



J N P G R O U P
CONSULTING ENGINEERS

**Flood Risk Assessment and
Drainage Strategy Technical Note -
Updated Drainage Strategy**

Project: Ford Airfield – The Landings
Arundel

Client: Redrow Homes and Wates Developments

Reference: C85228-JNP-XX-XX-RP-C-1000 P02

Date: 10 February 2021

Job name: Ford Airfield – The Landings

Job No: C85228

Note No: C85228-JNP-92-XX-RP-C-1000

Date: 10/02/2021

Prepared by: Anthony McNevin

Subject: FRA and Drainage Strategy Technical Note – Updated Drainage Strategy

1. Executive Summary

- 1.1 JNP Group were instructed by Redrow Homes and Wates Developments to prepare a Flood Risk Assessment (FRA) and Drainage Strategy report to support an outline planning application for the Ford Airfield, Arundel development site. The development will comprise of up to 1500 dwellings and includes commercial, employment and leisure infrastructure and a primary school.
- 1.2 The development was registered for outline planning on 28 February 2020. The Arun District Council (ADC) Drainage Engineer provided outline planning comments in respect to the surface water drainage in April 2020. The ADC Drainage Department did not object to the development but recommended 4 no. planning conditions.
- 1.3 This report takes the comments raised by ADC and provides more detail to enable definitive conditions to be agreed. It provides clarity to avoid ambiguity during the detailed design phase. This will enable the development layout to be confirmed. It is essential that all parties clearly understand what ADC and West Sussex County Council will be willing to approve during forthcoming reserved matters applications.
- 1.4 To enable this, a detailed investigation has been carried out and the relevant supporting information accompanies this report. This includes:
 - Comprehensive winter soakaway testing and groundwater monitoring which covers the entire site.
 - A thorough survey of the offsite sewer which discharges surface runoff from the runway area to the River Arun.
 - A detailed assessment of existing catchment areas, points of discharge and historic culverts which may have crossed the site in the past.
 - Drainage solution optioneering and detailed designs and calculations.
- 1.5 The FRA and Drainage Strategy Report issued in February 2020 highlighted that infiltration drainage will be used where it is feasible and appropriate, subject to further winter site investigation testing.
- 1.6 Based on the work outlined above, updated drainage strategy proposals are provided. The findings of the winter site investigation have changed the drainage strategy in the north of the site, however, the proposed solutions for the south of the site remain the same.

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1.7 These are in summary below:

- **North of the Site** - Transport surface water via a sewer network to an onsite infiltration basin and discharge into the ground.
- **Northern Roundabout** - Provide a new soakaway for offsite highway works.
- **Employment Zone** - Discharge surface water to the ground using soakaways located on site.
- **Northwest parcels** - Transport surface water via a sewer network to an onsite infiltration basin and discharge into the ground.
- **South of the Site** - Transport surface water via a sewer network to an attenuation basin and provide a pumping station to discharge, at a restricted flow rate, to the River Arun in the east. Surface water runoff from the airfield currently discharges to the River Arun in the east via the private offsite sewer.
- **Southwest** - Transport surface water via a sewer network to an attenuation basin and underground storage and discharge at a restricted flow using a gravity sewer to a tributary of the Ryebank Rife, via the route of the existing 150mm dia sewer from the site.
- **Southeast** - Transport surface water via a sewer network to an attenuation tank and discharge at a restricted flow using a gravity sewer to a second tributary of the Ryebank Rife, via the route of the existing 450mm dia sewer from the site.

1.8 Only the south of the site will require a surface water pumping station to discharge offsite. All other alternative options for the south have been investigated and are not viable because:

- **Infiltration drainage** – The winter site investigation proves this is not viable.
- **Discharge by gravity to the offsite sewer** - The existing offsite sewer is too shallow. Connecting to the invert of the offsite sewer and providing an incoming onsite gravity sewerage system and attenuation basin requires significantly more raising of ground across the south of the site than a pumping station solution.
- **Using swales onsite, rather than a piped network, to transport flows across the site** – Due to the size of the site, the distances involved and the flat topography this still requires significant ground raising to discharge by gravity to the offsite sewer. Deep watercourse channels would be needed to receive incoming connections from development parcels. Due to the flat site topography there is a risk the channels could suffer groundwater ingress.

1.9 An attenuation basin and pumping station is also required to serve the south of the site because:

- It requires the least raising of ground levels across the site than all other options.
- It is the most sustainable option as it requires significantly less fill to be imported to the site

than alternative options.

- It enables all main surface water sewers and the pumping station to be adopted and maintained by Southern Water.

- 1.10 Detailed information is provided in the appendices to support the drainage strategy and should be reviewed to fully understand the constraints which impact upon the development site drainage.
- 1.11 Redrow Homes and Wates Developments firmly believe the drainage strategy should be formally agreed with ADC to enable the development layout to be finalised and the scheme to progress further. We welcome the opportunity to work with ADC to achieve this.

2. Introduction

- 2.1 JNP Group were instructed by Redrow Homes and Wates Developments to prepare a Flood Risk Assessment (FRA) and Drainage Strategy report to support an outline planning application for the Ford Airfield, Arundel development site. The development will comprise of up to 1500 dwellings and includes commercial, employment and leisure infrastructure and a primary school.
- 2.2 The development was registered for outline planning on 28 February 2020. The planning application number is F/4/20/OUT. The FRA and Drainage Strategy report by JNP Group reference is C85228/ R001E dated 14 February. This technical note should be read in conjunction with the FRA report.
- 2.3 The FRA was submitted whilst supplementary soakaway soil infiltration rate testing and groundwater level monitoring was carried out over the winter period of 2019/2020.
- 2.4 The Arun District Council (ADC) Drainage Engineer provided outline planning comments in respect to the surface water drainage in April 2020. The ADC Drainage Department did not object to the development but recommended 4 no. planning conditions. The comments raised and recommended planning conditions are provided in Appendix A.
- 2.5 This technical note responds to the comments and queries raised by the ADC Drainage Engineers. It also provides an updated surface water drainage strategy for the development based on the results of the winter 2019 / 2020 soakaway testing and groundwater monitoring.
- 2.6 The ADC Drainage Engineers commented:
- “The Development layout should not be agreed until such time that there is a workable and substantially agreed surface water drainage proposal”*
- For the development to proceed further Redrow Homes and Wates Developments require ADC to formally agree the surface water drainage proposal. The drainage strategy and supporting information is provided in significant detail to enable this.
- 2.7 The aim of this report to reach agreement with ADC regarding the surface water drainage strategy beyond ambiguity and where possible remove or discharge the outline planning conditions.

