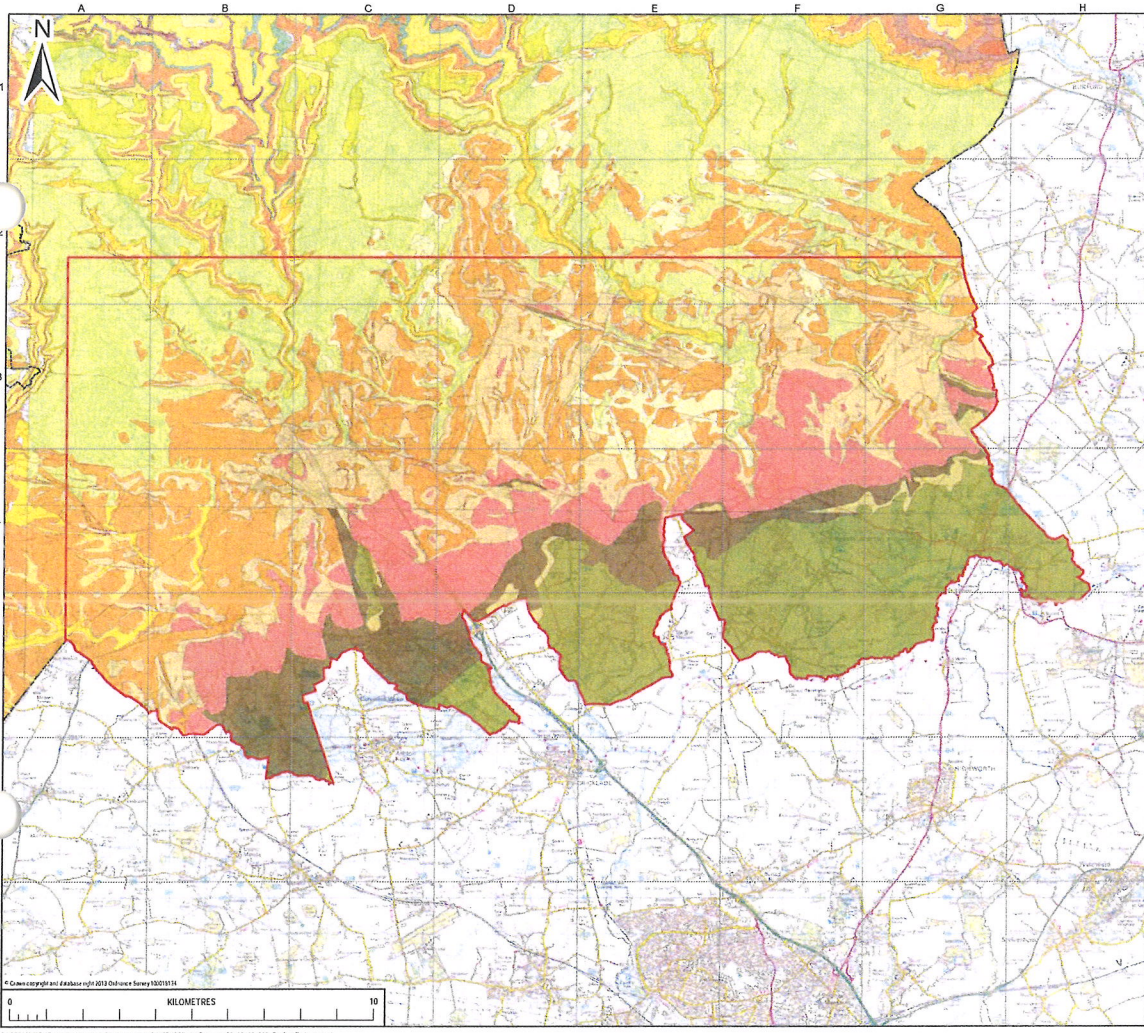
PROJECT  
**GLOUCESTERSHIRE GROUNDWATER MANAGEMENT PLAN**

TITLE  
**SUPERFICIAL GEOLOGY COTSWOLD**

SCALE	PRODUCTION	PRODUCTION	REVISED	REVISED	APPROVED
1:100,000	A3	KA	JC	AB	PT
OFFICE	DATE	DATE	DATE	DATE	DATE
1	08/04/14	04/03/14	06/03/14	06/03/14	
Sheet No	5125400/COTS/002				0

Project: 5125400/COTS/002 Gloucestershire GWMP (AB)10 - Cotswolds 5125400\_002\_GeologySuperficial.mxd





# ATKINS

NOTES  
1. DO NOT SCALE FROM THIS DRAWING.

- KEY**
- Study area
  - County boundary
  - District boundary
  - Altham oolite formation
  - Ashted limestone formation
  - Blue lias formation and chameaux mudstone formation (undifferentiated)
  - Bridgwater oolite formation
  - Combrash formation
  - Chalfeld oolite formation
  - Cleeve oolite member
  - Crickley member
  - Dyham formation
  - Fulke's earth formation
  - Forest marble formation
  - Forest marble formation
  - Hampton formation
  - Kilnseye formation
  - Kilnseye clay member
  - Kilnseye sand member
  - Lockington member
  - Marlstone rock formation
  - Nogive member
  - Oxford clay formation
  - Sigston limestone formation
  - Sigston member
  - Scottish member
  - Typton limestone formation
  - White limestone formation
  - Witley mudstone formation

0	Client Issue	KA	20-03-14	JC	AB	PT
01	Client Review	KA	05-03-14	JC	AB	PT
A	Internal Review	KA	05-03-14	JC	AB	PT
REV	DESCRIPTION	DR	DATE	CHKD	REV'D	ACSH

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**Gloucestershire**  
 COUNTY COUNCIL

PROJECT  
**GLoucestershire GROUNDWATER  
 MANAGEMENT PLAN**

TITLE  
**BEDROCK GEOLOGY  
 COTSWOLD**

SCALE	1:100,000
DATE	04-03-14
PROJECT NO.	5125400/COTS/003
REVISION	0

5125400/COTS/003

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