Kingfisher Pond - Northstowe Hydrogeological Assessment

Phase II Report

FWM8714-RT002-R01-00

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Executive Summary

In 2015 residents in Longstanton reported that water levels in the local Kingfisher Pond had declined. There have been ongoing concerns since then. The year 2015 coincided with initial development at adjacent Northstowe Phase 1.

HR Wallingford has been commissioned by South Cambridgeshire District Council (SCDC) on behalf of Longstanton Parish Council (the client) to complete an independent review on the hydrogeology of Northstowe, Cambridgeshire. HR Wallingford proposed a three phase approach which was:

I. Review the hydrology and hydrogeology of the Kingfisher Pond and surrounding area prior to concerns being raised about its condition (2015) and develop a conceptual model of the area;
II. Review the more recent hydrology and hydrogeology and determine if the Kingfisher Pond has changed since 2015 and, if there is a change then;
III. Determine the cause of the changes in the hydrology and hydrogeology of the Kingfisher Pond.

The Phase I report was completed and distributed to Longstanton Parish Council and South Cambridgeshire District Council in February 2021. That report detailed how the pond and local hydrogeology operates under natural conditions.

The key findings of that report were:

- There is no evidence in the data of a long-term trend of reducing rainfall in the area (1961-2015).
- The pond is sited in drift deposits (known as River Terrace Deposits (RTD)) of sands and gravels which overlay low permeability clay.
- There is limited measured data on water levels in the Kingfisher Pond prior to 2015.
- There are several useful boreholes in the area, which show:
  - That there is no long term evidence of groundwater levels declining before 2015;
  - The water level in the pond is at approximately the same level as groundwater level in the drift deposits.
- There is a pipe which controls the level in the pond when water levels are high.
- Water in the Kingfisher Pond and drift deposits are in hydraulic continuity, meaning that the water levels in the pond will reflect water levels in the drift deposits.

SCDC and Longstanton Parish Council (LPC) were in agreement of the conclusions presented in the Phase I report. The report was distributed to local residents and other stakeholders who were in agreement with the understanding of the Kingfisher Pond's hydrogeology. However there were some comments on the report. To ensure transparency all the comments received regarding the Phase I report have been added to an appendix in a revised Phase I report.

This report completes the **second phase** and presents HR Wallingford's understanding of how the Kingfisher Pond has changed since 2015 and if the groundwater levels and other hydrogeological features

have changed. The report presents climatological data, groundwater records, land-use change reports and observational evidence. The key findings are presented in Box 1:

Box 1: Summary of key findings of the changes to local hydrogeology of the Kingfisher Pond

Our key findings are:

The groundwater levels have been reported on both a regional and local scale. The results show that:

- The chalk observation boreholes at Redlands Farm and Therfield Rectory show that regional groundwater levels were normal during most of the period 2015-2021, yet below normal during 2017 and 2019. The groundwater levels rose to above normal conditions in early 2021. The groundwater levels in these boreholes generally correlate with regional climate.
- Groundwater levels in the RTD in Environment Agency monitoring boreholes do not suggest a significant change in regional groundwater.
- Groundwater levels on the site of Northstowe initially declined in autumn 2015. This followed below average spring rainfall and the dewatering of Northstowe Phase 1A.
- Boreholes monitored on the site of Northstowe show that groundwater levels were below typical levels throughout March 2017 to December 2020. This did not coincide with prolonged dry weather.

Local land use change includes both the construction of the A14 and the construction of Northstowe. Analysis of planning reports show that:

- Construction dewatering of the RTD aquifer to a depth of 5 m below ground level occurred in two phases: Phase 1A in May to September 2015 and Phase 1B in May to November 2016.
- The Northstowe surface drainage strategy comprises of swales and two greenways feeding the clay lined attenuation ponds.
- The urbanisation of the site has reduced the surface area of permeable land available for direct infiltration and recharge of the RTD.

Observational evidence and photographs confirm that the water levels in the Kingfisher Pond and other local ponds initially declined in autumn 2015. The minimum level observed at the Kingfisher Pond occurred in 2017 when the Kingfisher Pond completely dried out. The pond's water levels have remained below normal between autumn 2015 and 2020.

The report concludes that groundwater elevation in the RTD underlaying Longstanton and the Kingfisher Pond have dropped to below normal conditions in the period between autumn 2015 to autumn 2020.Observations in winter 2020/21 show that the water level in the Kingfisher Pond and other water features on the RTD have now risen to near pre construction levels.

What happens next?

We propose a two week review period for stakeholders to consider the contents of this Phase II report. Any comments should be sent to a.wilcox@HRWallingford.com before 23rd April 2021. If these comments change our understanding of the Phase II report we will address them, if not we will begin Phase III of the project which is to summarise the reasons for the changes to the local hydrogeology and the Kingfisher Pond.

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1. Introduction

1.1. Background

Longstanton is a village and civil parish located 10 km north east of Cambridge, Cambridgeshire. Throughout the village there are several water features, including the Kingfisher Pond. The Kingfisher Pond is a large pond with a surface area of 3000 m^2 (when full) and a depth between up to 2.0 m. The pond is a popular site for residents and can support an abundance of wildlife including the pond's namesake Kingfishers which have nested in the banks of the pond. The Kingfisher Pond is located on the main site of Northstowe Phase 1 (52°17'6.53"N, 0° 3'0.60"E) (Figure 1.1).

The water levels in the Kingfisher Pond were reported to decline in autumn 2015, coinciding with a reported decline in water level at several other lakes, ponds and wells in Longstanton. HR Wallingford are reviewing these reported changes in the Kingfisher Pond since 2015. Other hydrogeological features which are located in the RTD are also being reviewed to understand the extent of changes to the local hydrogeology.

HR Wallingford completed and distributed the Phase I report to SCDC and LPC in February 2021. The report was to review the hydrology and hydrogeology of the Kingfisher Pond and surrounding area prior to concerns being raised about its condition (2015) and develop a conceptual model of the area the local hydrogeology. The emphasis of the Phase I report was on the importance of the River Terrace Deposits (RTD) which underlay Longstanton and are the principal water supply to surface water features including the Kingfisher Pond. The RTD are classified as a Secondary A aquifer with significance to local groundwater (WSP, 2014a; Environment Agency, 2017a).

The key findings of the Phase I report were:

- There is no evidence in the data of a long-term trend of reducing rainfall in the area (1961-2015).
- The pond is sited in RTD which consists of sands and gravels which overlay low permeability clay.
- There are several other ponds and lakes also situated on the drift deposits. These will be affected by a change in groundwater level under the assumption they are also in hydraulic continuity with the drift deposits.
- There is limited measured data on water levels in the Kingfisher Pond prior to 2015.
- There are several useful boreholes in the area, which show:
  - That there is no long term evidence of groundwater levels declining before 2015;
  - The water level in the pond is at approximately the same level as groundwater level in the drift deposits.
- There is an overflow pipe which controls the level in the pond when water levels are high.
- Water in the Kingfisher Pond and RTD are in hydraulic continuity, meaning that the water levels in the pond will reflect water levels in the drift deposits. This means that if water levels in the RTD rise then the water levels in the Kingfisher Pond will also rise, up to the level of the overflow pipe. Likewise if groundwater levels in the RTD fall, then water levels in the Kingfisher Pond will fall.

Following the Phase I report, this report describes the change in groundwater level and other relevant information since 2015. This report presents analytical data and observational evidence compiled in the local area from 2015 onwards, the approximate time at which there were reports that the water levels in the Kingfisher Pond had declined.

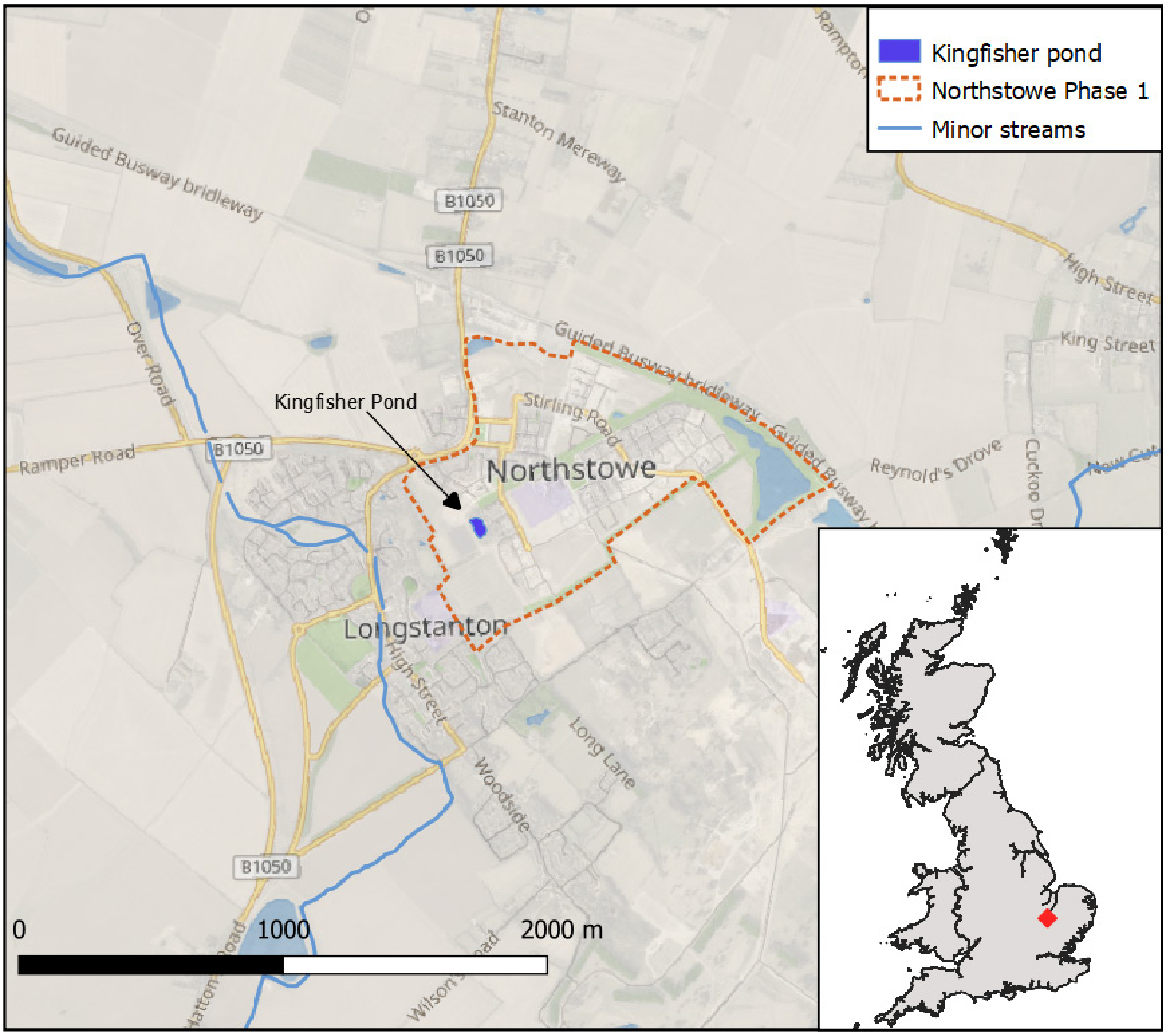

Figure 1.1: Map of Longstanton and Northstowe, highlighting the location of the Kingfisher Pond in relation to Northstowe Phase 1

Source: OpenStreetMap reproduced in QGIS. Map data copyrighted OpenStreetMap contributors and available from https://www.openstreetmap.org.

1.2. Report scope

This report is intended to document the changes occurring in the Kingfisher Pond from January 2015 onwards. The focus of this report is the Kingfisher Pond, however other local ponds within the same hydrogeological system are considered where appropriate. This report does not intend to conclude on causes of changes in groundwater level as this will be included in the Phase III report.

The conclusions within this report are based upon analytical assessment of available data, resident survey results and a site visit. A complete summary of all data obtained is provided in Appendix A.

The report intends to present and analyse available data of the following:

- Local climate data (Section 2)
- Local and regional groundwater data (Section 3)
- Land use change (Section 4).

Additional anecdotal and observational information is provided in the following sections:

- Timeline of the observed changes with accompanying photographs (Section 5)
- Details of the site visit (Section 6).

A summary of all data presented in Sections 2 to Section 6 is provided in Section 7.

The aim of this report is to:

- Analyse and present available climatological data.
- Analyse and present available hydrogeological data.
- Review available literature of planning reports and land use change.
- Provide a timeline of the observed changes in the Kingfisher Pond and other local ponds and lakes.
- Conclude if the local groundwater levels have changed since 2015.
- Outline next steps, including consulting on this document to ensure that all relevant parties have accessed it and agree with it, before Phase III commences.

2. Climate data

2.1. Overview

HR Wallingford's Phase I report presented rainfall data for the period January 1961 to December 2014. The data indicated that though high interannual variability occurred there was no long term trend identifiable. This section focuses on comparing the rainfall from January 2015 to March 2021 with the long term average (LTA).

The data analysed in this section is:

- Cambridge National Institute of Agricultural Botany (NIAB) meteorological station rainfall (Met Office, 2021) located approximately 5 km south east of Longstanton.

The key findings in this section are

- The long term annual average rainfall is 505.0 mm/year.
- The total rainfall occurring between 2015 and 2019 does not indicate an overall increase or decrease in rainfall. However, more detailed analysis shows that there were periods when it was wetter and drier than normal, in particular:
  - Spring 2015 was drier than average, however total rainfall for 2015 was similar to the LTA.
  - Summer 2016 was drier than average, however total rainfall for 2016 was similar to the LTA.
  - Summer and early autumn of 2017 were wetter than the LTA, and the total rainfall for the same year was greater than the LTA.

- Summer 2018 was particularly dry, however high spring and autumn rainfall contributed to annual totals which were within the normal range indicated by the LTA.
- Spring rainfall in 2019 was below average, though autumn rainfall was higher than average which resulted in cumulative rainfall totals being 12 % above the LTA.
- Total rainfall for 2020 was 32 % above the LTA. This continued into early 2021, with January and February rainfall totals above the average for the time of year.

