Maple Cross Water Level fluctuations **Affinity Water comments 08/02/2021**

Slide 3 Absolute WL plot.

Northern BHs (101-201) – Chalk water levels are generally higher than the gravel levels during high background WLs. The same occurs for the Eastern BHs (102-202) but 102 is flooded when [redacted] is off so cannot say with certainty. 104 appears to have the lowest GWL around the 7th Dec with [redacted] ON – contours at different times would help show the difference of variable abstraction on GW flow direction to understand gradients? (See screenshot below for suggested dates as red vertical lines). 103 appears higher than 203 (Chalk) but this is reversed later when [redacted] is off.

[redacted]

Slide 4 Normalised WL plot.

Logger sensitivity means that graphs are stepped, not smooth lines, but this does not detract from the overall changes.

Most graphs follow a similar pattern, which reflects the more distant Denham Way chalk plot. This has a higher range of water levels, and is not 'capped' by the presence of the lakes, rivers and canal, which at the Tier site restrict the maximum height levels can rise to due to due to upward leakage to whatever outlet is available.

All graphs show a significant effect to rainfall recharge, from individual spikes, to rises and falls due to the pattern and amount of rainfall. From lower values at the beginning of November (following a period of little rainfall), levels began to rise due to significant rainfall events in mid to late December. Then then peaked around the 27-28th and began a recession due to the lack of rainfall and recharge. Rainfall on the 11-12 Jan then caused a spike in groundwater levels on the 12th, followed by a more comprehensive rise on the 14th. Denham Way then continued to rise, whilst around the Tier site, levels regressed and then spiked again on the 16th due to another recharge event, which is reflected in the

Denham way data, but continued to rise, due to the combined recharge from further up gradient. This demonstrates that whilst the background groundwater levels are controlled by the regional trend, in the valley, superimposed on this are small changes due to rapid recharge and discharge from rainfall events. This impacts on both the shallow and deeper aquifer units, but to a differing degree.

There are also small changes in water levels due to the influence of abstraction. The site is located relatively closely to three Affinity groundwater sources, to the northeast, east and south. These are normally baseload stations, but their abstraction was varied at times during this period to see if a signature could be detected at the site.

Two of the hydrographs do not follow the above pattern. 104S has an unreliable trace and shows trends that whilst similar at times to the other data varies in magnitude so should be discounted from discussion. 102S, whilst generally following the general trend, from late December to the middle of January shows a rising trend to begin with and then falls, but is at a higher relative value than previously, only re-joining its former pattern in the middle of January. It is understood that the location of this borehole flooded, and this probably accounts for this difference. Despite the flooding issue though, it still exhibits the greatest fluctuation of all, except for Denham Way Chalk OBH.

Slide 5 [redacted] Test

[redacted] was switched off on the 15th December, whilst [redacted] and [redacted] continued at a steady abstraction, with a few shout interruptions to the end of the test. On the 24th December, all three stations switched off for a short time.

There is a clear signal of the switch off of [redacted] in 202D, 102S and 201D. None of the others (including Denham Way) showed any discernible impact as this was set against a small overall rise in groundwater levels. There is an indication of delayed rises and falls on the 16/17 December for a few, but this may not be due to the switch off. 102S/202D are closer to [redacted], so this is to be expected, with 201D also reflecting a small rise, but less than that seen at 102S as it is further away from [redacted]

One of the short switch offs at [redacted] on the 21st December shows a small impact on 201D, but not at any of the others. Also to be expected as this is the closest site to [redacted]. –

At the end of the [redacted] test, all three stations switched off for a short time. There was a spike in all OBH, shallow and deep in response to this, including Denham Way. It is difficult to discern any significant change to water levels following the resumption of abstraction at [redacted] and [redacted], due to the background rising trend, but 201D and 202D do show a slightly falling water level over this period, whilst all others were flat (with the exception of 102s as mentioned above).

201D, 202D, 203D & 105S respond to [redacted] going OFF – The rainfall in the main signal test period masked the response but in subsequent shorter outage the recovery is picked up. In the previous instance, rainfall did not cause such a recovery. To a lesser extent 101, 103, 106 also showed a recovery– 102 appears unimpacted but probably flooded so cannot say with certainty.

Slide 6 [redacted] Test

[redacted] was switched off on the 30 December for a short while. All three chalk OBH showed a rise and fall in relation to this event, along with 105s,103s and 106s. 105s, 103s and 203d showing the greatest rises. This is to be expected, given their relative distances from [redacted].

