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HEYWOOD UNIT TRUST

PLOT P11 AND PLOT M9/400, HEYWOOD DISTRIBUTION PARK

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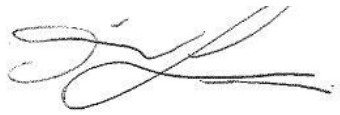

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EXECUTIVE SUMMARY

Enviros Consulting was commissioned by SEGRO Industrial Estates Ltd on behalf of Heywood Unit Trust to undertake a flood risk assessment for proposed developments at Heywood Distribution Park in Rochdale to accompany an outline Planning Application.

The site is located in flood zone 1 indicating that the risk of flooding from major fluvial or tidal sources is very low. As such the sequential test, used by planning authorities to direct development away from areas of high flood risk, indicates that all types of development at this site are potentially appropriate.

A review of the local situation confirmed that the floodplain shown on the Environment Agency flood map is correct and that there are no significant sources of flooding.

Site drainage should ideally follow the SuDS (Sustainable Drainage) management train, which favours local flood control and ideally infiltration where possible. The underlying soil is however likely to be mostly boulder clay and there may be relatively high groundwater levels. As such, infiltration may on the whole be unfeasible.

The Environment Agency have indicated that the site is to be attenuated for the 1 in 100 year event (plus 20% climate change) against the runoff being discharged to Brightley Brook from the current site. Indicative calculations suggest that the volumes to be attenuated to achieve the required outflow are equal to 280 m^3 and 1276 m^3 for plot P11 and plot M9/400 respectively.

Given current development footprint proposals permeable paving with below ground storage may be appropriate for both P11 and M9/400 where car parks, lorry parks and roadways exist.

An alternative is to consider controlled surface water flooding, provided water does not pose a significant risk to users of the site, and that runoff can be controlled and will not enter surrounding property. To achieve these requirements, some sections of the edges of the respective car parks and/pre lorry parks should be raised to contain water. Also, warning signs should be provided for when the development becomes operational.

At the detailed design stage, if it is possible to modify the development footprint sufficiently alternative consideration of utilising attenuation ponds for drainage at sites P11 and/or M9/400 may prove to provide a further site drainage option. Moreover, there exists the possibility to consider routing water from site P11 and/or M9/400 into attenuation ponds or wetland features near to the freshwater ponds that drain into Brightley Brook.

1. INTRODUCTION

This report was commissioned in August 2008 by SEGRO Industrial Estates Ltd on behalf of Heywood Unit Trust. The work concerns the provision of advice on the hydrological constraints to development at and around two plots located in Heywood Distribution Park, Rochdale. A location map is provided in Figure 1. In the preparation of this report consultation has taken place with the Environment Agency (EA) and United Utilities.

1.1 Background

It is proposed that the current plot M9/400 (see Figure 6 for location in relation to Heywood Distribution Park) be developed with a warehouse, 3 storey offices and car/lorry parking facilities. The precise layout of these has yet to be determined. Plot P11 is planned to be redeveloped with a main warehouse, a second warehouse, 2 storey offices and a car/lorry park. Again, the precise layout of planned development is yet to be determined.

1.1.1 Sequential Assessment

The EA flood map (Appendix 2) shows that the whole site is located in flood zone 1_1 indicating that flooding from major fluvial or tidal sources is not likely.

The sequential test as set out in Planning Policy Statement 25: Development and Flood Risk (Reference 1), states that all types of development are potentially appropriate in such areas.

1.1.2 Requirement for a Flood Risk Assessment

Despite the above the EA is expected to object to any planning application for the site on the potential grounds of flood risk unless a FRA is carried out. This is because both sites cover an area of over 1 hectare. As such, a requirement set out in PPS25 (reference 1) states that a flood risk assessment must be undertaken.

For such a site, where no major flood sources exist, the primary focus of assessment is the management of runoff from the development. It must be demonstrated that proposals would not exacerbate flooding elsewhere. Additionally on brownfield sites it is typically necessary to also demonstrate that peak rates of flow should not be greater than the current levels and, where possible, that levels would be reduced to a lower rate (ideally Greenfield rates).

In addition to this PPS25 requires that localised sources of flooding such as sewers, drains and smaller streams that may not be represented on the EA flood map are also considered.

1 The EA flood map was produced as part of a nationwide project to provide visual representation of the extent and risk of flooding throughout England and Wales. This was undertaken for all tidal sources and fluvial sources where catchments are greater than 3km^2. The flood map classifies land as being in one of three zones (flood zones 1, 2 or 3). In areas defined as flood zone 3, the EA estimate that the annual risk of flooding exceeds 1% or 0.5%, for fluvial or tidal sources respectively. In flood zone 2 the annual risk is estimated to be between 0.1 and 1% for fluvial or between 0.1 and 0.5%, for tidal sources. In flood zone 1 the annual risk is assessed to be less that 0.1%.

1.2 Objectives

The objectives of this assessment are to:

- Identify mechanisms by which the site could flood,
- Undertake a formal assessment of the risk posed to the development from all identified flood risk sources and mechanisms,
- Assess the storm water runoff potential for the site and the requirements for its attenuation and disposal,
- Produce a baseline flood risk assessment compliant with the guidance contained within PPS25,
- Identify any other key hydrological constraints to development in any areas of the site.

1.3 Report Synopsis

Chapter 2 describes the site and the surrounding area. Chapter 3 covers the risk of flooding to the site and the consequences to the proposed development should flooding occur. Chapter 4 then discusses the management of site runoff within the site. The report is then concluded in Chapter 5.

2. SITE DESCRIPTION AND BACKGROUND

A site visit was undertaken by Enviros staff on the 19h August 2008.

2.1 Current Site

There are two current sites to be developed, both located within Heywood Distribution Park. The distribution park is a brownfield site comprising mostly warehouse and distribution facilities. The development complex comprises approximately 80 ha in total.

Sites P11 and M9/400 are housed within this area. Site P11 covers an area of approximately 5.1 ha and is centred around Grid Reference SD 846 098. Plot M9/400 is not named on the current site plans. However, the area exists east of plot M9 and west of plots P5 and P4. It covers an area of approximately 7.8 ha and is centred around grid reference SD 837 095. Site photographs are included in Appendix 1. Site P11 is shown in Figure 2 whilst the layout of unit M9/400 is shown in Figure 3 (the location of the two plots is shown on Figure 6).

2.1.1 Land cover

Plot P11:

The site is essentially triangular shaped and is currently occupied by a car park and small portable cabin café to the south and east, with a lorry park to the north and west comprising a hard cover. To the north east of the site a grassed mound approximately 5 m high is found, thought to comprise of material originating from the adjacent distribution park. On the northern and southern boundary there is a raised strip of land approximately 3 m high. This strip of land extends to the north-eastern boundary. The plot in total comprises approximately 3.9 ha impermeable surface (as determined by BJB Consultancy Ltd.).

Plot M9/400:

The site is largely permeable (approximately 4.9 ha) comprising grass and trees. However, a car park and buildings located to the east and north of the site make up approximately 2.7 ha. (Note that these figures are approximate and rounded to one decimal place). A gated access for fire fighting vehicles exists within the north/northeast section of plot M9/400.

2.1.2 Topography

There is a topographic survey available for the entire Heywood Distribution Park.

Plot P11:

The general slope of the site is in a south-westerly direction. Maximum and minimum heights are 123.7 m AOD and 115.0 m AOD respectively over a distance of 270 m. A more pronounced slope exists to the northeast of the site, especially, where a 5 m mound extends down to the existing car park over a short distance. Also, land to the south and north is raised by up to approximately 3 m.

Plot M9/400:

The site has a very slight gradient in the general direction of north to south/ northwest to southeast. The line of steepest gradient that best represents the overall site grades from a maximum height of 120.9 m to a minimum height of 115.4 m over a distance of 380 m, and in a south-easterly direction.

2.1.3 Geology / Hydrogeology

Plot P11:

WSP compiled a report in 2003 based on its findings of 13 boreholes about the site. They found various thicknesses of silt/clay with brick, cement and glass (made ground) above silts and sand. Generally, all borehole contamination assessments were below intervention levels (with the exception of Total Petroleum Hydrocarbons (TPH) which were attributed to tarmac fragments within the sample. PBA conducted a study in 1995 that in part entailed excavation of pits within the mound located to the northeast of the site down to a depth of 4.9 m. This comprised mainly rubble and organic clay. However, 1 trial pit showed the natural soils below were sandy. A summary of geology for this plot is given in Table 1 extracted from a Land Quality Appraisal in an accompanying report by Enviros (in prep.).

Table 1 Geology/hydrogeology of Unit P11

Unit	Composition	Thickness	Presence of Groundwater?	Aquifer Type
Material in Mound (above 118m aOD)	Gravelly organic clay and demolition material	Up to approximately 5m	Not present	N/A
Made Ground (below general ground level)	Silts, clays with clinker, brick and concrete	Ranging from 0.3m – 5.3m. Made Ground thicker over north east where old clay pit previously located.	Yes (Water strikes at 2.8m to 3.7m)	Perched water
Drift	Glacial Till (Boulder Clay)	Previous WSP report identified thickness of 10.5m	Possible	Possible Minor Aquifer
Solid	Coal Measures (Westphalian A)	Unknown but significant	Possible	Minor Aquifer

Plot M9/400:

Enviros recently carried out a ground contamination assessment of Plot M9, which was reported in the Ground Contamination Site Investigation Interpretive Report dated June 2007, referenced SL0170015 P2 F.

The Enviros investigation identified a layer of Boulder Clay of between approximately 3 m and 8 m thick. Sandstone/mudstone (Coal Measures) was encountered at depths of between approximately 5 m and 9 m. The report concluded that the contamination risk to future site users and controlled waters associated with Plot M9 was Low.

2.2 The Surrounding Area

Heywood Distribution Park is located south of the East Lancashire Railway. It is bounded by Mill Hill Lane to the west and Pilsworth road to the south and east.

2.2.1 Land Use

The area is generally used for distribution and storage facilitation.

2.2.2 Local Drainage Systems and Water Supply

See Figure 7 for a layout of indicative existing foul and surface water drainage within Heywood Distribution Park provided by BJB Consultancy Ltd. The predominant feature is Brightley Brook. However there are other hydrological features.

Brightley Brook

Brightley Brook is a tributary of Hollins Brook, which is a tributary of the River Roch. To the northwest of the site it drains through a culvert under the railway. Historic analysis of the brook shows that the river was culverted underneath the railway but previously existed on the site as a small channel that drained ultimately to the south of the site. However, in the mid 1990s, the stream was culverted below ground level around unit P4 until it reappeared towards the north of what is now Plot P4 before draining into a fresh water pond. This pond has an area of approximately 0.5 km^2. This then drains underground via a culvert to a second pond of an area of approximately 0.2 km^2. There is then an overflow which flows underneath Pilsworth Road via a culvert that drains into Brightley Brook channel. Brightley Brook runs west to east, and located south of and, generally, adjacent to Pilsworth Road.

The culverted Brook that exists in the centre of the site flows generally in the direction north to south. The elevation at the point where the resurfacing underground culvert drains into the first pond is at approximately 114.4 m AOD. Where the ponds overflow into the more natural channel that exists south of the site, the brook drains an area of 0.64 km^2 (Reference 3) (probably excluding the drainage ponds). Before joining Hollins Brook, it drains an area of 1.17 km^2, but this is approximately 2.5 km downstream of the aforementioned point.

Other Hydrological Features

There are two ponds located approximately 25m north east of Plot P11. A small unnamed drain is shown 20m south east of Plot P11. Both of these features are however separated from the site by the presence of an embankment.

Foul Sewers and Surface Water Drains

United Utilities do not have any information regarding sewer pipes for Heywood Distribution Park. Dave Driver (Park manager) confirmed that all pipes are privately owned by the proprietor of Heywood Distribution Park.

Plot M9/400:

A plan submitted by BJB consultants show that there is a 450mm surface water sewer that runs along the north eastern perimeter of site M9/400. This drains into a surface water storage tank/interceptor located to the south of the Distribution Park before draining into Brightley Brook.

