Job No:	C85529
Job Name:	Land off Marshgate Drive, Hertford
Note No:	TN001
Date:	16/02/2017
Subject	Basic Flood Risk Assessment and Floodplain Compensation Principles
By:	POF
Checked:	CA

1. Introduction

1.1. This technical note provides details about the Basic Flood Risk Assessment carried out by JNP for Land off Marshgate Drive, Hertford. The main principles of floodplain compensation are presented in a separate section following the Flood Risk Assessment.

1.2. This technical note is to be read with the following information.

- SK-001 Local Area LiDAR Plan.
- SK-002 Local Watercourses Plan.
- SK-003 Q1000 Flood Depth Map.
- SK-004 Wider Area LiDAR Plan.
- SK-005 Existing Ground Profile Plan.
- TN-002 Site Visit Notes.
- 27/10/2014 WYG Groundwater Monitoring at Hertford Areas B and C.
- 06/01/2017 CGL Geoenvironmental due diligence assessment.
- 25/01/2017 Hertford District Council email re: historical flooding.
- 30/01/2017 Environment Agency email re: modelling inconsistencies.
- 14/02/2017 Environment Agency meeting notes.
- Environment Agency Product 4 data (reference HNL 34722).
- Environment Agency Product 4 data (reference HNL/34722/JH).

2. Site Details

2.1. The site is a former gasworks located at Marshgate Drive, Hertford, Hertfordshire SG13 7JY (centred at grid reference 533260, 213210). The site is partially located in the Environment Agency's (EA) Flood Zones 2 & 3 and constitutes a major development as set out in Article 2 (1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010, being for over 100 new residential units and B3 industrial use. The development is at an early stage of design development and a fixed layout is not yet available.

2.2. The site is split into two separate areas. One area is bounded by Mead Lane to the south, referred to in this document as the southern area. To the north of this southern area, and bounded by the River Lee Navigation Channel to its north, is the sites northern area. The site is shown in Figure 1 overleaf.

