

Design Summary Document App D Lid Rife Bridge Opt Tech Note

Pell Frischmann

Project	Barnham Eastergate Westergate
Document Title or Subject	A29 Realignment – Lidsey Rife Bridge Options
Document Reference	13394-PEF-XX-BR-RP-S-000002
Revision Reference	P02
Date	January 2022

1 Executive Summary

Pell Frischmann has been commissioned by CC Projects, Ashmarden Limited and Hanbury (PM) Ltd (promoting the site together as 'The Southern Consortium') to provide transport planning and highways consultancy services in connection with emerging masterplan proposals for a strategic residential-led mixed use development on land forming part of the site allocation at Barnham/ Eastergate/ Westergate, (BEW), West Sussex. The application site comprises land south of Barnham Road and north of the railway as well as the route of the A29 realignment including the early connection referred to as the Hanbury Link (the 'Site'). The development is referred to as BEW Parcel SC1.

Outline planning permission (with all matters reserved except for the A29 realignment) for the demolition of existing structures and mixed use development to provide residential dwellings (Use Class C3), care home/senior living accommodation (Use Classes C2/C3), flexible retail and community floorspace (Use Classes E/F2/sui generis), a primary school, plus associated open space, landscaping, drainage and all other associated ancillary works; and realignment of the A29 and early connection to existing A29, including construction of a new road carriageway, junctions and associated infrastructure.

This technical note aims to consider the feasibility of a proposal for a new bridge over a floodplain east of the existing Lidsey Road. The proposed structure will carry the realigned A29 carriageway and will be aligned approximately east-west.

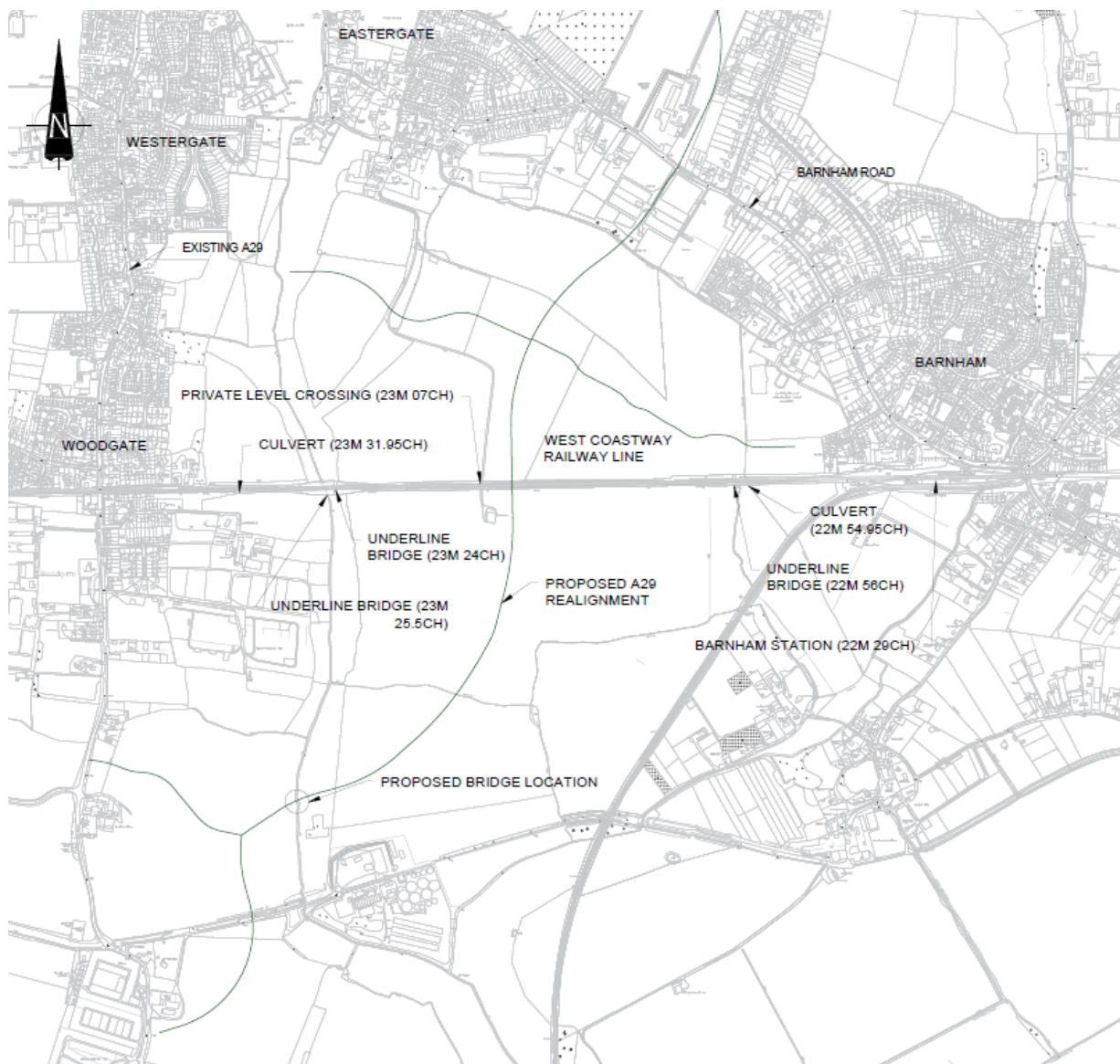


Figure 1: Location Plan

Initially two proposals for the structure were considered

- Option 1: 200 m Multi-Span Bridge with a Typical Prestressed Concrete Y8 Beam Arrangement
- Option 2: 30m Single Span Bridge with a Typical Prestressed Y6 Beam Arrangement

However, recent discussions with the Environment Agency have reduced to the flood level to 2.2m AOD at point of crossing. As a result, the structure clearance can be reduced and therefore the multi span bridge is no longer a viable option. For information purposes, the multi span structure proposal is included within this report.

2 Description of Site

The proposed bridge location is located approximately 525m east of Lidsey Road (Figure 2). An existing watercourse goes across the proposed location. The site is a flood plain, therefore poor ground conditions are to be expected. To the east of the proposed bridge location, there is a pond as well as the Lidsey Oil Field site. Detailed ground investigations and site surveys have not been completed. However due to the isolated site, it can be assumed that the proposed structure is not likely to result in any major diversions of existing services.