A foul water drain runs along the eastern side of unit M9 (adjacent and west of the plot) in a north to south direction. This drains into a foul water sewage located to the south west and away from Heywood Distribution Park. A foul sewer also appears at the far south eastern corner running generally south. This appears to route to the mid-southern edge of the Distribution Park; however the current information does not show the route of this foul sewer outside of the site boundary.

Unit P11:

In the southern corner of plot P11 there is a 375mm diameter surface water sewer which runs in a north east to south west direction. This appears to drain ultimately into an interceptor and thereafter into a surface water storage lagoon before discharging into Brightely Brook. Although the sewer incorporates a series of over-flow pipes that drain into Brightley Brook where they run parallel.

A foul water drain runs in the same direction as the surface water pipe along the edge of Heywood Distribution Park. United Utilities only have information for sites outside of Heywood Distribution Park. However, - a combined 450mm vitrified clay pipe runs south west to north east at the very northern edge of plot P11.

Mains Supply

Plot M9/400

Immediately to the north of the proposed plot is a 100mm HPPE 1994 sleeve in a 7 inch cast iron pipe that runs west to east along the northern perimeter of the site. The cast iron pipe probably pre-dates to the 1930's when the site was used for military purposes. A further pipe, of the same construction and size, joins this one to the mid-north edge of the plot and runs north-west to south-east along the north-eastern site perimeter. In total, these pipes run along the north perimeter of the site for approximately 500m.

A mains also exists for a small section next to the south-west perimeter of the site; a 90mm PE 1994 sleeve in a 4 inch cast iron pipe that runs in a west-east direction and thereafter south and away from the site.

Plot P11

Mains water supply pipes run within the proposed site in the south east corner. The first pipe is a 160mm HPP 1994 that runs southeast to northwest. This pipe joins a 160mm HPPE sleeve in a 8inch cast iron pipe that runs in a northeast to southwest direction, forming a right angle at the confluence with the other pipe.

All along the southern edge of this site, there is a 160mm HPPE 1994 sleeve in a 7 inch cast iron pipe. This runs in a southeast to northeast direction. A collection of pipes of similar material and size run along Pillsworth Road, that borders the southern edge of Plot P11, and follows the eastern perimeter of the site in a northeast to southwest direction.

2.2.3 Topography

The general topography of the land slopes from northwest to southeast, especially in the western side of the site. There is variance in the eastern side of the site with a general north to south trending slope, becoming northeast to southwest further south where, in the far south-west, the lowest site elevation of 111 m AOD occurs. The maximum elevation of Heywood Distribution Park is found at the northwest of the site at 123 m AOD.

2.2.4 Geology / Hydrogeology

The solid geology map indicates that the site is underlain by Coal Measures. The drift geology map shows that boulder clay overtops this. The Environment Agency's Groundwater Vulnerability map indicates that the site is underlain by a Minor Aquifer (Coal Measures) overlain by soils of generally High (U) leaching potential (a classification conservatively given in urban areas due to lack of data).

There are no source protection zones (SPZ's) within the vicinity of the site.

2.3 Development Plans

Figures 3 and 5 show the development plans for the site at P11 and M9/400 respectively. The precise layout has yet to be determined. Plot M9/400is planned to be redeveloped with the following (with approximate areas):

- A warehouse (3.4 ha)
- 3 storey offices (0.3 ha)
- A car park with 307 spaces (0.5 ha)
- A lorry park (1.7 ha) with 70 trailer spaces, 28 loading docks and an adjoining roadway

To keep:

- A gated access for fire vehicles, which is to remain (1 ha)
- Approximately 0.6 ha land is to remain around the periphery of the buildings of the site

Plot P11 is planned to be redeveloped with:

- A large warehouse (1.6 ha)
- A second warehouse (0.2 ha)
- 2 storey offices (0.1 ha)
- A car park (0.4 ha)
- A lorry park with loading docks, roadway and car spaces (1.5 ha)

To keep:

- Mound to the northeast (0.5 ha)
- Small areas totalling 0.3 ha are proposed to remain undeveloped

3. EXTERNAL FLOOD SOURCES

Current guidance (Reference 4) recommends that a Flood Risk Assessment should consider all possible sources of flooding for a given site. A large number of specific mechanisms exist. However, on a site specific basis many of these can often be easily discounted. Table 1 summarises a range of potential risks and the possibility that these may be relevant to this site.

Table 2 Summary of potential flood source

Flood Type	Source	Pathway	Consider further
Fluvial	Brightley Brook	Culvert failure and corresponding breach	Yes
Fluvial/ Artificial	Ponds that drain Brightley Brook	Overtopping and subsequent overland flow	Yes
Drainage	Storm sewers	Blockage and surcharge	Yes
Mains supply	Mains Supply	Pipe Burst	Yes
Overland flow	Ground slope and nature	Intense rainfall and overland flow	Yes
Groundwater	Alluvial Deposits	Groundwater	Yes
Other / Artificial	Small drain to the southeast of Plot P11	Failure/overland flow	No*
Other / Artificial	Small pond northeast of plot P11	overtopping/overland flow	No*

* These features are separated by a large mound of earthen material that will remain intact and are in any case small.

3.1 Risk Assessment

The risk assessment methodology used within this project is set out in Appendix 3 and is written based on guidance provided in PPS25. The guidance recommends that flood risk is assessed through consideration of both the magnitude of potential impacts and the probability of occurrence. The magnitude of impact is then dependent on two factors. These are the sensitivity of potential receptors and the severity of the flooding. There are therefore three criteria on which flood risk is assessed. These are:

- Sensitivity of the receptor,
- Severity of flooding, and
- Probability of occurrence.

3.1.1 Sensitivity of receptor

The nature of the proposed developments is commercial and industrial including warehouses, car parks and offices. The development is therefore defined as ‘less vulnerable development’ within PPS25.

Given this the sensitivity will be defined as medium.

Human health is classified as being highly sensitive. Human health issues include any plausible threat to life or health of any person.

Development in general has the potential to impact the flood risk posed to off site receptors. All off site development is considered, as a default, to be very highly vulnerable to any increase in flood risk and therefore it is important that any adverse off site impact to flood severity or frequency are avoided.

No potential impacts to off site receptors have been identified for this site other than those which may arise via changes to the runoff regime. This issue is covered in Chapter 4.

3.1.2 Severity and Probability of flooding

The criteria used to classify both severity and probability of flooding are fully defined within Appendix 3 and their assignment as relevant to this study is discussed below and summarised in Section 3.6 (see Table 3 therein).

3.2 Fluvial

The EA flood map is shown in Appendix 2 and clearly shows that the whole site is located in flood zone 1 indicating that the annual risk of flooding at the site from major fluvial and tidal sources is less than 0.1%.

3.2.1 Brightley Brook

Brightley Brook is culverted underground. If a breach were to occur it would likely either discharge into the surrounding soil, migrate to the surface where-after it would cause overland flow or else fail at the open part north of the site (Figure 7). Two possible scenarios, potentially relevant to the site are discussed below.

1. The culvert that exists underneath the site, and which extends underneath the railway, is likely to be historic and therefore is assigned a conservative probability of impact of moderate because its age may make it prone to failure. Water would need to emerge above land for there to be a potential hazard. Even if this were to occur, water would route either along the roadway or else directly south. The land which is situated above the culvert is generally 1 m lower than the adjacent edge of plot M9/400. It is also at least 100 m away. Should water route this way, formal drainage and the fact that a lorry park is planned to the east of this plot, should mean the severity of impact is low. This yields an overall low risk

2. The culvert that was designed when unit M9/400 was developed is relatively new and as such the probability of failure is assumed to be low. Moreover, if water were to reach the surface, the slope of the land is generally in a southerly direction and away from the development. A small section of unit M9/400 does, however, run parallel to this section of the culvert and therefore, although unlikely to affect this area, the severity of impact is assumed to be moderate. The overall risk is therefore assessed to be low.

3.3 Services

3.3.1 Water Mains

No building is permitted over public sewers or water mains, without a special agreement such as a Building Over Agreement. Any such building might cause damage and would restrict or interfere with the Undertakers rights of access for inspection, repair, maintenance, or renewal (United Utilities, 2008).

Plot P11

If building were to occur over the water mains which are known to exist on site – or if mains were located near to any buildings here, the severity of impact is assumed to be moderate should a burst occur because of their close proximity. However, given that the pipes are relatively new and the fact that the effects from such bursts are usually restricted to a relatively confined area, the probability of impact is considered to be low.

Mains also exist along Pilsworth Road that runs south of the site. The probability of impact is deemed low due to the relatively new age of the pipes and the fact that formal drainage exists along the roadway should a failure occur. Water could pool onto the site should a failure occur, but owing to drainage and the generally lower elevation of Pilsworth Road, most water would route down-road. The severity of impact is therefore deemed to be low.

The overall risk from water mains flooding at plot P11 is therefore deemed to be very low.

Plot M9/400

The probability of flood impact from mains burst along the north and north-eastern section of the site is deemed to be low owing to the fact that these are relatively new pipes, The severity of impact is deemed to be moderate because of the proximity of mains to the site (although any flooding would be routed first through the gated access zone for fire vehicles). This gives an overall low risk.

3.3.2 Foul Sewers and Surface Water Drains

Plot P11

Surface water and foul water sewers currently exist to the south of the site and potentially (though assuming they will be partially relocated) where the proposed plot of land is to be redeveloped and built on. This covers a small area. Should the pipes fail, the severity of impact would be low because water would be routed in a southwest direction, away from the site. The probability of impact is low because the pipes cover such a small area of the site and would therefore have to fail in a very specific location to affect sensitive receptors. The overall risk is therefore deemed to be very low.

Plot M9/400

Surface water pipes run generally 500 m along the north and northeast of the site. The probability of impact is therefore deemed to be moderate as a conservative measure. However, the severity of impact is deemed to be low because the typical distance between the pipe and any proposed building is 50 m, and also that critical pathways to sensitive receptors would be broken by a roadway and gated access for fire fighting vehicles between the proposed building and the site. (The depth of any water arising from such flooding is not likely to be large enough to prevent emergency fire fighting vehicle access, which can utilise two access points). Overall, the associated risk is assessed to be low.

A report submitted by Watts and Partners suggests that flooding occurred in the adjacent residential area north of Unit P4. It was initially suspected that this may be due to the then newly culverted Brightley Brook. However, it was shown that a collapsed drain resulted in flooding to the north of the site, which flowed over the railway and into a neighbouring residential area. This has been repaired. It does however show that drainage to the north, where there is a cluster of pipes near plot M9/400 may flow in that direction and away from the plot.

3.4 Overland Flow

Plot M9/400:

The general topography of this area is generally flat with a typical slope of 0.01 m/m. Moreover, the site is formally drained and other buildings would divert flow in a southeast and also a southwest direction. In addition, a car park is proposed to the east of the plot and an existing area for fire vehicle access is proposed to remain along the northern face of the plot. Therefore the probability of impact is assessed to be low and the severity of impact is assessed to be low, giving an overall very low risk.

Plot P11:

Land that surrounds Plot P11 along the north and south is either flat or else sloping away from the site. Therefore overland flow is not considered to be an issue in this regard. However, to the northeast, a mound exists, which is 5 m higher than the surrounding area. Also, land to the south and north is raised by approximately 3 m. However, this made ground would allow for infiltration and some storm runoff. Additionally, formal drainage should be designed to cope with runoff generated. To the northeast a car park with drainage is proposed in any case. Hence, the probability of impact is deemed to be moderate, but the severity of impact is deemed to be low. This gives an overall low risk.

3.5 Groundwater

The British Geological Survey do not map the area for groundwater at a sufficiently high resolution. However, reference to Table 1 shows that the water strikes (within unit P11) at a minimum depth of 2.8 m from the made ground surface. Therefore, the probability of impact is deemed to be very low and the severity of impact is deemed to be very low here. This gives an overall negligible risk.