3. Existing Catchment Areas and Points of Discharge

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- 3.1 JNP Drawing No C85228-SK130, titled Existing Catchment Areas and Points of Discharge is provided in Appendix B. This drawing was presented to David Easton, ADC Planning Department, during a meeting held on 7 May 2019 to demonstrate the drainage strategy guided the conceptual design for the development
 - 3.2 The existing ground levels onsite are flat to gently sloping. The direction of natural falls across the existing ground is represented by green arrows on the above drawing. The proposed ground profile of the development generally mimics the existing ground profile.
 - 3.3 There are no existing watercourses or open ditches within the development site. There is a small pond on the edge of the northern boundary. However, this has a very small catchment area and would only receive flows from a larger area if water collected on the surface of the site and overtopped the 3.500m AOD contour.
 - 3.4 The north of the development site is not served by a positive drainage system (i.e a sewer network) or land drainage system. Surface water discharges by partial infiltration and evapotranspiration.
 - 3.5 The majority of the original airfield infrastructure discharges to an underground piped drainage system which discharges to the River Arun to the east of the site. This private sewer flows under the Rudfield Industrial Estate and Church Farm enroute to the River Arun. As part of our drainage strategy work, we have traced and CCTV surveyed the route of the offsite sewer. This is discussed in Section 3 below.
 - 3.6 The existing surface water sewers, from the airfield infrastructure, are unrestricted in terms of flow rate.
 - 3.7 More recent infrastructure immediately adjacent to the existing airfield, comprising of an access road and the Ford Materials Recycling Facility, discharge surface water to a large open channel adjacent to Ford Road. This connects to an ordinary watercourse which is a tributary of the River Arun.
 - 3.8 The west of the site falls towards Yapton Road. The vehicular site entrance and access road, into the site off Yapton Road, discharges surface water via a 150mm diameter sewer connection, to an ordinary watercourse located adjacent to the Ford Air Rifle Range. This is a tributary of the Ryebank Rife.
 - 3.9 There is a second sewer outfall from the site, 450mm diameter, located in Horsemere Green Lane. This discharges to a separate tributary of the Ryebank Rife which lies adjacent to Northwood Farm.
 - 3.10 The latest proposed drainage strategy for the development, discussed in more detail below, proposes to reuse the existing points of discharge:
 - Northern part of the development site – Infiltration to the ground
 - Southern part of the development site – Discharge to the River Arun to the east. The flows from site will be restricted to Greenfield Runoff Rate (QBar) and will be less than the existing unrestricted flow from the onsite sewers which discharge to the River Arun. This provides a betterment in the flow rate from site.
 - Southwestern and South-eastern parts of the development site – Discharge, via existing
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sewer outfalls, to the Ryebank Rife in the west. However, the flows from the site into the existing 150mm and 450mm dia sewers will each be restricted to 2.0 l/s to provide betterment from the existing flow rates from the site.

4. Existing Culverted Watercourses Which Cross the Site

- 4.1 The ADC Drainage Engineer has advised that *"at least one culverted watercourse is believed to cross the site (southern area), but there may be more, since some of the infrastructure (across the airfield) may have been laid in former ditches"*.
- 4.2 Copies of historical maps for the Ford Airfield Site are provided in Appendix B. Maps are provided for 1876, 1896, 1910, 1950, 1961, 1966, 1978, 1981, 1992, 2002, 2010 and 2014.
- 4.3 Only the 1910 map shows a ditch to the south of the site flowing eastwards. An extract of the map is provided below:

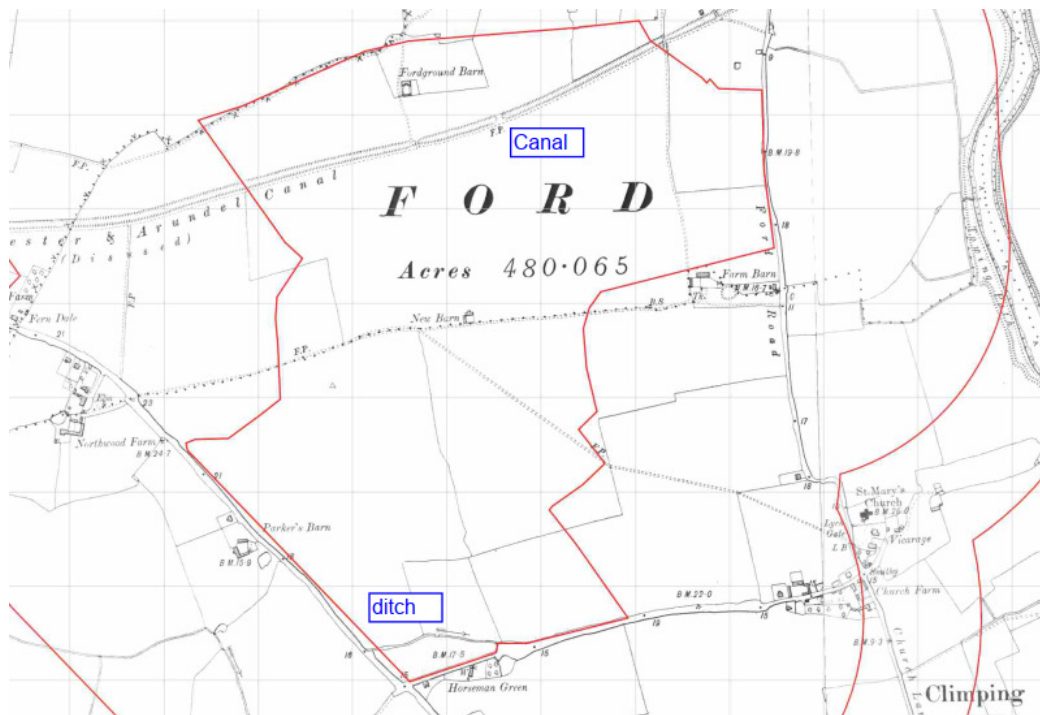


Fig 1 1910 Historic map of the site showing the ditch

- 4.4 The outfall from the historic ditch appears to coincide with the 450mm dia sewer pipe which leaves the site boundary in Horsemere Green Lane.
- 4.5 In January 2019 CD Surveys attempted to trace this sewer onsite but were forced to abandon the survey of the incoming sewers due to heavy siltation.

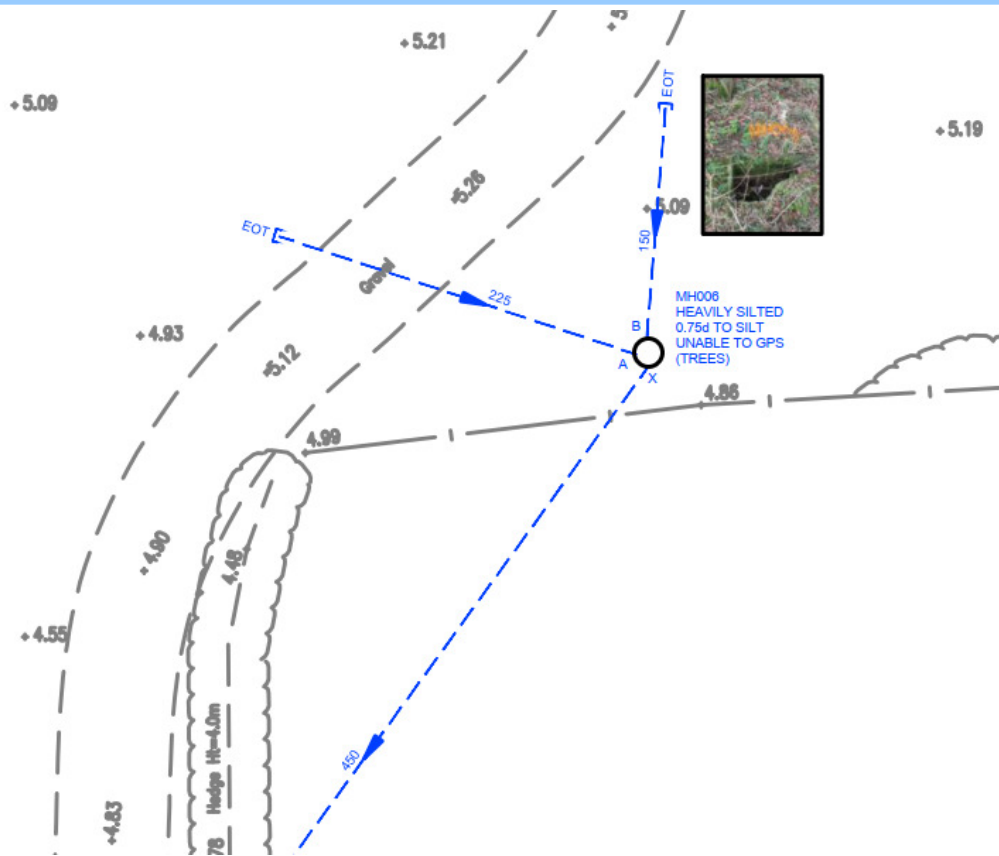


Fig 2 Extract from CD Surveys drainage investigation drawing showing extent of trace at the suspected culvert. Jan 2019

- 4.6 This historic ditch is located within proposed greenspace. If a culvert is uncovered at this location, and proven to be a live connection, it can be diverted within the greenspace and connected to the existing 450mm dia outfall sewer.