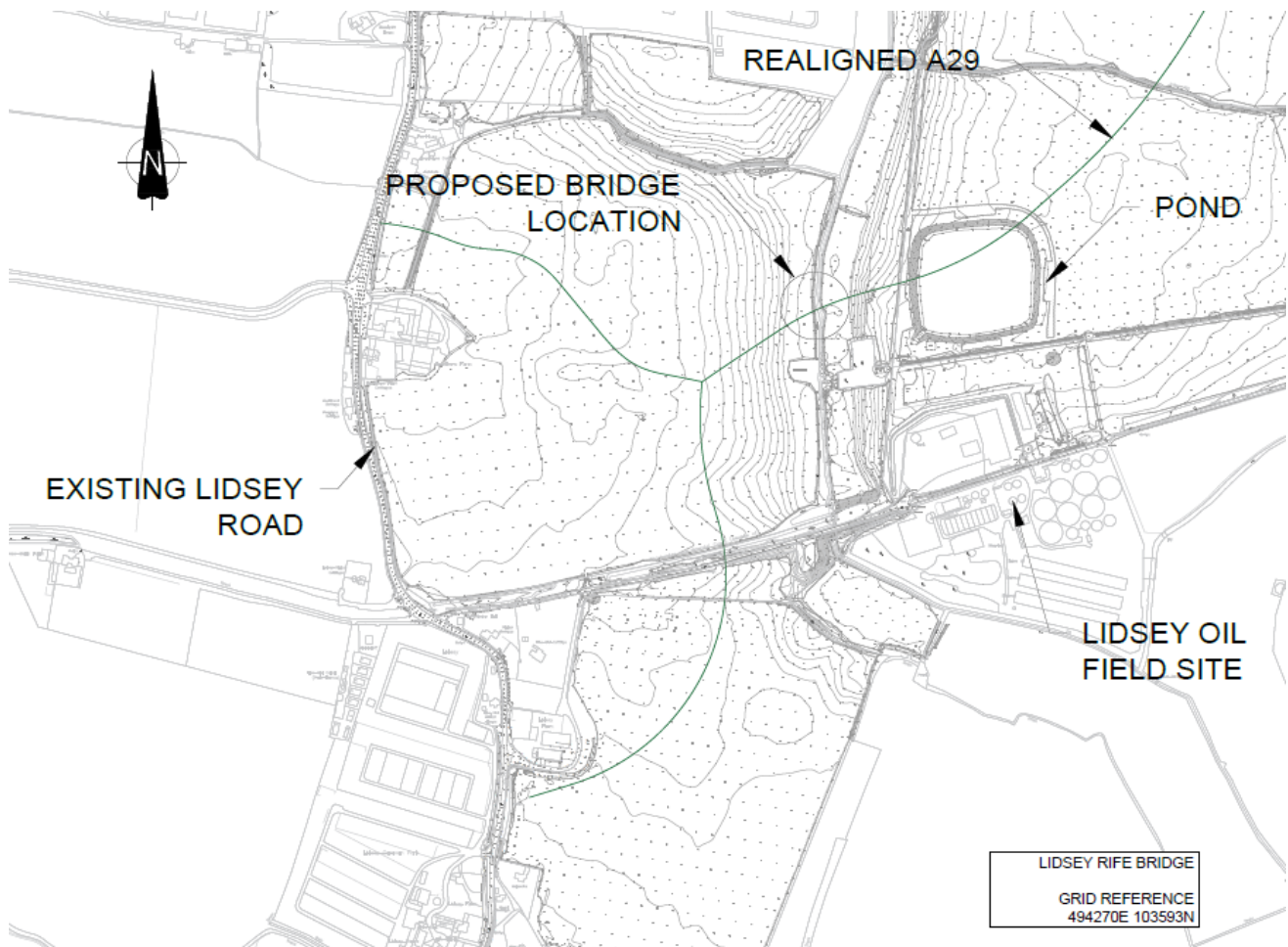


Figure 2: Location plan for proposed Lidsey Rife Bridge.

3 Bridge Options

Initially, two bridge options were considered, a multi span structure and a single span structure. The multispan option was initially developed based on the assumption the carriageway level was 6.0m above the existing ground level. However, recent discussions with the Environment Agency have reduced the flood level to 2.2m AOD at point of crossing. The carriageway level is now 4.359m above existing ground level. As a result, the structure clearance can be reduced and therefore the multi span bridge is no longer a viable option. For information purposes, the multi span structure proposal is included within this report.

The purpose of the bridge is to allow for vehicular and pedestrian traffic on the proposed realigned A29 carriageway. A single and multi-span arrangement were identified as the structural forms.

It is evident that the ground conditions will primarily dictate the suitability of an appropriate structural form. A multi-span arrangement will allow for a lower approaching span footprint but will increase the number of foundations to support the structure. On the other hand, a single span structure, will have a larger approaching span footprint but reduced piling works for pier foundations. It is worth noting that the structure will be founded on weak compressible ground, therefore if a multi-span structure is chosen, then sufficient articulation of the structure should be accommodated for. The arrangement of bearings will become very important, but increased number of bearings will also introduce maintenance issues.

It is also worth considering the need for future changes on the bridge for example widening. If such changes are required in the future, then choosing a prestressed concrete deck arrangement is ideal rather than a cable-stayed structure. It is not anticipated that such changes will be required, however the flexibility offered by prestressed and composite beam arrangements during construction makes it suitable as a proposal for this scheme. Moreover, a limitation to the single span option is the limited span of a typical off the shelf prestressed beam.

Cost is also a limiting factor to consider. Construction of a cable-stayed or suspension bridge structure will involve greater structural analysis, tighter design tolerances and increased construction risk. The piers will also need to be founded on good foundations otherwise settlement will occur. In addition, these structural forms do not fit into the aesthetic landscape of the surrounding region and thus were deemed not viable.

The alignment of the bridge is crucial to determining the construction methods chosen and the subsequent structural form of the bridge. If the structure is curved or skewed, then construction methods such as incremental launching is not ideal as it requires a constant radius of curvature and tighter tolerances. On the other hand, precast beams and slabs can be easily dropped in using a crane and is significantly cheaper. However, it is important to ensure that there is bracing between the beams to provide lateral stability, in addition to having good ground conditions for the placement of heavy construction equipment such as cranes.

Based on these conditions, the structural choice was narrowed down to the following:

- Option 1: 200 m Multi-Span Bridge with a Typical Prestressed Concrete Y8 Beam Arrangement
- Option 2: 30m Single Span Bridge with a Typical Prestressed Y6 Beam Arrangement

3.1 Existing Site Constraints

Various site constraints have been identified that will influence the structural form. These constraints are discussed in this section.

3.1.1 Environmental and Ground Conditions

It is preferred to have minimal environmental impact due to the proposed structure. As the site is in a flood plain, installation of sandbags during foundation works is recommended. By raising the cut-off level for the piles, it avoids having to carry out deep excavations in poor ground, therefore increasing safety and reducing the risk of contamination of the nearby watercourses. Avoiding deep excavation also reduces the risk of their collapse and instability. Careful monitoring of the pile

positions during construction should be completed to ensure they meet the requirements for the pile columns. This also avoids the need to pre-install casings and thus saving time and costs.

While no detailed ground investigation has been conducted, it is likely that poor ground conditions are present at this proposed site location, due to it being a flood plain. As a result, the geological formation will influence the number of piers and foundations of the structure. By using single shorter span design, it reduces the number of piers in poor ground conditions, thus saving time and costs. However, for extended multi-spans large volumes of spoil will need to be removed, therefore the presence of additional on-site construction plants increases the risk of collisions and injuries. A potential hazard identified is the lack geotechnical information which may lead to unsafe, inappropriate, or uneconomic foundation design. Additionally, the lack of appropriate knowledge may also prevent the contractor to understand the geotechnical risk and develop suitable safe systems of work.

3.1.2 Transportation

The size and delivery of the beams to the site will be a critical issue. Longer spans will be difficult to transport, therefore shorter span designs are preferred. Fabrication and transportation costs are reduced as well as the impact to the environment and the local community. The need for specialist transport and long vehicles is avoided with a shorter span design, which also results in reduced risks of knocks and accidents to the beam elements.

A proposed design with shorter spans results in easier lifting into place and requires a smaller crane, thus reducing construction costs. The absence of heavy plant and crane lifting operations reduces the risk of injury to the workforce and again minimises the risk of damaging the beam elements. Moreover, an increased span lengthens the time that the workforce is working from heights. This causes increased risks of falling, dropping tools from height and instability in ground conditions.

3.2 Design Requirements

3.2.1 Headroom

Flood modelling has been completed to identify the levels of a 1:100yr flood level with and without accounting for climate change. The flood levels for these models were the following:

- | | |
|--|-------|
| ➤ 1:100yr flood level without accounting for climate change: | 1.84m |
| ➤ 1:100yr flood level accounting for climate change: | 2.20m |

From these models, the headroom of the proposed designs should be greater than the largest value which was the 1:100yr flood level accounting for climate change (2.20 m).

3.2.2 Span

As the site is in a flood plain, it is ideal to minimise the number of foundations and piers of the structure. As discussed earlier, reduced transportation and construction costs are advantages gained from a shorter span design. Therefore, a single span structure is preferred.

