20 July 2023

Manor Farm Options Report for Lower Thames Crossing

Prepared for Stuart Mee

This report sets out the water balance issues facing Stuart Mee at Manor Farm, and some potential options to present to the Lower Thames Crossing Project Team. All options are presented without prejudice and to aid discussion between all the parties involved. No party should be held to account based on the recommendations.

1. Background

The proposed Lower Thames Crossing (LTC) requires the construction of a cutting which will intercept the spring-flows supplying Stuart Mee's irrigation system. Abstraction for his irrigation system is authorised under licence no. 8/37/55/76, which provides for up to 150,000 m3/yr, 182 m3/hr, to be taken via a gravity feed sump between Nov and Mar to fill a reservoir (fishing lake) for subsequent irrigation. The main irrigation pump and controls are located at the reservoir with irrigation water piped throughout the farm during the summer.

In this report we consider the finding of LTC's water balance work and look at the possible options for ensuring that Stuart Mee's supply of water is maintained after the construction of the new road.

2. Review of the Water Balance Work

To summarise, the water balance report produced by LTC concluded that runoff is the main source of water to the reservoir and that over the three years of monitoring the reservoir the water balance ranged between +29,505m3 and -37,478m3 (see Table 1).

There are a number of issues with the data which mean that we have low confidence in the runoff figures calculated in the report. We will consider each of these in turn.

2.1 Catchment size

The LTC's work was based on a catchment size of **0.593km2**. This is a lot smaller than the original catchment area calculated by Paul Bradford (1.6km2) and is also much smaller than the catchment defined by the FEH catchment boundary and the LIDAR data. The reasons the LTC give for reducing the catchment area relate to the roads acting as a hydrological boundary.

Table 1: Water balances as reported in the LTC water balance report.

Inflow	2020	2021	2022
Precipitation, m3	18,803	18,800	13,875
Runoff, m3	68,170	51,202	46,049
Total inflow	**86,973**	**70,002**	**59,924**
Outflow	2020	2021	2022
Evaporation, m3	28,318	22,931	27,276
Abstraction, m3	45,969	17,566	70,126
Total outflow	**74,287**	**40,497**	**97,402**
Balance	**12,686**	**29,505**	**-37,478**

However, there is no evidence to suggest this is the case. Road drainage will usually add to the local hydrological inputs unless it is culverted into another catchment, which seems unlikely for the majority of the catchment. Therefore, I don't see any reason not to include the wider catchment boundaries. Keeping to the LIDAR and FEH boundaries, we get a catchment size of **1.03km2** (see Figure 1). This is still smaller than the area defined by Paul Bradford. However, Paul did not have access to the LIDAR data.

2.2 Flow data

The flow data concluded a catchment yield of 55,140m3 over the whole year (based on average of 3 years) Our confidence in the flow data is low. The position of the doppler probe meant that lower flows were not being recorded and there is no way of knowing below what flow this error was occurring. Correspondence with In-Situ's Binod Acharya (their doppler expert) showed that the probe is not designed to work in low flow situations. Binod said:

> *"for the depth measurement, the sensor must be mounted such that the depth sensor is always covered by water to a depth of at least 50mm (2 inches)."*
>
> *"I would recommend a wedged weir for your application. This would ensure there is enough water above the sensor during the trickle flows and wouldn't cause extra maintenance."*

This is acknowledged in the LTC report, however, I am not confident that removing the zeros and averaging the remaining flows is going to provide an adequate fix for this problem. This still creates a zero flow when flows are low for more than a day and we do not know how the probe performs when operating in 0 to 5cm of water. So the range of flows that were affected is unknown.

Figure 1: Catchment area based on FEH and LIDAR boundaries.

When we visited the site we estimated a flow of 2-3l/s coming through the culvert. The sensor was above the water level at this time, suggesting that flows would need to be considerably more for the probe to function accurately. It is therefore highly likely that any baseflow element coming from the unlined lake/moat at the center of the catchment will not have been measured, as well as a considerable amount of the increasing and receding flows.

We understand that the flow data was then modeled to create the water balance output, however, the model will only be as good as the averaged flow data that has been put into it.

To emphasize the disparity between the measured flows and what we would expect the catchment to yield, here are two examples of simple catchment estimation methods that give us a rough idea of yield. In our experience we have found these methods to give us reasonable estimate of flows in catchments of this type. I have carried out these calculations based on both catchment areas of 0.0593km2 and 1.03km2.