2.2. Rainfall

Cambridge NIAB meteorological station is located approximately 5 km south east of Longstanton and is therefore selected as an appropriate estimate for local rainfall. Table 2.1 shows the long term rainfall as a monthly average recorded at Cambridge NIAB meteorological station. The annual LTA (1961-2020) is 505.0 mm/year. Maximum rainfall occurs in August (53.6 mm/month) and a minimum in February (34.1 mm/month), however the interannual fluctuation associated with this long term average is high as demonstrated in the Phase I report (HR Wallingford, 2021).

Table 2.1 presents the monthly rainfall for each month between January 2015 and February 2021. Monthly rainfall greater than 10% above LTA is highlighted blue. Monthly rainfall lower than 10% below LTA is highlighted orange.

Cumulative monthly rainfall for 2015 to 2020 is presented in for each year in Figure 2.1 and as a six year cumulative total in Figure 2.2. Annual totals for the full period 1961 to 2020 are provided in Figure 2.3.

2.2.1. Review of the data

Table 2.1, Figure 2.1, Figure 2.2 and Figure 2.3 show that:

- The six year cumulative rainfall (2015 to 2021) is generally below the LTA (Figure 2.3).
- **2015:** Rainfall between February and June 2015 was 43.5 % of the term average for this 5 month period. This was followed by heavy rainfall in July where rainfall was 72 % above the July LTA. Rainfall for August and September 2015 was below normal however autumn rainfall for 2015 was comparable to the LTA.
- **2016:** In 2016, the records indicate a wetter than average spring but drier than average summer and autumn. Cumulative annual rainfall for 2015 and 2016 was below the LTA. However the total annual rainfall is within 10% of the cumulative annual total and therefore considered to be within a normal range.
- **2017**: overall rainfall was 19.8% higher than the LTA, with highest rainfall occurring in late spring and summer. This heavier rainfall followed low rainfall recorded in Mach and April.
- **2018**, the overall rainfall was similar to the LTA. However summer rainfall was significantly below average, with only 0.8 mm recorded in June.
- **2019 -2020**: Total rainfall for 2019 and 2020 were all above the LTA. Both years indicated a dry spring but wetter than average autumn.
- **2021:** Available data for 2021 is limited to January and February 2021. At the time of this report, the data for 2021 is indicated a “provisional” on the Met Office database. Initial data indicates that rainfall in January and February in 2021 was 56% above the LTA.

Table 2.1: Monthly rainfall totals recorded at Cambridge NIAB meteorological station

Month	1961-2020 LTA	2015	2016	2017	2018	2019	2020	2021
Jan	45.8	46.7	49.8	48.0	47.4	21.2	49.8	81.0
Feb	34.1	30.8	24.6	43.4	32.0	27.2	66.0	44.6
Mar	37.3	19.4	50.4	29.8	64.2	37.4	18.8	
Apr	40.1	20.2	58.8	12.8	64.6	10.8	29.8	
May	44.8	42.2	39.4	64.8	43.8	41.4	1.6	
Jun	49.5	19.0	66.4	59.0	0.8	79.2	51.0	
Jul	45.9	78.8	18.2	94.8	12.4	33.2	50.6	
Aug	54.5	47.4	44.0	64.2	62.8	35.8	104.0	
Sep	48.4	32.8	45.2	58.6	23.6	70.6	51.4	
Oct	53.4	49.8	19.6	22.4	61.4	78.0	116.4	
Nov	51.6	49.0	56.8	36.6	29.6	57.0	30.8	
Dec	46.4	49.8	25.4	70.8	55.2	75.4	96.5	
TOTAL	505.0	485.9	498.6	605.2	497.8	567.2	666.7	NA

Source: Cambridge NIAB meteorological station (Met Office, 2021)
Monthly rainfall which is greater than 10% above or below the long term average is highlighted blue or orange, respectively.

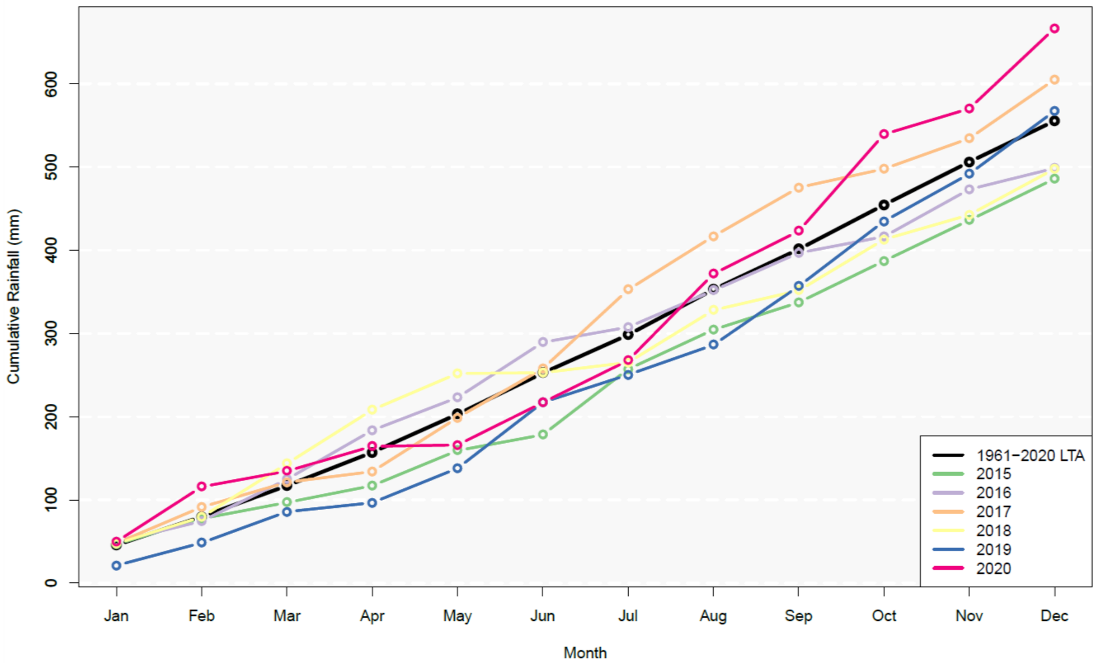

Figure 2.1: Cumulative monthly rainfall at Cambridge NIAB for the LTA 1961-2020 and annual cumulative rainfall for 2015 to 2020

Source: Cambridge NIAB meteorological station (Met Office, 2021)

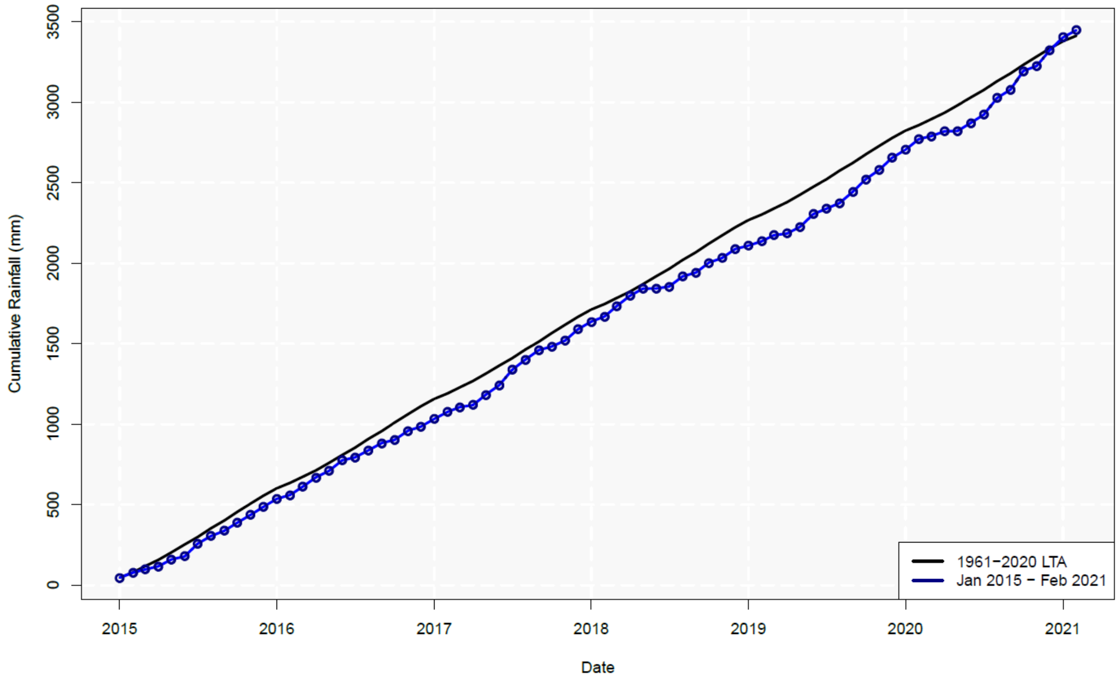

Figure 2.2: Cumulative six year rainfall at Cambridge NIAB 2015 to 2020

Source: Cambridge NIAB meteorological station (Met Office, 2021)

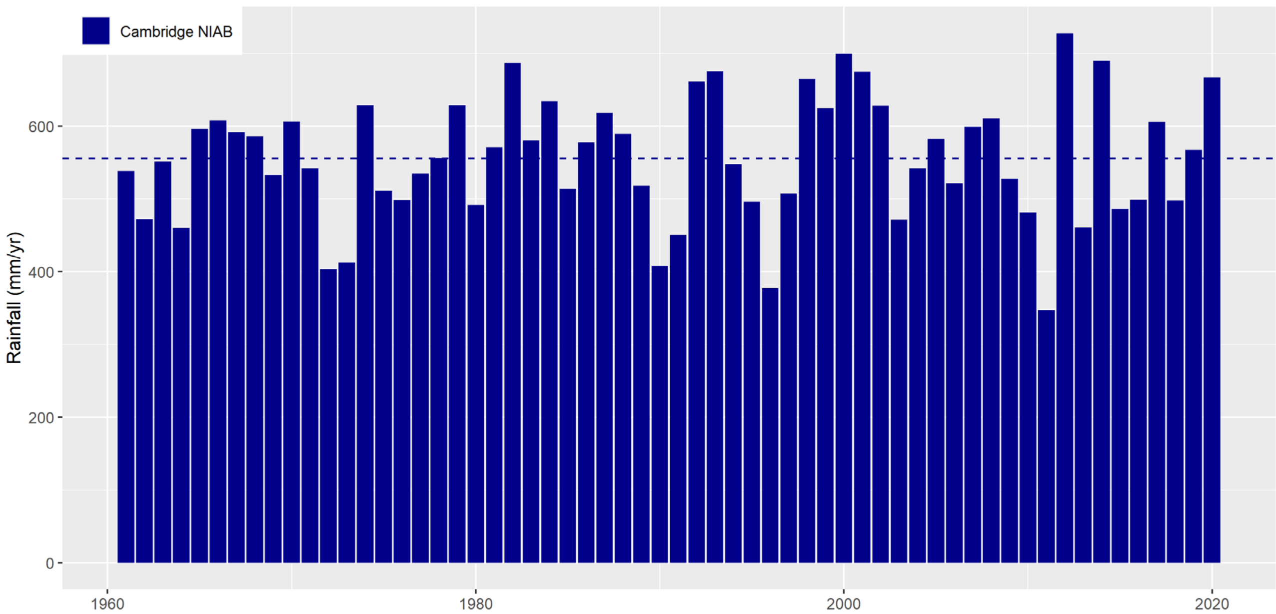

Figure 2.3: Annual rainfall recorded at Cambridge NIAB. Data presented from January 1961 to December 2020

Source: Cambridge NIAB meteorological station (Met Office, 2021)

3. Groundwater elevation

3.1. Overview

Groundwater elevation is reviewed on both a local and regional scale. Regional data is reported for two Environment Agency groundwater index wells situated in the regional chalk aquifer. Local groundwater is reported for Environment Agency monitoring boreholes on the RTD and additionally for monitoring boreholes on the site of Northstowe Phase 1. This is to determine the changes occurring both in the RTD which is in hydraulic continuity with the Kingfisher Pond and additionally to determine trends in groundwater elevation occurring on a regional scale.

The data analysed in this section is:

- Environment Agency monthly water situation reports and groundwater index wells (Environment Agency, 2016; Environment Agency, 2017b; Environment Agency, 2018; Environment Agency, 2019; Environment Agency, 2021).
- Environment Agency monitoring boreholes within 10 km of Longstanton (Environment Agency, 2020).
- Northstowe groundwater boreholes (Wardell Armstrong, 2017; WSP, 2014a, L&Q, 2021).

The key findings of this section are:

- The chalk observation boreholes at Redlands Farm and Therfield Rectory show that regional groundwater levels were normal during most of the period 2015-2021, yet below normal during 2017 and 2019. The groundwater levels rose to above normal conditions in early 2021.
- The Environment Agency monitoring boreholes at Unwin's Farm (Cottenham) and New Farm (Landbeach) located in the RTD do not exhibit any long term change in groundwater level.
- There is limited groundwater data for the period between 2015 and 2017. However, boreholes monitored at Northstowe show that groundwater levels declined between March 2015 and January 2016. However, groundwater elevation recorded on site in January 2016 was similar to that recorded in January 2015.
- The data from the borehole logger (deployed in March 2017) on Northstowe Phase 1 shows that groundwater level remained below the level Wardell Armstrong consider to be typical elevation between March 2017 and December 2020.
- Groundwater levels recorded by the same borehole logger at Northstowe have risen to above the normal levels in January to March 2021.

3.2. Regional groundwater levels

The Environment Agency has a network of groundwater index wells around the United Kingdom (Environment Agency, 2021). The groundwater index wells (or observation boreholes) are regularly monitored and are situated in locations with minimal artificial influences to ensure that the monitored groundwater level is representative of regional conditions. They are used to understand the severity of drought and risk of groundwater flooding.

For the purpose of this report, the two boreholes of interest are Redlands Farm and Therfield Rectory (Figure 3.1). These boreholes are the closest available index boreholes to the Kingfisher Pond. Both of the boreholes are situated in the chalk aquifer and are therefore not representative of the RTD aquifer underlying

Longstanton and the Kingfisher Pond. However, these observation boreholes allow for interpretation of any changes on a regional scale of regional groundwater level as a result of climate.