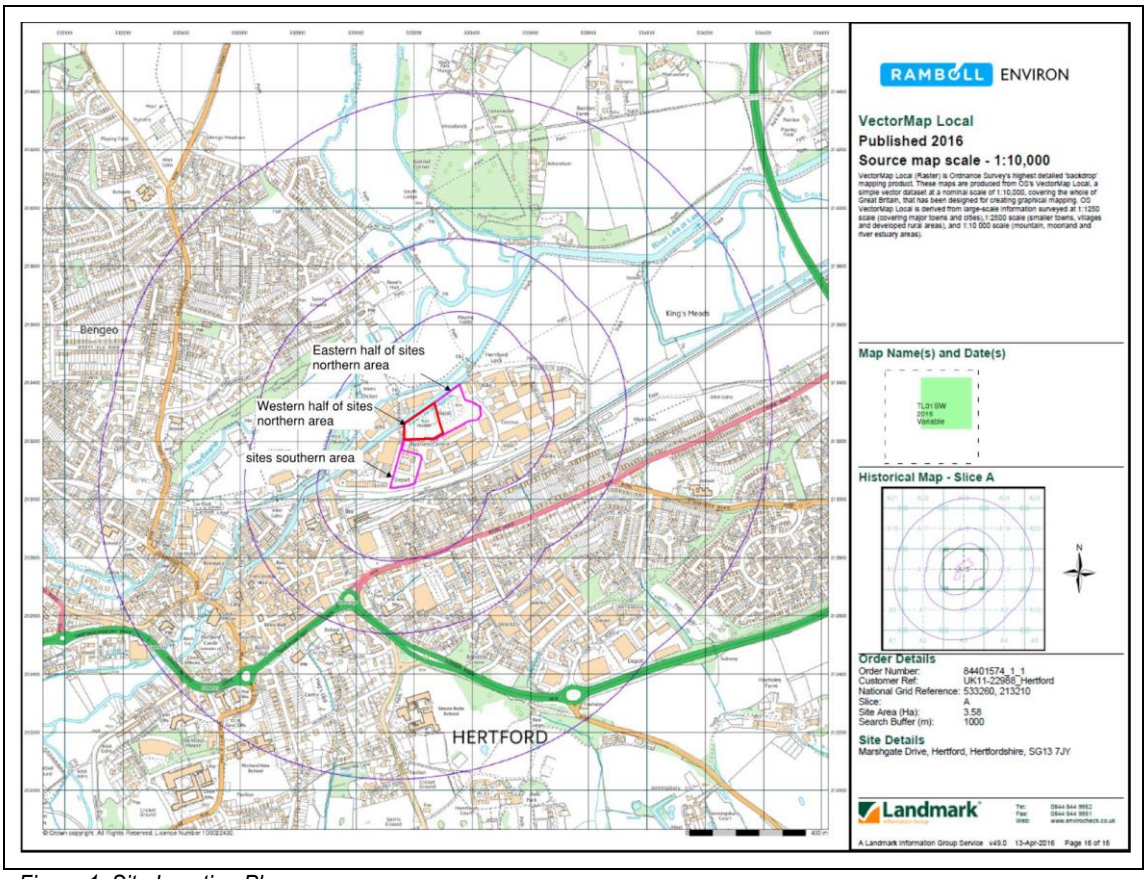

Figure 1: Site Location Plan

3. Topography

3.1. This section should be read in conjunction with JNP's Wider Area LiDAR plan (reference C85529-SK-004), Local Area LiDAR plan (reference C85529-SK-001), and Existing Ground Profile plan (reference C85529-SK-005).

3.2. LiDAR data obtained from the EA shows that the site is situated at the base of the River Lee Valley. The LiDAR data indicates that the site is also located at the bottom of a smaller local valley leading north-east from Mead Lane down to the site's northern area.

3.3. Topographically, the site's northern area is split in two; as highlighted in Figure 1. The western half of this northern area is set between 38.00 and 39.00m AOD and the eastern half is set between 35.25 and 36.50m AOD. These levels are separated by retaining walls/steep banks from north to south across the central part of this area. The south-eastern corner of the northern area has a 35.25m low spot where a former gas silo was located.

3.4. The sites southern area has a low spot in its south-eastern corner with levels between 36.38 and 37.00m AOD. Levels are flat across the remainder of the area, being typically between 37.00 and 37.50m AOD.

Basic Flood Risk Assessment

4. Fluvial

4.1. This section should be read in conjunction with JNP's Local Watercourse Plan (reference C85529-SK-002) and Q1000 Flood Depth Map (reference C85529-SK-003).

4.2. The site is located at the bottom of the River Lee valley. A fluvially influenced canal; the River Lee Navigation Channel (classified by the EA as a Main River) is immediately north of the site. The River Lee northern branch partially flows into the canal and a separate branch flows further north, merging with The River Beane and the River Rib. To the north-east, the River Lee Navigation Channel re-joins the River Lee northern branch and continues to flow eastwards to the New River which is approximately 700m to the east of the site.

4.3. To the south of the site, Hag's Dell flows west to east before merging with the River Lee southern branch approximately 375m to the south-east of the site. Hag's Dell passes through culverts under Gascoyne Way, Ware Road and Mead Lane respectively, with small stretches of open channel between (under 50m in length).

4.4. The EA have carried out fluvial flood modelling on all the watercourses near the site. The modelling data for the area has been provided as part of a Product 4 request in January 2017 (HNL 34722). This contained numerous inconsistencies and following an email from the EA regarding this on the 30th January 2017 (provided with this Technical Note), the modelling data for the southern watercourses was re-provided in February 2017 (HNL/34722/JH). The modelling data for the southern watercourses still contains inconsistencies but represents the best available data at this time. Despite the known inconsistencies, the EA confirmed that the January 2017 data remained the best available data for flood risk from the northern watercourses.

Risk from Northern Watercourses

4.5. The EA fluvial flood modelling suggests no risk of fluvial flooding from watercourses to the north of the site, due to the raised towpath and retaining wall between the River Lee Navigation Channel and the site boundary. The towpath and retaining wall are raised a minimum of 0.1m above the maximum 1 in 1000 year flood levels.

4.6. While there is no direct risk to the site, there is a potential residual risk to the site because the 1 in 1000 year fluvial flood level is shown to be 37.44m AOD; up to 1.91m higher than on-site levels. In the event of a breach of the towpath and retaining wall this could pose significant risk to the sites occupants. A site visit was carried out by JNP in February 2017. The combined thickness of the towpath and retaining wall is approximately 5m and based on visual inspections appears to be in good condition. Therefore, it is considered very unlikely that a breach scenario could occur.