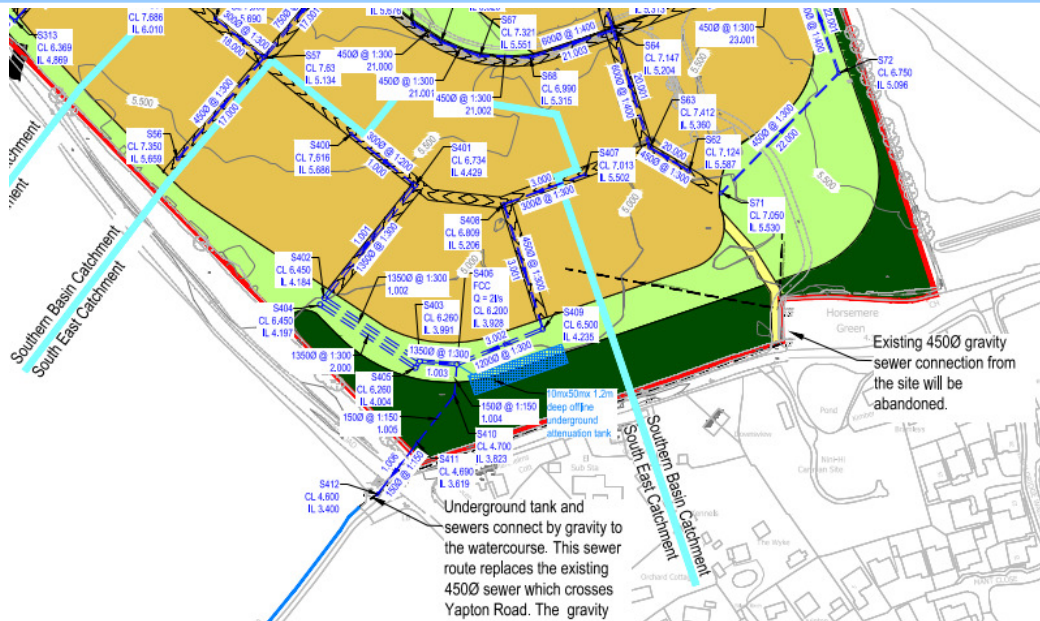


Fig 3 Extract from the development Drainage Strategy drawing showing the historic ditch is located in a proposed area of greenspace

- 4.7 The historic maps do not show any other known former ditches which cross the airfield site. In addition, there is no evidence of a wider network of filled ditches across the airfield.

5. Existing 675mm Diameter Offsite Sewer Discharging to the River Arun

- 5.1 In November 2020 Redrow Homes and Wates Developments appointed Dene -Tech Services Ltd to trace and CCTV survey the existing private gravity sewer which receives surface water from Ford Airfield and discharges it to the River Arun.
- 5.2 A sewer connectivity survey layout drawing is provided in Appendix C. This drawing shows the surveyed sewer route through Ford Airfield, the Rudford Industrial Estate and Church Farm before reaching the River Arun.
- 5.3 The CCTV survey recorded:
- The total length of the sewer network from site to the River Arun = 1577m
 - Total length successfully CCTV surveyed = 697m
 - Total length of abandoned survey = 880m. The survey was mainly abandoned due to blockages and silt in the sewer.
 - Based on the surveyed sections the inspected pipes are in an acceptable structural condition
 - Not all manholes are constructed to current adoptable standards
 - Future Service and Operational works comprise of removal of silt, settled depositions and

blockages.

- 5.4 The sewer passes under existing buildings and at least 1 no. manhole is located inside a warehouse building. There are a number in incoming surface water connections from the industrial estate.

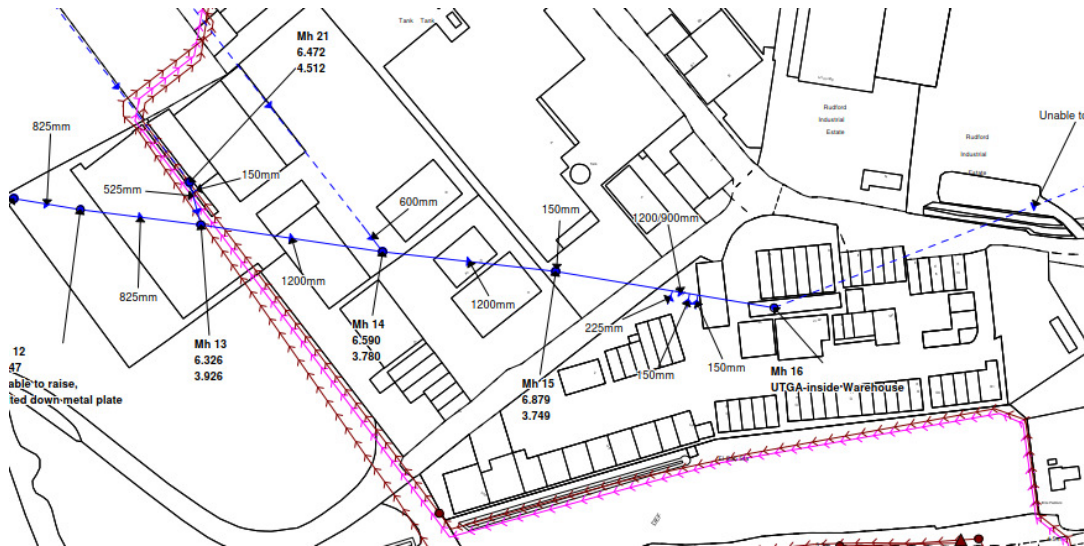


Fig 4 Extract from the Dene-Tech Services Limited CCTV survey of the offsite sewer to the River Arun showing the sewer route under existing buildings and incoming surface water connections at the industrial estate.

- 5.5 JNP has previously raised concerns in our FRA report regarding connecting the new development into the existing private surface water sewer.
- 5.6 JNP have highlighted to Southern Water (SW) that it might be necessary to serve the development using surface water pumping stations. SW has confirmed it would be willing to adopt surface water pumping stations
- 5.7 Southern Water is yet to confirm whether it would be willing to adopt the new surface water

infrastructure onsite if it connects to the offsite sewer and if it would be prepared to adopt the offsite sewer. JNP are currently clarifying Southern Water's position based on the findings of the CCTV survey.

- 5.8 The drainage trace and CCTV survey has confirmed the depth and invert level of the offsite sewer at the boundary of the development site. This enables JNP to assess the impact of raising the drainage infrastructure and finished ground levels across the south of the site to enable a gravity sewer connection from the development site to the private sewer. This is discussed in more detail in Section 11 below.

