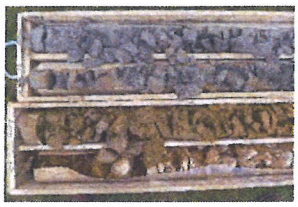
3. Groundwater Monitoring and Review of Flood Risk at Fairford, Water Resource Associates (WRA), November 2018

Fairford Town Council

# Groundwater Monitoring and Review of Flood Risk at Fairford

**Approved Final Report**
**November 2018**



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Cover photographs: Spring in field off Lovers Lane, cable-tool rig drilling borehole B5, A2 core and well-head completion.

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# Summary


## Preamble

Situated in a river basin within the Cotswold Water Park, Fairford has historically suffered many flooding incidents, from overspill from the River Coln but also groundwater, surface water and sewage flooding. Flooding from these other sources has continued since the EA flood alleviation scheme for the River Coln was carried out in 2013, and further investigation was required.

An important part of determining the potential for groundwater emergence or flooding is in understanding the underlying geology and the potential for it to store and transmit groundwater. The geology and hydrology of Fairford is extremely complex; it includes superficial deposits of sands and gravels which may indicate areas more vulnerable to groundwater flooding as a result of prolonged rainfall raising groundwater levels, and also underlying bedrock of much lower permeability, mudstone and limestone which can prevent or reduce infiltration of groundwater from superficial deposits. Fairford also has many springs, where groundwater emerges to the surface, and this gives potential for surface water flooding. There is also a gradient, running roughly NW to SE, which determines the direction of surface water flow. Interaction between these factors increases the potential for flooding. It is likely that groundwater in the superficial layers is recharged by infiltration from rain, runoff and surface water, and also via groundwater from underlying aquifers. This means that when flooding occurs it is slow to subside. It is concluded that SuDS solutions using infiltration are unlikely to be effective in the low-lying areas to the south of the town because of frequent high groundwater levels.

## Background

The Fairford Neighbourhood Development Plan [NP] was rejected in 2017 by the Examiner partly on the grounds that "insufficient hard evidence" had been provided to support the strategy that future housing development should be located on land away from the River Coln. The NP Steering Group therefore commissioned this hydrological study to provide that hard evidence, through the investigation and monitoring of groundwater levels in areas representative of proposed development at Fairford. The work also included a review of documents produced by other consultants and utilities relating to recent flooding in the town.

It was accepted by FTC that the River Coln flood risk has been improved through construction of a new bund and other infrastructure by the Environment Agency in 2013.

## Scope and Objectives

The focus of work has been to gain an understanding of groundwater levels so that future development planning can be sited in appropriate places which are not subject to high groundwater levels, so that can infiltration schemes can operate effectively, using CIRIA guidelines to keep maximum groundwater levels at least 1 m below the bottom of soakaways.

## Mapping and Geology

### Topography

LiDAR data and geological mapping was used to investigate lineaments and micro-relief of the town area which would help in locating monitoring sites and interpreting characteristics of proposed development sites.

### Geology

The Fairford town area is underlain successively by Oxford Clay, Kellaways Sand, Kellaways Clay, Cornbrash Limestone and Forest Marble mudstone. The hydrogeology of the Fairford town area is dominated by the interaction between Cornbrash, Terrace deposits, alluvium and the River Coln, and the buried geological boundary between the Cornbrash limestone and Kellaway Clay is located just south of the urban area.

The Cornbrash Formation is part of the Great Oolite Group and consists of intercalated limestone and marl up to 4.5 m thick with local anomalies, and forms a well-dissected gently-sloping landscape with a uniform dip of one degree.

Superficial deposits consist of river alluvium, glacial head deposits in two valleys on the west side of town, then three terrace deposits [old alluvium]: Northmoor, Summertown-Radley and Hanborough. Most of the town area south of London Road and Horcott Road is characterised by up to 5 m of the Northmoor sand and gravels. The Summertown-Radley terrace is confined to higher areas on the west side of along Cirencester Road and south through Burdocks. There are some remnant higher level terraces of little significance for local groundwater.