Figure 3.1: Location map of groundwater index wells and hydrogeology. Location of Therfield Rectory and Redlands Hall is highlighted in the red box

Source: NERC (CEH, BGS) 2017

The Environment Agency publishes monthly situation reports which detail the recent rainfall, groundwater levels and river flows. For the purpose of this report the monthly situation reports for the East of England have been reviewed. Data for the two groundwater index wells of interest (Therfield Rectory and Redlands Hall) between 2015 and 2021 are compiled in Figure 3.2.

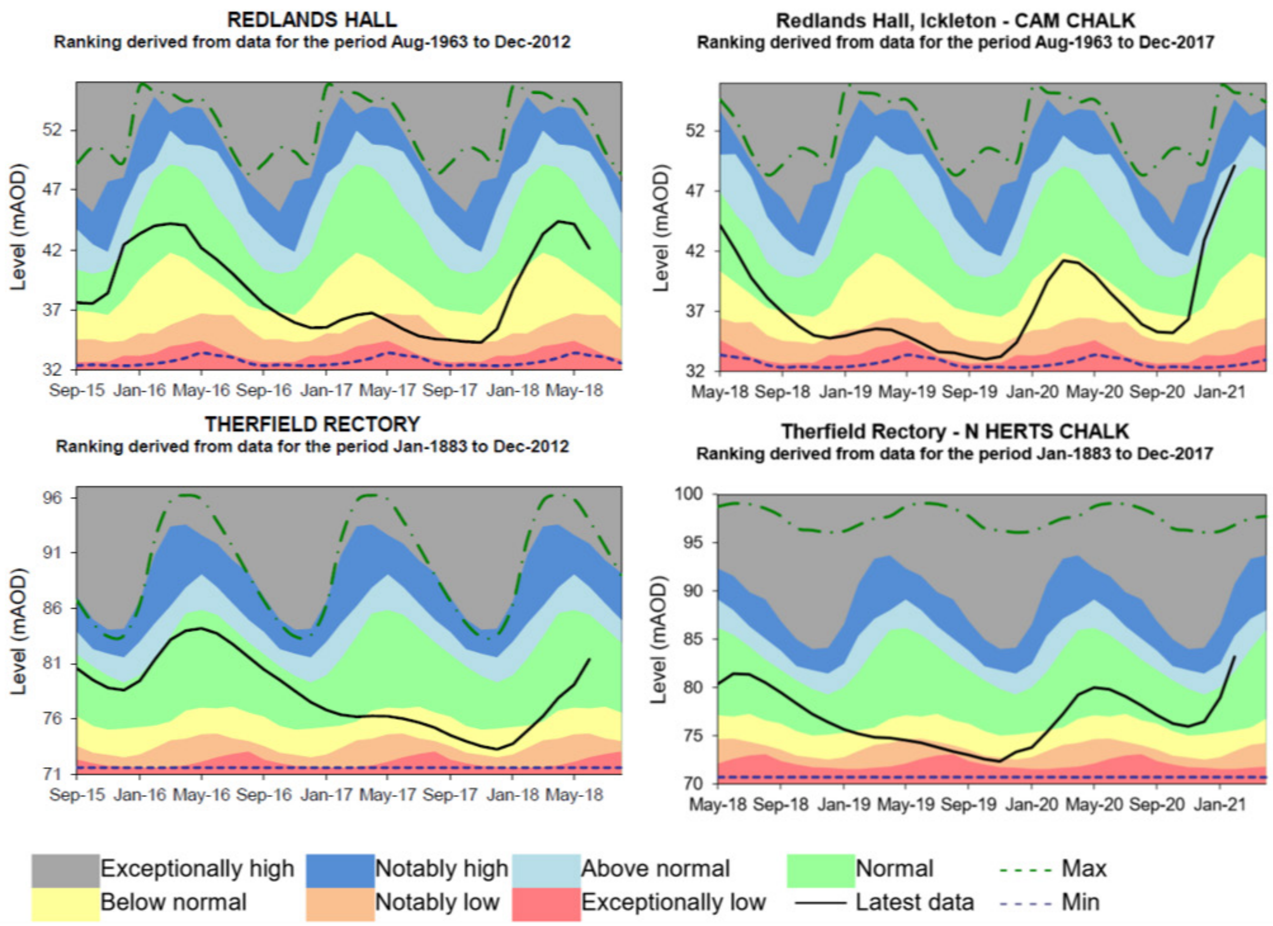

Figure 3.2: Redlands Hall and Therfield Rectory groundwater levels compiled from September 2015 to February 2021

Source: Environment Agency East Anglia Report June 2018, Environment Agency East Anglia Report February 2021

3.2.1. Review of the regional groundwater level data

Figure 3.2. provides the change in groundwater elevation at two chalk groundwater index wells and a classification of the groundwater elevation with respect to normal levels for the time of year.

Here, the period of review is September 2015 to January 2021.

- 2015: The groundwater levels at both index wells are categorised as “normal”. In winter 2015/16 both groundwater index well are notably in the higher band of the “normal” category.
- 2016: The groundwater levels at Redlands Hall fall to “below normal” in autumn 2016. The groundwater levels at Therfield Rectory remain “normal” throughout 2016.
- 2017: Throughout 2017 both groundwater index wells remain “below normal” or “notably low”.
- 2018: In spring 2018, groundwater elevation record at both index wells rises back to the “normal” classification. For Therfield Rectory groundwater index well, the elevation remains in the “normal” category throughout the remainder of 2018. However, Redlands Hall decline sharply in autumn 2018 through to winter 2018/19.
- 2019: Both wells were classified as “normal” or “below normal”.

- 2020/21: Groundwater elevation rose to "normal" for Therfield Rectory but remained "below normal" at Redlands Hall throughout 2020. Winter 2020/21 saw a distinct increase in groundwater elevation at Redlands Hall well and Therfield Rectory well. Both index wells reached "above normal" groundwater levels. This is the first occurrence of "above normal" groundwater elevation recorded within this five year review period.

The monthly situation reports for the East of England attribute the flux in groundwater elevation with regional rainfall. Lower than average rainfall results in a depressed groundwater elevation whereas wetter conditions will raise groundwater elevation. For example, where groundwater elevation was at its minimum in 2019, this coincided with low rainfall. The monthly situation report for the East of England published in January 2019 states that the period May 2018 to January 2019 have been the fourth driest since records began in 1910. Rainfall for the 12 month period prior to 2019 was classified as "below normal" at 86% of the LTA. Groundwater levels recorded at Redlands Hall and Therfield Rectory reflect this trend.

Change in groundwater elevation has a lagged response to regional rainfall. This varies depending on the local geology, antecedent conditions and surface run-off. The results summarised in this section reflect the general regional conditions from notably dry in 2017 and 2019 to above normal in 2021. This information can be used to provide context for groundwater elevation recorded locally in Longstanton but should not be used as a direct comparison between sites.

3.3. Local groundwater levels

The previous subsection describes groundwater levels in the chalk aquifer. This subsection describes groundwater levels in boreholes in the RTD.

In HR Wallingford's Phase I report (2021), the groundwater levels recorded by the Environment Agency at Unwin's Farm and New Farm were presented for all available data up to December 2014. The location of these boreholes is indicated in Figure 3.3. The boreholes are situated in the RTD, overlaying the Gault Formation (BGS 2020c; BGS, 2020d). The data in the Phase I report indicated that, seasonal fluctuations aside, the regional groundwater levels had remained stable in the four decades leading up to 2015.

All data post January 2015 is included in Figure 3.4 and Figure 3.5. A groundwater reading was taken at Unwin's Farm during the site visit in March 2021 and included in the graph presented.

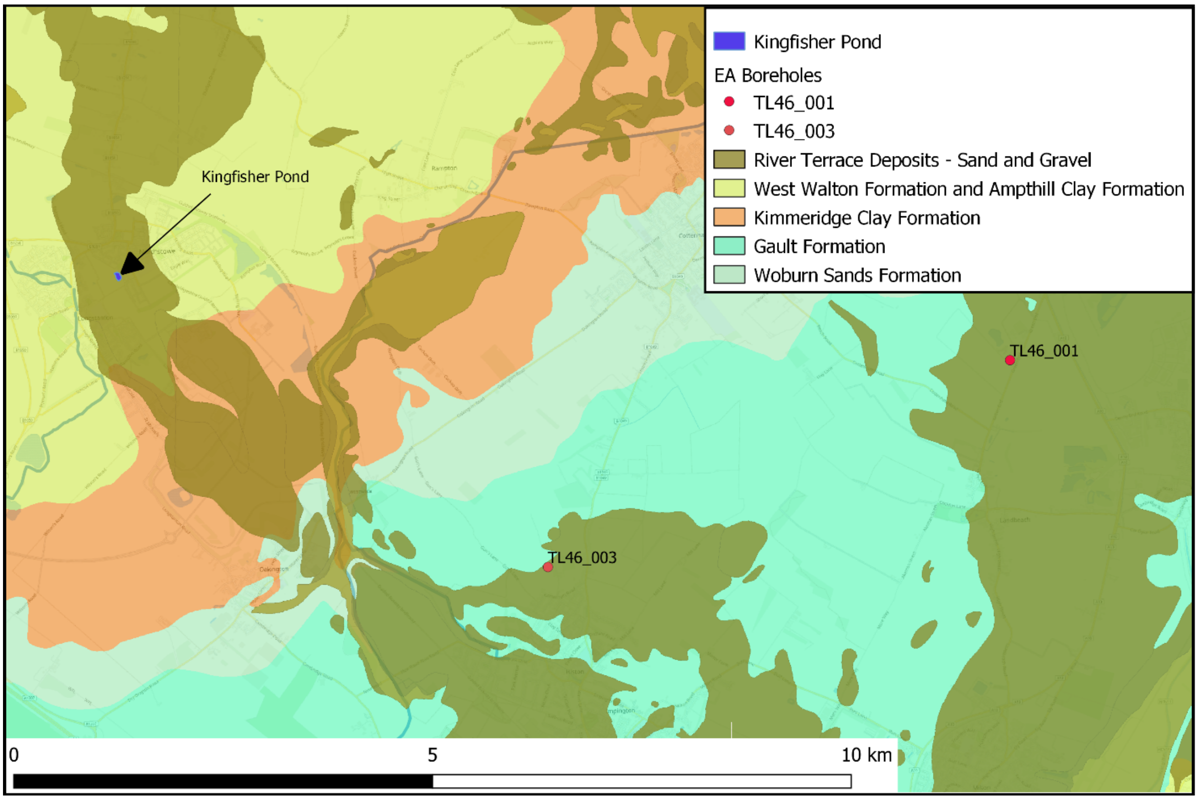

Figure 3.3: Map of boreholes TL46_001 (New Farm, Landbeach) and TL46_003 (Unwin's Farm, Cottenham) in relation to the River Terrace Deposits and the Kingfisher Pond

Source: British Geological Survey 1:50 000 drift and bedrock geology, reproduced in QGIS. All rights reserved.

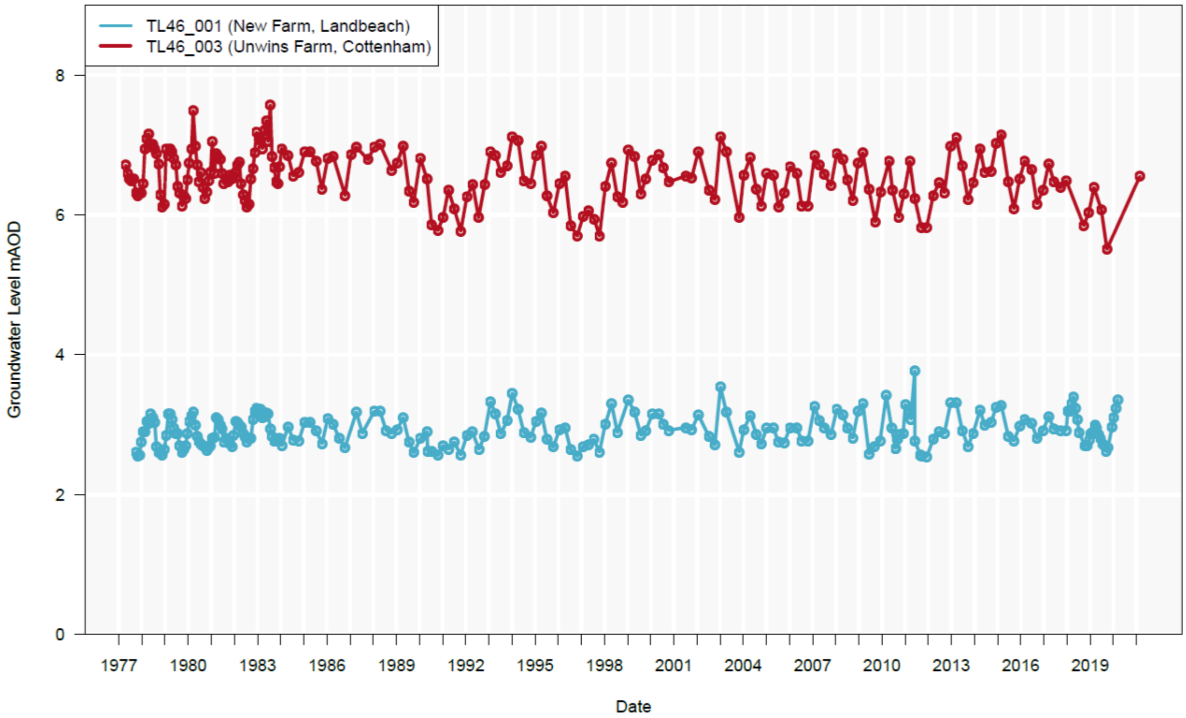

Figure 3.4: Groundwater levels at boreholes within 10km of Longstanton (1977 – 2021)

Source: Environment Agency, 2020. Measurement at Unwin's Farm on 23/03/2021 recorded by HR Wallingford