6. Winter 2020 Soakaway Testing and Groundwater Monitoring

- 6.1 Between 17 February 2020 and 2 March 2020 RSK Environmental Limited carried out winter soakaway testing and groundwater level monitoring across the development site.
- 6.2 Testing was carried out during a significantly wet period of heavy rainfall both before and during the site works. The groundwater level monitoring shows that groundwater levels started to dramatically increase onsite in December 2019 when compared against the data for previous months and the site monitoring data from winter 2018 /2019.
- 6.3 The results of the site investigation and infiltration testing are provided in a letter report and attachments provided by RSK dated 16 April 2020.
- 6.4 For ease of reference the results are shown on the following drawings in Appendix D.
- C85228-D109 Groundwater Level Monitoring Plan
 - C85228-D122 Infiltration Rate Test Location Plan February 2020
- 6.5 Soakaway testing was carried out at both shallow (0.5 to 0.6m below existing ground level (begl)) and deep (1.5 to 3.0m begl) depths in the allocated site investigation parcel which cover the entire site.
- 6.6 The groundwater monitoring confirms that groundwater flows northwards beneath the site and there is a significant difference in the maximum recorded groundwater level from the southern site boundary to the northern site boundary.
- In December 2019 the groundwater level was recorded at 6.082m AOD in the South of the site (at monitoring well DS22Z [Parcel 19] - 0.580m begl).
 - In December 2019 the groundwater level was recorded at 2.012m AOD in the North of the site (at monitoring well DS3Z [Parcel 4] - 1.785m begl).
- 6.7 The winter site investigation results have been used to review and where required reassess the drainage strategy for the development. This is discussed in more detail, for each area of the site, below.

7. The Northern Infiltration Basin

- 7.1 The soil infiltration rate testing across the northern half of the site produced variable results where

individual tests ranged from 6.5×10^{-7} m/s to 1.1×10^{-5} m/s.

- 7.2 Generally, based on our experience, with other LLFA's across the country, infiltration drainage solutions are not preferred where soil infiltration rates are slower than circa 5×10^{-6} m/s because this requires large, deep features which do not achieve the required half drain down in 24 hours.
- 7.3 Good and consistent soil infiltration rates were recorded at the proposed location of the Northern basin (Parcel 4). The tests were carried out at 1.8m deep, which is representative of the proposed base level (2.450m AOD) of the basin, achieving an infiltration rate of 6.1×10^{-5} m/s.
- 7.4 Our preferred solution is to discharge surface water from the northern parcels, via a piped sewer network, to a single infiltration basin located in Parcel 4.
- 7.5 The maximum recorded winter groundwater levels in the vicinity the proposed infiltration basin are shown below. It is considered that the proposed base level of 2.450m would reduce the risk of groundwater ingress into the basin based on the worst case winter results taken during a significantly wet period.

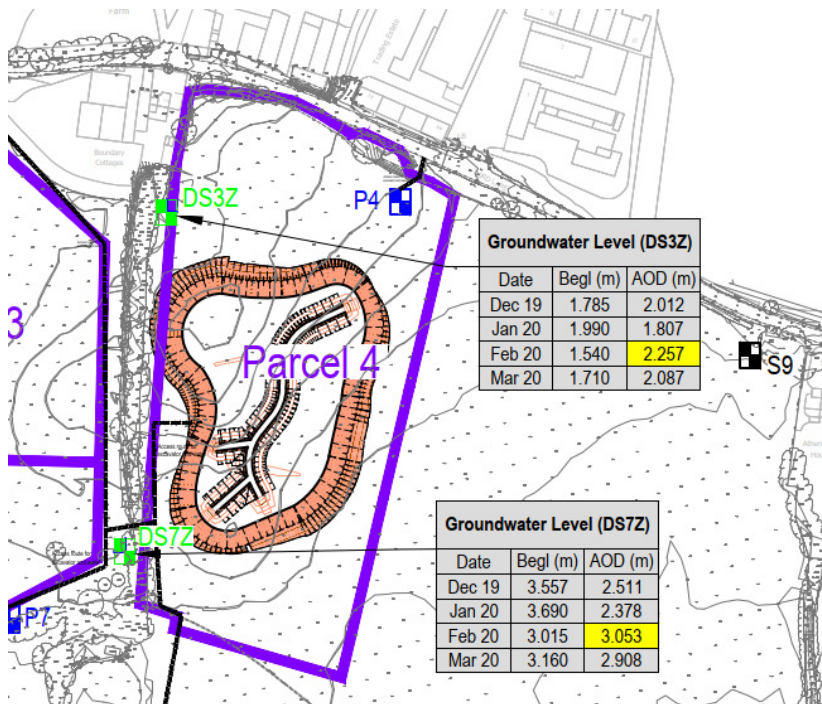


Fig 5 Winter 2020/19 groundwater monitoring results

- 7.6 Based on previous correspondence, ADC has advised that it does not require clearance between the base of the SuDS feature and the maximum anticipated groundwater level. It is proposed to use infiltration permeable paving / tanked permeable paving within the parcel design to improve water quality where possible.
- 7.7 Freeboard will be greater in periods of less intense rainfall as shown below.
 - July 2020 Groundwater Level DS3Z = 1.007m AOD
 - July 2020 Groundwater Level DS7Z = Dry i.e deeper than 1.068m AOD

- 7.8 The northern infiltration basin is located in the lowest part of the site where existing ground levels are circa 3.0m AOD. Based on the current design the top water level in the infiltration basin will be circa 4.030 m AOD for the 1 in 100 year + 40%CC design event. The lowest ground level around the crest of the infiltration basin is 4.700m. The natural slope of the land locally in this area provides additional storage and protection greater than 100 year + 40% CC design storm event as the finished ground level at the nearest housing parcels will be circa 5.3m AOD.
- 7.9 The natural slope of the land in the vicinity of the infiltration basin enables an underground sewer network to be laid across the northern half of the site to the basin, with limited raising of ground levels. Based on the detailed sewer network design and proposed highway vertical alignment, provided in Appendix E, we estimate that on average the ground levels along the primary and secondary road network will need to be raised in the region of 500mm above existing ground levels.

Please refer to Drawing no. C85228-D110 titled Indicative Proposed Ground Levels Sheet 1 of 2 in Appendix E. An extract of the drawing is provided below for reference.

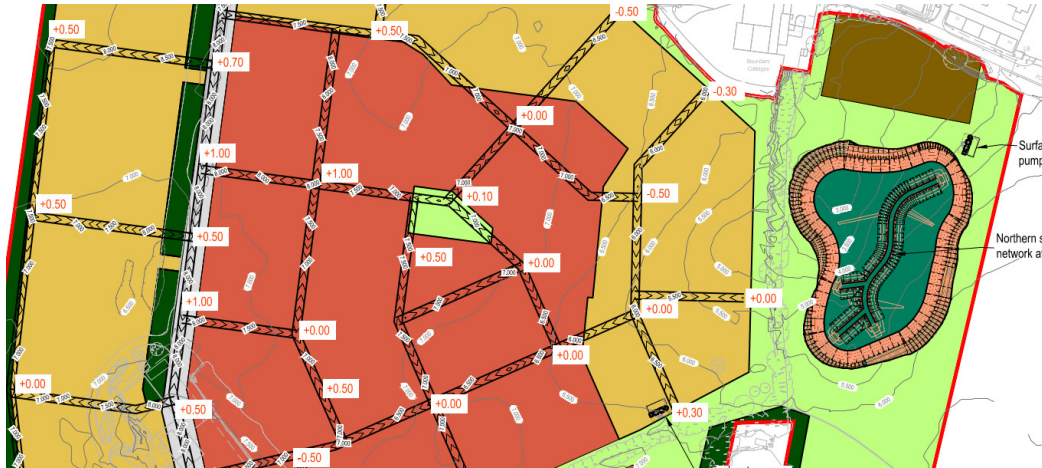


Fig 6 Extract of C85228-D110 titled Indicative Proposed Ground Levels Sheet 1 of 2 in Appendix E showing proposed difference in ground level

- 7.10 The proposed design of a single infiltration basin to serve all parcels in the north of site is in our opinion, more robust than multiple soakaways and basins in individual parcels, which would rely on individuals to maintain. The basin is located in the lowest part of the site where the infiltration rates are significantly better than the parcels located to the northwest.