3.3 Option 1 – 200m Multi-Span Bridge

This alternative proposal comprises of a multi-span bridge, consisting of a typical prestressed precast concrete Y8 beam arrangement with reinforced concrete frame abutments, wingwalls and columns founded on pile foundations. The total span length is 200m, with 6No. 33m clear spans. It is assumed that no stats diversions or protection would be required, however additional site survey will need to be completed to confirm.

To accommodate the carriageways arrangement, the deck will be 18.5m in width, comprising of 4m cycleway/footway, 1m verge and 1No. lanes in either direction. The reinforced concrete slab will be supported on 17No. prestressed precast concrete Y8 beams.

The main advantages associated with this proposal are as follows:

- Minimal footprint of land-take of the approach spans, reducing the environmental impact from the addition of excess materials on the flood plain site.
- The reduced footprint of land-take of the approach spans removes the need for any flood mitigation measures.
- Whilst more supports are required, there is less overall footprint and reduced loading from the approaching embankments compared to Option 2.
- Greater space available around the structure allowing for safer construction.
- Less likely to damage the current ecosystem and habitat present.
- Potential for a better aesthetically pleasing form of the structure.

For further information, see Appendix A.

3.3.1 Structural Form

The form of the superstructure is primarily dictated by the span requirements and aesthetic goals. The use multi-span structure can result in a cheaper design than having a single span structure spanning the same distance. This is due to the longer spans requiring a thicker deck to resist the greater moment from the increased loads. However, there is also increased foundation costs due to the increased number of piers. It is likely that the benefit gained from the multi-span design will be offset by the difficult ground conditions due to the flood plain.

It is ideal to have equal pier spacing due to the following advantages:

- Easier and quicker construction.
- Cheaper fabrication costs due to the same deck designs for the spans.
- A more robust structural design.

3.3.2 Maintenance Requirements

The reduced land-take, due to the shorter approach spans, provides a safer access for maintenance and inspection of the abutments and associated bearing. This proposal also prevents the maintenance crews working deep into the flood plains. However, the increased number of piers and the multi-span design will make it difficult and costly to inspect the bearings near the midspan of the bridge. Additionally, the multi-span design also introduces many expansion joints which creates further routes of degradation. Due to the increased vulnerable locations, risk of structural damage increases therefore causing an increased maintenance cost over the lifetime of the structure. This combined with the reinforced concrete y-beam arrangement presents the risk of corrosion of reinforcement and the subsequent spalling of concrete.

3.3.3 Constructability

Construction on a flood plain will present significant challenges as discussed earlier. Some clearance of existing vegetation will be required but it is not likely to be extensive. Access to the site is viable but additional strengthening of the ground will be required to enable construction traffic to safely carry out the associated works. As identified earlier, the main risk arises from the unstable ground conditions due to the site being in a flood plain.

This proposal requires increased piling and foundation works due to the increased number of piers. Additionally, deep excavations in poor ground will take place which reduces safety and increases the risk of contamination of the nearby watercourse. The contractor should also implement safe systems of work to minimise any construction risks.

3.4 Option 2 – 30m Single Span Prestressed Bridge

This proposal comprises of a single span bridge, consisting of a typical prestressed beam arrangement, reinforced concrete frame abutment, wingwalls, and founded on pile foundations. The total span is 30m, where the reinforced concrete slab will be supported on 17No. prestressed precast concrete Y6 beams at 1m C/C spacing. The span of this proposal is shorter than Option 1 due to the span limitations of a single precast prestressed concrete beam.

To accommodate the carriageway arrangement, the deck will be 18.5m in width, comprising of 4m cycleway/footway, 1m verge and 1No. lanes in either direction. There is potential to construct culverts within the embankments as flood mitigation

measures, however this will increase both capital and operational costs, in addition to increased maintenance liabilities as discussed later in section 3.4.2.

The main advantages associated with this proposal are:

- Minimal stakeholder disruption through pilling works.
- Decreased construction risk from the absence of pilling works, however there is a greater overburden pressure on the soil from the approach embankment. This may introduce difficulties in providing sufficient ground resistance to carry the increased loading.
- No foreseen conflict with existing services.
- Minimal number of bearing and expansion joints, reducing the possible routes of degradation.
- Ease in transportation of the beam elements to site, however this proposal also involves significant import of material to the site for the approaching embankments.
- Reduced complexity and quicker construction due to fewer complex details.
- Reduced number of beams to be transported to site than the longer 200m multi-span option.
- Prestressed beams typically provide slimmer, stronger, and lighter beams.
- Speed of construction is increased as well as having the potential to provide a lower cost solution for greater spans.
- Reduced use of concrete due to the prestressing.
- Stiffer sections are possible, i.e., less deflection.
- Less steel area required at ultimate limit state (ULS).

For further information, see Appendix B.

3.4.1 Structural Form

The structural form of the superstructure is different to Option 1. In Option 2, the proposal involves using a single span structure. The reduced number of piers and foundations are preferred over Option 1 due to the reduced construction costs and increase safety of workers. While the design may not be as aesthetically pleasing as Option 1, the larger approach spans in Option 2 allows for a safer construction of the main span.

Both the options involve the use of prestressed beams. It is worth noting that prestressing can be divided into two sub-categories: pre-tensioning and post-tensioning. Pre-tensioning is where the internal steel reinforcement is stressed prior to the concrete being poured and gained strength. Whereas post-tensioning is when the beam is pre-cast or cast in-situ with ducts in them and then a tendon is fed through, tensioned, and then anchored off. If internal post-tensioning is used, then it is important that sufficient reinforcement is provided at the anchorage points as well as sufficient concrete cover. However, if external post-tensioning is used, then it is important to protect the steel from moisture and corrosion.

3.4.2 Maintenance Requirements

Due to the reduced number of piers and expansion joints within Option 2, it is more than likely to result in a reduced maintenance costs over the lifetime of the structure. The reduced number of spans also limits the possible routes of degradation into the structure through complex detail that is present in Option 1.

If culverts for flood mitigation are deemed necessary, then it will increase the maintenance requirements. The number of culverts depends on the flood mitigation strategy. The more culverts that are required the greater the expense to maintain them. These culverts are in found at the bottom of embankments in a flood plain, therefore likely to be filled and blocked with silt and clayey material. To clear any such blockages and to inspect them, personnel trained to enter confined spaces will be required. This will increase the maintenance costs which will need to be accounted for in the long-term life of the structure.

In both options prestressed beams used which creates additional maintenance requirements. It is difficult to inspect the condition of internal tendons for the prestressed beams, however they are protected from the external environment due to the concrete cover. It is therefore vital to provide adequate cover to these tendons and to conduct scheduled inspections to identify structural defects earlier. If any pre-stressing tendons were to fail, then it is likely to cause explosive failure, thus leading to complete structural failure.

Overall, if adequate maintenance and inspections are not completed, then there is an increased risk of structural failure. It is important that prestressed bridges should have proper maintenance in order to identify and limit any structural damage.

3.4.3 Flood Mitigation Strategy – For Option 2

Due to the larger impact on the site from the embankments of the approach spans, there is an increased risk of flooding for Option 2. The larger footprint of the embankments, results in a reduced width of the flood plain therefore, increasing the flood risk. There is potential for reduce the risk of flooding through the construction of culverts within the embankments, however it introduces additional maintenance costs in addition to inspection risks.

While increasing the headroom of the structure will result in accommodating for higher water levels, it is not a viable strategy due to the alignment of the proposed route. This increase in the headroom will also further increase the materials usage, construction costs and time, as well as having a greater environmental impact.