### Water Supply

Until 1946, Fairford used to be supplied by a spring issuing from the Cornbrash, at the junction with Forest Marble under Fairford Old Mill with an average yield of 155 $m^3/d$ [1.8 l/s]. Houses which were not included in this network were dependent on wells 2.7 to 3 m deep in the gravel deposits and Cornbrash across the town.

The supply was then replaced by a Thames Water groundwater supply using boreholes from deeper limestone in the Great Oolite Group, leaving the Cornbrash essentially unexploited in the present-day. Groundwater levels in the Burdocks observation well show the impact of groundwater abstraction.

## Groundwater Investigation and Monitoring

### New Observation Boreholes

Three boreholes were drilled in the town area to identify lithology, groundwater presence and thickness of gravel and limestone, terminating in the upper part of Forest Marble mudstone.

- A2 on the edge of the Coln House rugby pitch, to investigate the Summertown-Radley terrace deposits; GL 91.4 mOD; 0-2.8 mbgl superficial deposits, 2.8-7.2 mbgl Cornbrash limestone.
- B2 at the end of St Marys Drive, to investigate groundwater conditions in the Cornbrash limestone; GL 91.2 mOD; 0-1.6 mbgl superficial, 1.6-3.7 mbgl Cornbrash limestone.
- B5 at the junction of Lovers Lane and Leafield Road to investigate Cornbrash springs in the field at that point; GL 94.0 mOD; 0-0.7 mbgl superficial, 0.7-3.4 mbgl Cornbrash limestone.

The boreholes were cased and equipped with sensor-loggers and monitored for six months.

### Well Inventory

Reconnaissance-inventory was carried out of wells and springs in the area, and five dug-wells dipped monthly. This information was supplemented by historical records obtained from BGS and the Environment Agency for three sites:

- Fairford Cinder Lane.... Oct-2002 to Jun-2018.
- Fairford Burdocks, ..... Aug-1996 to Jun-2018.
- Ampney Crucis..... Jul-1993 to Apr-2018 [Dips: Dec-1958 to May-2018]

## Groundwater Assessment

### Groundwater in the Great Oolite and Borehole A2

There is a national index monitoring site at Ampney Crucis which provides the longest local record of 60 years, free from abstraction influence. This borehole is 61 m deep with groundwater level generally within the Forest Marble, and it recorded the highest groundwater levels in 2014, 1982 and 1965, confirming that the 2018 monitoring at Fairford has not been done under extreme conditions. The overall range in GWL at Ampney Crucis is 6.07 m, while the average range is 3.085 m, typical of the 2017-2018 part of the record. Maximum groundwater levels may be about 1 m higher than average winter levels, if not constrained by local spring discharge.

The 2018 range recorded at A2 in Fairford is 1.74 m [83.2 to 84.94 mOD], and regression analysis was used with caution to extend the A2 record using the Ampney Crucis data, showing that average range in groundwater levels at A2 would be 2.3 m, with a maximum value of 85.9 mOD, and freeboard of 1.4 m below ground level of 87.3 mOD.

### Groundwater in Superficial Deposits

The Northmoor terrace outcrops in a broad arc through Horcott and Fairford town south of London Road into the industrial estate and gravel workings. Groundwater levels are monitored by a 4.6m deep borehole at Cinder Lane with a 16-year record. Although groundwater maxima occurred in the winters of 02/03, 06/07, 07/08, 12/13, 13/14, the highest level occurred in July 2007.

The overall range of levels in the Northmoor gravels at Cinder Lane is 2.72 m [78.74 to 81.45 mOD] and ground level is 83.31 mOD. Maximum groundwater levels were simulated for the period 1991-2018, using the available record for the River Coln at Fairford, which showed a T200 freeboard of 1.2 m at Cinder Lane.

Likewise, groundwater levels were simulated for the dug-well records using the Mar-Aug 2018 monitoring period and records at Cinder Lane, Burdocks and Ampney Crucis.