2.2.1 Catchment area reduction from a local gauging station

Gaynes Park Gauging Station on the River Ingrebourne is 4km to the west of the abstraction point. It represents a local set of data for us to compare flows. If we do a simple catchment area reduction we get the following results:

Gaynes Park Gauging Station = catchment area 47.9km2

NRFA mean annual daily flow = 0.329m3/s (28,425m3)

Note: Gauged flow benefits from Brentwood STW discharge. So flows will be slightly higher than would be naturally.

Manor Farm catchment (higher) = 1.03km2 or 2.1% of Gaynes Park catchment area.

Manor Farm catchment (lower) = 0.593km2 or 1.2% of Gaynes Park catchment area.

Estimated available resource = % of catchment/100x0.329m3/s

Yield from local data

1.03km2 catchment = 0.0093m3/s (691m3/day) = 252,215m3/yr

0.593km2 catchment = 0.0054m3/s (395m3/day) = 144,175m3/yr

This is clearly on the high side, partly because there is so much more going on hydrologically in the Ingrebourne catchment, but also because of the additional inputs of STW discharge. However, you would still expect the monitoring data to record at least 50% of these totals.

2.2.2 Effective rainfall estimation

Alternatively, we can get a rough idea of the yield of a catchment by using the long-term average rainfall and evaporation data. When you run this calculation for Manor Farm you get a yield of 119mm over the year. When applied to the two catchment sizes, this gives:

Yield from long-term effective rainfall

1.03km2 catchment = 122,570m3/yr

0.593km2 catchment = 70,567m3/yr

This method gives approximately 50% of the yield calculated from the Gaynes Park data and therefore is probably a better estimate. Whatever method you use you get significantly more annual yield than the LTC flow monitoring suggests.

2.3 Conclusions regarding the water balance

There is uncertainty regarding both catchment area and catchment yield. Therefore, we would suggest using both the LTC catchment area and our larger suggested catchment area to consider the likely range of water balance scenarios.

Simple catchment yield calculations, based on catchment characteristics and other local data sources suggest that we would expect considerably more than the average 55,140m3/yr recorded when monitoring, even when using the LTC catchment area. This fits with the understanding that the flow monitoring did not record a full range of flows, however it is hard to estimate exactly how much water has been missed.

This suggests that the actual yields that this catchment provides are likely to be somewhere between 70,000m3 and 120,000m3 annually. When you feed this into the catchment balance it generates an inflow range of 87,000m3 – 137,000m3. This fits more closely with the licence quantities, which the EA would have assessed as achievable from the catchment when issued in 2007.

3. Proposed Solution

When considering a solution for the protection of Stuart Mee's water source, we would propose two elements:

1. A like-for-like element
2. An insurance element to protect against the possibility of the like-for-like solution not delivering.

3.1 Options for the Like-for-Like Element

3.1.1 The importance of maintaining the existing supply

The water balance discussion suggests that on average between 58% and 91% of the licence quantity enters the reservoir each year (depending on which catchment area is used). This is typical of a double-year storage reservoir, where inflow over two years is used to build up full storage. Although this may not have been the intention of the original licence, it seems likely that this is what is happening on the ground. Understanding this is critical to finding the best option, because if the inflow drops below 50% of the licence quantity, then the reservoir becomes a three-year storage reservoir, which is a fundamentally different from the system what Stuart Mee currently operates. Needing three years to get the quantities on the licence would put the farm at much higher risk of running out of water in dry periods and would devalue the land due to the reduced reliability of the abstraction.

An added factor with this reservoir, is that it is also used as a commercial fishery. Therefore, drawing down levels is not an option, as it might be on a normal agricultural reservoir. This is another reason to maintain the full percentage of inflow that the current runoff provides.

3.1.2 Previously proposed solutions

LTC have proposed a number of solutions to ensure that Mr Mee is able to continue to abstract water. These include:

1. Re-routing the drain.

2. Partially 'tanking' the cutting to prevent dewatering of the shallow groundwater reserves.

3. Constructing new chalk boreholes to provide an alternative source of supply.

Our concerns about these options are set out in our Initial Abstraction Licence Impact Assessment, written by Paul Bradford in May 2022. I will not repeat the concerns here, other than to say that none of these solutions in themselves solve the issue.

3.1.3 Preferred option for the like-for-like element

We feel that the option that has the most chance of maintaining Mr Mee's current abstraction system is to pump the water from one side of the road/railway to the other. By intercepting the runoff from the catchment before it reaches the new road and piping it to the other side, would mean minimal loss of water.