3.4.4 Constructability

Construction for Option 2 is feasible. The 30m span is typical of an off the shelf product and can be transported to site with relative ease. The reduced number of columns and pilling works, compared to options1, ensures a safer construction and limits large ground excavations that are likely to collapse. But there is a significant import of material, therefore the surrounding roads will need to be durable and adequate to transport such heavy loads. In addition, there is a risk of damaging the local environment through the placement of foreign material to build up the approaching embankments and from dust pollution due to the transportation of large quantities of soil. Dust pollution will become a significant issue during hotter weather and adequate preventative measures should be in place during construction.

Due to the large quantity of soil to be transported, it is important to identify and use local facilities that can provide the suitable soil fill. This will reduce transportation costs and limits mud and other debris entering the roads.

However, for both options, ground conditions need to be further assessed through ground investigations.

4 Recommendations

Several recommendations have been highlighted within the earlier sections of the report. A main recommendation is the lack of geotechnical knowledge of the proposed site location. The important next step should start with carrying out a geotechnical investigation to determine the design parameters. This will help determine a more representative construction costs to both the options than what was calculated earlier.

A review of existing stats should be completed to identify whether the assumption made of no major diversion of any buried service was correct. If not, this will affect the cost and feasibility of both the options.

After implementing the above recommendations, a detailed review of ecological surveys should also be completed. The local habitat and ecosystem should be understood in detail to identify any significant impacts because of the proposed structure.

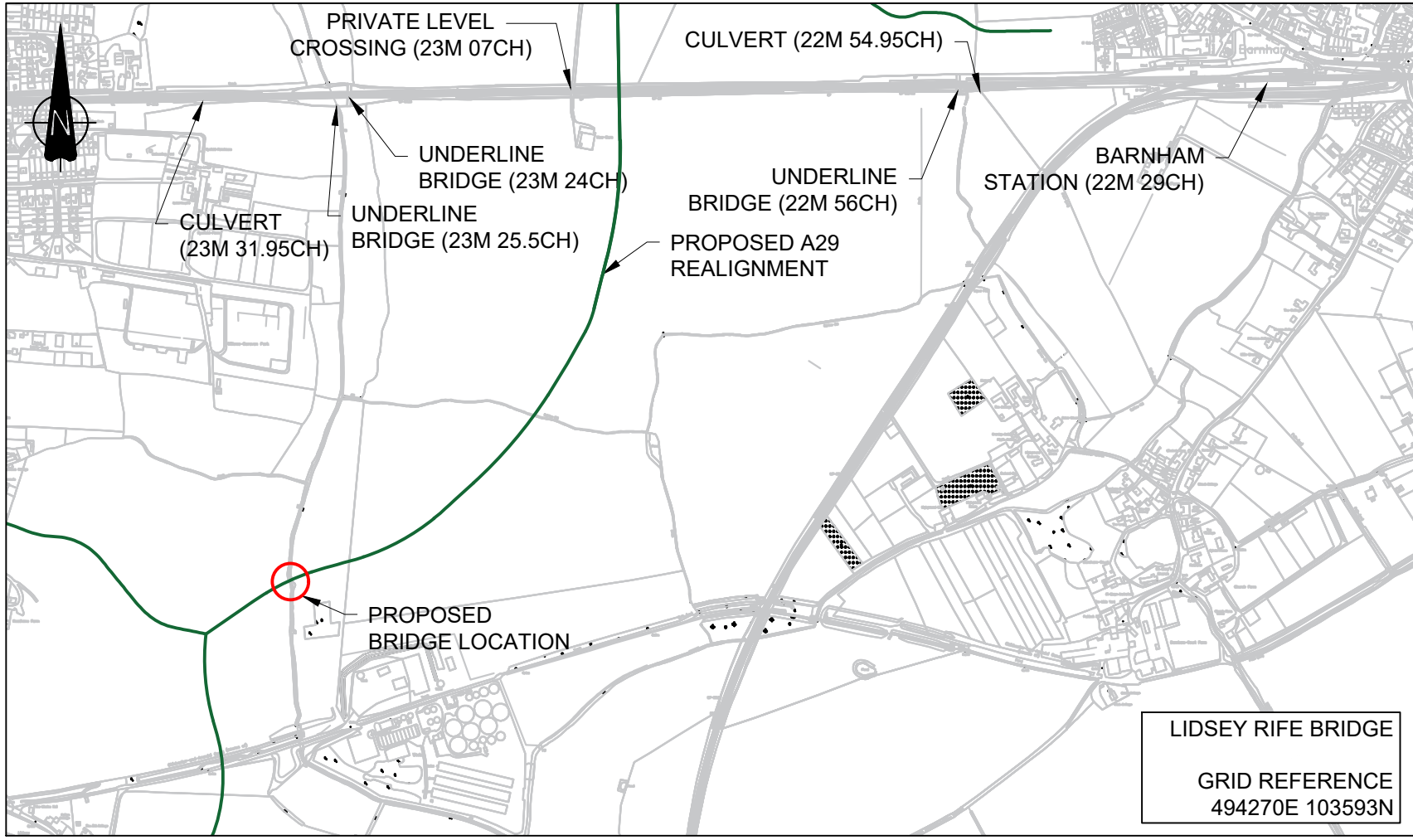
	Option 1	Option 2
Structural Form	200 m Multi-Span Bridge with a Typical Prestressed Concrete Y8 Beam Arrangement.	30m Single Span Bridge with a Typical Prestressed Y6 Beam Arrangement
Main Advantages	- Minimal footprint of land-take of the approach spans. - No need to vast quantities of imported fill. - No need for flood mitigation measures. - Less footprint of the approaching embankments. - Greater space available around the structure allowing for safer construction. - Less likely to damage the current ecosystem and habitat present. - Potential for a better aesthetically please form of the structure.	- Minimal stakeholder disruption through pilling works. - Decreased construction risk from the absence of pilling works - No foreseen conflict with existing services. - Minimal number of bearing and expansion joints. - Ease in transportation of the beam elements to site. - Reduced complexity and quicker construction due to fewer complex details. - A slightly reduced span make is easier to transport than the beams in Option 2. - Prestressed beams typically provide slimmer, stronger, and lighter beams. - Speed of construction is increased. - Has the potential to provide a lower cost solution for greater spans. - Reduced use of concrete due to the prestressing. - Stiffer sections are possible, i.e., less deflection. - Less steel area required at ultimate limit state (ULS).
Main Disadvantages	- Increased stakeholder disruption through pilling works. - Increased construction risk during pilling works. - Difficult to inspect the greater number of bearings near the midspan.	- Greater overburden pressure on the soil from the approach embankment. - There is significant import of material to the site for the approaching embankments. - Greater flood risk if mitigation strategy is not enforced adequately. - Increased maintenance demands due to the culverts. - Increased maintenance demands from the prestressing tendons. - Greater reinforcement detailing and steel usage.