Groundwater levels at plot M9/400 are likely to be similar to those close to Brightley Brook, which is lower than plot M9/400. However, it is possible that water could strike at the surface in places so the probability of impact is conservatively assessed to be moderate. Nonetheless, the severity of impact would be low and so the overall risk is assessed to be low.

3.6 Summary table of risks

The probability and severity of each type of flooding has been assessed in line with the methodology and guidance set out in Appendix 3. This is then combined with the assessment of receptor sensitivity to define the level of flood risk on a scale ranging from negligible to high.

Typically risks assessed to be low or less are acceptable whereas risks assessed to be moderate or high require additional mitigation or management to enable development to proceed.

It is assessed that there are no potentially significant risks posed by external flood sources to the site (Table 3).

Table 3 Flood Risk summary table

Flood Source		Pathway	Receptor	Sensitivity	Severity of impact	Probability of impact*	Flood Risk
Fluvial	Old Culverted Brightley Brook by railway line	Failure and overland flow	Plot M9/400	Medium	Low	Moderate	Low
Fluvial	New culverted Brightley Brook to south	Failure and overland flow	Plot M9/400	Medium	Moderate	Low	Low
Services	Water Mains	Failure and overland flow of onsite mains	Plot P11	Medium	Moderate	Low	Low
Services	Water Mains	Failure and overland flow of mains along Pilsworth Road	Plot P11	Medium	Low	Low	Very Low
Services	Water Mains	Failure and overland flow of mains along north section	Plot M9/400	Medium	Moderate	Low	Low
Services	Surface water and foul water sewers	Failure and overland flow resulting from pipes located to north/northeast site	Plot M9/400	Medium	Low	Moderate	Low
Services	Surface water and foul water sewers	Failure and overland flow resulting from pipes located near the south of the site	Plot P11	Medium	Low	Moderate	Low
Overland Flow	Embankments to north and south	Water flowing over ground surface	Plot P11	Medium	Low	Moderate	Low
	Surrounding land	Water flowing over ground surface	Plot M9/400	Medium	Low	Low	Very Low
Groundwater	Minor aquifer	Groundwater striking at surface	Plot P11	Medium	Very Low	Very Low	Negligible
	Minor aquifer	Groundwater striking at surface	Plot M9/400	Medium	Low	Moderate	Low

4. STORM WATER MANAGEMENT

Flood risk in any area is controlled by a number of contributing factors throughout the catchment. At the local scale, when developing or re-developing a site, it is usual to acknowledge the part that this will play in contributing, or potentially alleviating, flood risk to the immediate surrounding area.

4.1 Design Standards

The Environment Agency's standing policy for site redevelopments is that runoff from a site should not be increased and that a decrease of site runoff towards greenfield levels is desirable. Where possible, this should be done using **Su**stainable **D**rainage **S**ystems (SuDS).

The Environment Agency standard requirement is that site drainage systems should be designed based on the 1% annual probability design event. In addition to this potential increases in storm severity associated with climate change over the development lifetime will need to be considered. The Environment Agency have advised to allow for a climate change factor of 20%.

The Environment Agency have stated that the maximum allowable rate of discharge from this site will be that which discharges from the existing site into Brightley Brook. Any flows in excess of this will need to be infiltrated to the ground or stored on site and released slowly over time.

4.2 Storm Water Management Principles

Site drainage systems should be developed based on sustainable drainage principles as laid out in a number of guidance documents including PPS25.

4.2.1 Site Discharge

An order of preference exists for drainage receptors. Infiltration drainage should be used where possible. Where this is not possible, or does not provide sufficient capacity, attenuated discharge to watercourses should be sought. However, in this instance adequately controlled discharge to existing privately owned storm sewers may provide a credible drainage solution for this site.

Infiltration

Discharge to the ground, or infiltration, is normally the preferred drainage solution. However, the effectiveness of infiltration is completely dependent on the physical conditions at the site. Potential obstacles include:

- Zones of low permeability preventing infiltration.

  Where soil may allow infiltration, infiltration testing at the site could be undertaken to determine the practical viability of infiltrating storm water to the ground. This testing should be undertaken in line with the guidance contained in BRE 365 (Reference 6) or CIRIA R156 (Reference 7) and the results used to firstly check feasibility and secondly to size the necessary infiltration features. Clearly, in areas where the soil has high clay content, infiltration systems do not provide a viable option then no further consideration is warranted.

- Presence of leachable contamination at the site

  Where ground contamination exists, the use of infiltration techniques can promote the leaching of contaminants into the aquifer beneath part of the site. This should be avoided wherever possible and therefore in such circumstances infiltration is not recommended.

  However, from the available test data, ground contamination is unlikely to be considered as a major barrier to the use of infiltration drainage at the two plots.

- Shallow groundwater table

  For infiltration drainage devices Building Regulation approved document H[2] states that these, "should not be built in ground where the water table reaches the bottom of the device at any time of the year".

  Groundwater levels are not deep, and may be too shallow at this site, especially at low points of site M9/400 which may well be sufficiently close to the surface for infiltration to prove impractical.

- Source protection zones

  As discussed in Section 2.2, the site is not located in a source protection zone.

As detailed in Section 2.2, the majority of the site is likely to be underlain by boulder clay which is relatively impermeable. Moreover, groundwater levels (especially at site M9/400) may be relatively high and therefore permeable paving in such areas would be impractical.

Discharge to Surface Water Drainage

If infiltration techniques prove not to be suitable at this site, at least in part, then attenuation storage of some kind should be used to achieve the requisite run-off rates. This method involves restricting site runoff to an agreed limit (or the existing 1 in 30 year event in this case, relating to the typical design capacity of existing pipes) and then temporarily storing any excess storm water on the site.

The way this water is stored and attenuated can vary depending on the context and nature of the development being proposed. The Environment Agency would however normally request that surface storage systems that are used as 'tanked' systems are not considered sustainable. Potentially appropriate features for attenuating the runoff might include:

- Ponds,
- Wetland areas,
- Swales, and
- Low sensitivity floodable areas (open space or car parking).

2 Approved Document H - Drainage and Waste Disposal, Office of the deputy Prime Minister, 2002 Revision

4.3 Proposed Drainage Strategy

It should be noted that this assessment is intended to support an outline planning application for which proposed development layouts have not been finalised and such detailed statements regarding the management of storm water within the final development are not possible. The following descriptions therefore relate to;

a) the general principles that will be followed when undertaking detailed design; and

b) demonstrating that a workable solution could feasibly be created at the site given environmental constraints and outline designs.

4.3.1 Drainage Principles

A **Su**stainable **D**rainage **S**ystem aims to mimic natural systems whereby water is held close to the source, then released slowly over time. This acts to both reduce peak discharge and to promote the settlement of sediment thereby improving the water quality of any resulting discharge.

Whilst the provision of SuDS within development sites is not as yet a statutory requirement in England its inclusion is strongly recommended in all recent guidance documents. The failure to include such features within the final development is also likely to result in the Environment Agency objecting to the development on the grounds that flood risk has not been adequately addressed. This matter can be appropriately advanced at the detailed application stage.

The final sustainable drainage strategy for this site will be designed in line with the SuDS management train. This requires that;

1. Source control techniques such as permeable paving, green roofs and rainfall harvesting are incorporated into the development design wherever reasonably possible.

2. Where appropriate infiltration drainage is encouraged

3. In situations where it is not possible to discharge all surface water to the ground, storm water will be controlled and discharged as locally as possible with excess storm water stored on the site in surface water features.

4. Off site solutions and hard engineering to achieve the design criteria will only be considered where it can be demonstrated that more sustainable options above are not possible.

4.3.2 Workable Drainage Solution

If it is assumed that infiltration drainage alone is not sufficient at this site (due to impermeable ground conditions), then site runoff will need to be discharged to Brightley Brook (via surface water pipes from the site) at a controlled low rate.

Site P11:

Current peak discharge from site P11 is estimated at approximately 1193 l/s (Appendix 4) for the design event (1 in 30 year event not including climate change allowance). This estimate is based on 75% of the existing site being covered by hardstanding.

In line with the SuDS management train, source control mechanisms should be used across the site wherever possible. Hence, in areas where infiltration may prove possible, it is suggested to use permeable paving where water can infiltrate into the underlying soil.

Permeable paving allows water to seep through the surface, either by using inherently porous materials or by leaving gaps between individual paving units. Storage can be provided using Stormbloc© (or similar) technology whereby hollow crates with high vertical load bearing capacity are constructed beneath areas of hardstanding. Alternatively, storage space would typically be filled with gravel or similar material for filtration of storm water. Additional treatment can be provided, for example through the provision of oil interceptors. Oil interceptors can be used in combination with infiltration techniques if storm water is first captured using impermeable membranes and then routed via the interceptors before passing into, for example, an infiltration trench.

Use of permeable paving with below ground storage allows water either to be infiltrated to the ground or, as may be applicable here, discharged at controlled rates.

Site runoff can be reduced to this low rate by allowing water to collect on site and drain away at a controlled rate. Flow is typically controlled using a hydraulic structure such as a sluice or a hydrobrake and water is stored upstream of this. A wide range of different possibilities exist as to precisely how such storage could be incorporated into a development. Some possibilities are listed below:

- swales and filter strips;
- filter drains and permeable pavements;
- soakaways;
- below ground storage;
- basins and ponds;
- floodable areas.

Given the present development layout proposals it is likely that only permeable pavements and below ground storage would prove suitable for the site given the specific conditions. Hence, it is suggested available road surfaces, car parks and lorry parks are not adopted and are surfaced with permeable paving incorporating closed storage-attenuation systems underneath.

Should this entire area be surfaced with permeable paving and underground attenuation tanks, then assuming a void space of 100% (i.e. Stormbloc ©), tanks would have to have a required depth equal to the volume to be attenuated over the area to be covered.

The Environment Agency have stated that the volume of water that should be attenuated be for the 1 in 100 year event (with 20% climate change allowance) relative to what is currently being discharged to Brightley Brook (i.e. the 1 in 30 year current runoff event).

Assuming a 75% impermeable cover following redevelopment, the surface runoff generated for the post-developed site given the design event set by the Environment Agency would be equal to 2171 l/s (Appendix 5), with a volume to be attenuated equal to 280 m^3 (Appendix 6). The depth required to construct a below ground storage device is equal to the volume to be attenuated over the design area. Therefore, should 0.5 ha be surfaced with permeable paving the closed storage system would need to be designed to a depth of 5.6 cm.

In areas of heavy load vehicles or regularly used car parking, it may be useful to use a closed storage system with a gravel fill to allow filtration of oils. Assuming a void space of 33%, then to develop 0.5 ha with permeable paving, a closed storage system would need to be designed to a depth of 16.8 cm.

A further option is to consider allowing controlled surface water flooding of the available car park and lorry park areas (approximately 1.9 ha). The Environment Agency have stated that this is acceptable providing there is no significant risk to users of the site and that there is ample notice to warn users of the risk of flooding (e.g. by notice boards) and that water can be contained and will not enter surrounding property. We note, that current guidance (Reference 4, paragraph 6.13) suggests that:

'Car parking may be appropriate in areas subject to flooding, provided flood warning is available and signs are in place. Car parks should ideally not be subject to flood depths in excess of 300mm depth since vehicles can be moved by water of this depth.'

This relates to car parking rather than lorry parking, but a 300 mm maximum depth of flooding is deemed a reasonable maximum. For example, the attenuation that is required for the 1 in 100 year runoff event plus climate change over and above the 1 in 30 year runoff event for the current site is equal to 280 m^3. Assuming a uniform rainfall event over flat concrete, this would therefore flood the total available area (1.9 ha) to a depth of 15 mm, or half the area to a depth of 30 mm.

It is recommended that should this option be considered, notices of flood warning are clearly visible, contain adequate information, are sufficiently numerous and appropriately located. The perimeter of parking areas would also need to be slightly raised in order for any potential water to be contained so to not affect any external receptors. (The final plan would need to show that the proposed layout poses no or negligible risk to external receptors due to potential flooding from the designed runoff event). Topographic differences in the site should be noted where water could pool in lower areas.