4.7. The EA released revised climate change allowances in February 2016. These may show an increase in flood levels along the canal. Given the minimal freeboard above the canal, it is possible that the towpath and retaining wall could overtop in these revised climate change scenarios.

4.8. The EA's hydraulic flood modelling covers a good range of flood events up to the 1 in 1000 year storm and relatively small increases, so we propose a stage-discharge approach to assess the impacts of the revised climate change allowances. This involves plotting the modelled events and extrapolating the new climate change allowances. We consider additional hydraulic modelling to be unnecessary given the relatively small increases in levels in the more extreme flood events modelled by the EA. This is something that was agreed in principle with the EA during the 14th February 2017 meeting, provided a low sensitivity to climate change is demonstrated and an appropriate freeboard is given.

4.9. To carry out the stage-discharge approach, the latest EA flood risk information was received in January 2017. This information shows modelled fluvial flood levels in the canal behaving typically (increasing in

level during the more extreme flood events). However, flood flows behave erratically, with higher maximum flows in more frequent storms than in extreme storms. The EA confirmed that this was due to model instabilities in an email dated 30th January 2017 (provided with this Technical Note). This does raise concerns as to the models accuracy. However, as this modelling is the best available information we have continued to base our assessment on that at this stage. A stage-discharge approach is not possible due to the erratic flows, so a modified approach has been taken, extrapolating the difference in levels from the 1 in 100 year and 1 in 100 year +20% fluvial flood event to demonstrate the maximum level in a 1 in 100 year +35% and a 1 in 100 year + 70% fluvial flood. The results are given in Table 1 below.

Table 1: River Lee Navigation Channel Fluvial Flood Levels

			Return Period					
Node Label	**Easting**	**Northing**	**100yr**	**100yr+20%**	**100yr+35%**	**100yr+70%**	**200yr**	**1000yr**
Ch42700	533175	213280	37.33	37.35	37.37	37.40	37.34	37.44
Ch42650	533221	213311	37.33	37.35	37.37	37.40	37.34	37.44
Ch42600	533264	213340	37.33	37.35	37.37	37.40	37.34	37.44
Ch42550	533302	213364	37.33	37.35	37.37	37.40	37.34	37.44
Ch42491	533345	213393	37.33	37.35	37.37	37.40	37.34	37.44