This will mean re-locating of the abstraction point on licence 8/37/55/0076 to the east of the proposed new road. At the new abstraction point, water would be directed into a pumping sump before being pumped around the new and existing roads/railway, and into the current gravity system that runs west of the road to the reservoir. (see Like-for-like elements in green on Figure 2)

The irrigation main that brings water back across the roads in the summer, will also need to be reinstated after the new road has been constructed. It is possible that the same pipe could be used to serve both these purposes. The best way to connect the new and existing systems will be confirmed in the options development (Stage 2 of our proposal).

3.1.4 Uncertainties of delivering like-for-like

Having said that this option presents our best chance of creating a like-for-like system, there are a couple of key issues that may mean it doesn't deliver:

- It is possible that some of the drainage from the banks of the current M25 road may no longer be captured at the new abstraction point.
- Water that currently runs along the drains at the southern boundary of the catchment are likely to be disrupted by the construction of the new road, or potentially directed away from the new abstraction point.

In order to minimize this potential reduction in catchment area, we would suggest the following steps are taken:

- Where possible LTC look to direct drainage from the new road into ditches that supply the catchment to the abstraction point.
- That the drains on the southern boundary of the catchment are considered when positioning the new abstraction point in order that this part of the resource is maximized.

Therefore, since it is not possible to be certain how well the like-for-like option will perform, it would be appropriate to add an insurance element to the solution.

3.2 Options for the Insurance Element

We have already said that a reduction of just 10% in the current inflow to the reservoir could switch it to a three-year storage facility. Therefore, we suggest that at least 40% of the current licence quantity should be mitigated for by the provision of an alternative supply. We suggest that, in combination with the like-for-like element suggested above, LTC also support Stuart Mee with an insurance element. The following three options all have some potential in providing insurance against a failure of the like-for-like element.

3.2.1 Development of licence 8/37/55/20

Part of the insurance element should be to develop the licence already existing at Kemps Farm. This licence currently allows the abstraction of 6,819m3/yr. This abstraction point was considered in our previous report 'Report to EA V0.4'. We concluded that the catchment area was approximately 0.8km^2. Looking again, this may be on the high side, but even if we assume a catchment area of just 0.4km2, based on the effective rainfall method detailed earlier in this report, the catchment could yield up to 50,000m3 a year. It is quite feasible that 30,000m3 of this could occur in the winter.

So, our conclusion is that this licence could potentially support a larger abstraction. Mr Mee doesn't own the land where the current reservoir is sited. However, he does own the ditch where the abstraction point is located. Therefore, by creating a new abstraction sump adjacent to the ditch, on Mr Mee's land, would allow abstraction into the main reservoir (see Figure 2). There are already some irrigation mains in this area. These would need to be upgraded and connected into the new system.

3.2.2 Development of shallow groundwater

Another part of the insurance element of the option could be to develop a shallow groundwater source. The source would need to have sufficient continuity with surface waters to allow the EA to regulate it based on surface water flows. For the majority of Mr Mee's land the gravels are contributing water to the same catchment as his other abstractions, making it very unlikley that other resources would be avaiable. However, in the north western part of the farm, to the north of the reservoir, is an area of gravels that looks likely to be contributing water to the River Ingrebourne catchment. The Ingrebourne is a water avaiable catchment (according to the oding, Beam, Ingrebourne and Mardyke Abstraction Licensing Strategy). Therefore, it would be worth exploring this as a potential insurance option. If we could secure a 30,000m3/year from the gravels, together with an increase in licence 8/37/55/20, would provide the 40% of current licence volume that we are looking for.