If flexibility exists with the design of the development footprint then it may be practical to consider an alternative approach to the permeable paving and closed storage underneath as outlined above such as incorporation of an attenuation pond should sufficient land area exist to facilitate such a feature. It is recommended that at detailed design stage a re-evaluation of SuDS options be undertaken.

Plot M9/400

Following the same reasoning as described above, permeable paving incorporating closed storage-attenuation systems underneath may also prove the most viable solution for M9/400. However, if possible, permeable paving that allows infiltration into the underlying ground would be even more favourable. Current peak runoff based upon the 1 in 30 year runoff event for the site, assuming a 35% hardstanding, is estimated as being equal to 614 l/s (Appendix 7).

The peak runoff predicted for the post-developed site given the 1 in 100 year event (plus 20% climate change allowance) is estimated at 2302 l/s (Appendix 8). The attenuation required is estimated as being equal to 1276 m^3 (Appendix 9).

If all the available area to be surfaced with permeable paving is used (2.2 ha), then the closed storage system would require a depth 5.8 cm. If a gravel fill is used within the closed storage system (33% void space) then the depth increases to 17.4 cm. Again, the particular areas that would be developed and the extent of any infiltration will need to be considered at a more detailed planning stage.

If controlled surface water flooding of the land available due to the proposed car park and/or lorry park is considered, then - providing the same provisions are adopted as for those suggested for the same method applied to unit P11 - assuming a uniform rainfall event over flat concrete, this would therefore flood the total available area (2.2 ha) to a depth of 58 mm, or half the area to a depth of 116 mm.

If flexibility exists with the design of the development footprint then it may be practical to consider an alternative approach to the permeable paving with closed storage underneath as outlined above such as incorporation of an attenuation pond should sufficient land area exist to facilitate such a feature.

Moreover, there exists the possibility to route surface runoff to undeveloped land located nearby the freshwater ponds in the south of the site where water could be attenuated by, for example, a pond or wetland feature. It is recommended that at detailed design stage a re-evaluation of SuDS options be undertaken.

5. CONCLUSIONS AND RECOMMENDATIONS

Following the completion of this Flood Risk Assessment, in line with the recommendations of PPS25, the following conclusions have been made:

1. The Environment Agency flood map indicates that the site is located within flood zone 1. As such under the sequential test all development types are potentially appropriate.

2. Consideration of flood mechanisms, not shown on the Environment Agency flood map, suggests that all flooding risks are either low or less.

3. Site drainage should ideally follow the SuDS (Sustainable Drainage) management train, which favours local flood control and ideally infiltration where possible.

4. The Environment Agency have indicated that the site is to be attenuated for the 1 in 100 year event (plus 20% climate change) against what is being discharged to Brightley Brook from the current site (assumed to be equal to the 1 in 30 year event – a traditional standard in storm sewer design). Indicative calculations suggest that the volumes to be attenuated to achieve the required outflow are equal to 280 m^3 and 1276 m^3 for plot P11 and plot M9/400 respectively.

5. Given the present development layout proposals permeable paving is thought to provide the best solution for both P11 ands M9/400 where car parks, lorry parks and roadways are proposed.

6. Infiltration to the ground may prove impractical due to underlying boulder clay and potentially relatively high groundwater levels. Therefore in order to achieve the necessary site attenuation it is recommended that permeable paving with closed storage situated underneath be developed for the site to a depth necessary to achieve the requisite attenuation volume.

7. A further option is to consider controlled surface water flooding of the areas proposed to be developed with a lorry park and/or car park. However, such flooding must be shown to not affect external receptors such as nearby buildings, and not pose a risk to users. Available guidance suggests the maximum permissible flood depth in car parks should be 300mm. As a guide, the height of flooding to be expected up to the maximum design event would be equal to 15 mm over the whole available area within plot P11 or 58 mm within plot M9/400. To achieve containment of any water, some floor raising will be required along the edges of the respective car park and/or lorry park.

8. If controlled surface water flooding of the lorry park is considered, it is recommended that adequate signs are in place to notify potential users that may be affected by flooding of the lorry park.

9. At the detailed design stage, and should modification to the development footprint free up sufficient space, it may be feasible to alternatively consider incorporating standard attenuation ponds in to the site drainage at P11 and /or M9/400. Alternatively, land to the south located close to the freshwater ponds that drain into Brightley Brook could be developed into attenuation features such as ponds or wetland receptors of site discharge.

6. REFERENCES

1. Planning Policy Statement 25: Development and Flood Risk, Communities and Local Government, 2006.

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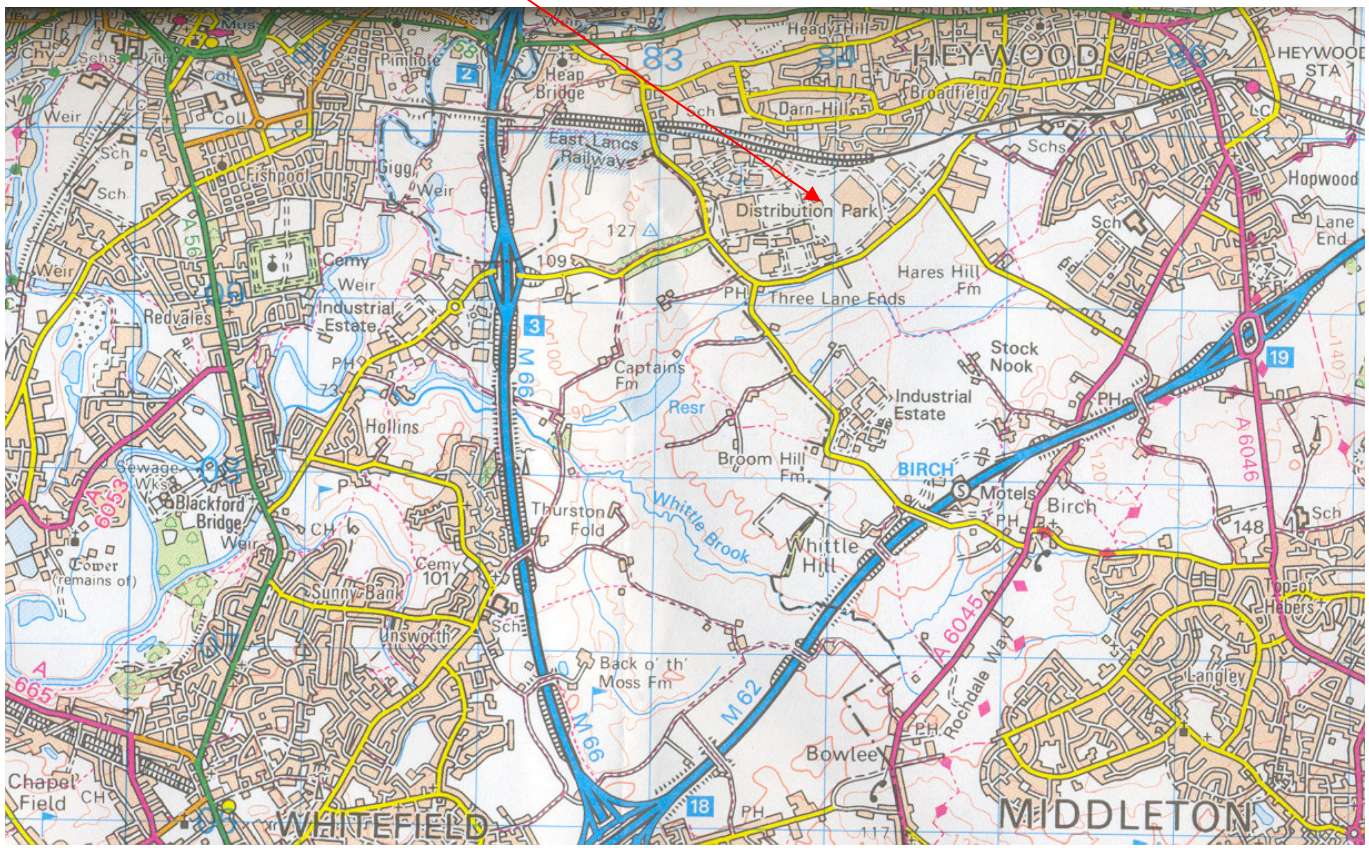
9. Communities and Local Government. Code for sustainable Homes – Technical Guide, 2008.

10. Harvesting rainwater for domestic uses: an information guide (Reference number GEHO0108BNPN-E-E), 2008

11. CIRIA C697, The SUDS Manual, 2007

FIGURES

FIGURE 1 SITE LOCATION PLAN



CLIENT

The Heywood Unit Trust

PROJECT

Plot M9. Heywood Distribution Park, Bury

DRAWING

Figure 1. Site Location Plan

SCALE	CAN
NTS	SL0170015
DRAWN	
CHR	

ENVIROS

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FIGURE 2 CURRENT SITE LAYOUT – PLOT P11

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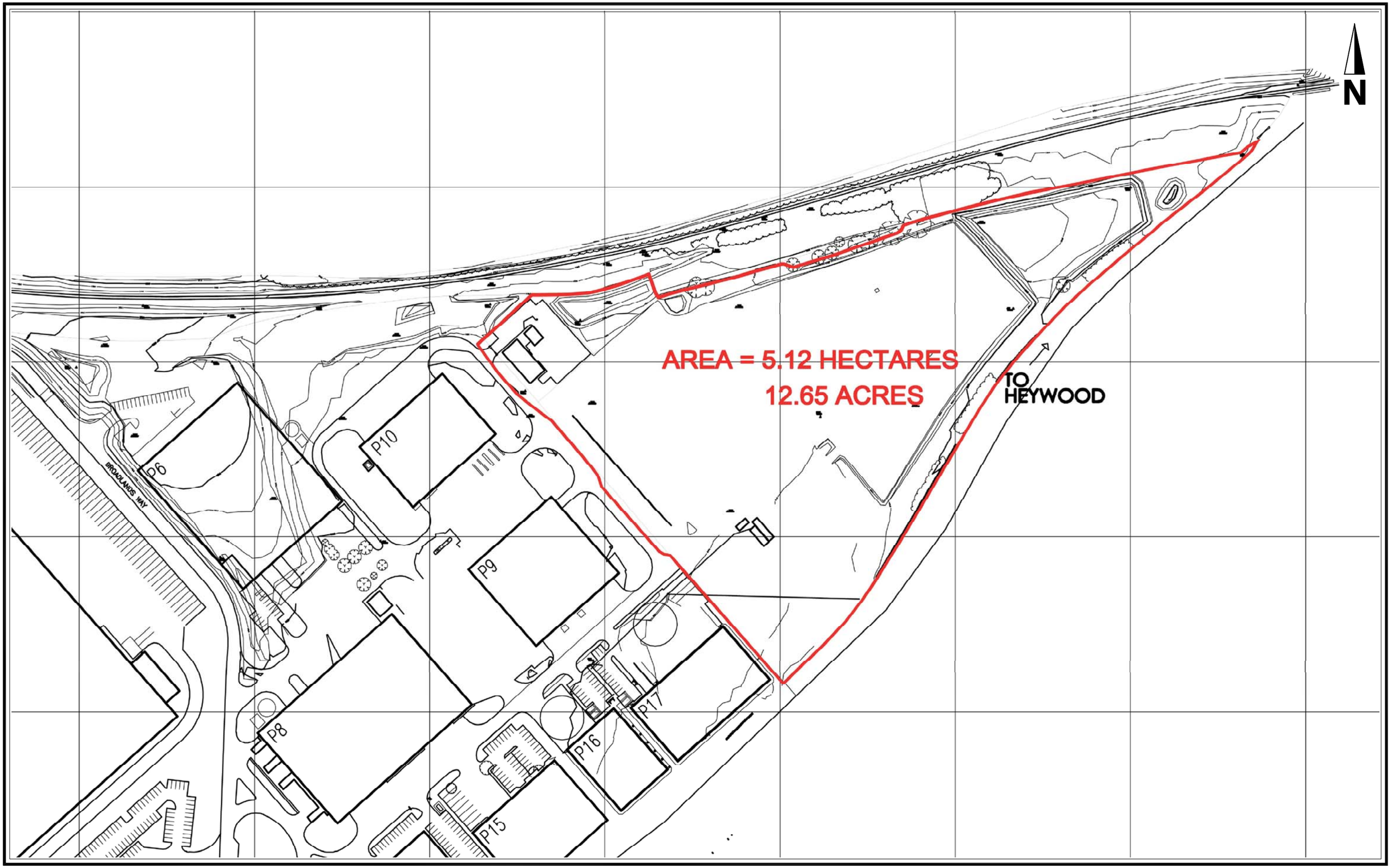
File name: JSF3611.dwg Plot date: Aug 27, 2008 - 1:07pm Ref: I:\DG\CADTEAM\new-cans\SE0750007a\