4.10. The node locations relative to the site are provided in Figure 2 below.

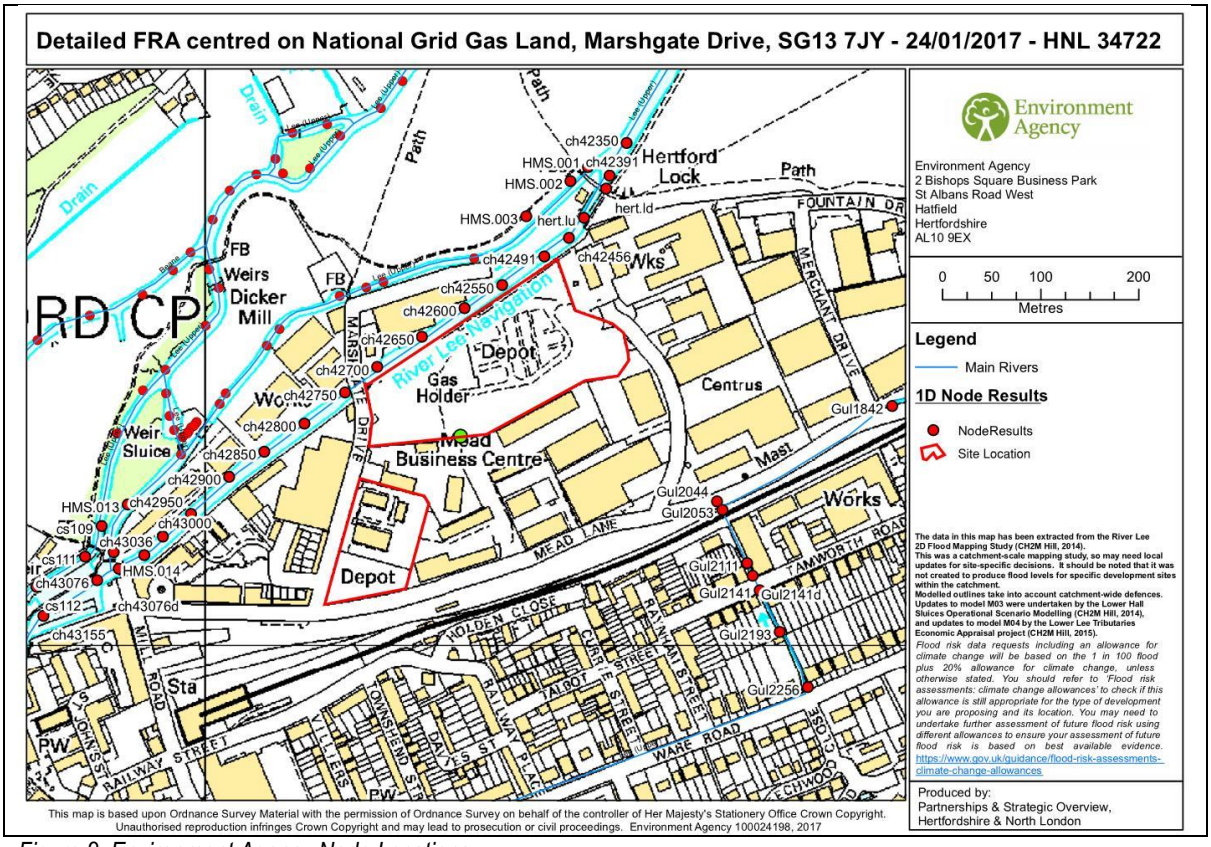

Figure 2: Environment Agency Node Locations

4.11. The results of the modified stage-discharge assessment demonstrate that there is no risk of fluvial flooding from northern watercourses to the site in all modelled storm events, including the forecasted impacts of climate change.

Risk from Southern Watercourses

4.12. The below assessment is based on the EA's flood data provided in February 2017 (HNL/34722/JH). For the southern watercourses, this supersedes the EA's flood data provided in January 2017 (HNL 34722).

4.13. On-site flood levels are extracted from the EA's 2D flood height mapping in the sites northern area, with flood extents compared to the topographic survey to extract levels in the sites southern area (due to illegible 2D flood height labels in this area).

4.14. The EA's hydraulic flood modelling covers a good range of flood events up to the 1 in 1000 year storm and relatively small increases, so we propose a stage-discharge approach to assess the impacts of the revised climate change allowances rather than additional hydraulic modelling. This is something that was agreed in principle with the EA during the 14th February 2017 meeting, provided a low sensitivity to climate change is demonstrated and an appropriate freeboard is given.

4.15. On-site flood flows cannot be provided on site, making a true stage-discharge assessment impossible. Consequently, a modified assessment has been made, extrapolating the difference in on site flood levels (provided within the EA's data) from the 1 in 100 year and 1 in 100 year +20% fluvial flood event to demonstrate the maximum level in a 1 in 100 year +35% fluvial flood and a 1 in 100 year + 70% fluvial flood.

4.16. The maximum onsite flood levels including the assessed climate change levels are provided in Table 2 below.

Table 2: On-site fluvial flood levels from EA modelling data

Area	Flood Levels (m AOD)							
	1in50	1in75	1in100	1in100+20%	1in100+35%	1in100+70%	1in200	1in1000
Northern	N/A	35.63	35.65	35.81	36.09	36.21	35.74	35.98
Southern	N/A	36.70	36.70	36.72	36.74	37.77	36.70	36.83

4.17. The impacts of climate change shown by our assessment do not appear representative of the risk to the site on the basis of levels given for the 1 in 200 year and 1 in 1000 year fluvial event, and the lack of sensitivity to climate change noted in the southern area and in the watercourses to the north of the site. Consequently, the assessment of risk to the site from southern watercourses is based on the 1 in 1000 year fluvial flood level.

4.18. From a review of the EA's fluvial flood mapping, it appears that the source of this flooding is Hag's Dell (also known as The Gulphs) to the immediate south of the site, with water emanating from the Ware Road culvert and the immediately upstream area of open channel. The flood water follows the local topography, down to the site via local roads and the small localised valley that enters the sites north eastern area from Mead Lane, partially crossing the sites south-eastern corner.