8. The Ford Road Roundabout Infiltration Basin (Option)

- 8.1 Soil infiltration rate tests were carried out within 77m of the centre of the proposed Ford Lane roundabout. The following infiltration rates were recorded.
- 1.80m deep = 1.64×10^{-5} m/s (slowest test rate)
 - 0.75m deep = 7.93×10^{-5} m/s (slowest test rate)
- 8.2 In February 2020 groundwater was measured at 4.000m bgl (3.181m AOD) in proximity of the

proposed roundabout.

- 8.3 Based on the above infiltration rates we recommend that the Section 278 highway works, to provide the new roundabout and amendments to Ford Lane on the approach roads, should discharge surface water runoff to a standalone highway drainage soakaway.
- 8.4 The soakaway would be located in the central island of the roundabout. A design proposal and calculations which confirm this, is provided in Appendix H.

9. The Employment Zone Infiltration Soakaways

- 9.1 Soil infiltration rate tests were carried out within the employment zone parcel. The following infiltration rates were recorded.
 - 2.10m deep = 1.75×10^{-5} m/s (slowest test rate)
 - 1.20m deep = 1.08×10^{-6} m/s (slowest test rate)
- 9.2 In February 2020 groundwater was measured 3.210m begl (2.447m AOD).
- 9.3 The employment zone can be served by soakaways. A design proposal and calculations which confirm this, is provided in Appendix G.

10. The Northwest Infiltration Basin

- 10.1 The original FRA report and drainage strategy provided an attenuation basin and pumping station in the northwest of the site to serve a small number of parcels in an area of low-lying ground.
- 10.2 Soil infiltration rate tests were carried out at the proposed location of the basin. The following infiltration rate was recorded.
 - 2.70m deep = 2.07×10^{-5} m/s (slowest test rate)
- 10.3 In February 2020 groundwater was measured 2.410m begl (5.358m AOD).
- 10.4 This part of the site can be served by an infiltration basin. However, it will be necessary to locally raise the ground levels in the parcels furthest from the basin, to facilitate a gravity system to discharge surface water to the basin.
- 10.5 A design proposal and calculations which confirm this, is provided in Appendix H.

11. The Southern Attenuation Basin

- 11.1 The original JNP Group FRA report and drainage strategy recommended an attenuation basin and pumping station to serve the majority of the south of the site. The south of the site is significantly flatter than the north and has a higher water table. Therefore, more significant earthworks and raising of existing ground is required to discharge surface water to the attenuation basin via a gravity sewerage system.
- 11.2 Based on the winter 2019 / 2020 site investigation the highest groundwater levels and slowest soil infiltration rates recorded in the south of the site are shown below. This information is also shown

on the following drawings in Appendix D.

- C85228-D109 Groundwater Level Monitoring Plan
- C85228-D122 Infiltration Rate Test Location Plan February 2020

Parcel	Infiltration Rate m/s (Shallow)	Infiltration Rate m/s (Deep)	Groundwater Level - m BEG L	Groundwater Level - m AOD
13	3.62×10^{-6} (0.75m)	Test failed (1.50m)	1.380 (Feb 20)	5.726
14	7.77×10^{-7} (0.50m)	1.15×10^{-6} (1.00m)	1.260 (Feb 20)	5.904
15	Test Failed (0.75m)	Test Failed (1.50m)	Well static	Well static
16	Test Failed (0.50m)	Test Failed (1.00m)	1.020 (Dec 19)	5.611
17	4.24×10^{-7} (0.50m)	Test Failed (1.00m)	Well static	Well static
18	Test Failed (0.75m)	Test Failed (1.50m)	Well static	Well static
19	Test Failed (0.80m)	No Test	0.893 (Dec 19)	5.396
20	4.88×10^{-7} (0.80m)	No Test	0.580 (Dec 19)	6.082
21	No Test	2.77×10^{-7} (2.80m)	1.830 (Dec 19)	4.467
22	4.78×10^{-6} (0.60m)	No Test	Well static	Well static
23	Test failed (0.80m)	6.22×10^{-7} (1.6m)	0.923 (Dec 19)	4.952
24	Test Failed (0.50m)	No Test	0.335 (Feb 20)	4.816

Notes

- No test - no infiltration rate test was at the specified depth
- Test Failed - test failed to record infiltration in accordance to BRE 365 test requirements
- Well static – No variance in water level in the well was observed. It is assumed this is due to very poor soil conditions.

Table 1 Winter 2019/ 2020 soil infiltration and groundwater monitoring test results

- 11.3 The above infiltration rate tests show very slow / poor rates were observed. In a large number of test locations the water level failed to reduce, even with monitoring carried out over a 24 hour period.
- 11.4 The groundwater monitoring shows the water table across the south of the site is significantly higher than the north of site. Groundwater levels in the southwest are particularly high. The lowest groundwater levels are in the southeast where the southern basin is located (Parcel 21).
- 11.5 The above results show that infiltration is not viable for the southern parcels of the development. We do not consider that individual swales, basins, soakaways or infiltration permeable paving can be provided on a parcel by parcel basis. The flat ground and high water table does not allow for a robust infiltration solution. Flood routing for exceedance flows would be a particular concern.
- 11.6 The infiltration rate test carried out at the southern basin provided a rate of 2.77×10^{-7} m/s. Calculations show that it would not be possible to provide a large infiltration basin at this location, to serve the south of the site. The half drain down time would be in excess of 4 days.
- 11.7 To act as an infiltration basin, the bottom of the basin would need to be above the worst-case winter groundwater level of 4.467m AOD. This would require site levels to be significantly raised to

provide a gravity sewerage system, across the site, to discharge water to the infiltration basin. This is explained in more detail in Sections 11.12 and 11.13 below.

- 11.8 The winter site investigation findings support the drainage strategy to serve the southern extremity of the site using attenuation and discharge, at Greenfield Runoff Rate QBar, to the River Arun and the Ryebank Rife as discussed in Section 2 above.
- 11.9 Discharging surface water from the southern attenuation basin into the existing 675mm dia offsite sewer, discussed in Section 4 above, has been considered in detail and is explained in more detail below. Detailed design strategy drawings and calculations for this option are provided in Appendix I to openly demonstrate how this has been assessed.
- 11.10 The CCTV and drainage trace survey proved that the 675mm offsite sewer is shallow and has minimal fall. The downstream lengths of the offsite sewer do not suddenly become steeper or deeper offsite. The sewer gradient between MH10 to MH11 is 1 in 1156 and between MH14 to MH15 is 1 in 2866. This does not meet acceptable design standards.
- 11.11 Therefore, a gravity sewer connection from the site would be between MH010 and MH011, as shown on the diagram below. The approximate invert level of the sewer connection would be 4.200m to 4.300 AOD.