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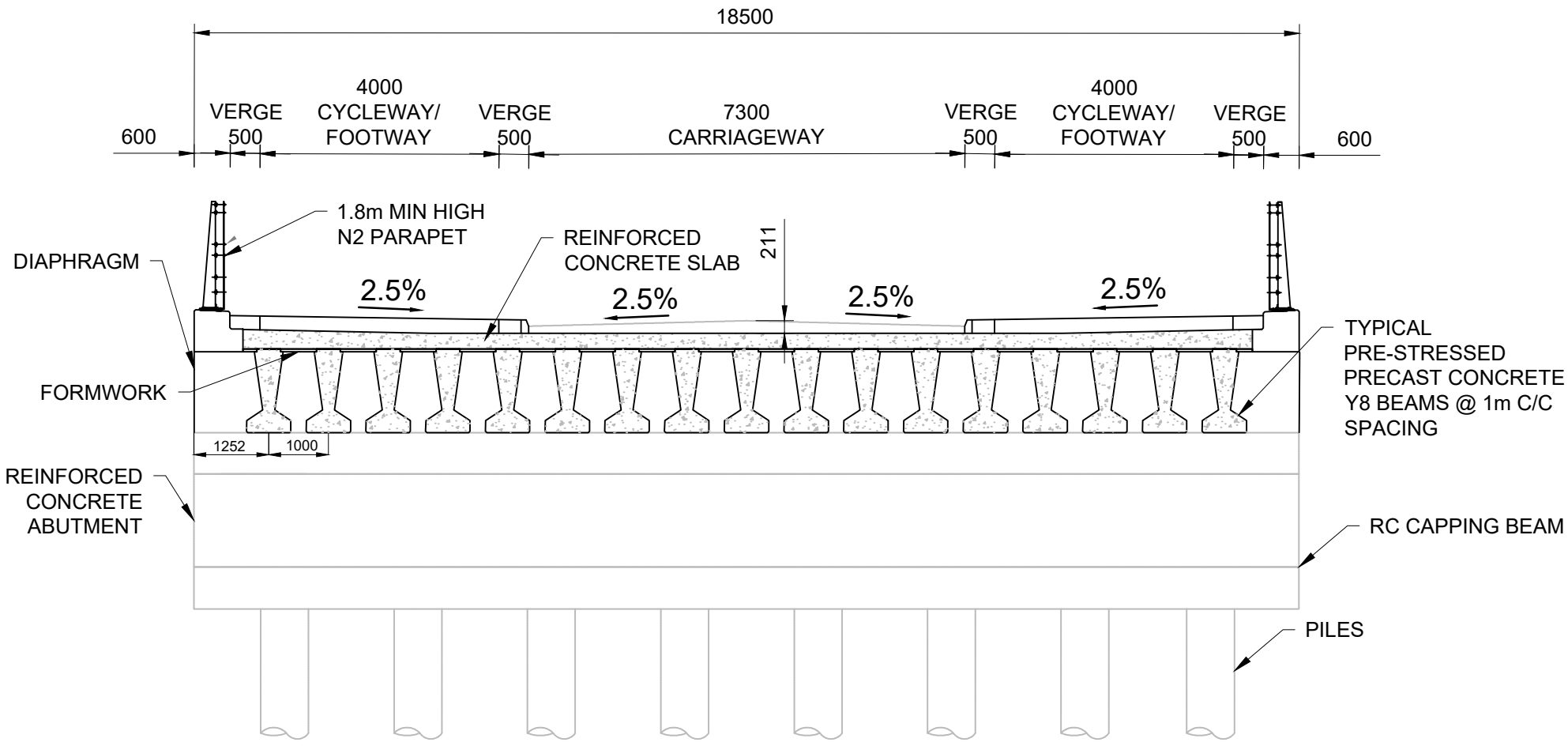
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Rev	Suit	Description	Date	Originator	Checker	Approver
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P02		For Information	14-Jan-22	KK	AK	AK

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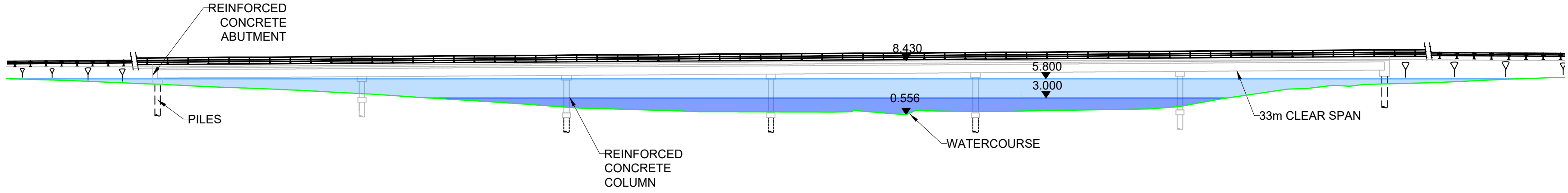
Appendix A – General Arrangement for 200m Multi-Span Option



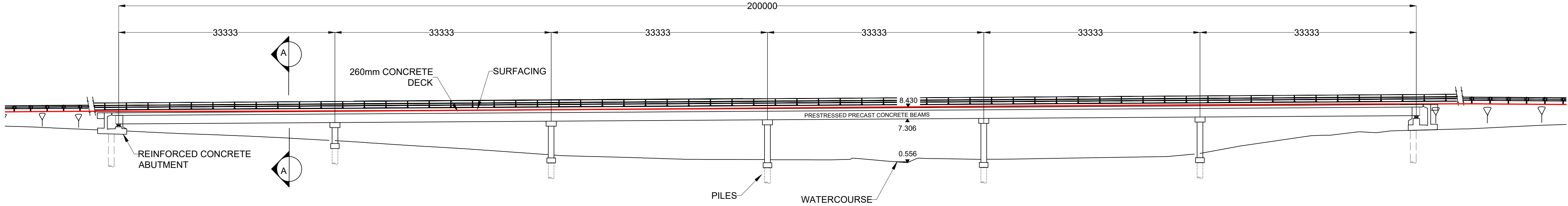
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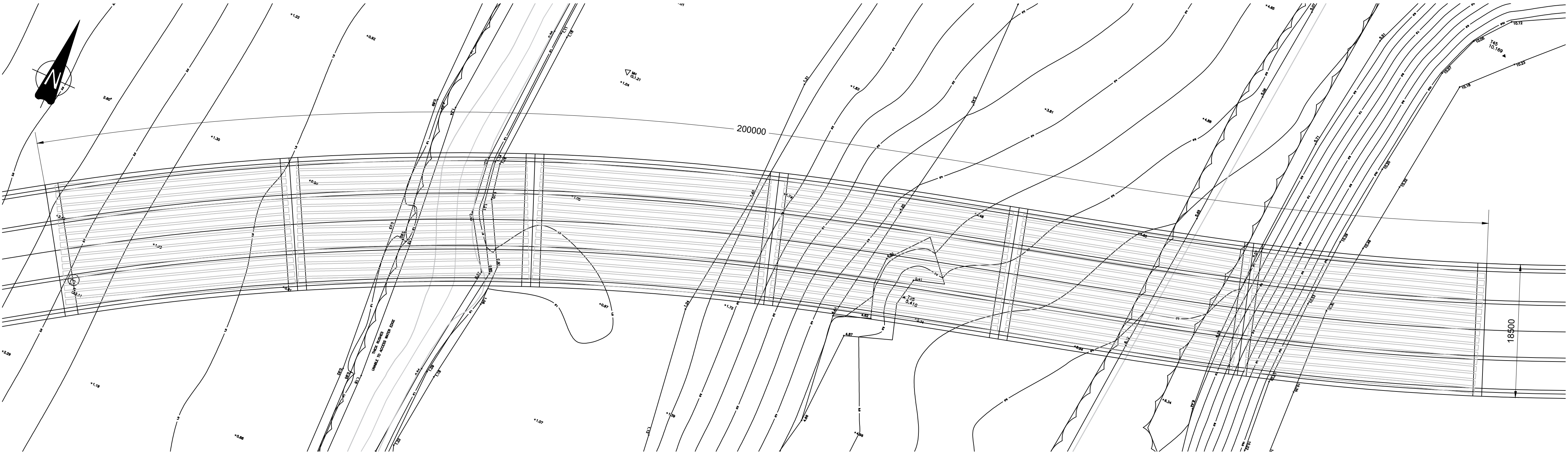
SECTION A-A
SCALE 1:100



WEST ELEVATION
SCALE 1:500



WEST ELEVATION
SCALE 1:350



PLAN
SCALE 1:350

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 - THE LAND LOCATED NORTH AND SOUTH OF THE NETWORK RAIL BOUNDARY FENCE IS OWNED BY THE CHURCH COMMISSIONERS FOR ENGLAND AND IT IS REGISTERED UNDER THE FOLLOWING TITLE NUMBERS:
NORTHERN AREA: WSX309559 (74.60HA)
SOUTHERN AREA: WSX309592 (49.13HA)