### Cornbrash Groundwater

The Cornbrash limestone is relatively thin and although water levels appear to be high during most winters, the formation dewaters during spring-summer, falling to levels controlled by groundwater in the Coln valley. Two wells in the Cornbrash were monitored and Comrie was dry by 17-July despite having over 2 m of water in the well in winter. Likewise, springs at the junction of Lovers Lane and Leafield Road were flowing in winter, but they also dried up over the same period. Boreholes B2 and B5 were drilled to confirm water levels and the thickness of the Cornbrash in this area.

Since Meysey Hampton abstraction was reduced in 2004, the borehole at Burdocks overflows in winter: however, it would appear that the Forest Marble mudstone prevents vertical rise into the Cornbrash.

### Maximum Groundwater Levels

Extreme value frequency analysis was carried out at Fairford select sites in order to assess potential groundwater flooding and freeboard with reference to the 1 in 200-yr groundwater level [T200]. This showed that levels would exceed ground level at Riverdale and Comrie. While this is likely to be true of the Northmoor terrace, it is geologically less likely at the higher-level Cornbrash site where groundwater maxima will be depressed by peripheral spring discharge, as with the Ampney Crucis record. It can be concluded however that groundwater levels in the Cornbrash will be close to the surface in T200 conditions.

In contrast, the Summertown terrace analysis shows that groundwater rise is contained with more than a metre of freeboard under T200 conditions.

## Implications for Development

### Summertown-Radley Terrace

This terrace deposit of 3.0 to 4.4 m thickness and underlying Cornbrash has permanent groundwater and represented by data from A2 and Coln House dug-well. Although groundwater levels are closer to the surface at Coln House dug-well, the area is unlikely to experience groundwater flooding and maximum levels remain well below ground surface.

Part of the F50 site along the southern boundary and south-west boundary will experience high groundwater levels, where the area lies along the boundary with the Northmoor terrace deposits and valley of the Dudgrove Brook. There is scope for infiltration schemes in the northern portion of F50 and area to the north.

### Northmoor Terrace

Groundwater in the Northmoor Terrace reflects the regime of the River Coln and this will dominate F44. Although Horcott Road forms local high ground which may impede the entry of floodwater directly from the river, F44 is low-lying [83 to 84 mOD], and river flood level is 84.0 mOD, which suggests that F44 would be vulnerable to groundwater emergence from the alluvial deposits. No area can be considered suitable at this location.

The other Northmoor terrace sites are located east of the river at F15, F38, F39C, F39D and F52. These sites may be represented by data for Cinder Lane and the Keble Fields ground investigation. Cinder Lane showed a freeboard of 1.2 m under T200 conditions, particularly where Northmoor deposits overlie the Cornbrash limestone. This suggests that F15 and F39D satisfy requirements and the development area could be larger, whereas parts of sites F39C and F52 are likely not to have sufficient freeboard. F38 is closer to the monitoring well at Riverdale which showed a risk of groundwater flooding in T200 conditions.