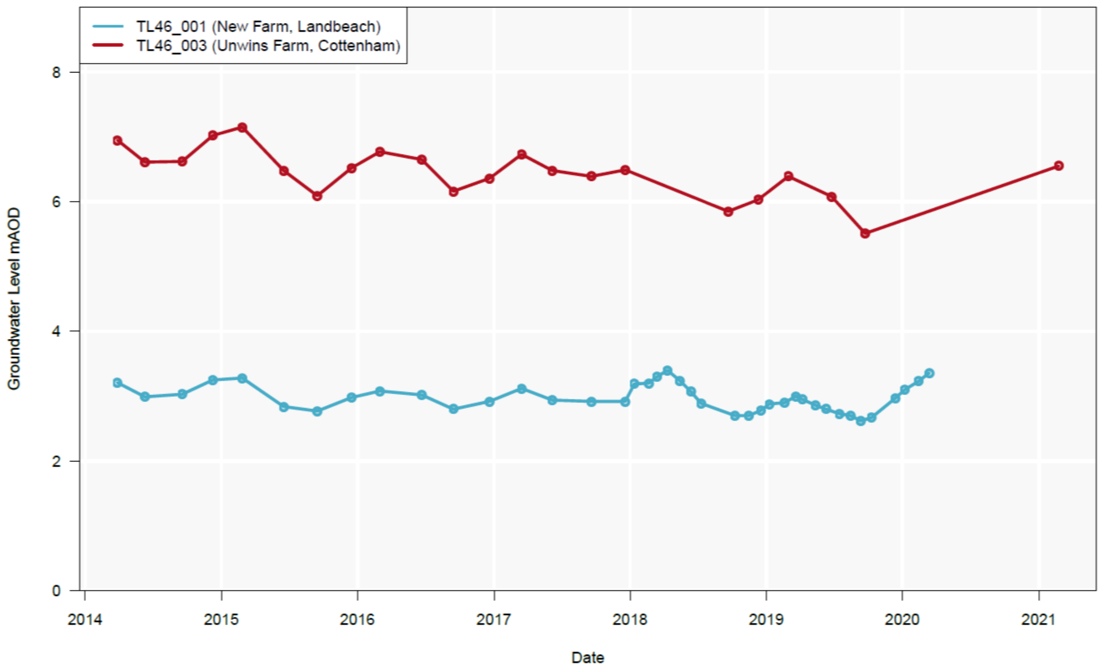

Figure 3.5: Groundwater levels at boreholes within 10km of Longstanton (2014 – 2021)

Source: Environment Agency, 2020. Measurement at Unwin's Farm on 23/03/2021 recorded by HR Wallingford

As caveated in HR Wallingford Phase I (2021), the data logged at these boreholes is not collated at regular intervals. Therefore absolute groundwater level between the recorded data points cannot accurately be interpolated. The results presented in Figure 3.4 and Figure 3.5 are intended to show the long term trend and give an indication of seasonal fluctuations.

3.3.1. Review of local groundwater level data

The groundwater levels presented in Figure 3.4 and Figure 3.5 demonstrate the seasonal fluctuations in the RTD. Minimum groundwater elevation typically occurs in September or October and maximum groundwater elevation typically occurs in March.

Figure 3.4 presents data for the entire data record available. This graph does not indicate that there is a long term increase or decrease in groundwater elevation. Groundwater elevation recorded at Unwin's Farm has several low periods, notably the early 1990 and the late 1990s however groundwater elevation recovered in the proceeding years.

At Unwin's Farm, the groundwater elevation recorded in September 2019 was a record low (5.51 mAOD). However, given the data between 2015 up to September 2019 is within normal variability, the minima in September 2019 is not considered to be part of a long term trend. There are no measurements available for 2020 at Unwin's Farm. The measurement taken by HR Wallingford in March 20021 was recorded at 6.55 mAOD.

Figure 3.5 shows the data subset to the period 2014 to 2020. Minimum groundwater elevation at Unwin's Farm in successive years following 2015 remain below the 2014 minimum. However, in the context of the full data period in Figure 3.4, this variability was not outside the long term range recorded between 1977 and 2020.

The data recorded at New Farm indicates a similar trend up to 2017, however the recorded groundwater elevation in 2018 exceeds that of the preceding 4 years. There is no long term increase or decrease in groundwater elevation present in the data up to 2020 for the New Farm borehole.

3.4. Northstowe groundwater levels

The third set of groundwater level data is that collected by the developer of Northstowe via a series of commissioned boreholes.

Groundwater elevations for Northstowe are available from monitoring undertaken following the initial ground investigation and supplementary ground investigations (Wardell Armstrong, 2017; WSP 2014a). The supplementary ground investigation was completed in April and May 2014 by contractor Applied Geology under the direction of WSP. Additional work was undertaken in July 2014 (WSP, 2014a).

Table 3.1 provides a summary of groundwater levels recorded post ground investigation. The locations of these boreholes is indicated in Figure 3.6.

Table 3.1: Summary of borehole groundwater levels at Northstowe Phase I

Borehole	Geology of response zone	Range of monitored groundwater levels (mAOD))	Date of record
BH111	River Terrace Deposits	7.14 - 7.33	April – July 2014
BH124	River Terrace Deposits	7.11 - 7.34	April – July 2014
BH125	River Terrace Deposits	7.20 - 7.40	April – July 2014
BH126	River Terrace Deposits	7.34 - 7.53	April – July 2014
BH144	River Terrace Deposits	6.91 – 7.55	April – July 2014

Source: Data extracted from WSP (2014a)

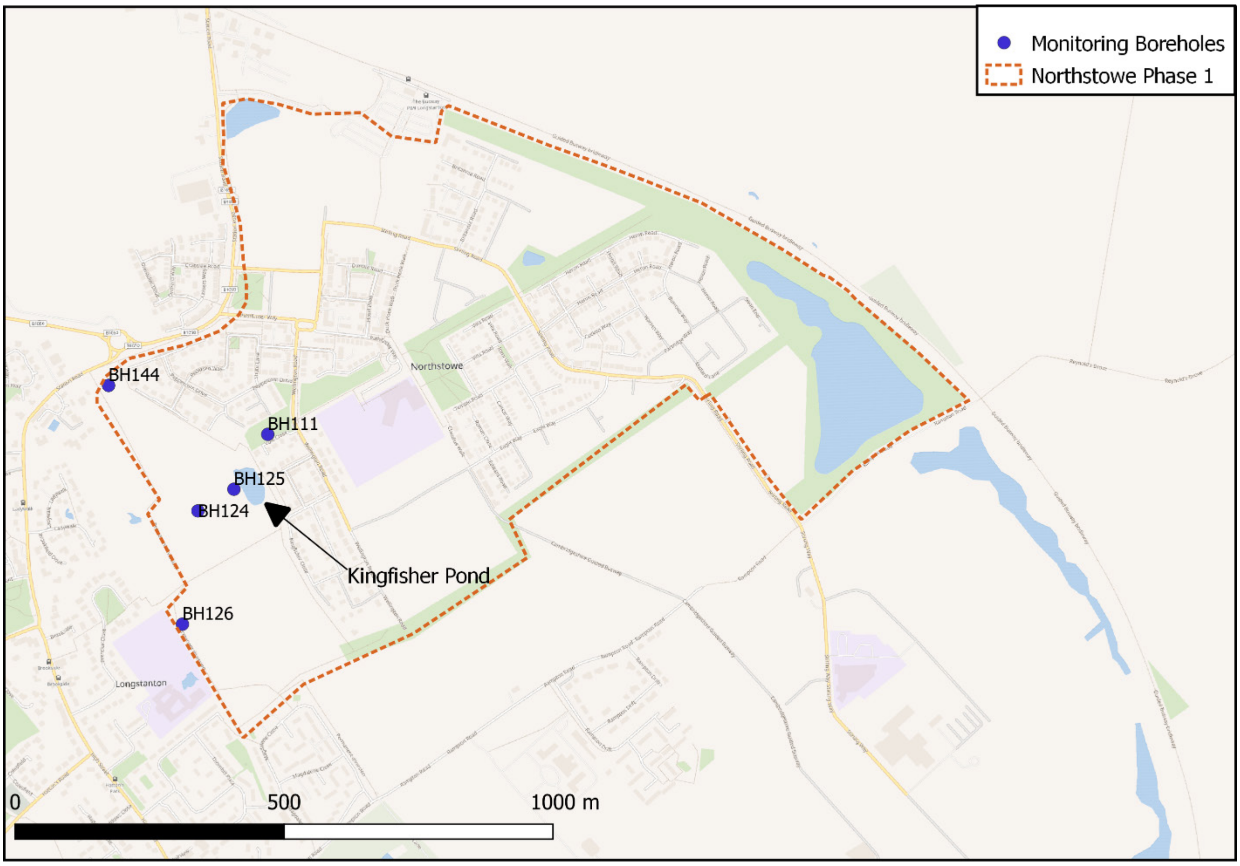

Figure 3.6: Map highlighting locations of boreholes of interest at Northstowe Phase 1

Source: Locations from Wardell Armstrong (2017) reproduced in QGIS

3.4.1. Manually dipped data

There is limited data available on the boreholes between 2015 and 2017 when initial observations of a decline in water level at the Kingfisher Pond were reported.

The data which has been collated for this period is presented in Figure 3.7 (extracted from Wardell Armstrong, 2017). The data presented in the graph includes daily rainfall, borehole groundwater elevation and the surface water level recorded at the Kingfisher Pond. Interpolating the groundwater level between the singular data points is problematic given the daily fluctuations of groundwater level and the lack of data points for long periods.

However, the available data for BH125 and BH136 recorded in January 2015 and January 2016 shows that groundwater elevations recorded in January 2016 were comparable to those recorded in January 2015. Groundwater levels in March 2017 were lower than the winter of 2016.

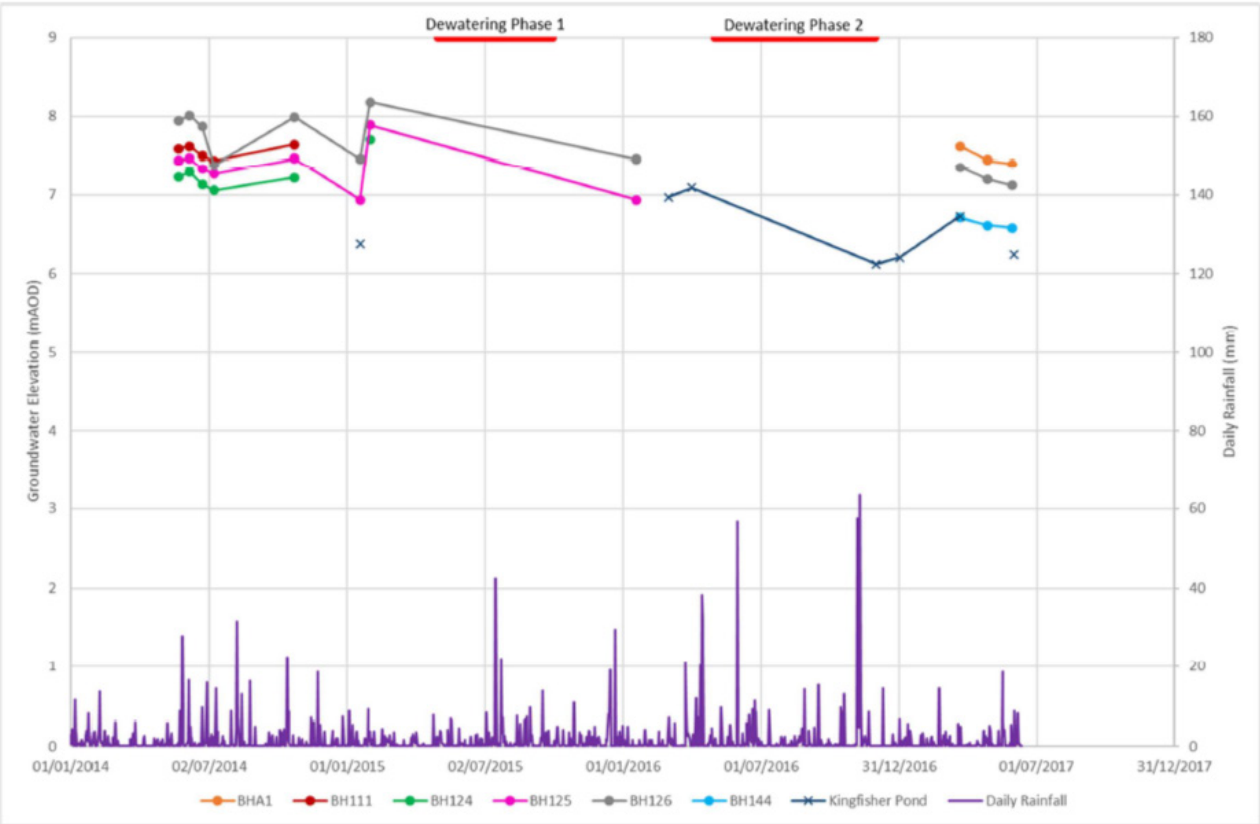

Figure 3.7: Groundwater elevation for Northstowe monitoring boreholes, surface water elevation for the Kingfisher Pond and daily rainfall for the period January 2014 to May 2017

Source: Extracted from Wardell Armstrong (2017)

3.4.2. More frequent data

Pressure transducer data loggers were deployed in March 2017 at sites on Northstowe Phase 1 (Wardell Armstrong, 2017). The data from the BH144 log was provided by L&Q in March 2021. BH144 is located on the western edge of Northstowe Phase 1 on the RTD aquifer. The boreholes is approximately 300 m north east of the Kingfisher Pond (Figure 3.6).

Data is provided for the period March 2017 to March 2021.The data loggers from BH144 shown in Figure 3.8 and Figure 3.9 show that the groundwater elevation fluctuates seasonal between approximately 6 mAOD and 7.1 mAOD between 2017 and 2020. Minimum groundwater elevation occurs in October and a maximum occurs in February. Between March 2017 and December 2020 the groundwater elevation did not exceed the “typical” groundwater level for BH144. Winter groundwater levels generally exceed the lowest pre-works level however summer groundwater levels are up to 0.8 m below the lowest pre works level. In February and March 2021 the groundwater levels rose up to 0.4 m above the typical level.

The summer recession in 2018 and 2019 shows rapid daily fluctuations within the seasonal decline. This could be indicative of local hydrogeological activity affecting the groundwater elevation. However, the RTD has a quick response to rainfall given the shallow water table and therefore rainfall trends may also be responsible for the patterns in the graph.