KEY

	1:100YR+ 105% CLIMATE CHANGE FLOOD LEVEL = 5.8 AOD
	1:100YR FLOOD LEVEL = 3.0M AOD

P03	CLIENT REFERENCE CHANGE	KK	KK	AK	14/01/2022
P02	ISSUE FOR INFORMATION	AG	AK	AK	05/05/2021
P01	DRAFT	KK	AK	AK	16/10/2020
REV	DESCRIPTION	DRN	CHK	APP	DATE

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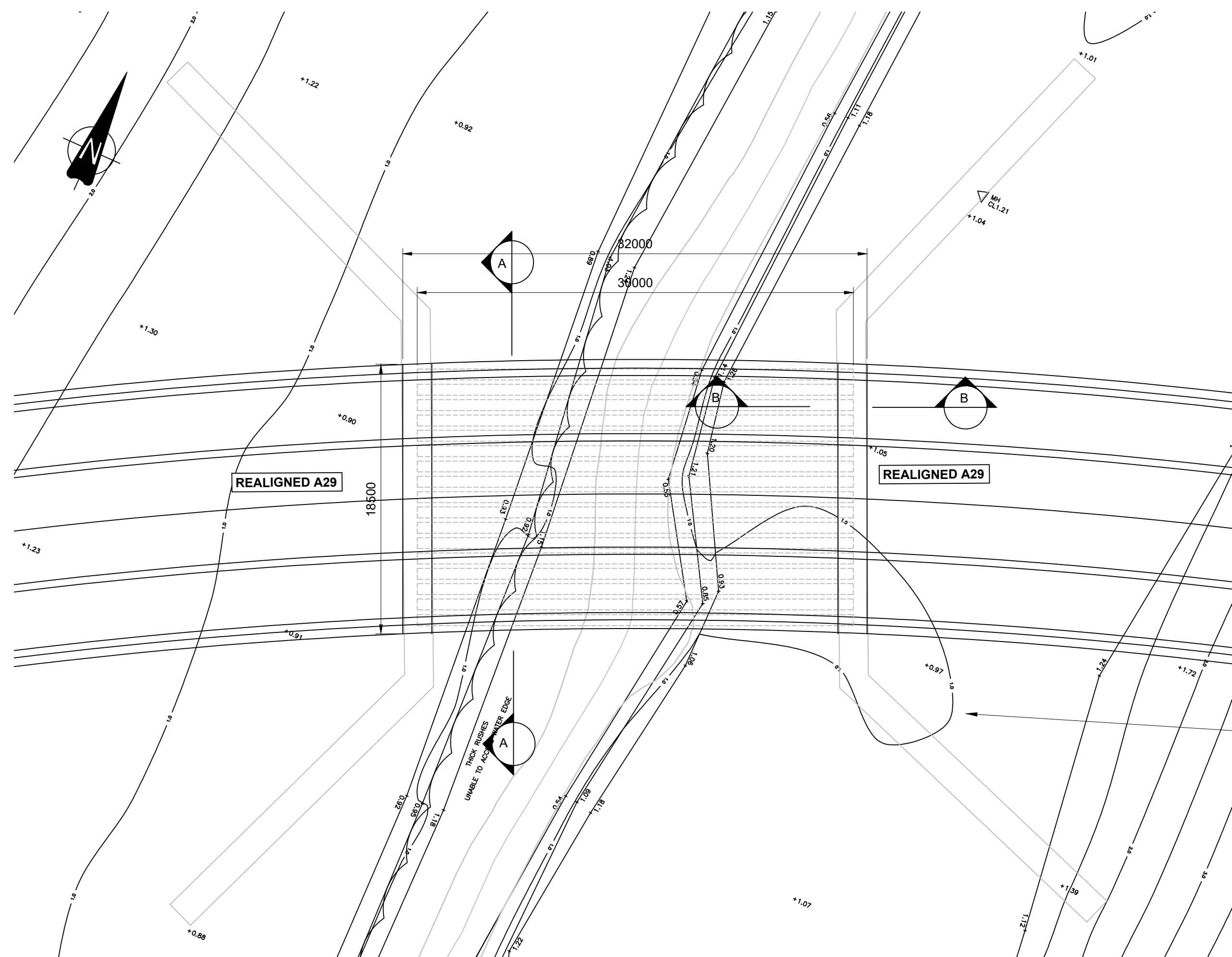