4.19. The eastern half of the sites northern area would be partially inundated by a 1 in 75 year fluvial event. As shown on the Q1000 Flood Depth Map (reference C85529-SK-003), fluvial flood levels are shown to reach up to 35.98m AOD in this half during the 1 in 1000 year fluvial event. Across much of this half, this results in maximum depths of 0-0.25m. However, in the south-eastern corner of this half, depths can reach up to 1m. There is no flooding shown in the higher north western area of the site in all storms up to and including a 1 in 1000 year fluvial flood event. The volume of floodwater stored in this area of the site in the 1 in 1000 year event is 3965m3. This covers an extent of 10,388m2.

4.20. A very small area of the low-lying south-eastern corner of the southern area of the site is inundated in a 1 in 75 year fluvial flood event and all more extreme modelled scenarios but the remainder of this area remains dry in all modelled fluvial events. As shown on the Q1000 Flood Depth Map (reference C85529-SK-003), maximum depths of 0.45m could occur in the south-eastern corner. The total flood storage during the 1 in 1000 year event is 46m3. This covers a 259m2 area.

Safe Means of Escape

4.21. The EA's Flood Map suggests that there is safe, dry access to and from the site in all modelled storm events on-foot. However, the eastern half of the sites northern area may have difficulty escaping that area during a fluvial flood event. Additionally, parts of the road network away from the site are within Flood Zone 2, meaning there may not be access to and from the site during a less frequent storm flood (between a 1 in 100 year and 1 in 1000 year fluvial event). Our strategy for mitigating this risk will involve residents signing up to the EA's free Flood Warning Service in operation at the site. This aims to give residents a minimum 2 hours warning ahead of a flood event, allowing preparations for safe evacuation to be made. This is something that the EA agreed to in principle during the 14th February 2017 meeting.

EA Fluvial Flood Modelling Discrepancies

4.22. The EA note in their email on 30th January 2017 (provided with this Technical Note) that there are a number of inconsistencies in their modelling. In addition to the inconsistent flows in the River Lee Navigation Channel (discussed in section 3.1.1 above), the EA note "it was found that the volume of water within the smaller watercourses [to the south of the site] was too large and was causing unrealistic flooding, and therefore the volume was reduced". It is unclear how the volume was found to be too large and how an appropriate reduction was determined.

4.23. In addition to the EA's comments, the site visit carried out in February 2017 by JNP was on a wet day following prolonged rainfall but no flow was observed in the channel. This is considered unusual given the high risk suggested by the EA's modelling.

4.24. A Flood Risk Assessment (FRA) carried out in support of a residential development to the south east of the site (planning reference 3/15/0539/FUL) noted that the flood extents in that area were incorrect as a topographic survey demonstrated that the top of bank was higher than the in-channel flood level and therefore the sites position in Flood Zone 3 was erroneous. The EA had no objection to this argument, demonstrating that there is a known issue with the modelling.

4.25. Although they do note some history of fluvial flooding from Hag's Dell up to Mead Lane, Hertford District Council (HDC) have confirmed in an email dated 25th January 2017 that there is no history of fluvial flooding to the site.

4.26. On the basis of the above information, there is evidence from a number of sources that the modelling to the south of the site is inaccurate and could be overestimating the risk of flooding to the site.

5. Coastal and Tidal

5.1. The site is located inland and is not near any tidally influenced watercourses; therefore, there is low risk of flooding from this source.

6. Groundwater

6.1. Groundwater flooding occurs when the water table rises to the surface, and is most likely to occur in low-lying areas underlain by permeable rocks (aquifers).

6.2. WYG and CGL have provided geotechnical information for the site (dated October 2014 and January 2017 respectively). A summary is provided below:

- The ground is composed of Made Ground between 0.30m and 4.80m bgl, Floodplain Gravel between 0.30m and 7.20m bgl, White Chalk between 3.3m and 7.4m bgl.
- All layers have variable thicknesses.
- The Kempton Park Gravel is an EA designated Secondary Aquifer and White Chalk is an EA designated Principal Aquifer.

- The information for the southern area suggest groundwater at around 2.10m below ground level (bgl) at its lowest point.
- There is no groundwater monitoring information for the site's northern area.
- No hydraulic continuity between the site and River Lee Navigation Channel is assumed due to the difference in levels.