Gallagher Estates Limited
Groundwater Elevation Graphs

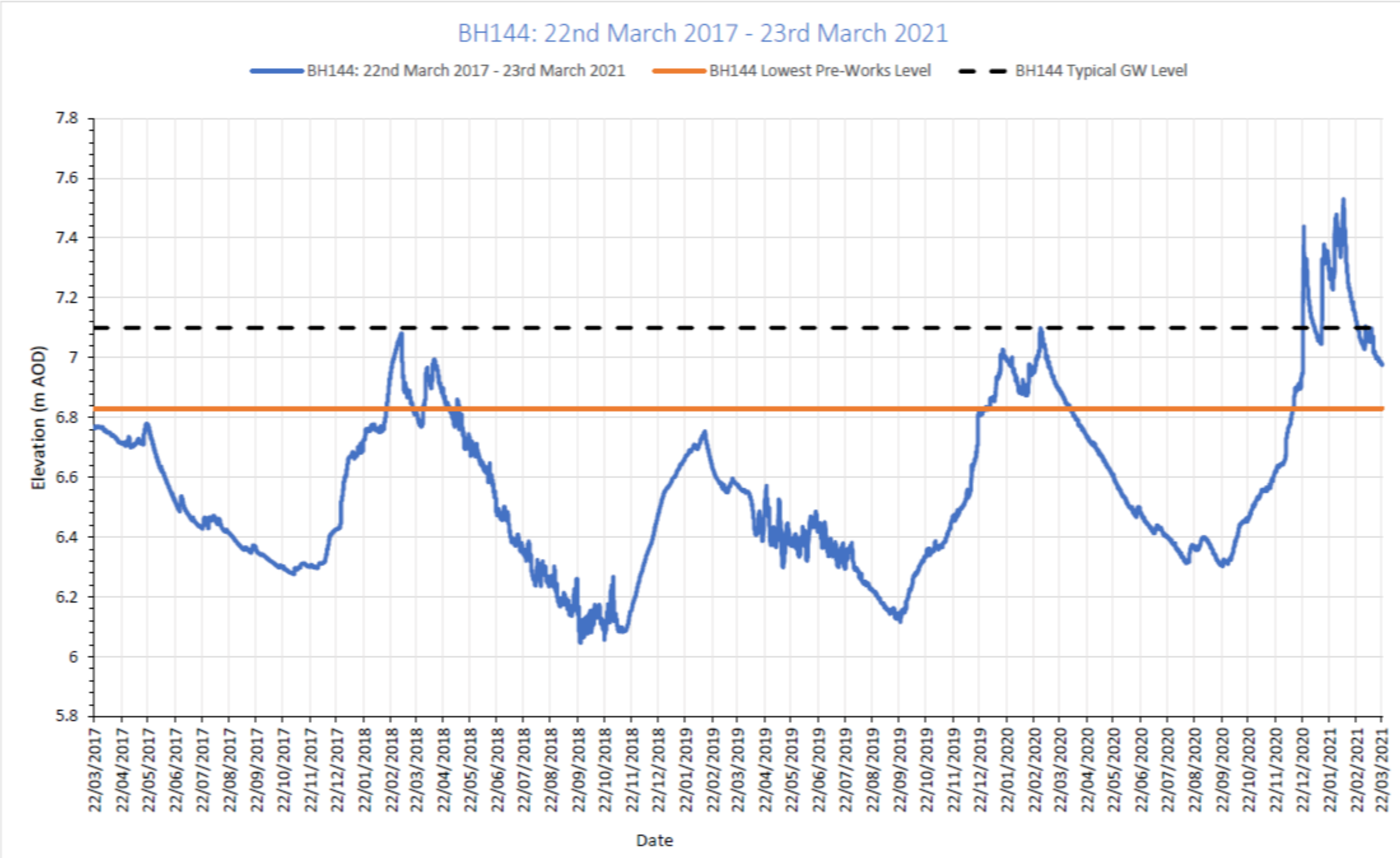

Figure 3.8: BH144 groundwater elevation. March 2017 to March 2021

Source: Gallagher Estates , 2021

Gallagher Estates Limited
Groundwater Elevation Graphs

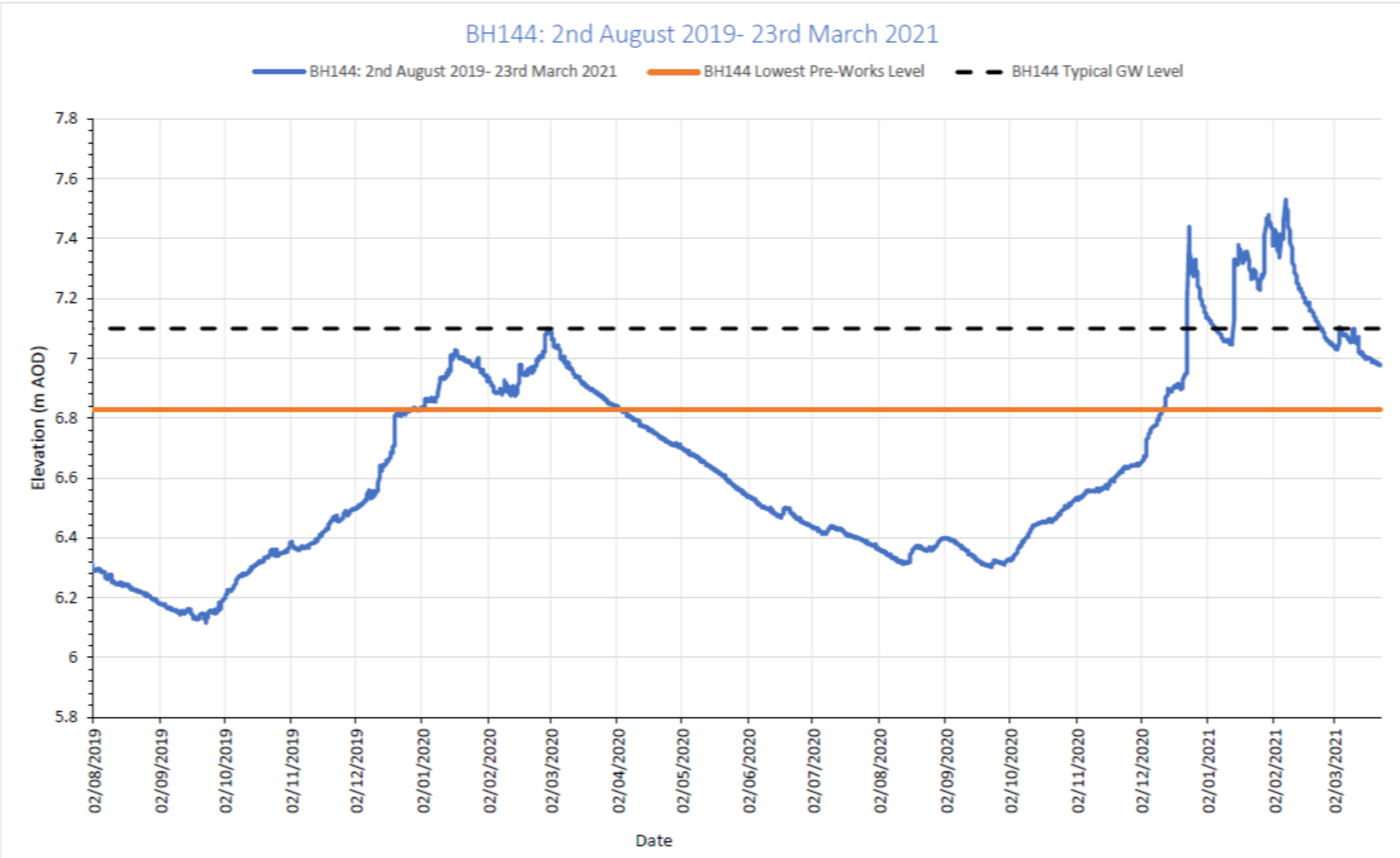

Figure 3.9: BH144 groundwater elevation. August 2019 to March 2021

Source: Gallagher Estates , 2021

4. Land use change

4.1. Overview

The local area has undergone significant land use change in recent years. The two most significant constructions are the development of Northstowe and the construction of the A14 bypass.

The scale and timeline of these significant land use change are reviewed in this section in the context of how the land use change may affect the local hydrogeology.

The data reviewed in this section is:

- Satellite Imagery (Google Earth).
- Wardell Armstrong Interim Report (2017).
- Northstowe Phase 1 Geo-technical report (WSP, 2014a).
- Northstowe Phase 1 Planning Condition Discharge. Surface Water Drainage Strategy (WSP, 2014b).
- Highways England planning information (Highways England, 2021).

The key findings of this section are:

- The construction of the A14 began in November 2016, bypassing Longstanton approximately 3 km to the south.
- The A14 highway does not intersect with the RTD within approximately 7 km of the Kingfisher Pond.
- The surface drainage design collects water in the clay lined attenuation ponds on the site of Northstowe.
- Surface run off is channelled to these ponds via a series of greenways across the site of Northstowe.
- The purpose of the surface drainage plan is to mitigate flood risk and to protect the site against 1 in 200 year rainfall events plus 30% climate change return period.
- The land use change on the site of Northstowe has likely reduced the surface area of permeable land which would previously naturally have allowed infiltration to and recharge of the RTD.
- The surface water strategy drainage plan indicates that surface water runoff from the sports pitches, allotments and orchards will infiltrate the RTD. This is intended to allow water to recharge the RTD. However, this strategy of infiltration will differ from the direct recharge which would have occurred naturally pre construction of Northstowe.

4.2. Northstowe

The largest land use change in the local area is the construction of Cambridgeshire's new town of Northstowe. Northstowe is a large development including up to 10,000 homes, a primary school and community leisure facilities (SCDC, 2020). Northstowe Phase I is a 97 ha site situated next to Longstanton. Hatton's road attenuation ponds form an additional 24 ha of Northstowe Phase I and are situated to the south west of Longstanton (Gallagher, 2012).

4.2.1. Dewatering

Construction on the site of Northstowe commenced in 2015. Construction dewatering of the RTD underlaying Northstowe occurred in two phases: Phase 1A (May to September 2015) and Phase 1B (May to November 2016). The locations of these two areas are shown in Figure 4.1.

Absolute volumes of dewatering are not known however the following details of dewatering are provided in Wardell Armstrong (2017):

- Dewatering works comprised the installation of a wellpoint (surface vacuum pump) system within 2-3 m wide trenches.
- A total of 1,030 wellpoints were installed for 1.5 km of trenches with a wellpoint spacing of approximately 1.5 m.
- Wellpoints were installed by jetting tube with an excavator.
- Generally single-sided, but double-sided systems were used where drawdown levels were greater, and where clay layers had reduced bulk permeability.
- Typical flow rates were 5 litres per second per 100 m length of trench.
- Typical groundwater drawdown was approximately 5 m below ground level.
- There was no groundwater monitoring during Phases 1A and 1B.

The purpose of the dewatering is to lower ground levels in the local area to facilitate construction The dewatering operation took place over a short time window with all but the very initial flow recycled back into the groundwater table on-site. During the initial Phase 1A dewatering, the water levels at the Kingfisher Pond were recorded to decline (observational evidence of this decline is further discussed in Section 5). As a result, during the Phase 1B dewatering, water was discharged back to the Kingfisher Pond to recycle water in the immediate area of the dewatering works.

The data provided in the bullet points above indicates that the groundwater level drawdown was up to 5 m below ground level. Wardell Armstrong (2017) suggest that the impact of dewatering activity was temporary and following the cessation of dewatering, ground water levels should recover, but were impeded by low rainfall in early 2017. There is no data available on the occurrence of any further dewatering past November 2016.

The discharge of water back to the Kingfisher Pond did not sufficiently return water levels to pre-construction water levels in the long term. This is further discussed with observational evidence in Section 5.

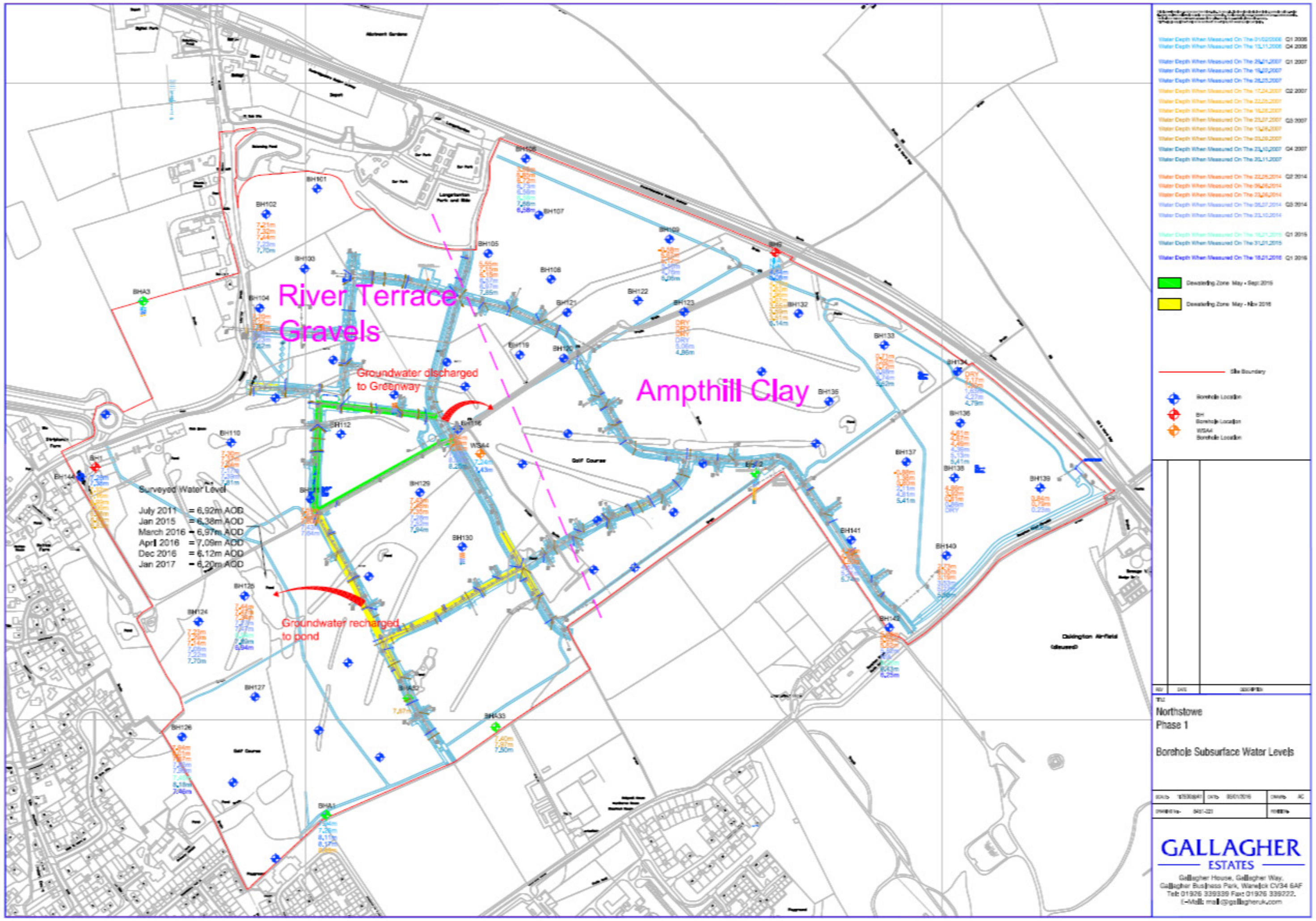

Figure 4.1: Borehole subsurface water levels. Site of Phase 1A dewatering indicated in green. Site of Phase 1B dewatering indicated in yellow