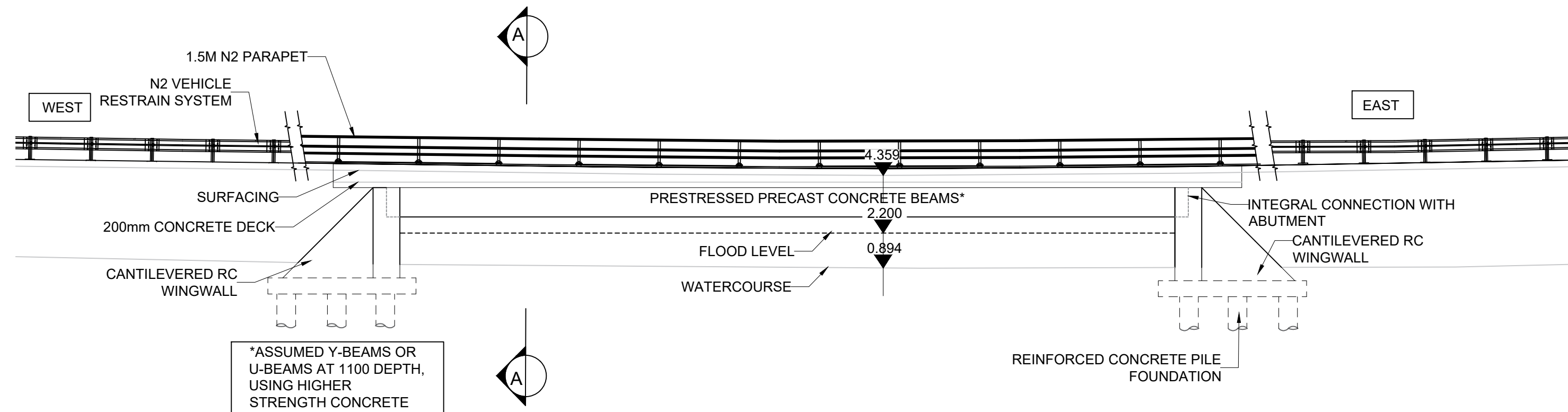
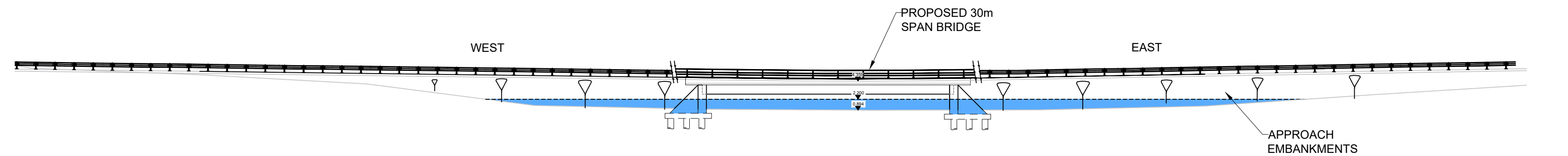
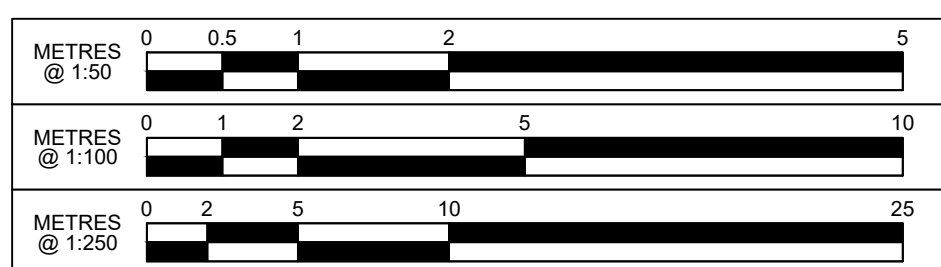
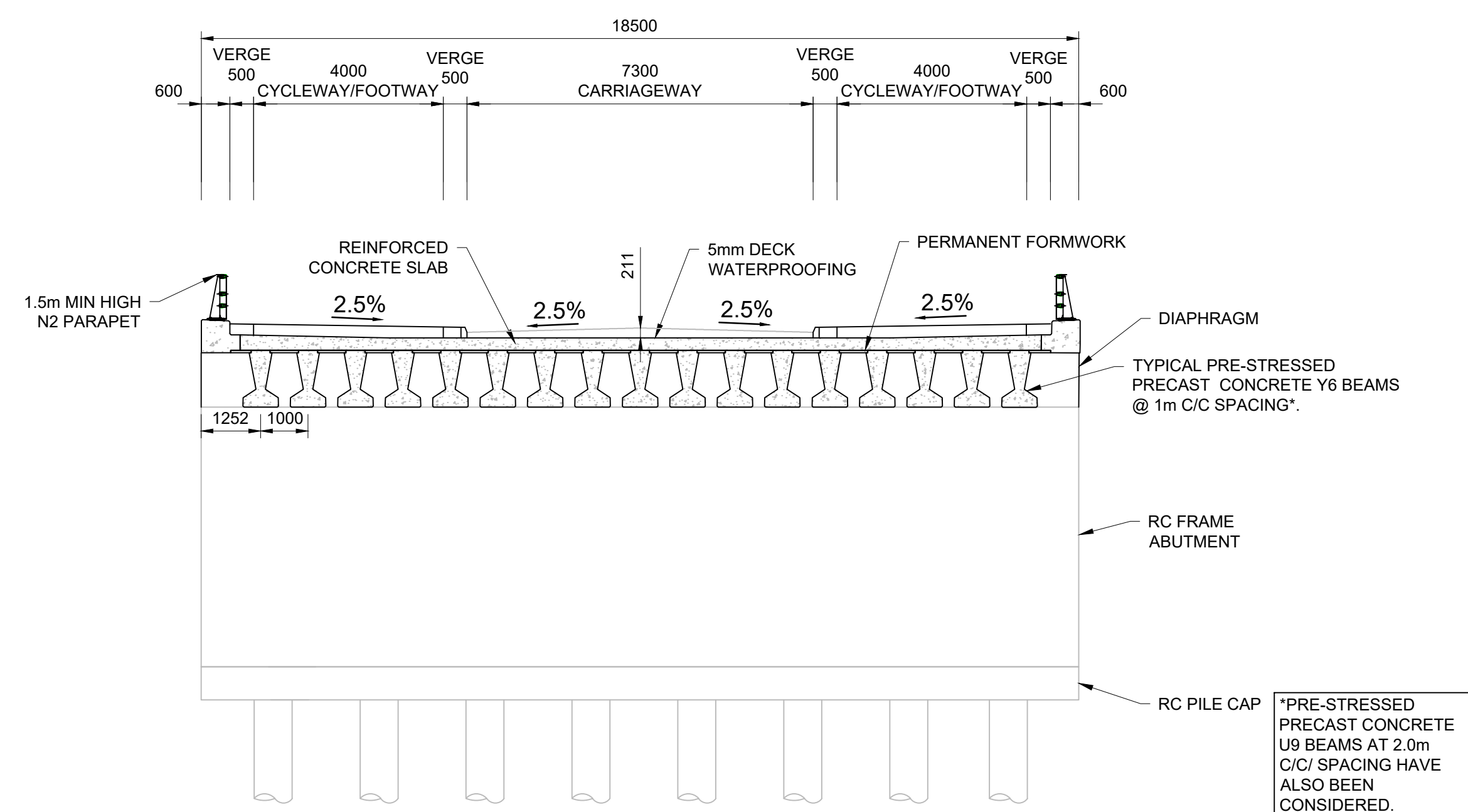
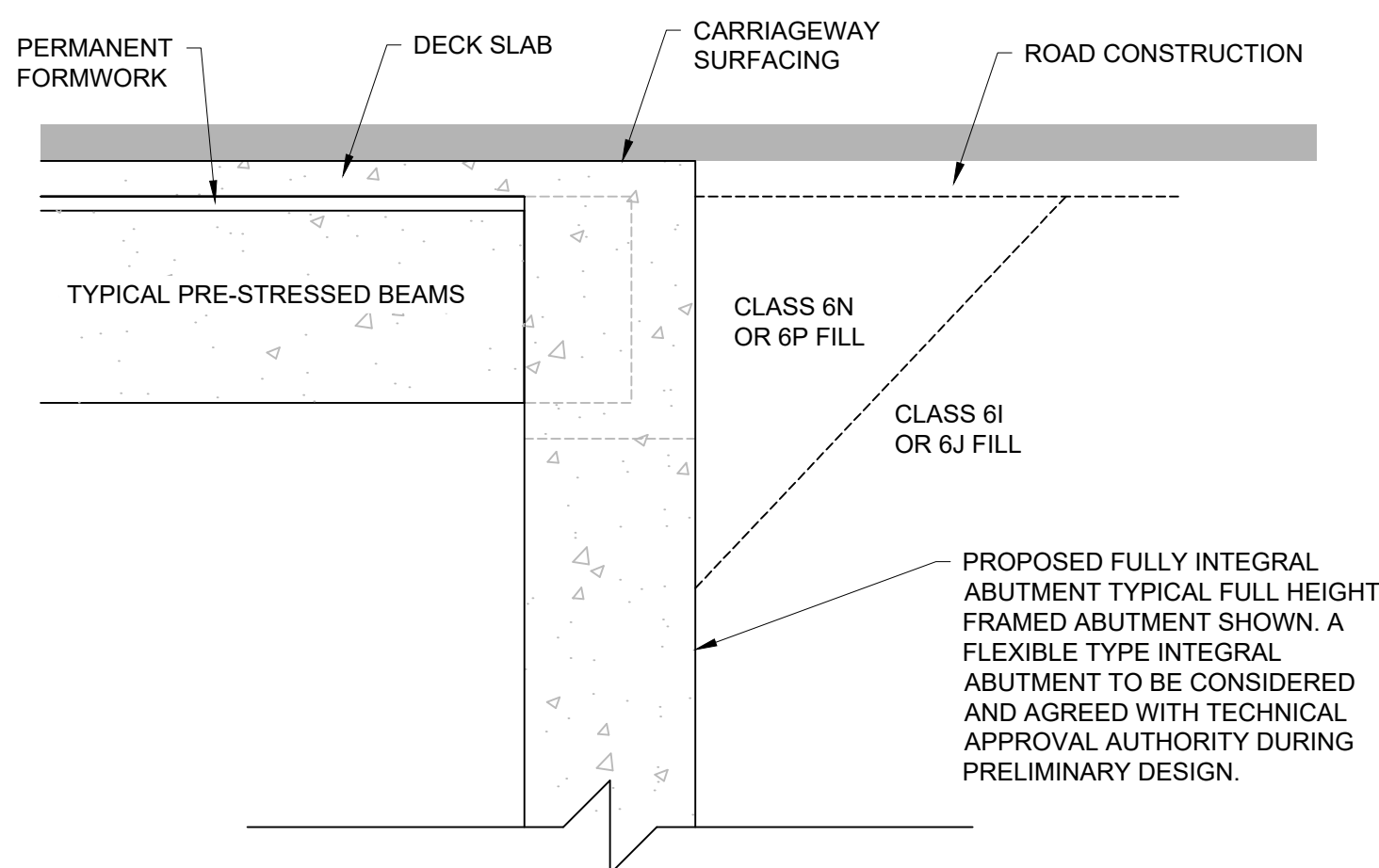
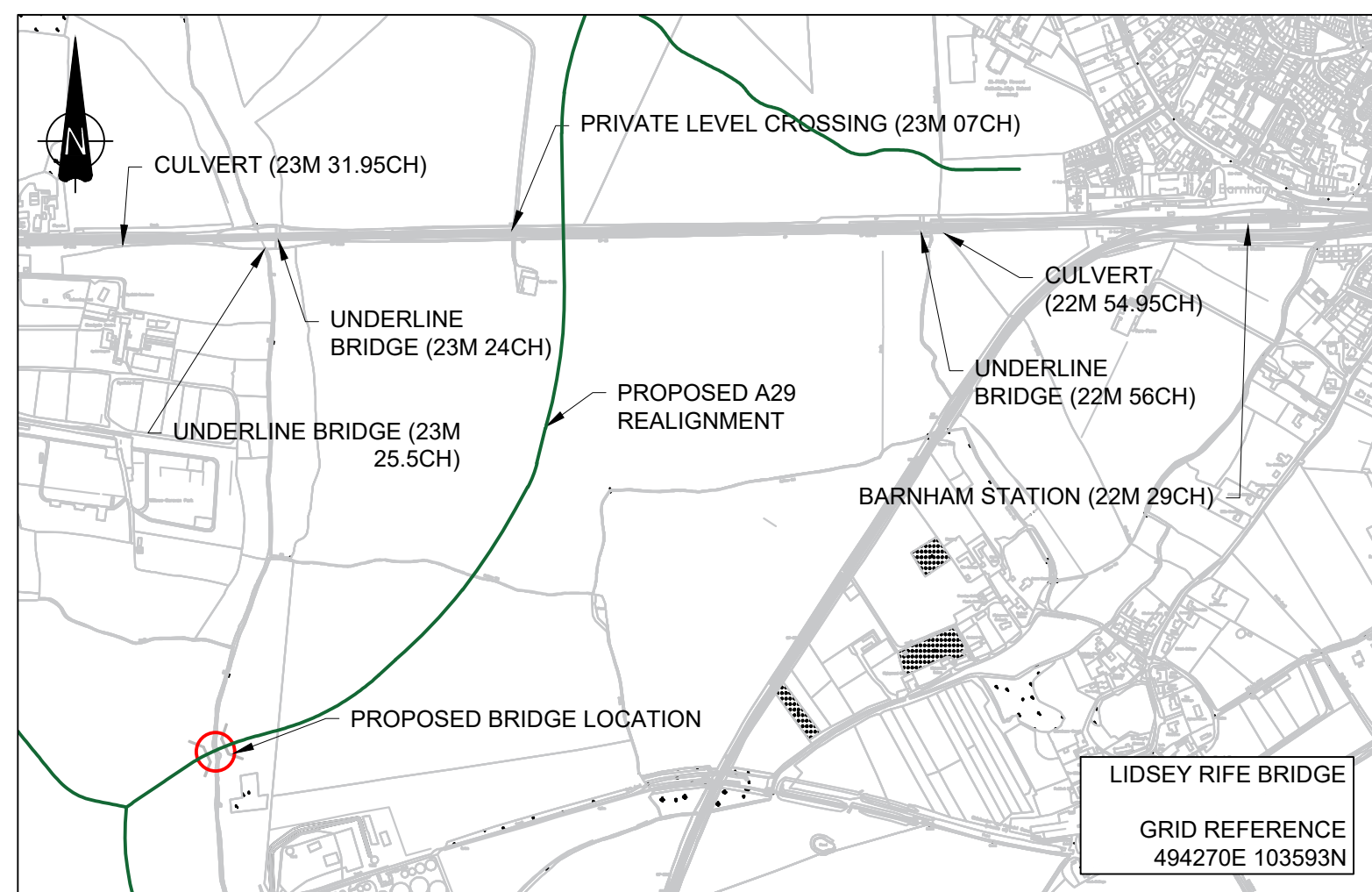
Client
**CC PROJECTS
ASHMARDEN Ltd
AND HANBURY(PM) Ltd**