NOTES:

1. Based upon Drawing No. 08010 SK03 dated 22.07.08 supplied by Bennett Architects and Master Planners.

HEYWOOD UNIT TRUST

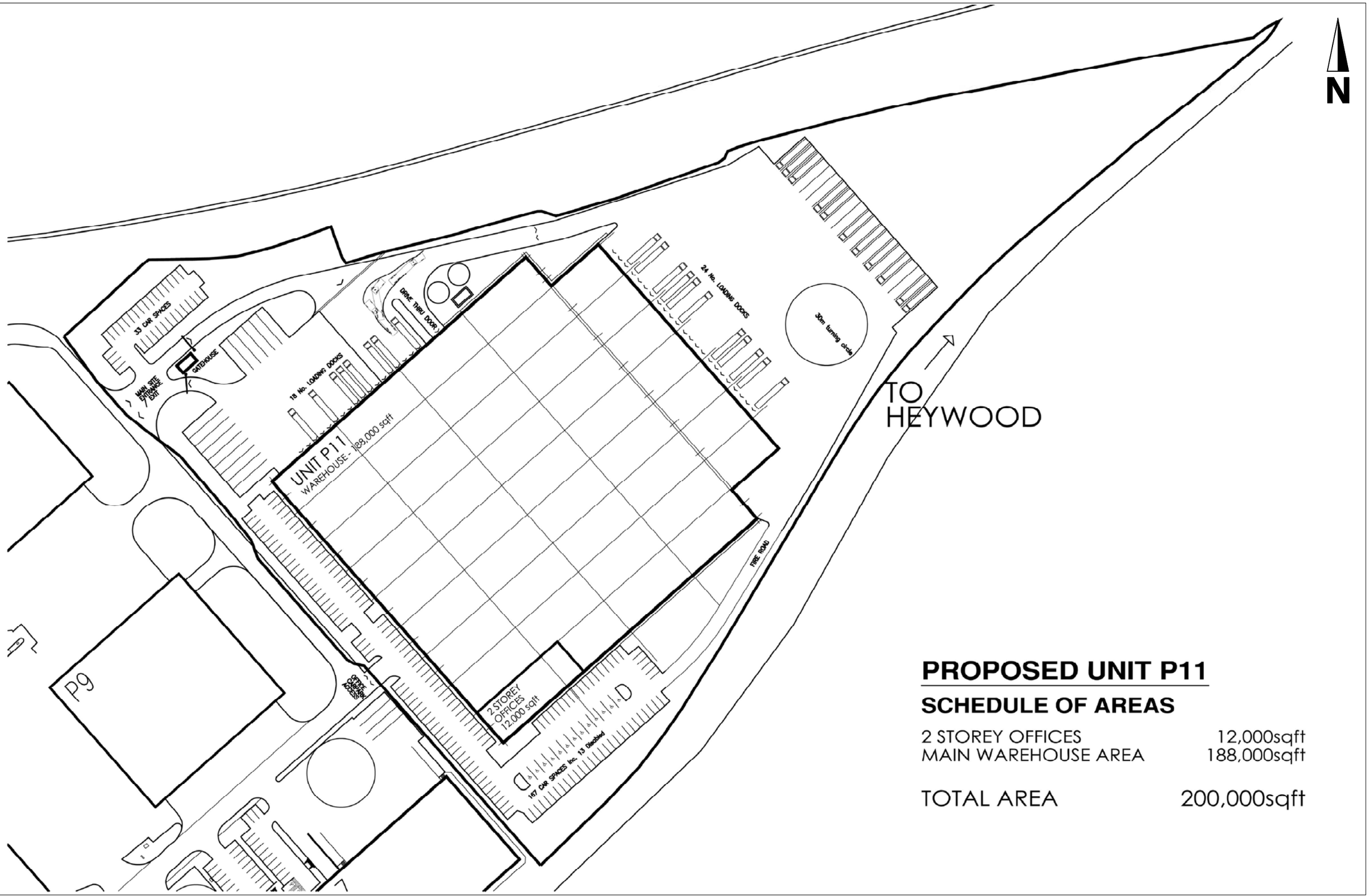
ENVIROS

SCALE	1:2,000 @ A3
CONTENT	LTY
CHECKED	
CAN	SE0750007A
DRAWN	JSF
DATE	AUG 2008

HEYWOOD DISTRIBUTION PARK
PROPOSED DEVELOPMENT OF
UNIT P11

FIGURE 2
CURRENT SITE LAYOUT PLAN

FIGURE 3 DEVELOPMENT PLAN – PLOT P11



PROPOSED UNIT P11

SCHEDULE OF AREAS

2 STOREY OFFICES	12,000sqft
MAIN WAREHOUSE AREA	188,000sqft
TOTAL AREA	200,000sqft

NOTES:

1. Based upon Drawing No. 08010 SK05A dated 13.08.08 supplied by Bennett Architects and Master Planners.

HEYWOOD UNIT TRUST

ENVIROS

SCALE	NTS
CONTENT	LTY
CHECKED	
CAN	SE0750007A
DRAWN	JSF
DATE	AUG 2008

HEYWOOD DISTRIBUTION PARK
PROPOSED DEVELOPMENT OF UNIT P11

FIGURE 3
PROPOSED SITE REDEVELOPMENT LAYOUT PLAN

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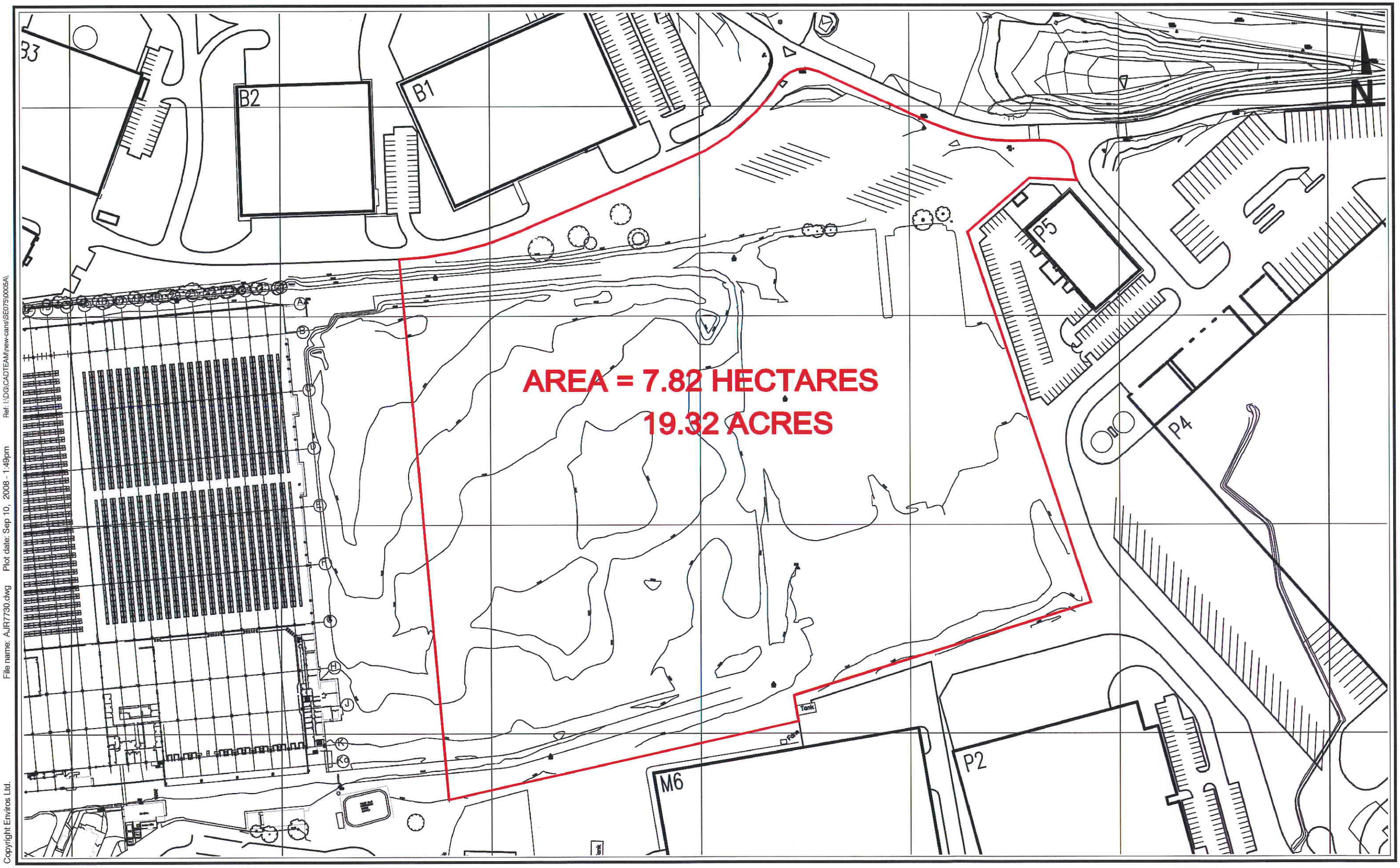
File name: JSF3612.dwg Plot date: Aug 27, 2008 - 1:16pm Ref: I:\DG\CADTEAM\new-cans\SE0750007a\

FIGURE 4 CURRENT LAYOUT – PLOT M9/400



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File name: AJR7730.dwg Plot date: Sep 10, 2008 - 1:49pm Ref: I:\DG\CADTEAM\new-cans\SE075\0005A\

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1. Based upon Drawing No. 08010 SK03 dated 22.07.08 supplied by Bennett Architects and Master Planners.