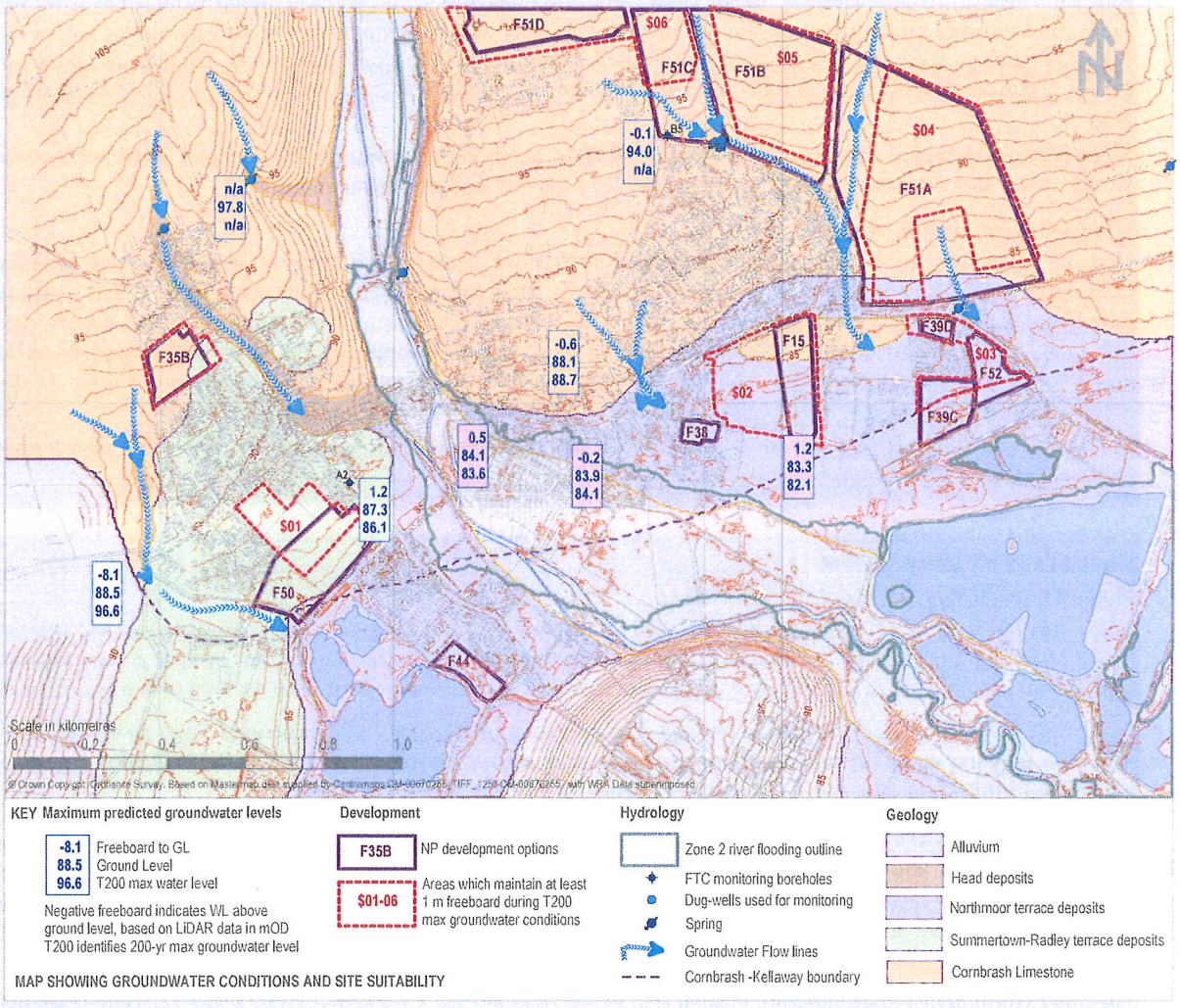
### Cornbrash outcrop

In general terms, the Cornbrash outcrop area is characterised by groundwater levels close to the surface during winter which give rise to numerous springs, followed by progressive dewatering of the formation during the spring and summer recession. Evidence of groundwater discharge was confirmed in the shallow valley infilled with head deposits west of Dynevor Place, which follows a route under Milton Farm and into the Coln. The Milton site F35B is distant from this dry valley, so should have reasonable freeboard during times of high groundwater, as confirmed in the dug-well at Dynevor Place.

At the Leafield sites F51A-C, groundwater levels are artesian and close to the surface during winter at several locations, and geological data was provided by boreholes B2 and B5. The low-lying parts of this area do not achieve the desired freeboard, and would be subject to groundwater flooding.

Fairford Park site 51D is at a higher elevation and should achieve the required freeboard. Groundwater flowlines have been drawn to identify areas which would be expected to have higher aquifer permeability and high groundwater levels during flood conditions.

The following figure shows the groundwater conditions and site suitability.




MAP SHOWING GROUNDWATER CONDITIONS AND SITE SUITABILITY