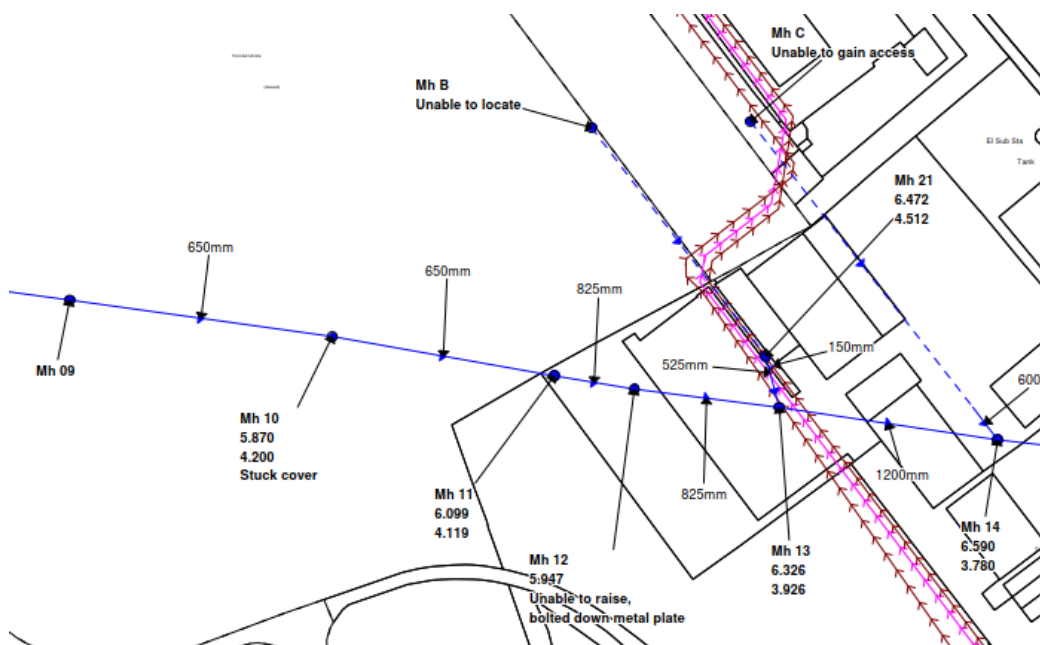


Fig 7 Extract from the Dene-Tech Services Limited CCTV survey of the offsite sewer to the River Arun showing the private foul sewer crossing the site boundary between manholes Mh 10 and Mh 11

- 11.12 The level difference between the invert of the offsite sewer and the sewer outfall at the attenuation basin, from the onsite sewerage system, is 650mm. This allows for:
- The gradient of the sewer from the 675mm offsite sewer connection to the outlet / hydrobrake of the attenuation basin = 350mm fall

- Fall across the base of the attenuation basin = taken as nil (Note - based on best practice this should be 1 in 300 min, but it increases the level difference even further and therefore has been omitted from the design. We have not allowed for a dry weather flow channel through the basin).
- Level difference at the step between the invert level of sewer inlet and the base of the attenuation basin = 300mm (this is a standard adoptable drainage requirement for water companies to prevent blockage, sedimentation at the sewer outfall)

11.13 Therefore, to connect by gravity to the 675mm offsite sewer, the invert level of the new onsite sewer at the inlet to the attenuation basin is 4.950m AOD. The ground level across the site would need to increase by approximately an additional 750mm higher, than the pumping station solution. This clearly is not viable. The difference in ground levels between the existing ground and proposed finished levels are provided in JNP Drawing C85228 D185 titled Indicative Proposed Ground Levels (Gravity Option), provided in Appendix I.

11.14 Providing a pumping station enables the base of the basin and the ground levels across the to be lower. The invert level of the incoming sewer, at the basin inlet, can be 4.200m AOD. This is based on providing a tanked dry weather channel (with a fall) through the base of the basin to the pumping station. The tanking prevents groundwater entering the adoptable surface water sewer network. The base of the attenuation basin would be 4.500m AOD and raised higher than the maximum recorded groundwater level. Therefore, the basin inlet sewer is 750mm lower than the gravity sewer option and significantly reduces the extent of raising ground levels and hence importing of suitable soils across the site. For comparison with the gravity sewer option, the difference in ground levels between the existing ground and proposed finished levels for this option are provided in JNP Drawings C85228 D111 titled Indicative Proposed Ground Levels, provided in Appendix I.

11.15 This pumping station solution was presented in the original JNP Group FRA and Drainage Strategy report for outline planning. It remains the the only viable and sensible solution for the southern parcels of the development.

11.16 The rising main from the pumping station will discharge to the existing open channel at the entrance to the Ford Airfield off Ford Road. This flows to the River Arun in the east. It mimics the existing flow from the airfield which discharges to the River Arun via the offsite 675mm sewer. However, the flow from the pumping station will be restricted to Greenfield Runoff rate QBar and therefore there will be a betterment in flow from the development site.

11.17 We do not recommend pumping the flow from the southern attenuation basin to the 675mm offsite sewer. This is a private sewer and might prevent Southern Water adopting the onsite surface water drainage infrastructure due to the following reasons:

- It is private sewer and is not been regularly maintained
- The asset is approximately 80 years old
- Buildings have been constructed over the sewer which could prevent a sewer requisition agreement

- It is extremely unlikely any of the building owners would consent to build over agreements retrospectively.
- The specification of the sewer is does not meet current adoptable standards
- There are incoming sewers from other existing premises further downstream. Existing incoming flows are not regulated.

11.18 ADC has previously advised that surface water pumping will be the option of last resort. JNP Group concur with this view. However, based on detailed investigations and the evidence presented, we ask ADC to confirm agreement to the use of surface water pumping as part the drainage solution for the south of the development. To summarise, the alternative solutions are not viable because:

- Infiltration – Soil infiltration rates testing and raised groundwater levels show the site does not permit infiltration.
- Onsite attenuation and gravity sewers connecting to the existing 675mm dia offsite sewer - The invert level of the existing sewer is too high and this would result in raising the finished ground levels onsite significantly higher than the ground raising already required for the pumping station solution. This is not feasible from an earthworks perspective due to the volume of addition fill materials that would need to be imported to site.

12. The Southwest Attenuation Basin

12.1 With reference to Table 1 above, winter site investigation testing was carried out in the following parcels located in the south west of the site.

Parcel	Infiltration Rate m/s (Shallow)	Infiltration Rate m/s (Deep)	Groundwater Level - m BEGl	Groundwater Level - m AOD
16	Test Failed (0.50m)	Test Failed (1.00m)	1.020 (Dec 19)	5.611
19	Test Failed (0.80m)	No Test	0.893 (Dec 19)	5.396
22	4.78×10^{-6} (0.60m)	No Test	Well static	Well static
24	Test Failed (0.50m)	No Test	0.335 (Feb 20)	4.816

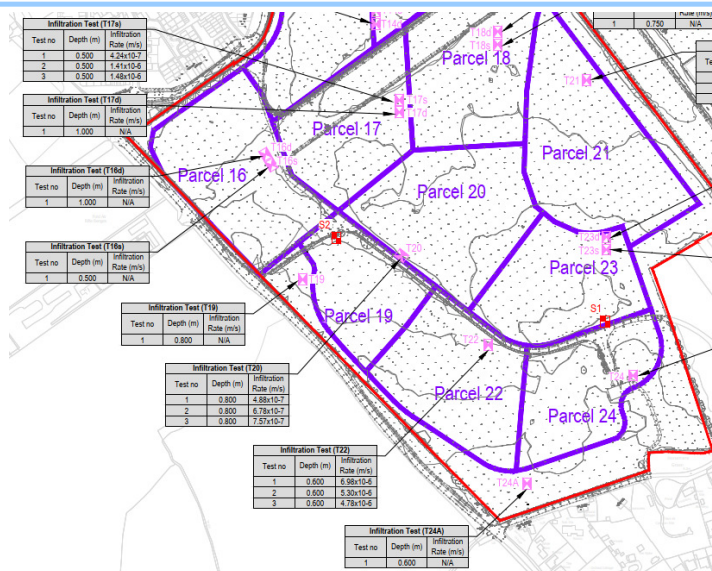


Table 2 Winter 2019/ 2020 soil infiltration and groundwater monitoring test results in the Southwest of the site