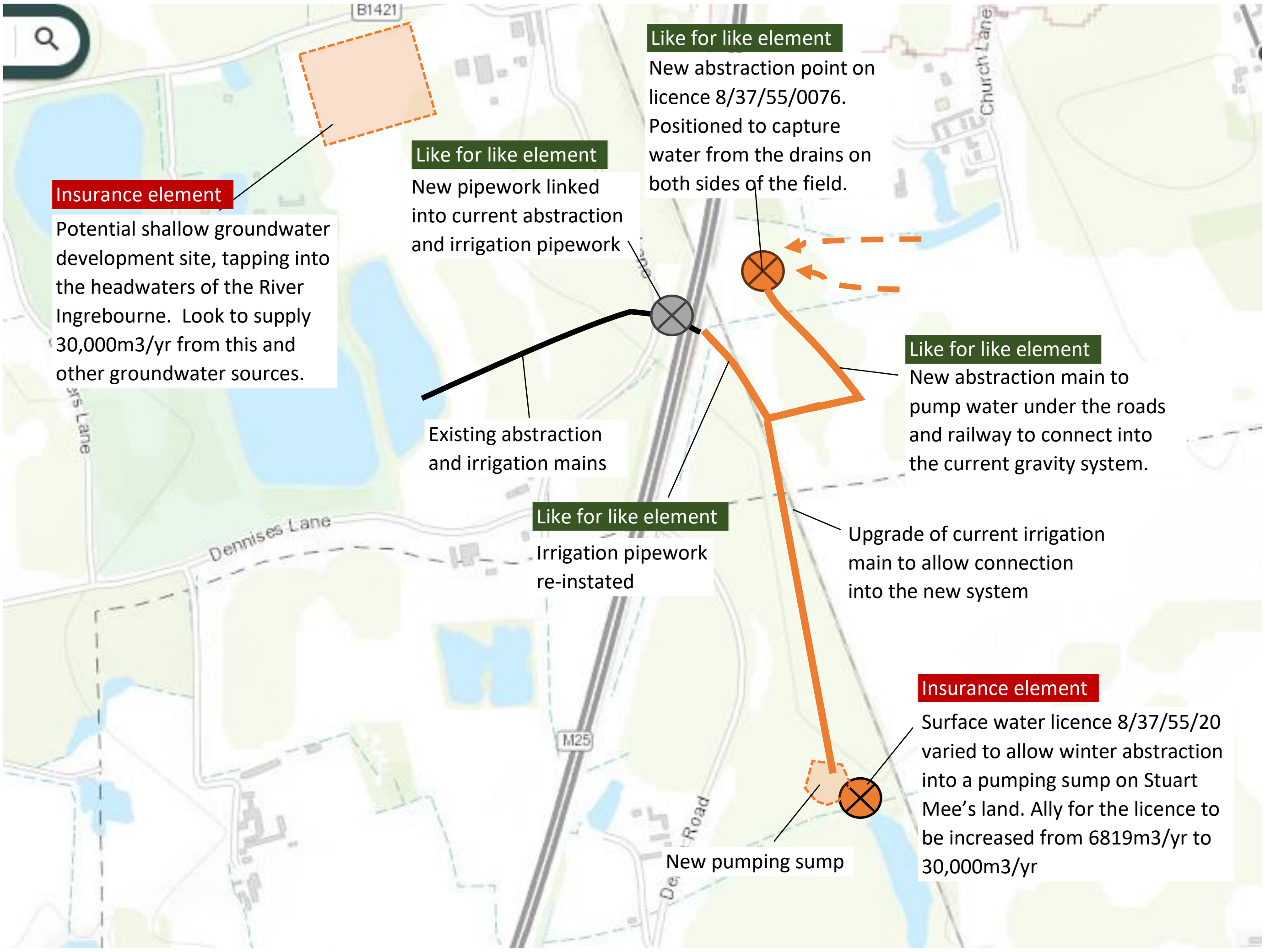

Figure 2: Map of the proposed like-for-like and insurance elements of the option. New elements are in orange.

3.2.3 Development of chalk groundwater

This has been looked at in part reports. There is likely to be a some available resource based on our discussion with the groundwater team in relation to other chalk boreholes in the area. However, the chalk at this location is known to have poor yields and the water quality is likely to be characteristic of fossil/historic water. Therefore, there is some doubts as to whether chalk boreholes would be able to supply enough water of sufficient quality to meet Mr Mees irrigation requirements. I recommend we still ask the EA about availability, but that this is considered as a back up insurance option that should be explored in detail if the other insurance options do not provide what we need.

4. Conclusions and recommendations

We recommend that a pumped system is installed to give the best chance of creating a like-for-like solutions. However, there is some uncertainty around how this will change the water balance and the post-construction drainage. This means that an insurance element needs to be included as part of any final solution. The insurance elements presented have the potential to provide up to 40% of the current licence quantity to ensure that the reservoir does not switch to a three-year storage facility.

As part of stage 2 (Options Development) we recommend the follow actions:

1. The pumped system described in 3.1.3 is taken to the design stage. This will provide outline design of abstraction and pumping infrastructure and indicative costs.

2. An enquire is made with the relevant EA teams to find out the feasibility of permitting:
    a. an increase to licence 8/37/55/20 (Kemp Farm)
    b. abstraction from the gravels in the north-western part of the farm.
    c. abstraction from the chalk.

Important Note: All the solutions proposed in this report are dependent on gaining permission from the Environment Agency. Therefore, we will not know if either the like-for-like or the insurance options are fully feasible until we have completed the stage 2 options development work.

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