Source: Wardell Armstrong (2017)

4.2.2. Urbanisation

To highlight the scale of the land use change of the local area, Figure 4.2 and Figure 4.3 show a satellite map of the local area pre Northstowe development in September 2012 and in May 2020. The contrast of the two images highlight the scale of the development of Northstowe and the change from un developed land to the current state of development. This has important implications for surface run off and for infiltration of surface water into the RTD. Increased urbanisation will reduce recharge to the RTD unless there is a sufficient surface drainage plan to allow the run-off to infiltrate the soil and recharge the RTD. This is further discussed in Section 4.2.4.

Prior to the development of Northstowe, the Phase 1A site supported predominately pastoral and arable agricultural land on the south-eastern and northern parts of the site. A former golf course and associated infrastructure was located through the centre (WSP, 2014a). The undeveloped land on the former Northstowe site would therefore be predominantly top soil overlying the RTD and the Ampthill Clay. The topsoil is typically sandy slightly gravelly clay; clay slightly gravelly sand; or sandy slightly gravelly silt (WSP, 2014a).Subsoil was present beneath topsoil at most locations. Where encountered the topsoil was comprised of soft to firm brown sandy to very sandy gravelly clay.

Figure 4.2: Satellite imagery of Longstanton and Northstowe, September 2012. The location of the Kingfisher Pond is highlighted within the blue circle. The approximate area of Northstowe Phase 1 is highlighted by the red dotted line

Source: Google Earth

Figure 4.3: Satellite imagery of Longstanton and Northstowe, May 2020. The location of the Kingfisher Pond is highlighted within the blue circle. The approximate area of Northstowe Phase 1 is highlighted by the red dotted line

Source: Google Earth

4.2.3. Off site drainage

There area number of existing water courses which feed two catchments:

- The Reynolds Drain (part of the Beck Brook – Cottenham Lode catchment) to the north and east of the site.
- Longstanton Brook (part of the Swavesey Drain catchment) to the west of the site.

Three main ditches cross the site which drain south west to north east into Reynolds Drain (WSP, 2014b).

Northstowe Phase 1 surface water flows will form part of the catchment of the Reynolds Drain. According to the surface water strategy, no surface water run off will discharge to Longstanton Brook. The Phase 1 site is drained by the Reynolds Drain catchment via a series of ditches.

The series of ditches and culverts moves water off site. Two culvers are located within the Phase 1 site boundary (WSP, 2014b). with the third culvert located adjacent to Rampton Road on the eastern side of the track. The location of these culverts is indicated in Figure 4.4.

- Culvert 1 – Diameter 1950 mm, Invert Level 3.36 mAOD. Capacity 4,700 l/s
- Culvert 2 - Diameter 1275 mm, Invert Level 3.85 mAOD. Capacity 1,600 l/s
- Culvert 3 - Diameter 900 mm, Invert Level 4.36 mAOD. Capacity 620 l/s.

4.2.4. On site drainage

The Geo-environmental assessment (WSP, 2014a) states that the groundwater table is variable although generally shallow across the site, and will be responsive to weather conditions. In terms of infiltration drainage, despite the high RTD infiltration rates and permeable geology, the RTD is unsuitable for soakaway drainage due to the shallow water table. Soakaway drainage is also unlikely to be effective at sites situated in clay (WSP, 2014a).

The Surface Water Drainage Strategy for Northstowe (WSP, 2014b) provides details of how surface water is controlled on the site of Northstowe and how the design will mitigate flood risk. This describes the design of the surface water sewer network, surface water pumping station, greenways, swales, water park and Hatton's Road attenuation ponds.

There are two large clay lined attenuation ponds which provide storage to protect the site against 1 in 200 year rainfall events plus 30% climate change return period (WSP, 2014b). The ponds have sufficient capacity to receive flows from the Secondary School on Phase 2. The water park is 5.5 mAOD and the main attenuation pond has a base depth of 1.5 m. This connects to a smaller attenuation pond with a base level of 2.5 m. The attenuation ponds are intended to have a permanent water body to enhance ecology and amenity (WSP, 2014b). Figure 4.4 shows the design of the greenways and the intend surface drainage routes.

The greenways on the western side of Northstowe Phase 1 are situated on the RTD. The greenways on the eastern side are situated on Ampthill Clay. Where these drains are below the water table in the RTD, water in the RTD will drain to these greenways and to the attenuation ponds. Given the natural shallowness of the RTD water table, the greenways could therefore promote drainage of the RTD to the attenuation ponds preventing the RTD sustaining pre construction groundwater elevation. However, Wardell Armstrong (2017) state that where the greenway drains are located below the water table, it is within the Ampthill Clay (not connected to the RTD). The clays should therefore form a partial barrier to groundwater flow from west to east.

The football pitch to the west of the Kingfisher Pond is now clay covered (pers. comms. LPC, 2021). This allows for surface run-off from the playing field. The surface drainage plan (Figure 4.4) indicates that the water will flow eastward from the sports pitch towards the surface water sewer. In addition, the presence of the clay lined surface would reduce direct infiltration and recharge of the RTD which would otherwise naturally support the Kingfisher Pond.

There are 1.57 ha of allotments on the western part of the site adjacent to the sports pitches and the Kingfisher Pond. The geology underlying this area is the RTD underlain by Ampthill Clay. No formal surface water drainage was proposed for this area as the existing ground conditions offered suitable permeability rates. The soil investigation works identified that even when groundwater levels in the RTD reached a maximum, they did not present a constraint for soak away drainage from the allotments and orchards.

In HR Wallingford's experience, a development on the scale of Northstowe would reduce the surface area of permeable land available for direct infiltration of the RTD. The surface drainage strategy (WSP, 2014b) indicates that attempts were made in the proposed surface water strategy to reduce the percentage of impermeable land on Northstowe (Table 4.1). The surface water strategy also indicates that surface water runoff from the sports pitches, allotments and orchards will infiltrate the RTD. This is intended to allow water to recharge the RTD. However, this strategy of infiltration will differ from the direct recharge which would have occurred naturally pre construction of Northstowe.

Table 4.1: Percentage of impermeable land for the Northstowe proposed water strategy

Development Type	% Impermeable - Original Surface Water Strategy	% Impermeable - Proposed Surface Water Strategy
Residential	80	65
Local Centre/ Town Centre	100	100
Employment Areas	90	90
School	80	50
Roads and footways (from Primary Street and Dedicated Busway)	100	100
Green areas/ sports hub (for sewer design)	0	0

Source: Extracted from WSP (2014b)

Figure 4.4: Surface Drainage Map for Northstowe Phase 1

Source: Surface Water Drainage Strategy (WSP, 2014b)

4.3. A14 construction

The A14 Cambridge to Huntingdon improvement scheme includes a major new bypass to the south of Huntingdon and upgrades to 21 miles of the A14 (Figure 4.5). The A14 bypasses Longstanton to the south, connecting with Bar Hill junction. The junction is approximately 4 km to the south of Longstanton centre. Work officially started in November 2016 and the new road opened to traffic on Tuesday 5 May 2020 (Highways England, 2021).

This section of the A14 which bypasses Longstanton is not underlain with the RTD. The underlying geology of the A14 within close proximity to Longstanton is the Kimmeridge Clay Formation, West Walton Formation, Ampthill Clay Formation, Woburn Formation and Gault Formation (Figure 4.6). These formations are generally clay rich and do not contribute significantly to groundwater (BGS, 2020a). Figure 4.6 shows that the A14 does not overly the RTD within close proximity to Longstanton.

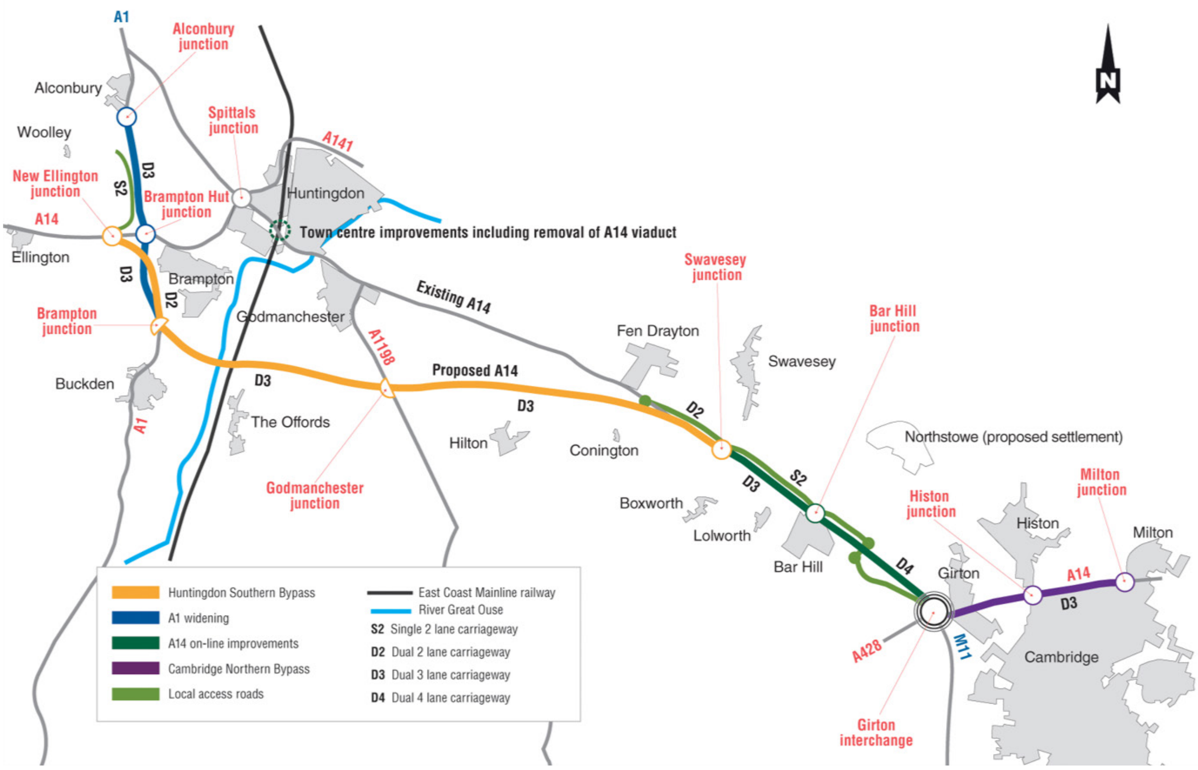

Figure 4.5: Cambridge to Huntington A14 proposed route map

Source: Highways England (2021)

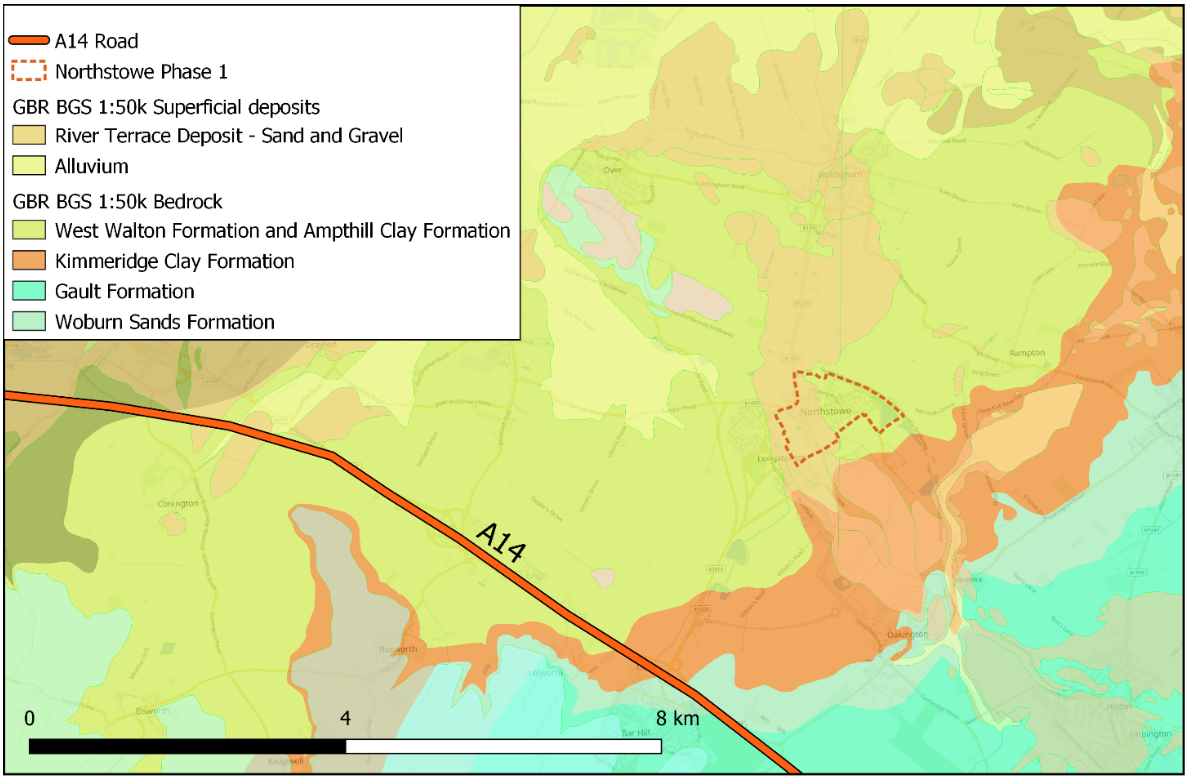

Figure 4.6: Geological map highlighting the location of the A14 and its proximity to Northstowe

Source: British Geological Survey 1:50 000 drift and bedrock geology, reproduced in QGIS.