HEYWOOD UNIT TRUST

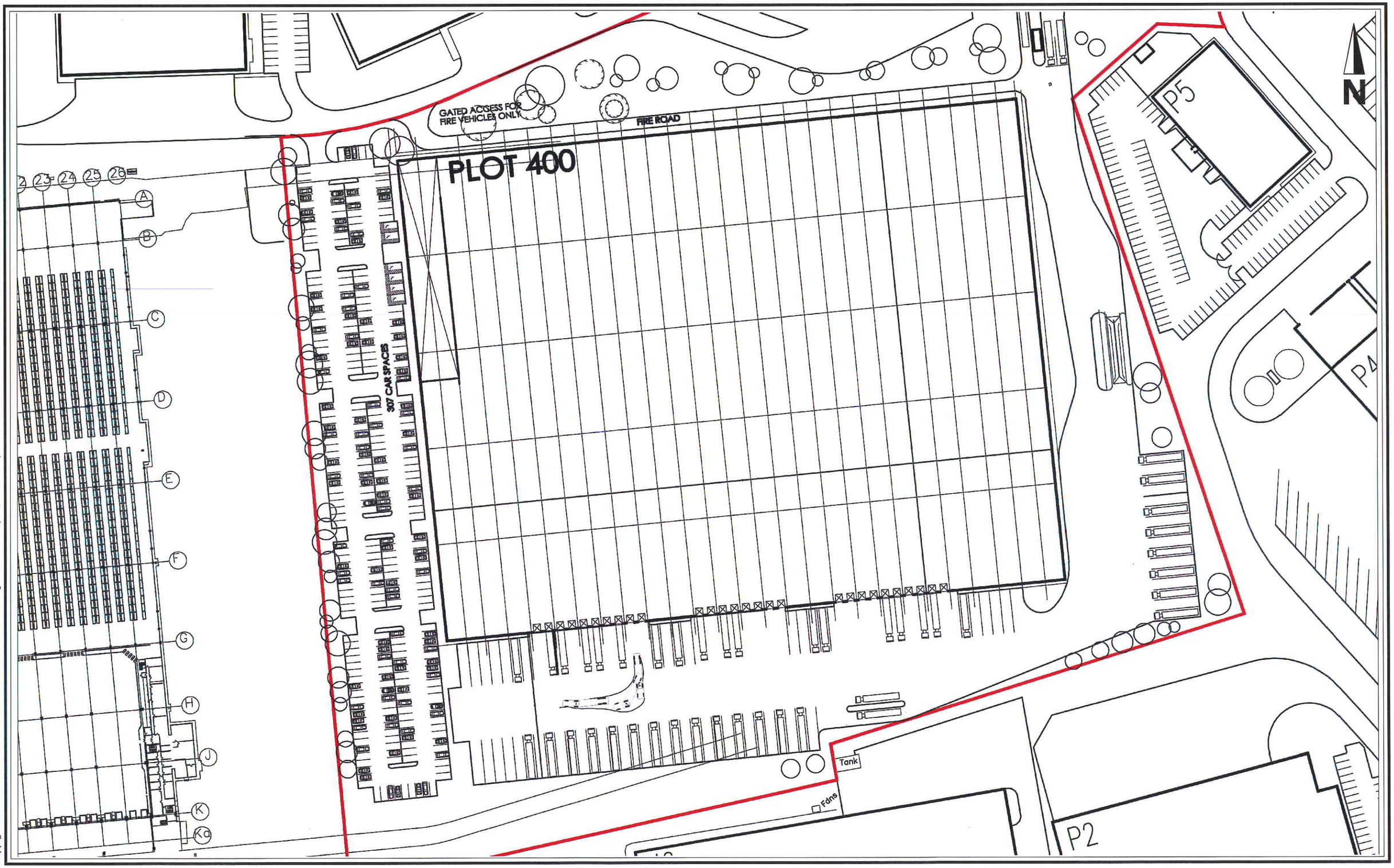
ENVIROS

SCALE	1:1250 @ A3
CONTENT	JEC
CHECKED	
CAN	SE0750005A
DRAWN	AJR
DATE	SEPT 2008

HEYWOOD DISTRIBUTION PARK
PROPOSED DEVELOPMENT OF UNIT P11

FIGURE 4
PLOT M400 CURRENT SITE LAYOUT

FIGURE 5 DEVELOPMENT PLAN – PLOT M9/400



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File name: AJR7731.dwg Plot date: Sep 10, 2008 - 1:56pm Ref: I:\DG\CADTEAM\new-cans\SE075\0005A\

NOTES:

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ENVIROS

SCALE	1:1500 @ A3
CONTENT	JEC
CHECKED	
CAN	SE0750005A
DRAWN	AJR
DATE	SEPT 2008

HEYWOOD DISTRIBUTION PARK
PROPOSED DEVELOPMENT OF UNIT P11

FIGURE 5
PLOT M400 PROPOSED SITE LAYOUT

FIGURE 6 HEYWOOD DISTRIBUTION PARK SITE LAYOUT – UNITS P11 AND M9/400

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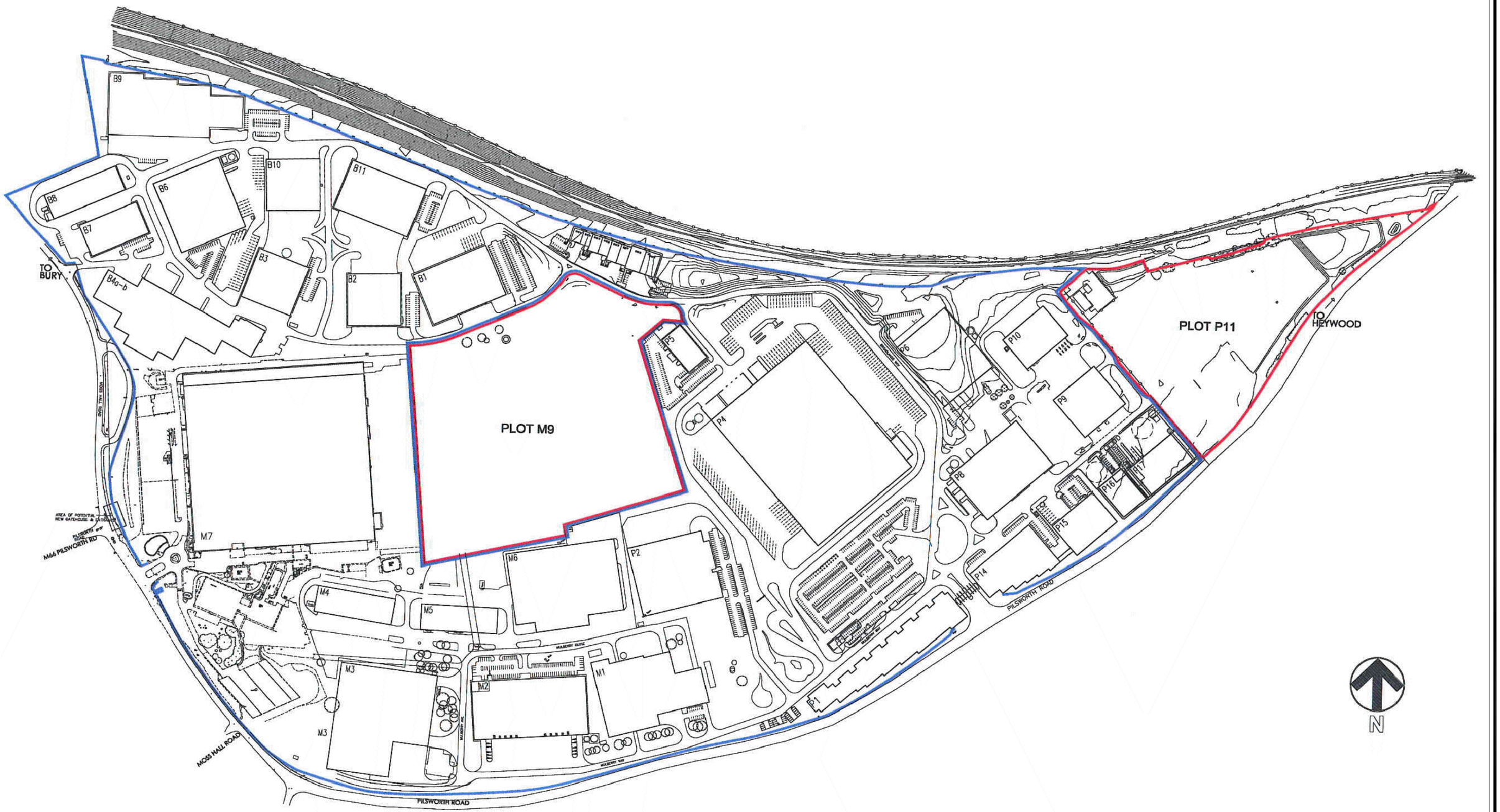
File name: JSF3633.dwg Plot date: Oct 07, 2008 - 3:19pm Ref: I:\DG\CADTEAM\new-cans\SE0750007a\



NOTES:

1. Based upon Drawing No. 08010 SK06 A dated 19.08.08 supplied by Bennett Architects and Master Planners.

HEYWOOD UNIT TRUST

ENVIROS

SCALE	NTS
CONTENT	JEC
CHECKED	
CAN	SE0750007A
DRAWN	JSF
DATE	SEPT 2008

HEYWOOD DISTRIBUTION PARK

FIGURE 6
HEYWOOD DISTRIBUTION PARK
SITE LAYOUT

FIGURE 7 SITE LAYOUT SHOWING CURRENT SITE DRAINAGE

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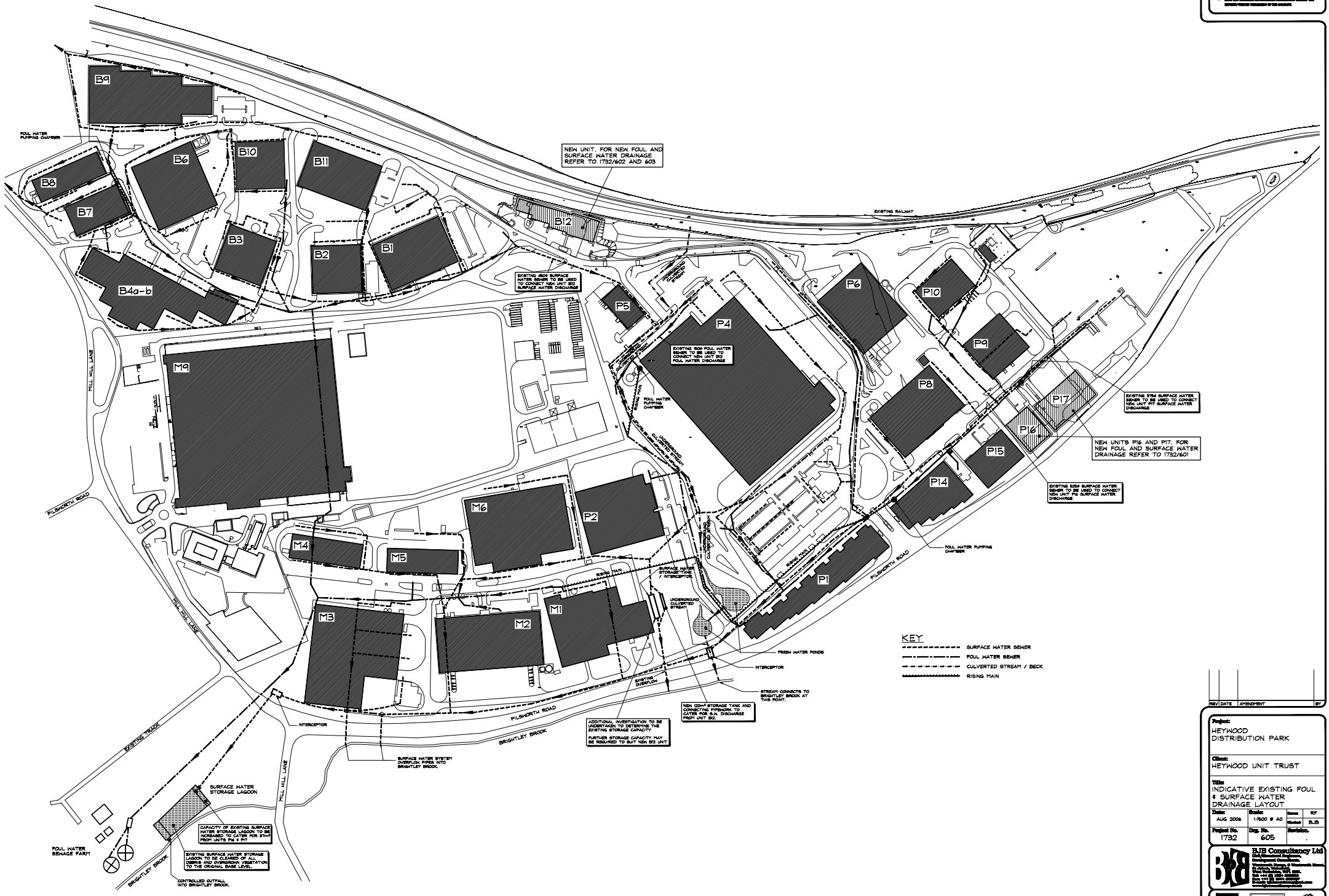


REV	DATE	AMENDMENT	BY

Project: HEYWOOD DISTRIBUTION PARK

Client: HEYWOOD UNIT TRUST

Title: INDICATIVE EXISTING FOUL & SURFACE WATER DRAINAGE LAYOUT

Date: AUG 2006	Scale: 1:1500 @ A0	Drawn	RF
		Checked	BJB
Project No. 1732	Dwg. No. 605	Revision.	-