6.3. Based on the available records, the sites underlying geology is permeable and there is potential that underlying aquifers could rise to ground level, particularly in the low-lying areas in the eastern half of the sites northern area. However, it should be noted that there are no records of flooding from this source in Hertford as per the findings of the 2016 East Hertfordshire District Council Strategic Flood Risk Assessment (SFRA). Groundwater monitoring of the northern area is required to better understand the risk of flooding from this source.

7. Pluvial (Overland Flows)

7.1. The site position at the base of the River Lee Valley puts it in a location where overland flows will naturally be directed, although there are localised low lying areas to the north of Mead Lane that may store and convey surface water away from the site. The site position at the bottom of the smaller local valley means overland flows that reach Mead Lane will naturally be conveyed down to the eastern half of the sites northern area. The higher levels in the western half of the northern area place it outside of the smaller local valley, suggesting a low risk of flooding from this source.

7.2. Overland flows could travel through the southern area of the site on-route to the sites northern area but it is unlikely that ponding will occur and the velocities of flood water are unlikely to be over 0.25m/s because it is outside the localised valley in the area, thus it is outside of the major overland flow path.

7.3. The EA has prepared a map showing Flood Risk from Surface Water. This correlates well with our assessment. The EA's mapping shows high risk of surface water flooding around the former gas silo location. The entire eastern half of the northern area shown to be at low-medium risk from surface water flooding. The EA's mapping suggests expected depths of over 900mm around the former gas silo in a 1 in 100 year storm event with depths of up to 900mm more generally in the eastern half of the northern area. Velocities of flood water are shown to be over 0.25m/s at the former gas silo location in the same storm event. Velocities in the wider eastern half of the northern area are shown to be less than 0.25m/s. These depths and velocities are considered accurate on the basis of the sites topography. The EA's mapping shows no risk of flooding to the western half of the northern area from this source in the 1 in 100 year storm.

7.4. The EA's surface water mapping suggests a limited flow path through the sites southern area with depths less than 300mm in a 1 in 100 year storm. However, this also suggests velocities of over 0.25m/s. It is considered that the flat nature of the southern area and its position outside of the smaller valley makes the velocities shown by the EA unlikely.

7.5. In summary, the risk of pluvial flooding is considered high in the eastern half of the northern site area, very low in the western half and low in the southern area. To reduce risk from this source, careful ground profiling should be provided to convey surface water away from development areas and any attenuation/floodplain compensation areas.

8. Sewer/Drainage

8.1. Sewer flooding is caused by excess surface water entering the drainage network and/or insufficient capacity in the surface and foul water network, but also due to 'one off' events such as blockages.

8.2. There are a number of sewers in the vicinity of the site, including a surface water rising main that runs through the northern area of the site and 2 sewers (one foul and one surface water) that cross through

the sites southern area. Therefore, there is a potential risk of flooding from this source if these exceeded their capacity or became blocked.

8.3. There are 4 records of sewer flooding in the sites SG137 Post Code area as per the findings of the 2016 East Hertfordshire SFRA. These records were obtained from Thames Water's DG5 register. For confidentiality reasons, it cannot be determined if these impacted the site or not.

8.4. Whilst historic incidents of sewer flooding may indicate areas at higher risk than others, the public drainage system is constantly upgraded and improved. Therefore, risk may be significantly lowered, thus making the historic occurrence of flooding an inadequate indicator of future problems.

8.5. The ground profiling required to offset the risk of pluvial flooding to the site should also be designed to minimise the risk of post-development sewer flooding.

9. Reservoir

9.1. The EA has produced a Reservoir Flood Map that displays a worst-case scenario of the area that could be flooded if a large reservoir were to fail. This map shows no risk of flooding to the site from this source.

10. Canal

10.1. The River Lee Navigation Channel runs immediately adjacent to the sites northern boundary. Although classed as a canal, the risk of flooding is considered fluvial as it receives flows from the River Lee Northern Branch and is classified as a Main River by the EA. Therefore, the risk from this source is assessed above in Section 2.

10.2. There are no other canals near the site and so the risk of flooding from this source is considered very low.

Indicative Floodplain Compensation Review

11. Existing Fluvial Storage Volumes

11.1. As covered in Section 4.19 - 4.20 of the 'Basic Flood Risk Assessment' above, the eastern half of the sites northern area stores up to 3965 m^3 fluvial water during a 1 in 1000 year event. The mean average depth of fluvial floodwater is 0.27m during the 1 in 1000 year event. Depths reach up to 1m in the local low spot in the south-east corner of this area (where a former gas silo was located).