The area is historically susceptible to flooding, particularly Bar Hill and Swavesey (Highways England, 2021). Attenuation ponds located along the A14 mitigate the flood risk using a surface drainage scheme comprising of carriage way drainage (slot drains) and attenuation ponds (Figure 4.7). There are 68 ponds proposed scheme wide. These ponds drain the surface run-off from the road. Given the underlying clay rich geology, prior to construction the natural surface run-off in the vicinity of the new A14 would previously have little impact on the RTD.

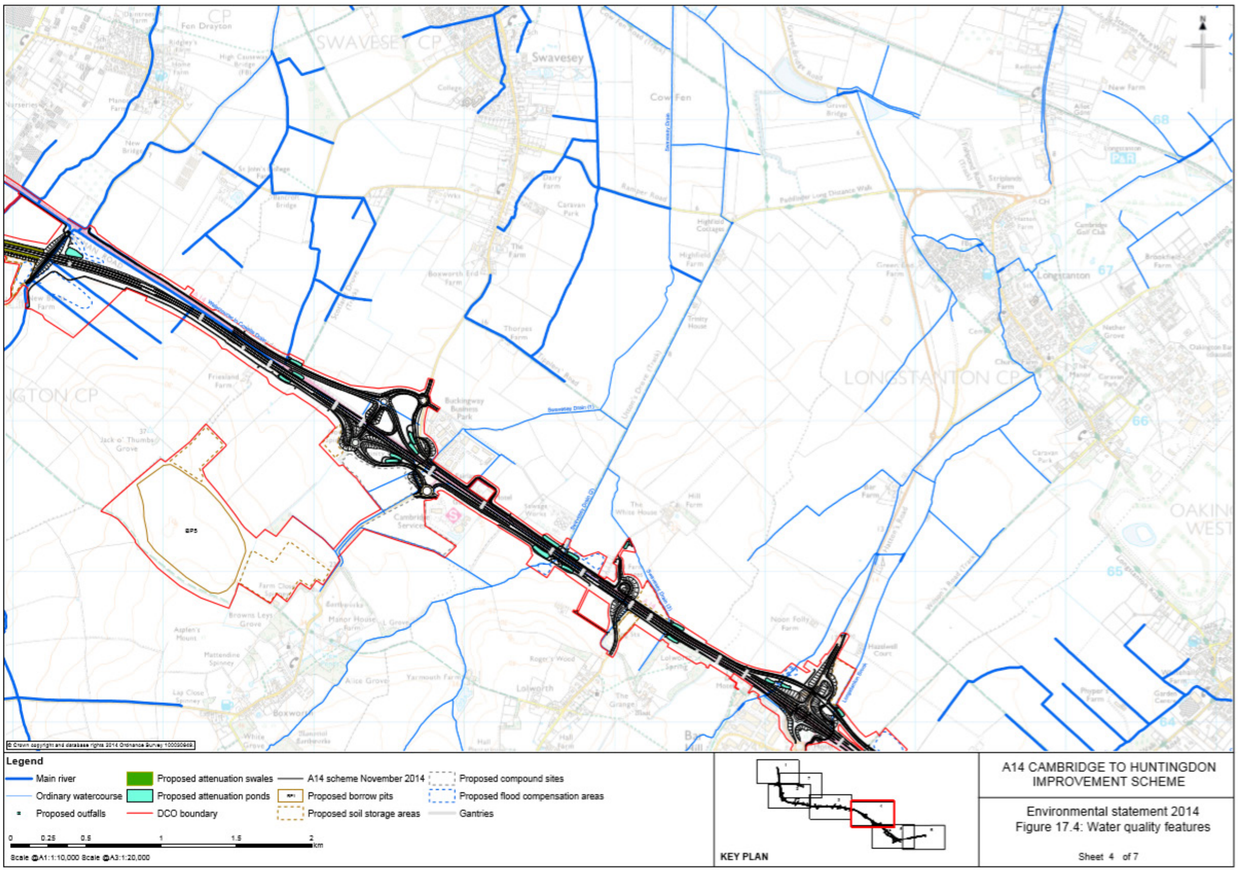

Figure 4.7: A14 Cambridge to Huntington improvement scheme highlighting the location of proposed swales and proposed attenuation ponds

Source: Highways England (2021)

5. Observed changes in Longstanton

5.1. Overview

This section documents the changes observed at the Kingfisher Pond and at other local ponds and lakes in Longstanton from January 2015 onwards. The data reported in this section comprises anecdotal evidence supported by photographs.

Observational evidence has been collated for the following sites:

- The Kingfisher Pond
- Hatton's Farm Ponds
- Private pond at St Michael's St
- Holy Well (St Michael's Church)
- Lady Walk Pond
- Nethergrove Lake
- Larkfield Nursey well.

Data reviewed in this section are:

- Photographs
- Emails documenting observed changes
- Resident surveys conducted by HR Wallingford in autumn 2020.

The key points for this section are:

- Observations at Hatton Farm Ponds reported low levels and fish kills in autumn 2015. This was the first reported concern of the decline in local water levels.
- The Kingfisher Pond's groundwater level were first noted to decline from mid 2015, concerns were sent to SCDC in December 2015.
- The water levels did not recover through 2016 and 2017. Water levels in the Kingfisher Pond completely dried out in 2017.
- The decline in pond levels recorded at the Kingfisher Pond coincide with the decline in other lakes, ponds and wells along the RTD.

5.2. Location of key features

Figure 5.1 provides an overview of the key hydrogeological features detailed in Section 5 and Section 6.

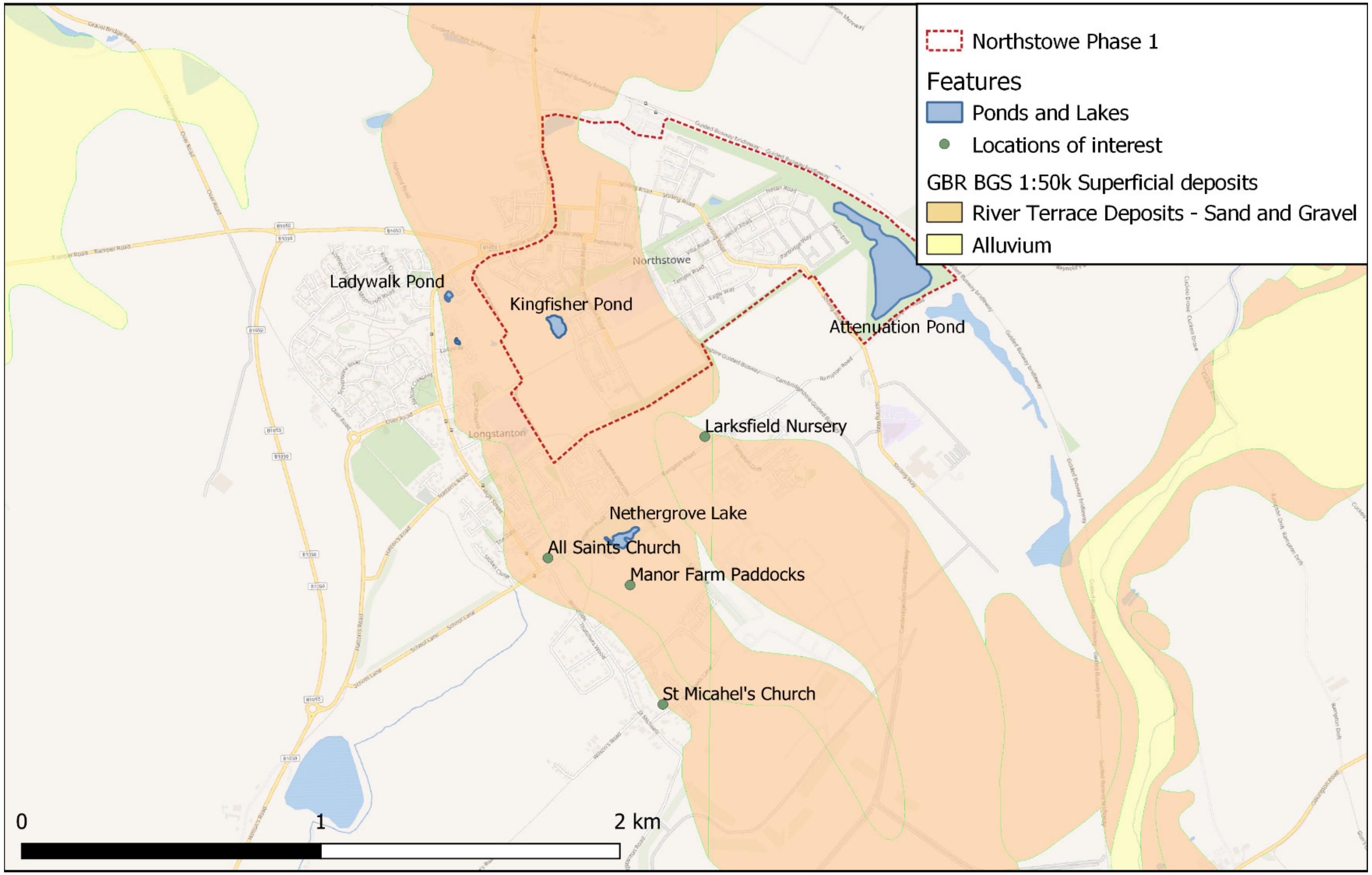

Figure 5.1: Longstanton locations of interest in relation to the River Terrace Deposit

Source: British Geological Survey 1:50 000 drift geology, reproduced in QGIS. All rights reserved

5.3. Observations 2015

There were no documented concerns regarding the groundwater level, ponds, lakes or wells in the local area prior to autumn 2015.

Photograph 5.1 shows the Kingfisher Pond in January 2015. Water levels are considered to be within the pond's natural range.

Photograph 5.1: The Kingfisher Pond, January 2015

Source: Clive Hayden

In autumn 2015, concerns were raised regarding the decline in water level at Hatton Farm Ponds. The reduction in water level in the pond resulted in fish kills. This was the first documented change in the local hydrogeology to be raised by local residents.

The first documented concerns of the change in the Kingfisher Pond were raised in December 2015. Photograph 5.1 shows the state of the pond at this time. The water levels have visibly dropped since the previous winter, exposing the banks of the pond.

Photograph 5.2: The Kingfisher Pond, December 2015

Source: Clive Hayden

5.4. Observations 2016

The water levels in the Kingfisher Pond continued to decline in the winter of 2015/16 and spring of 2016 (Photograph 5.3 , Photograph 5.4). Tree roots are visible exposed indicating the extent of water level decline.

Photograph 5.3: The Kingfisher Pond, March 2016

Source: Jo Toynbee

Photograph 5.4: The Kingfisher Pond, April 2016

Source: Clive Hayden

In summer 2016, Larkfield well was reported to run dry. This well supplies Larkfield Nursery and has a protected abstraction licence. There is no indication that the well has previously dried up even in severe historic droughts as far as records are available. This includes the severe drought in 1976.

Holy Well, situated in St Michael's churchyard, is supplied by the RTD aquifer. The well has historically been used for baptisms. The water levels in this well completely dried out in 2016 as documented in Photograph 5.5.

Photograph 5.5: Holy well, St Michael's church

Source: Hilary Stroude

Lady Walk Pond, situation in a residential cul-de-sac, also reported low water levels in summer 2016. Photograph 5.6 shows the condition of Lady Walk Pond in autumn 2016.

Photograph 5.6: Lady Walk Pond, autumn 2016

Source: Hilary Stroude

5.5. Observations 2017

In January 2017, the Kingfisher Pond was completely dried out as shown in Photograph 5.7. This photograph also highlights the depth of the pond to be relatively shallow, between approximately 1 m and 2 m.

Photograph 5.7: The Kingfisher Pond, January 2017

Source: Clive Hayden

In Summer 2017, plans for a fish rescue plan at Nethergrove Lake were investigated. This indicated that the water levels in the RTD were critically low in summer 2017.

In December 2017, the Kingfisher Pond was completely dry (Photograph 5.8) This was comparable to the previous winter. The overflow pipe which normally allows water to run from the Kingfisher Pond into the drainage system was likewise dry.

Photograph 5.8: The Kingfisher Pond, December 2017

Source: Hilary Stroude

5.6. Observations 2018 to 2020

The resident surveys state that throughout 2018 and 2019 the water level in the Kingfisher Pond and other hydrogeological features did not recover to their pre 2015 level.

Photograph 5.9 of construction works in September 2019 shows that the groundwater level is not visible. The depth of the trench is approximately 1.5 m to 2.0m below surface level, indicating that the groundwater elevation is below this level.

Photograph 5.9: Northstowe construction, September 2019

Source: Hilary Stroude

Photograph 5.10 is of a pond located on private property in St Michael's street in August 2020. This pond has been reported by the owners to have completely dried. It has been in this condition for several years. The depth of the pond is approximately 1.5 m.

Photograph 5.11 is of the Kingfisher Pond overflow pipe. This pipe was installed in 2019. It allows the Kingfisher Pond to drain into the ditch system when pond levels are high. The overflow pipe has not been required since installation as the water levels in the pond have been below the invert level of the pipe.