BJB Consultancy Ltd
Unit 5 Gilmorton Business Park, Gilmorton, Lutterworth, Leicestershire, LE17 5QJ
Tel: 0116 241 3232 Fax: 0116 241 3233
www.bjbconsultancy.co.uk

APPENDICES

1. SITE PHOTOGRAPHS



Photograph 1: First Pond Brightley Brook drains into



Photograph 2: Second pond Brightley Brook drains into



Photograph 3: Second pond overflow

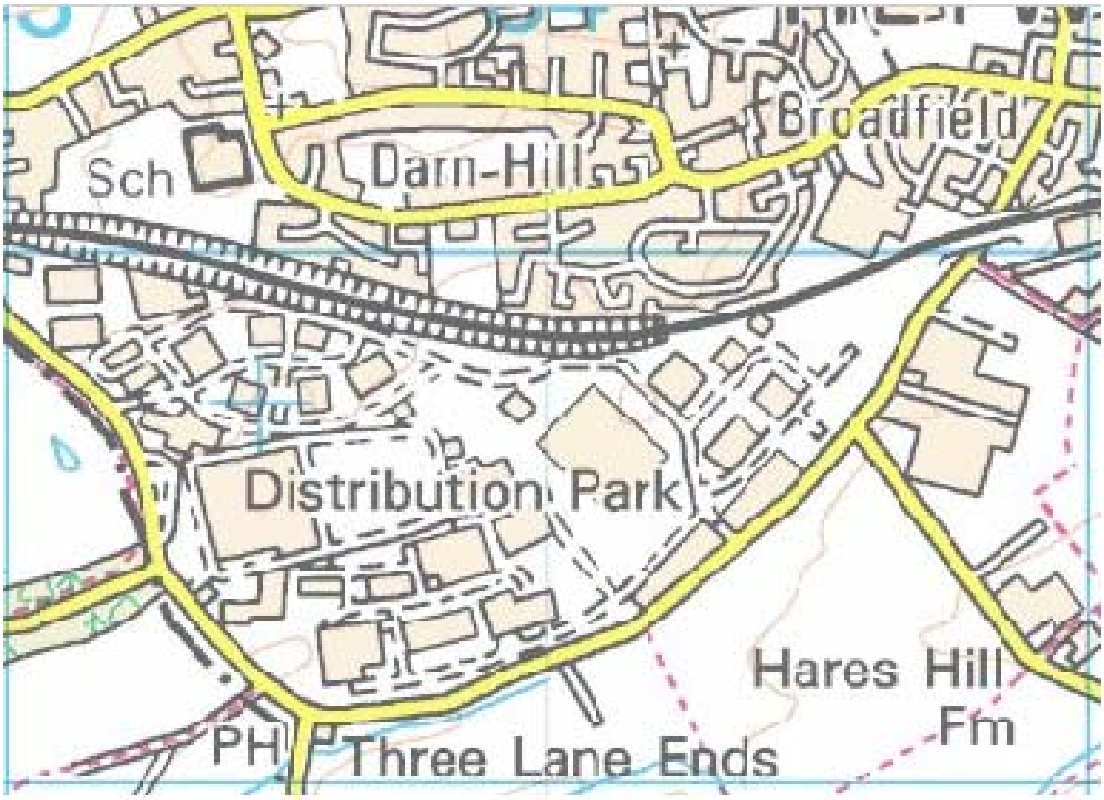


Photograph 4: Culvert where it discharges into Brightley Brook after passing under Pillsworth Road.



Photograph 5: Brightley Brook after flowing under Pillsworth road to the south

2. ENVIRONMENT AGENCY FLOOD MAP


Broadfield
Sch
Darn-Hill
Distribution Park
Hares Hill
Fm
PH
Three Lane Ends

3. FLOOD RISK ASSESSMENT METHODOLOGY

It is recommended by both the Environment Agency and DEFRA that the primary assessment tool within a flood risk assessment should be the sequential test as set out in Tables D1 and D2 of the draft version of PPS25: Development and Flood Risk. Such an assessment however, deals almost exclusively with the risks associated with tidal and fluvial sources and not the full range of flooding sources identified in Annex C of PPS25. In addition to this, the sequential test does not provide guidance for assessing the impact of mitigation and residual risk subsequent to development, as required by Annex G of PPS25.

Therefore in order to allow for the wider assessment of flood risk this more generalised assessment methodology has been developed. It should be noted that where applied to fluvial and tidal sources the results of the assessment should be cross checked against the results of the sequential test.

Assessment Methodology

In line with guidance set out in the draft version of PPS25: Development and Flood Risk, the key to the classification is that the designation of significance (or risk) is based upon the consideration of:

- The sensitivity of the receptor – takes into account the nature of the development or receptor and its likely response to increased risk.
- The magnitude of the potential hazard (i.e. severity) – takes into account the potential severity and nature of the flooding.
- The probability of occurrence (i.e. likelihood) – takes into account both the presence of the hazard and receptor, and the integrity of the pathway.

Classification of Sensitivity of the Receptor

When considering new developments, the classification of sensitivity is based (where possible) directly on the sequential test as set out within Table D2 of the draft version of PPS25. When considering off site impacts there is a general assumption that all developments are highly sensitive. This assumption can however typically be relaxed when considering 'Water Compatible' development or undeveloped land. Given this the Sensitivity of the receptor is ranked as shown in Table 1.

Table 1: Classification of sensitivity of receptor

Sensitivity of receptor	New Development	Off site
Very High	*Highly Vulnerable** developments	All built developments unless mitigating circumstances exist. Key access routes
High	*More Vulnerable** developments	Other access routes
Medium	*Less Vulnerable** developments	Undeveloped Land
Low	*Water Compatible** developments	-
Very Low	Flood attenuation features	-

* For definition of italicised terms please see Table D2 of PPS25

Classification of Magnitude of Potential Effect

To classify the magnitude of the potential effects it is necessary to look at the nature and scale of the individual impacts. These include, but are not confined to, the extent of flooding, the depth of flooding, the duration of flooding and the velocity of flood waters. For new developments the assessment is based on the likely post development situation, for off site receptors it is based solely on the likely deterioration.

Given this the magnitude of the potential effect is then ranked as shown below in Table 2.

Table 2: Classification of Magnitude of Potential Hazard

Magnitude of Hazard	***New Development***	***Off site***
High	Any one of the following criteria achieved: ▪ flood depths greater than 1m, ▪ flood flow velocities greater than 0.45m/s ▪ likely flood duration in excess of 24 hours	Any marked (>10%) increase in flood depth, flood flow velocity or flood duration. Any change in flood extent that impacts additional properties including access
Medium	Any one of the following criteria achieved: ▪ flood depths between 0.3m and 1m, ▪ flood flow velocity greater than 0.15m/s ▪ likely flood duration in excess of one hour ▪ Any restrictions to access and egress	Any other measurable increase of flood depths, durations, flow velocities or extent.
Low	All of the following criteria achieved: ▪ flood depths below 0.3m, ▪ likely flood duration below one hour ▪ flood proofing measures planned	Likely, but unquantifiable small increases of flood depths, durations, flow velocities or extent
Very Low	Planned or permitted flooding that does not adversely impact the built development	-
Negligible	No potential for flooding, or no identifiable impact of flooding	No likely increase in flood severity at any off site location

Magnitude of potential effect

The magnitude of the hazard and the sensitivity of the receptor are combined using a matrix (shown below – Table 3) to determine the magnitude of the potential effect.

Table 3: Matrix for determining the Magnitude of the potential effect

		Sensitivity of Receptor				
		Very Low	Low	Medium	High	Very High
Magnitude of Potential Hazard	High	Low	Moderate	Moderate	High	High
	Medium	Very Low	Low	Moderate	Moderate	High
	Low	Very Low	Very Low	Low	Moderate	Moderate
	Very Low	Negligible	Very Low	Very Low	Low	Low
	Negligible	Negligible	Negligible	Negligible	Negligible	Negligible

Classification of Probability of Occurrence

To classify the probability of occurrence for a potential effect it is necessary to understand how regularly a given event or outcome will come to pass. This can be assessed in a number of ways including assessments based on historical data, quantitative analysis, or experience from other similar sites. Often this assessment will be based on standard guidance. The magnitude of the potential effect is then ranked as shown below in Table 4.

Table 4: Classification of Probability of Occurrence

Probability of Occurrence	Potential effect
High	Any consequence would appear likely in the medium term and inevitable in the long term (Life time of the development).
	Equivalent to an annual probability of flooding of greater than 1% (0.5% for tidal) or *Flood Zone 3**.
Medium	Circumstances are such that an event is possible in the medium term and likely over the long term, although not necessarily inevitable.
	Equivalent to an annual probability between 0.1 and 1% (0.1 and 0.5% for tidal) or *Flood Zone 2**.
Low	It is unlikely that any consequence would arise within the lifetime of the development.
	Equivalent to an annual probability of less than 0.1% or *Flood Zone 1**.
Very Low	It is unlikely that any consequence will ever arise.

* For definition of italicised terms please see Table D1 of PPS25

It should be noted that in circumstances where sites are defended determining an accurate assessment of probability of flood occurrence is complex and assumptions that defences will not fail are unlikely to be acceptable. In such cases assessments can not be prescriptive and site specific assessments should be undertaken. Factors that should be considered include construction, age, condition, maintenance, exposure and other external pressures.

Risk Assessment

Once the magnitude of the potential effect and likelihood of occurrence have been assessed these are then combined using a risk matrix (Table 5) to assess the flood risk of each potential effect.

Table 5: Risk Matrix

		Likelihood of Occurrence			
		Very Low	Low	Medium	High
Magnitude of Potential Effect	High	Low	Moderate	High	High
	Moderate	Low	Low	Moderate	High
	Low	Very Low	Low	Low	Moderate
	Very Low	Negligible	Very Low	Low	Low
	Negligible	Negligible	Negligible	Negligible	Negligible

Typically flood risks assessed as low, or less are considered acceptable. If the assessment results in moderate or high risk, additional mitigation measure will be required to facilitate development.

In some situations the risk assessment procedure will result in an artificially low assessment of risk. This is particularly the case in situations where consequences of very rare flooding (i.e. breech scenarios) are so extreme that any residual risk however low should not be allowed. In such instances the assessed risk should be elevated. Such decisions must always be accompanied by detailed justification.

4. CURRENT DEVELOPMENT RUNOFF CALCULATIONS – UNIT P11

Current Modified Rational Method Calculation Sheet

Site Area (A) =	5.1	ha
Maximum Altitude =	123.7	m aOD
Minimum Altitude =	115	m aOD
Maximum flow path (L) =	270	m

These site descriptors can be used to calculate the time taken for water to travel from the furthest most point to the site outfall. After this period of time, known as the time of concentration, the entire site is contributing to site runoff. Maximum flow off the site should coincide with this.

This length of time can be calculated using the Bransby Williams formula shown below

$$T_c = \frac{58 .5 L}{A^{0.1} S^{0.2}}$$

Time of Concentration (T_c) = 10.6 minutes

The depth of rainfall that will fall within this, and any other, period of time can be estimated using Depth Duration Frequency (DDF) modelling as outlined in the Flood Estimation Handbook (IH, 1999). A series of descriptors are available on a one kilometre grid across the UK on the FEH CD ROM. These are used to obtain a rainfall depth, which can then be easily converted to intensity.