11.2. The south-eastern corner of the southern area of the site stores 46 m^3 fluvial water during a 1 in 1000 year event. This area is outside of the development area and should be retained at existing levels if possible to remove any need for compensation. The mean average depth of fluvial floodwater is 0.2m during the 1 in 1000 year event, with a maximum of 0.45m.

12. Direct/Indirect Fluvial Floodplain Compensation Requirements

12.1. Direct compensation (level for level) refers to the replacement of fluvial flood storage lost due to development at the same level as it is lost. In a typical floodplain, this means that the replacement storage will be filled at the same time during a fluvial flood event as per existing conditions. Additionally, it means that flood water can return to the watercourse in the same way as existing post-flooding.

12.2. The sites floodplain is atypical, set in a local low spot at the bottom of a valley leading off Mead Lane. Floodwater entering the site is subsequently cut-off from its source (Hag's Dell) and has no direct way of flowing into the local watercourse network. Thus, the site acts as an informal flood storage reservoir, storing the fluvial water until it either infiltrates into the ground or drains into the local sewer network. The timing of the site floodplains utilisation is dictated by the time it takes to flow overland from the top of the valley at Mead Lane to the south-east of the sites southern area, not by its levels.

12.3. Given the atypical floodplain, there is no benefit in using direct compensation of flood storage over indirect compensation (volume for volume only). Therefore, we propose to use indirect compensation to mitigate against the loss of flood storage proposed as part of the development. This is a principle agreed with the EA during the 14th February 2017 meeting.

12.4. We propose to provide full compensatory flood storage up to the 1 in in 1000 year level. This is a conservative approach used in lieu of the appropriate 1 in 100 year + 35% climate change allowance level due to the uncertainty around the validity of the EA's modelling at the site and the unrealistic results given from the modified stage-discharge assessment.

12.5. On-site car parking areas may form a part of the compensatory storage, including some undercroft parking. During the 14th February 2017 meeting, the EA agreed to the principle of providing compensatory flood storage in surface car-parking areas and potentially undercroft, following a review of the proposed layout.

13. Offsite Impacts

13.1. The sites informal flood storage reservoir to the north extends beyond the sites eastern boundary into the Lock House Industrial Estate (specifically the Smyle Building and immediately surrounding car parks).

13.2. By using indirect compensation, we will be able to prevent any additional runoff draining into this offsite area during a fluvial flood event. However, the volumes of flood storage provided must be beneath the lowest levels along the site boundary to minimise the risk of floodwater bypassing the compensatory storage and flowing into adjacent off-site areas. This is a principle agreed with the EA during the 14th February 2017 meeting.

13.3. The volumes of fluvial floodwater currently stored in existing areas of our site that are lower than the adjacent land (i.e. at the former gas silo location) do not pose any direct risk off-site as they would remain on-site until they infiltrate into the underlying soils. Post-development, these volumes will need to be disposed of in a manner that causes no additional risk to off-site areas.

14. Conclusions

14.1. Table 3 provided below, gives a summary of the flood risk sources and associated risk.

Table 3: Flood Risk Summary Table

Source of Flood Risk	Risk to Development	Comments
Northern Fluvial Watercourses	Very Low	Climate Change assessment demonstrates no risk to site over development lifetime.
Southern Fluvial Watercourses	High	Risk based on EA modelled data which has known inconsistencies.
Coastal and Tidal	Very Low	
Groundwater	Medium	No groundwater monitoring in northern area, underlying permeable strata.
Pluvial	High	High risk limited to the eastern half of the sites northern area.
Sewer/Drainage Infrastructure	Low-Medium	
Reservoir	Very Low	
Canal	Very Low	

14.2. The primary flood risk to the site is from Hag's Dell to the south of the site. As part of the developments mitigation strategy, a floodplain compensation scheme will be needed to minimise offsite impacts resulting from the development. A summary of the scheme is provided below:

- The scheme will provide full volume for volume compensatory storage for the 1 in 1000 year fluvial flood event;
- The schemes compensatory storage will be provided beneath the lowest levels along the site boundary;
- On-site car parking areas may form a part of the compensatory storage, including some undercroft parking.