Slide 7 [redacted] est

[redacted] was switched off on the 13/14 January. Unfortunately, not long after this event, there was a period of prolonged rainfall and recharge, raising all water levels (including Denham Way). However, there are indications that 201D, 102S and slightly later 101S, started to rise before the rain.

There was a second period of [redacted] off, following the rainfall event later on the 15 January. Here, a very clear signal was seen at 201D, with a smaller one 202D, as would be expected. 102S, 203D, 101S and to a lesser extent 103S did not show a rise in levels, but their water levels remained higher for longer than the remainder of the OBHs, which began falling over the period of the outage.

Slide 8 Relative positions of shallow and deep groundwater levels

101S and 102S show a generally higher level in the chalk than the gravels over the whole period of observations, with the exception of the end of the recession from the 6 to 14 January, when they were approximately equal. All three pumping stations were pumping over this period, albeit at different rates, and there was little rainfall over this period. It maybe worth totalling abstraction over this period relative to the first two weeks in December, where dips still indicate a difference, at even lower groundwater levels, so this may not be due to the increase in abstraction over this period.

102S and 202D show a different pattern, but this is likely to be influenced by the flooding, so no more can be said here. However, generally, it appears that chalk groundwater levels are above the shallow at this time of year.

103S and 203D show a different pattern again, with initially shallow being higher, then deep being higher from the middle of December onwards. The initial dips suggest the chalk was slightly higher than the gravel, so the logger traces could be suspect in their relative position.

Shallow groundwater levels for 106s and 105s do show a reversal, with almost similar levels from the 21 December to the 12 January. I remember you stating that there was an issue with the elevation of 105S so will comment no further at this time.

Overall, it appears that at this time of year, there is a higher chalk water level than in the gravels, which is to be expected, and with minor variations, the difference is maintained through the different abstraction phases and rainfall recharge events. Outlet levels are critical and maybe slightly different for both aquifers. If there are changes in sluice boards etc, then this may explain some of the subtle changes, but we cannot verify.

Lake Levels Slide 6

Inns Lake shows the highest fluctuation, and generally follows a subdued pattern of the Denham Way OBH groundwater level. However, there are two exceptions, which do not appear to be related to rainfall events or abstraction changes. There was of a rise in lake levels on the 3-4 December (which occurred in all the lakes (with the exception of Conns), contrary to all groundwater levels which were falling in at this time. This may well be due to some artificial increase in levels by means of boards on the lake outlets. There was also a rise and fall in Inns lake levels 5-8 January, which is reflected on some of the other lakes (Springwell and possibly Conns with a slight delay), but not in the groundwater levels, with the exception of the dubious trace from 104S. Major rainfall events are reflected in the lake levels, but are subdued, with a lower amplitude and a less spikey profile.

Springwell Lake general follows the same pattern as Inns Lake, but with a lower amplitude and has a more 'noisy' water level trace. There is no apparent signature of the switch off of the [redacted] source as the water level rises during the period of [redacted] off can be attributed to rainfall. When [redacted] was switched on, there was a rise in Springwell lake level! Springwell Lake has a direct inflow/outflow to/from the River Colne so river levels will mask any water level response to changes in abstraction.

Conns Lake has a generally flatter trace, but demonstrates several rises and falls over a matter of days that are not reflected in the groundwater levels, rainfall or changes in abstraction. These are most likely caused by board changes or inlet/outlet flow variations.

Lynsters A, B and C are very similar to each other to begin with, then show a slight variation with A increasing with time, C with a slightly lower rate of rise and B slightly decreasing with time after the 23 December. However, all three respond to the heavy rainfall on the 12 and 14th January and rise in line with all other lakes and groundwater levels at this time (although most lakes show a lower rise than in the groundwater).

Clubhouse and Marsh lakes are similar to around the 16 December (with Marsh being slightly higher than Clubhouse, then depart with Marsh declining by around 0.05m over 2 days. This coincides with the switch off of [redacted] Their pattern then remains roughly the same, with Inns being lower. Both lakes show a 0.05m decline in water levels on the 5 January. This is coincident with the return of [redacted] to service. This lowering was only stopped by the general rise of all lakes and groundwater in response to the rainfall on the 13th January. Clubhouse recovered by around 0.05m, whilst Marsh only by 0.25m, increasing the difference between these two lakes.

Whilst there is a general trend for lake levels to reflect background groundwater levels, there are significant differences at times, where changes in lake levels are not reflected in the groundwater levels. Most lakes show a different pattern to each other, not always coincident with rainfall or abstraction changes. This points to a partial, short term delay in water passing between the lakes and the groundwater and significant control of lake levels.