Rainfall Intensity (I) = 102.3 mm/hr during the 10.6 minute, 30 year storm

This rainfall intensity is converted to a flow off the site using the Wallingford procedure (1981). A number of further descriptor,s that can be defined on either a regional, local or site level, are required. These are:

UCWI (**U**rban **C**atchment **W**etness **I**ndex)	148	(non dimensional)
SOIL (Related to site permeability)	0.4	(non dimensional)
PIMP (**P**ercentage of **IMP**ervious Area)	18	%

These descriptors are used to claculate the percentage runoff (PR) from the site as follows.

$$PR = 0.829\ PIMP + 25\ SOIL + 0.078\ UCWI - 20.7$$

Therefore;
Percentage Runoff (PR) = 20.0 %

Given this site runoff can be estimated using the following formula

$$Q = 2.78 C_v C_t I A$$

Where: C_v (a routing coefficient) = 1.3, and
C_t = PR/100

Given the above peak flow from the site is estimated at **0.377** m^3/s

5. FUTURE DEVELOPMENT RUNOFF CALCULATIONS – UNIT P11

Post-Development Modified Rational Method Calculation Sheet

Site Area (A) =	5.1	ha
Maximum Altitude =	123.7	m aOD
Minimum Altitude =	115	m aOD
Maximum flow path (L) =	270	m

These site descriptors can be used to calculate the time taken for water to travel from the furthest most point to the site outfall. After this period of time, known as the time of concentration, the entire site is contributing to site runoff. Maximum flow off the site should coincide with this.

This length of time can be calculated using the Bransby Williams formula shown below

$$T_c = \frac{58 .5 L}{A^{0.1} S^{0.2}}$$

Time of Concentration (T_c) = 10.6 minutes

The depth of rainfall that will fall within this, and any other, period of time can be estimated using Depth Duration Frequency (DDF) modelling as outlined in the Flood Estimation Handbook (IH, 1999). A series of descriptors are available on a one kilometre grid across the UK on the FEH CD ROM. These are used to obtain a rainfall depth, which can then be easily converted to intensity.

Climate change allowance = 20 %
Rainfall Intensity (I) = 187.0 mm/hr during the 10.6 minute, 100 year storm

This rainfall intensity is converted to a flow off the site using the Wallingford procedure (1981). A number of further descriptor,s that can be defined on either a regional, local or site level, are required. These are:

UCWI (**U**rban **C**atchment **W**etness **I**ndex)	148	(non dimensional)
SOIL (Related to site permeability)	0.4	(non dimensional)
PIMP (**P**ercentage of **IMP**ervious Area)	75	%

These descriptors are used to claculate the percentage runoff (PR) from the site as follows.

$$PR = 0.829\ PIMP + 25\ SOIL + 0.078\ UCWI - 20 .7$$

Therefore;
Percentage Runoff (PR) = 63.0 %

Given this site runoff can be estimated using the following formula

$$Q = 2.78 C_v C_t I A$$

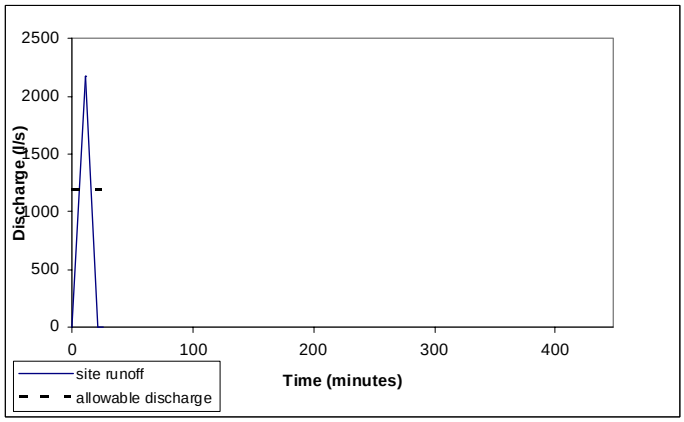
Where: C_v (a routing coefficient) = 1.3, and
C_t = PR/100

Given the above peak flow from the site is estimated at **2.171** m^3/s

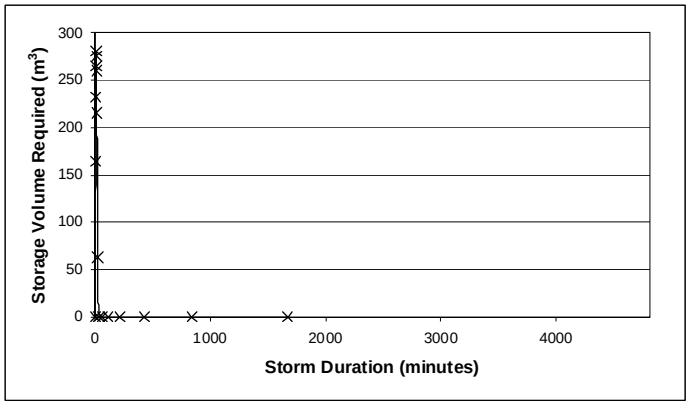
6. STORAGE REQUIREMENTS – UNIT P11

Storage Requirement Estimation, Calculation Sheet

During intense rainfall events the volume of water arriving at the site outfall will exceed the rate at which it is either possible or allowable to discharge it. In this situation on site storage is required to prevent flooding. For very short events, whilst peak flows are often very high, total volumes are relatively low due to the short time period. For very long events the outflow will be similar to or exceed the flow generated by the site, so again required storage volumes will not be large. Between these two extremes are a series of events where significant storage is required. A range of events must be considered to ensure that the design event is captured.



The graph above plots both the water arriving at the site outflow and the maximum allowable discharge. The area above this second line (dashed) corresponds to the required storage. This area has been calculated for a range of storm durations and the required storages obtained are plotted against storm duration below.



This indicates that the design storm for storage is the 10.6 minute 100 year storm.

To prevent flooding during this event **280** **m^3** of storage would be required.

7. CURRENT DEVELOPMENT RUNOFF CALCULATIONS – UNIT M9/400

Current Modified Rational Method Calculation Sheet

Site Area (A) =	7.6	ha
Maximum Altitude =	120.9	m aOD
Minimum Altitude =	115.4	m aOD
Maximum flow path (L) =	380	m

These site descriptors can be used to calculate the time taken for water to travel from the furthest most point to the site outfall. After this period of time, known as the time of concentration, the entire site is contributing to site runoff. Maximum flow off the site should coincide with this.

This length of time can be calculated using the Bransby Williams formula shown below

$$T_c = \frac{58.5L}{A^{0.1}S^{0.2}}$$

Time of Concentration (T_c) = 16.9 minutes

The depth of rainfall that will fall within this, and any other, period of time can be estimated using Depth Duration Frequency (DDF) modelling as outlined in the Flood Estimation Handbook (IH, 1999). A series of descriptors are available on a one kilometre grid across the UK on the FEH CD ROM. These are used to obtain a rainfall depth, which can then be easily converted to intensity.

Rainfall Intensity (I) = 72.9 mm/hr during the 16.9 minute, 30 year storm

This rainfall intensity is converted to a flow off the site using the Wallingford procedure (1981). A number of further descriptor,s that can be defined on either a regional, local or site level, are required. These are:

UCWI (**U**rban **C**atchment **W**etness **I**ndex)	148	(non dimensional)
SOIL (Related to site permeability)	0.4	(non dimensional)
PIMP (**P**ercentage of **IMP**ervious Area)	36	%

These descriptors are used to claculate the percentage runoff (PR) from the site as follows.

$$PR = 0.829\ PIMP + 25\ SOIL + 0.078\ UCWI - 20.7$$

Therefore;
Percentage Runoff (PR) = 30.7 %

Given this site runoff can be estimated using the following formula

$$Q = 2.78 C_v C_t I A$$

Where: C_v (a routing coefficient) = 1.3, and
C_t = PR/100

Given the above peak flow from the site is estimated at **0.614** m^3/s

8. FUTURE DEVELOPMENT RUNOFF CALCULATIONS – UNIT M9/400

Post-Development Modified Rational Method Calculation Sheet

Site Area (A) =	7.6	ha
Maximum Altitude =	120.9	m aOD
Minimum Altitude =	115.4	m aOD
Maximum flow path (L) =	380	m

These site descriptors can be used to calculate the time taken for water to travel from the furthest most point to the site outfall. After this period of time, known as the time of concentration, the entire site is contributing to site runoff. Maximum flow off the site should coincide with this.

This length of time can be calculated using the Bransby Williams formula shown below

$$T_c = \frac{58 .5 L}{A^{0.1} S^{0.2}}$$

Time of Concentration (T_c) = 16.9 minutes

The depth of rainfall that will fall within this, and any other, period of time can be estimated using Depth Duration Frequency (DDF) modelling as outlined in the Flood Estimation Handbook (IH, 1999). A series of descriptors are available on a one kilometre grid across the UK on the FEH CD ROM. These are used to obtain a rainfall depth, which can then be easily converted to intensity.

Climate change allowance =	20	%
Rainfall Intensity (I) =	131.3	mm/hr during the 16.9 minute, 100 year storm

This rainfall intensity is converted to a flow off the site using the Wallingford procedure (1981). A number of further descriptor,s that can be defined on either a regional, local or site level, are required. These are:

UCWI (**U**rban **C**atchment **W**etness **I**ndex)	148	(non dimensional)
SOIL (Related to site permeability)	0.4	(non dimensional)
PIMP (**P**ercentage of **IMP**ervious Area)	76	%

These descriptors are used to claculate the percentage runoff (PR) from the site as follows.

$$PR = 0.829\ PIMP + 25\ SOIL + 0.078\ UCWI - 20 .7$$

Therefore;
Percentage Runoff (PR) = 63.8 %

Given this site runoff can be estimated using the following formula

$$Q = 2.78 C_v C_t I A$$

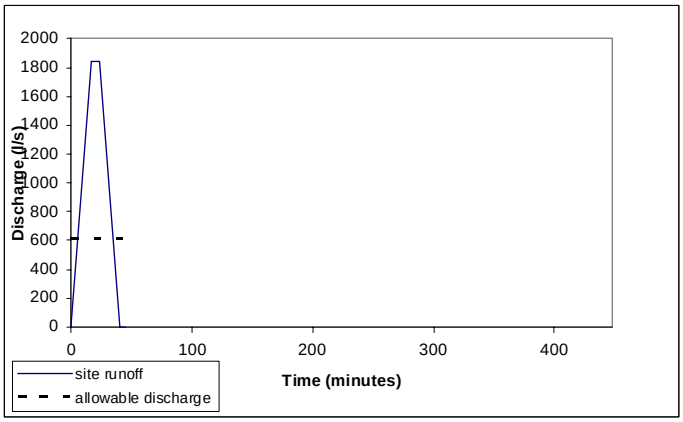
Where: C_v (a routing coefficient) = 1.3, and
C_t = PR/100

Given the above peak flow from the site is estimated at **2.302** m^3/s

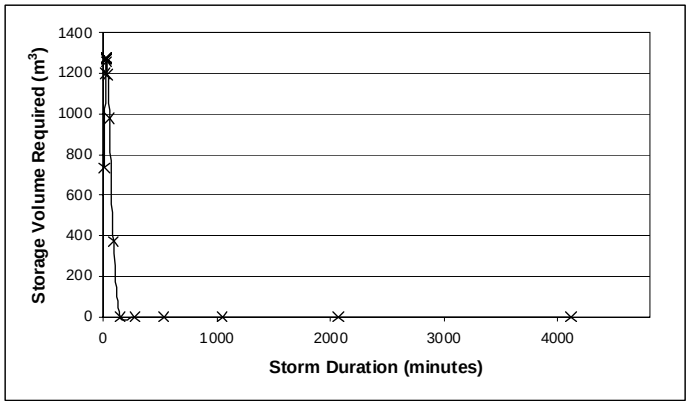
9. STORAGE REQUIREMENTS – UNIT M9/400

Storage Requirement Estimation, Calculation Sheet

During intense rainfall events the volume of water arriving at the site outfall will exceed the rate at which it is either possible or allowable to discharge it. In this situation on site storage is required to prevent flooding. For very short events, whilst peak flows are often very high, total volumes are relatively low due to the short time period. For very long events the outflow will be similar to or exceed the flow generated by the site, so again required storage volumes will not be large. Between these two extremes are a series of events where significant storage is required. A range of events must be considered to ensure that the design event is captured.



The graph above plots both the water arriving at the site outflow and the maximum allowable discharge. The area above this second line (dashed) corresponds to the required storage. This area has been calculated for a range of storm durations and the required storages obtained are plotted against storm duration below.



This indicates that the design storm for storage is the 23 minute 100 year storm.

To prevent flooding during this event **1276 m^3** of storage would be required.