Photograph 5.10: Private pond located on St Michael's street, August 2020

Source: Bethan Ball

Photograph 5.11: Overflow pipe of the Kingfisher Pond, October 2020

Source: Dave Smith

In autumn 2020, aerial photographs of the attenuation ponds on phase 1 (Photograph 5.12) show standing water in the attenuation ponds. As stated in Section 4.2, these ponds form part of the surface drainage strategy of Northstowe and are intended to attenuate surface run off. These ponds are clay lined.

Photograph 5.13 shows the low water level in the Kingfisher Pond in November 2020. The pond is not completely dry as was the case in previous winters of 2016 and 2017. Observational evidence from Longstanton District & Heritage Society suggests that the areas where the pond is directly on the gravel seam are several inches deep and therefore far below normal for this time of year.

Photograph 5.12: Attenuation Ponds on Phase 1, November 2020

Source: Longstanton & District Heritage Society

Photograph 5.13: The Kingfisher Pond, November 2020

Source: Longstanton & District Heritage Society

Additional observations of local changes have been recorded on Manor Farm Paddocks (Figure 5.1). The paddocks are the site of the old Domesday village. Evidence of old lanes, housing platforms and ridge and furrow remain to this day. The Manor Farm paddocks are located on the Longstanton gravels. Since the initial groundwater level concerns in 2015, local residents have reported the archaeology of the Manor Farm Paddocks has become more pronounced.. The shrinkage of the organic matter in the gravels has also led to tree roots being exposed on the surface of the ground and this has got more noticeable over the years since 2015.

5.7. Observations 2021

In January to February 2021 observations that the water levels in the ponds and lakes had risen is documented at multiple sites in Longstanton.

In March 2021 the water level at Nethergrove Lake, the Kingfisher Pond and Lady Walk Pond were reported by local residents to be at the highest elevation for several years.

Further observations from HR Wallingford's site visit in March 2021 are provided in Section 6.

6. Site visit

6.1. Overview

A visit to Longstanton was completed by HR Wallingford on Tuesday 23rd March 2021. The primary objective of this visit was to gain a greater understanding of the local area and the proximity of key locations. The site visit also collected photographs of the current condition of the Kingfisher Pond and other locations of interest.

The key points of this section are:

- At the time of the site visit the groundwater levels appeared to have partially recovered.
- Local residents stated that the water levels at the Kingfisher Pond, Lady Walk Pond and Nethergrove Lake were at their highest since autumn 2015.
- The water levels had been observed to have been rising since February 2021.
- The Kingfisher Pond had a depth approximately 0.5 m – 1.0m.

6.2. Observations

6.2.1. The Kingfisher pond

At the date of the site visit, the Kingfisher Pond had a water depth estimated to between 0.5 m and 1.0m. The centre of the pond was abundant with reeds indicating a shallow water level. Photograph 6.1 and Photograph 6.2 show the pond on this date.

This current state of the pond contrasts with previous reports of the pond having a low water level and previously completely dried out. The pond has therefore visibly recovered. Local residents confirmed that the level of water in the pond was at the highest it had been for several years (circa. 2015). The level of the pond had improved since February 2021.

Photograph 6.1: Kingfisher Pond, March 2021. No.1

Source: HR Wallingford (March 2021)

Photograph 6.2: Kingfisher Pond, March 2021. No.2

Source: HR Wallingford (March 2021)

Photograph 6.3: The Kingfisher Pond overflow pipe, March 2021

Source: HR Wallingford (March 2021)

6.2.2. Lady Walk Pond

Lady Walk Pond is a small pond situated in the cul-de-sac Lady Walk. As with the Kingfisher Pond, this pond had previously been reported to completely dry out. In January 2021, the pond was completely dry however during the site visit in March 2021 the pond had substantially recovered (Photograph 6.4), This indicates the groundwater levels had risen significantly between February and March 20021.Local residents reported that the Lady Walk Pond was at its highest level since autumn 2015. The pond had abundant reedbeds which indicate a relatively shallow depth approximately 0.5 m to 1.0 m.

Photograph 6.4: Lady Walk Pond, March 2021

Source: HR Wallingford (March 2021)

6.2.3. Nethergrove Lake

Nethergrove Lake has no additional inlets or outlets and is filled entirely naturally from groundwater, rainfall and surface run off.

Consistent with the Kingfisher Pond and Lady Walk Pond, Nethergrove Lake had notable increased water levels. Mr Graham Tweed confirmed that the water levels at Nethergrove Lake were at the highest during March 2021 compared with the previous 5 years.

Photograph 6.5: Nethergrove Lake, March 2021. No.1

Source: HR Wallingford (March 2021)

Photograph 6.6: Nethergrove Lake, March 2021. No.2

Source: HR Wallingford (March 2021)

6.2.4. St Michael's Church well

St Michael's Church has a historic well situated in the church yard. This well was historically used for baptisms which indicates it had a continual supply of water. This water is supplied from the RTD aquifer. The well at St Michael's church had previously been reported as drying out since 2015. At the time of the site visit in March 2021, the well at St Michael's Church had water indicating that groundwater levels had risen since the reporting of the dried out conditions.

A dip meter readings taken at the site visit recorded water in the well was 0.24 m deep and was 0.22 below standing level at the steps to the well. There was no fixed datum upon which to derive the absolute groundwater level.

6.2.5. All Saints Church

All Saints Church is situation on the corner of Rampton Road and the High Street. The church had visible cracks above the window and on the walls (Photograph 6.7). The structural changes were first reported in 2016. These structural changes could be the result of changes in the groundwater levels resulting in subsidence of the ground. However this can not be determined without detailed investigation of the structural integrity and architecture of the church. This is beyond the scope of this report.

The quinquennial review of All Saints Church (2017) reported on the structural changes as follows:

"….the below ground drainage should be checked as there are a number of cracks in the church which are suggesting some kind of movement probably caused by changing subsoil conditions."

Photograph 6.7: All Saints Church. Cracks above the church window are visible in this photograph

Source: HR Wallingford (March 2021)

7. Summary

The data and observations presented in this report describe the local climate, hydrogeology and land use change between 2015 and 2021 in the Kingfisher Pond and surrounding area The focus of this report has been changes to the RTD and the Kingfisher Pond.

The climatological data provided in this report summarises monthly rainfall totals recorded at Cambridge NIAB meteorological station, approximately 5 km south east of Longstanton. Analysis is focused to the period between 2015 and 2021. The monthly totals for this period are compared to the long term average for the period 1961-2020. The data shows that the cumulative rainfall for January 2015 to February 2021 was generally lower than the long term average. However, within this six year period there were both drier and wetter than average periods.

Spring 2015, summer 2016, autumn 2016 and summer 2018 were lower than 10% below the long term average. However annual cumulative rainfall for these years was within a normal range at within 10% of the long term average. Total rainfall for 2017, 2019 and 2020 were above the average annual LTA. More recent data for winter 2020/21 shows wetter than average rainfall. No data is currently available post February 2021.

Trends in regional rainfall would typically be reflected in groundwater level. However, rainfall records do not directly correlate with groundwater recharge as a lag is to be expected between rainfall and groundwater recharge. There are also additional influences besides direct rainfall on regional groundwater including surface run-off, antecedent conditions and land use.

In this report, data from the Environment Agency groundwater index wells at Redlands Hall and Therfield Rectory has been summarised. These groundwater index boreholes are situation in a chalk aquifer and are therefore not directly comparable to the Longstanton RTD. Nevertheless, analysis of regional groundwater levels provides an indication of regional climate. The chalk observation boreholes at Redlands Farm and Therfield Rectory show that regional groundwater levels were normal during most of the period 2015-2021, yet below normal during 2017 and 2019. The groundwater levels rose to above normal conditions in early 2021.

Natural groundwater levels in the RTD are generally considered to be responsive to rainfall due to the shallowness of the water table below ground level. The boreholes monitored by the Environment Agency within 10 km of Longstanton are selected for analysis as they are situated in the RTD aquifer. These are therefore more applicable to Longstanton hydrogeology than the chalk groundwater index wells. Data from these boreholes do not exhibit a long term trend. Groundwater elevation between 2015 and 2020 remained within normal natural fluctuation. Though groundwater recorded in September 2019 was a record low, this is not considered to be part of a long term decline. The groundwater levels recorded at the two Environment Agency RTD boreholes do not reflect the same trends as the chalk groundwater index wells. However, the lack of regular data points at these sites limits the conclusions that can be drawn from the data.

Data is also presented for boreholes on the site of Northstowe Phase 1. BH144 is located within 300 m of the Kingfisher Pond and situated in the RTD. The groundwater elevation in BH144 indicates that between March 2017 and December 2020, the groundwater elevation did not exceed “typical groundwater levels”. This data supports the conclusion that groundwater levels have dropped to below normal levels in the RTD during this period. However, in January to March 2021, the groundwater elevation has increased to exceed typical levels.

The low groundwater levels recorded in BH144 align with observational evidence of below normal water levels in the Kingfisher Pond. In 2017 photographs show local ponds completely dried up. The total rainfall in

2017 was above average, however both the borehole records and observations imply that this did not correlate with a sustained recovery of the water level at the Kingfisher Pond.

The increase in BH144 in winter 2020/21 coincides with observations that the elevation of the Kingfisher Pond, Nethergrove Lake and Lady Walk Pond visibly rose during this period. This additional coincides with trends documented at the chalk boreholes at Therfield Rectory and Redlands Hall and with the heavy rainfall recorded at Cambridge NIAB during this period.

Significant land use change in the local area has been discussed. This has been focused to the construction of the A14 and the construction of Northstowe. Reports available for the construction of the A14 show that the A14 does not intersect with the RTD in close proximity to Longstanton. Construction of the A14 began after the initial decline in water levels at the Kingfisher Pond.

The construction of Northstowe has affected the natural local hydrogeology in several ways. Initial dewatering was intended to lower groundwater levels in the RTD. Reports suggest that in 2015 and 2016 the dewatering reduced groundwater levels to approximately 5 m below surface level. There is no data to suggest further dewatering occurred post 2016. The development of Northstowe has also affected natural infiltration to the RTD. In HR Wallingford's experience, a development on the scale of Northstowe would reduce the surface area of permeable land available for direct infiltration and recharge of the RTD. The surface drainage strategy report indicates that plans were made to both maintain a high proportion of permeable land (compared with original plans) and to allow infiltration to the RTD from runoff from the sports pitches, allotments and orchards. The surface drainage strategy, which comprises of a network of two greenways and two attenuation ponds, is designed to mitigate flood risk by channelling surface run off to the attenuation ponds.

The report concludes that the groundwater levels have declined locally in the Longstanton RTD. This has resulted in the observed decline in water levels at the Kingfisher Pond as well as Nethergrove Lake, Lady Walk Pond and several local wells. The groundwater levels remained generally below normal levels throughout the period from 2015 to 2020. Recent heavy rainfall in winter 2020/21 has coincided with a period of recovery of local groundwater levels as documented by the boreholes and local observations.

8. Further work

This report has summarised key hydrogeological data for Longstanton for the period January 2015 onwards to understand how the groundwater levels have changed resulting in the observed decline in the Kingfisher Pond and other ponds. This report concludes that the groundwater level has dropped below the natural conditions between 2015 and 2020. Winter 2020/21 has indicated a recent increase in groundwater elevation which has coincided with above average rainfall.

It is important that key stakeholders agree this report before we move to Phase III which is to summarise why the conditions of the Kingfisher Pond and local groundwater levels have changed. We propose to ask two specific questions:

1. Do you agree with the data presented within this report?
2. Do you think more data needs to be considered within this report?

We propose that stakeholders review this report, and provide any comments to HR Wallingford directly via:

a.wilcox@hrwallingford.com.

We propose a deadline for receipt of comments of the 23rd April 2021 for receipt of those comments.

Once we have received these comments we will consider if our understanding needs to change. If not then we will progress to phase III which will be to conclude the cause of the change in water levels. We will then publish our Phase III report.

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Appendices

A. Data Summary

Table A.1: Summary of data sources

Data	Summary	Reference
Geological Data	British Geological Survey Solid and drift sheet map of Huntington- 187 (1:50,000)	BGS (1981)
	British Geological Survey solid and drift sheet map of Cambridge - 188 (1:50,000)	BGS (1975)
	British Geological Survey Drift Map WMS 1:50 000	BGS (2020c)
	British Geological Survey Bedrock Geology Map WMS 1:50 000	BGS (2020d)
	British Geological Survey Bedrock Geology Map 1:625 000	BGS (2020e)
	British Geological Survey borehole logs at locations in Longstanton and Northstowe	BGS (2020f)
Groundwater Levels	Environment Agency (East Anglia) groundwater levels	Environment Agency (2020)
	Environment Agency monthly situation reports	Environment Agency (2018;2021)
	Northstowe Phase 1 groundwater levels	WSP (2014a) Wardell Armstrong (2017)
	Groundwater Levels collected by HR Wallingford in March 2021	NA
	Groundwater levels recorded by borehole loggers at BH144 Northstowe Phase 1	L&Q (2021)
Reports	Wardell Armstrong Interim Report	Wardell Armstrong (2017)
	Northstowe Phase 1A Geo-Environmental Assessment	WSP (2014a)
	Northstowe Planning Application: Planning Supporting Statement	Gallagher (2012)
	HR Wallingford Phase 1 Kingfisher Pond and Northstowe Hydrogeology Assessment	HR Wallingford (2021)
	All Saints Church Quinquennial report March 2017	NA
	Northstowe, Phase 1 Planning Condition Discharge Surface water drainage strategy	WSP (2014b)

Data	Summary	Reference
Resident surveys conducted by HR Wallingford (2020)	Observational Evidence	NA
	Photographs	NA
	Emails correspondence between Longstanton residents, SCDC and LPC	NA
Climatological Data	HadUK-Grid Gridded Climate Observations on a 1km grid over the UK, v1.0.0.0 (analysed for a 3km buffer around the Kingfisher Pond)	Met Office (2019)
	Gauged rainfall at Cambridge National I Agricultural (NIAB) Meteorological station (1961-2020)	Met Office (2021)
	Climate hydrology and ecology research support system potential evapotranspiration dataset for Great Britain (1961-2017) [CHESS-PE]	Robinson et al (2020)
Site Observations	Site visit to Longstanton completed by HR Wallingford completed on 23/03/20201	NA

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