- 12.2 The results show that the southwest of the site is not suitable for infiltration drainage. The soakaway tests failed to provide an infiltration rate in accordance to BRE 365 test requirements as the infiltration rate was very slow.
- 12.3 The maximum groundwater level in this part of the site was 1.0m or less below ground level.
- 12.4 As identified in Section 2.8 the west of the site falls towards Yapton Road. The vehicular site entrance and access road, off Yapton Road, discharges surface water via a 150mm dia sewer, into an ordinary watercourse, a tributary of the Ryebank Rife.
- 12.5 Part of Parcels 16, 19 and 22, as shown in Table 2 above will discharge surface water to the existing sewer connection to the Ryebank Rife tributary. The flow from the development will be restricted to 2 l/s and therefore this provides betterment to the existing flow rate from the onsite sewer.
- 12.6 Attenuation will be provided using underground storage and shallow attenuation basins. The depth of the basins is constrained by the shallow groundwater level and depth of the existing drainage connection to the Ryebank Rife tributary.
- 12.7 A design proposal and calculations which confirm this is viable is provided in Appendix J.

13. The Southeast Attenuation Tank Sewer and Tank

- 13.1 With reference to Table 2 the groundwater levels in Parcel 24 and Parcel 22 are the shallowest across the site. Groundwater was recorded less than 0.5m below existing ground level.
- 13.2 Section 2.9 advises there is a second sewer outfall from the site (parcel 24), 450mm diameter, located in Horsmere Green Lane. This discharges to a separate tributary of the Ryebank Rife which lies adjacent to Northwood Farm.
- 13.3 Part of Parcels 22 and 24 will discharge surface water to the existing sewer connection to the tributary of the Ryebank Rife. The flow from the development will be restricted to 2.0 l/s.

-
- 13.4 Above ground attenuation is not feasible in this part of the site due to shallow groundwater. It is proposed to provide underground attenuation tanks and tank sewers for onsite attenuation.
 - 13.5 The development will include tanked permeable paving to provide water quality improvements and additional attenuation. Further information is provided in the FRA and Drainage Strategy Report reference is C85228/ R001E dated 14 February submitted for outline planning.
 - 13.6 A design proposal and calculations which confirm this is viable is provided in Appendix K.

14. Proposed Sitewide Finished Ground Levels

- 14.1 The ADC Drainage Department raised the following comment regarding finished ground levels:
“it is noted that ground levels will be raised across the site. The applicant needs to ensure that there is no negative drainage impact on adjacent developments/ infrastructure as a result.
- 14.2 The above sections of this report clarify and provide evidence of why it will be necessary to raise the ground level across the site.
- 14.3 Ground level raising in the north of the site is relatively modest. Siting the infiltration basin in the lowest part of the site helps to provide sufficient protection and cover over the surface water gravity sewerage drainage network without significantly increasing ground levels.
- 14.4 Across the north of the site, on average, the ground levels along the primary and secondary road network will rise by circa 500mm. The maximum increase in ground level, along the highway network, will be in the region of 1.0m above existing ground level. Please refer to Drawing no. C85228-D110 titled Indicative Proposed Ground Levels Sheet 1 of 2 in Appendix E.
- 14.5 The south of the site is flatter than the north. JNP Drawing No C85228-SK130, titled Existing Catchment Areas and Points of Discharge, provided in Appendix B, shows the difference in existing ground level across the site. The diagram below shows indicative highest and lowest ground levels across the south of the site.

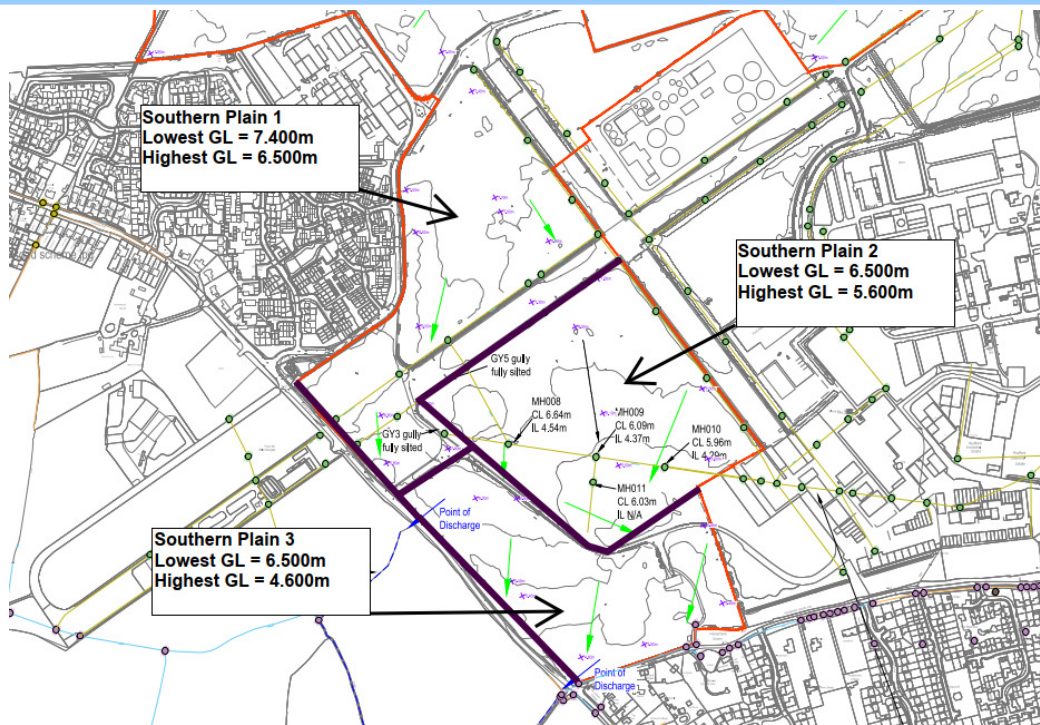


Fig 8 Difference in existing ground levels across the south of Ford Airfield

- 14.6 Sections 10.5 to 10.17 above demonstrate that infiltration across the south of the site is not feasible and providing an attenuation basin which discharges via a pumping station requires significantly less raising of existing ground levels across the site, when compared to other options. Therefore, it carries the least environmental impact in terms of importing fill to site for earthworks.
- 14.7 The difference in ground levels between the existing ground and proposed finished levels for the pumping station solution are provided in JNP Drawings C85228 D111 titled Indicative Proposed Ground Levels, provided in Appendix I. This is covered in more detail in the FRA and Drainage Strategy Report reference is C85228/ R001E dated 14 February submitted for outline planning.

15. Conveyance Swales Design Review

- 15.1 The ADC Drainage Department raised the following comment regarding finished ground levels:
- “Investigate the conveyance of water across the site via features that do not require significant construction depths or gradients i.e permeable paving / swales etc. The use of conventional fully piped system will not be suitable for this site due to topography.”*
- 15.2 The techniques suggested by ADC will be used on a parcel by parcel basis, where appropriate, to minimise ground raising within parcels and deliver surface water runoff to the primary surface water sewerage networks which are discussed above. However, there is still a requirement to provide the surface water sewers under the main highway routes to discharge water the infiltration/ attenuation basins.