Project
BEW PARCEL SC1

Drawing Title
**INITIAL BRIDGE OPTIONS
MULTI SPAN**

OS Ref:	Structure Type: Over Flood plain	ELR/Mileage:
Drawn	Name	Date
Designed	AK	16/10/2020
Checked	AK	16/10/2020
Approved	AK	16/10/2020
Drawing No.	13394-PEF-ZZ-XX-M2-S-000002	Revision
		P03

Appendix B – General Arrangement for 30m Single Span Option



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 10. PROPOSED DESIGN SHALL BE IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S DESIGN MANUAL FOR ROADS AND BRIDGES (DMRB) AND EUROCODES.
 - S1. ALL WORKS TO BE UNDERTAKEN IN ACCORDANCE WITH THE DEPARTMENT FOR TRANSPORT'S MANUAL OF CONTRACT DOCUMENTS FOR HIGHWAY WORKS (MCHW) SPECIFICATION.
 - S2. BACKFILL MATERIAL TO THE STRUCTURE SHALL BE OF CLASS 6I OR 6J IN ACCORDANCE WITH SPECIFICATION FOR HIGHWAY WORKS..
 - S3. PROPOSED WATERPROOFING SYSTEM SHALL BE IN ACCORDANCE WITH APP 20/01 OF THE SPECIFICATION.
 - S4. AN ADDITIONAL PROTECTIVE LAYER (APL) SHOULD ONLY BE USED WHEN REQUIRED BY INDIVIDUAL WATERPROOFING SYSTEM. WHERE APL IS USED IT SHOULD BE APPLIED IMMEDIATELY ABOVE THE PROPRIETARY WATERPROOFING SYSTEM. IN SUCH CASES A SEPARATE BBA ASSESSMENT OF THE SYSTEMS RESISTANCE TO AGGREGATE INDENTATION IS REQUIRED IN ACCORDANCE WITH IAN 96/07.
 - S5. THE LAND LOCATED NORTH AND SOUTH OF THE NETWORK RAIL BOUNDARY FENCE IS OWNED BY THE CHURCH COMMISSIONERS FOR ENGLAND AND IT IS REGISTERED UNDER THE FOLLOWING TITLE NUMBERS:

NORTHERN AREA: WSX309559 (74.60HA)
SOUTHERN AREA: WSX309592 (49.13HA)

KEY

1:100YR+ 35% CLIMATE CHANGE
FLOOD LEVEL = 2.2m AOD

P04	CHANGE TO CLIENT NAME (CC PROJECTS)	KK	IR	AK	14/01/2022
P03	SCALE BAR ADDED AND CHANGE TO CLIENT NAME	KK	IR	AK	15/11/2021
P02	ISSUE FOR INFORMATION	AG	AK	AK	05/05/2021
P01	DRAFT	KK	AK	AK	16/10/2020
REV	DESCRIPTION	DRN	CHK	APP	DATE

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Client	CC PROJECTS ASHMARDEN Ltd AND HANBURY (PM) Ltd
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Project	BEW PARCEL SC1
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Drawing Title

INITIAL BRIDGE OPTIONS
30m SINGLE SPAN
FRAME ABUTMENT

OS Ref:		Structure Type: Over Flood plain		ELR/Mileage:	
	Name	Date	Scale		
Drawn	KK	16/10/2020	NOT TO SCALE		
Designed	AK	16/10/2020	Suitability		
Checked	AK	16/10/2020	S2		
Approved	AK	16/10/2020	Drawing Status		
			FOR INFORMATION		

Approved	AK	10/10/2020	
Drawing No. 13394-PEF-ZZ-XX-M2-S-000003			Revision P04