- 15.3 Section 7 confirms that the North of the site can be served using an infiltration basin located in the lowest part of the site, where a good infiltration rate was recorded, and the groundwater level is lowest. The natural fall across the site to this low area assists with providing cover over the drainage network and minimises raising ground levels across the site.
- 15.4 A feasibility exercise was carried out to assess the impact of providing a conveyance swale through the south of the site. The following issues were identified which highlight this is not viable:
- Based on the distance required to cover the large, generally flat, site and provide a suitable fall along the channel the conveyance feature would be very deep (up to 2.5m deep) over most of the site. It would be a deep ditch rather than swale.
 - If located adjacent to the primary roads and provided with 1 in 3 gradient sides the ditch would be the region of 12.5m wide due to the required depth.
 - Significant ground raising would still be required over the south of the site to provide a gravity conveyance ditch from the head of the channel to the outfall. An attenuation basin would still be required at the outfall where ground levels are lowest.
 - The finished ground levels of the parcels would need to be raised sufficiently to discharge surface water to the conveyance ditch and to allow for flood routing and flood protection.
 - The groundwater levels are highest across the south of the site. There would be a risk of groundwater ingress and changing natural groundwater flow.
 - Ground raising onsite would be required to provide for suitable road crossings over the conveyance ditch.
- 15.5 The proposed piped sewerage network across the south of the site will still allow for the inclusion of shallow roadside swales across the site and particularly within housing parcels. These are important SuDS features that provide biodiversity and water quality improvements. In addition, by discharging the swales into the main sewers, via small diameter pipes, they also provide additional attenuation during more severe storm events. This will be carried out during detailed design for reserved matters.

16. Conclusions

- 16.1 The proposed surface water drainage strategy for the development discharges to the following existing points of discharge and mimics the existing flows to the outfalls:
- North of the development site – Infiltration to the ground.
 - South of the development site – Discharge to the River Arun to the east. The flows from site will be restricted to Greenfield Runoff Rate (QBar) and will be less than the existing unrestricted flow from the onsite sewers which discharge to the River Arun. This provides a betterment of the flow rate from site.
 - Southwest and Southeast of the development site – Discharge, via existing sewer outfalls,

to the Ryebank Rife in the west. However, the flows from the site into the existing 150mm and 450mm dia sewers will each be restricted to 2.0 l/s which provides a betterment to the existing flow rates from the site.

- 16.2 Winter soakaway testing and groundwater monitoring was carried out between 17 February 2020 and 2 March 2020 over a prolonged very wet period.
- 16.3 The results show that infiltration drainage solutions are viable in the north of the development site, particularly in the northwest corner where good infiltration rates were recorded and groundwater is deepest.
- 16.4 In the south of the site infiltration rates were slow and in some areas the tests failed to infiltrate into the ground. Maximum groundwater levels were generally 1.0m or less below existing ground level. This does not support the use of infiltration drainage.
- 16.5 This technical note should be read in conjunction with the FRA and Drainage Strategy report, reference is C85228/ R001E dated 14 February, submitted for outline planning. The findings of the winter site investigation have changed the drainage strategy in the north of the site. However, the proposed solutions for the south of the site remain the same.
- 16.6 The drainage Strategy for the development proposes as follows:
- North of the Site - Transport surface water via a sewer network to an onsite infiltration basin and discharge into the ground.
 - Northern Roundabout - Provide a new soakaway for offsite highway works.
 - Employment Zone - Discharge surface water to the ground using soakaways located onsite.
 - Northwest parcels - Transport surface water via a sewer network to an onsite infiltration basin and discharge into the ground.
 - South of the Site - Transport surface water via a sewer network to an attenuation basin and provide a pumping station to discharge, at a restricted flow rate, to the River Arun in the east. Surface water runoff from the airfield currently discharges to the River Arun in the east via the private offsite sewer.
 - Southwest - Transport surface water via a sewer network to an attenuation basin and underground storage and discharge at a restricted flow using a gravity sewer to a tributary of the Ryebank Rife, via the route of the existing 150mm dia sewer from the site.
 - Southeast - Transport surface water via a sewer network to an attenuation tank and discharge at a restricted flow using a gravity sewer to a second tributary of the Ryebank Rife, via the route of the existing 450mm dia sewer from the site.
- 16.7 The proposed drainage strategy achieves ADC's requirement to discharge the catchment areas via existing points of discharge.
- 16.8 All options to discharge surface water runoff from the south of the site have been investigated.
- Infiltration drainage – The winter site investigation proves this is not viable.

- Discharge by gravity to the offsite sewer - The existing offsite sewer is too shallow. Connecting to the invert of the offsite sewer and providing an incoming onsite gravity sewerage system and attenuation basin requires significantly more raising of ground across the south of the site than a pumping station solution.
- Using swales onsite, rather than a piped network, to transport flows across the site – Due to the size of the site, the distances involved and the flat topography this still requires significant ground raising to discharge by gravity to the offsite sewer. Deep watercourse channels would be needed to receive incoming connections from development parcels. Due to the flat site topography there is a risk the channels could suffer groundwater ingress and significant silting up.

16.9 An attenuation basin and pumping station is proposed to serve the south of the site because:

- It requires the least raising of ground levels across the site than all other options.
- It is the most sustainable option as it requires significantly less fill to be imported to the site than alternative options.
- It enables all main surface water sewers and the pumping station to be adopted and maintained by Southern Water.
- Southern Water are likely to refuse to adopt the onsite infrastructure if it connects to the private offsite sewer. The offsite sewer presents several construction issues that may not enable a sewer requisition.

16.10 A thorough survey of the offsite sewer has been carried out to enable all options to be reviewed and to confirm that using a pumping station to discharge surface water from the development is the most robust and suitable solution.

16.11 A detailed investigation of the development site has been carried out. This includes significant winter soakaway testing and groundwater monitoring which covers the entire site. The drainage strategy design and supporting calculations have been prepared in detail to confirm the proposed solutions are viable.

16.12 This technical note has addressed the outline planning comments raised by the ADC Drainage Engineer in respect to the surface water drainage issued in April 2020.

16.13 The Developers, Redrow Homes and Wates Developments request the drainage strategy to be formally agreed by ADC to enable the development layout to be finalised and the scheme to progress further. We welcome the opportunity to work with ADC to achieve this.

Document Issue Record

Technical Note No	Rev	Date	Prepared	Reviewed	Approved
C85228-JNP-92-XX-RP-C-1000	P01	09.12.2020	AM	AB	AB
C85228-JNP-92-XX-RP-C-1000	P02	10.02.2021	AM	AB	AB

List of Appendices

Appendix A – ADC Drainage Department Outline Planning Comments on Surface Water Drainage Strategy

Appendix B – Existing Catchment Areas and Points of Discharge & Historic Maps of the Development Site

Appendix C – Offsite Sewer Connectivity Drawing (Route Plan)

Appendix D – Winter 2020 Soakaway Testing and Groundwater Monitoring Results

Appendix E – The Northern Infiltration Basin

Appendix F – The Ford Road Roundabout Infiltration Soakaway (Option)

Appendix G – The Employment Zone Infiltration Soakaways

Appendix H – The Northwest Infiltration Basin

Appendix I – The Southern Attenuation Basin with gravity sewer outfall (not the preferred option but provided to confirm this has been assessed)

Appendix J – The Southwest Attenuation Basin

Appendix K – The Southeast Attenuation Tank Sewer and Tank

Appendix L – Final Sitewide Drainage Strategy Drawings

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