Haweswater Aqueduct Resilience Project - Proposed Bowland Section

Environmental Statement

Volume 2

Chapter 3: Design Evolution & Development Description

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Water for the North West

Haweswater Aqueduct Resilience Project - Proposed Bowland Section

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3. Design Evolution & Development Description

1) This chapter sets out the need for the Proposed Programme of Works, which centres on the condition of the existing aqueduct. It also outlines the potential solutions that were considered prior to adoption of the preferred option, and the design development process for the Proposed Bowland Section. It provides a description of the Proposed Bowland Section, including the new tunnel route, the design of the aqueduct and the envisaged construction methods and approaches. Chapter 3 also describes the proposed construction traffic routes which would serve the construction compounds, and provides the basis of assessment for Chapters 6 - 19 of this Environmental Statement (ES).

3.1 Needs Case

2) In the early 2000s United Utilities began planning major investment, which spanned over ten years, to ultimately enable the Haweswater Aqueduct to be taken out of service for the first time in over 60 years. The aim was to identify any future service risk to customers supplied by this ageing asset.

3) Several major steps had to first be taken including the £250 million construction of the West East Link Main (WELM), completed in 2011. The WELM, along with other activities such as upgrading Lostock Water Treatment Works to increase flow capacity, made it possible to take the Haweswater Aqueduct out of service (referred to as an *outage*) in 2013. A subsequent outage in 2016 allowed for more detailed investigations and some minor, targeted repairs.

4) Arranging and implementing outages on the aqueduct requires many months of planning, and the outages are very limited in terms of allowable duration (approximately four to six weeks), the time of year they can be delivered (normally October when demand for water is at its lowest) and the frequency (outages are only possible every two years). These tight constraints limit how much inspection work can be undertaken during each aqueduct outage. Due to the extensive works required, it would not possible to deliver the Proposed Programme of Works during an outage.

5) The data collected from the inspections in 2013 and investigations in 2016 uncovered areas of concern in the single line tunnel sections of the Haweswater Aqueduct relating to both future water supply and water quality risks. It is anticipated that the condition of these single line tunnel sections would continue to deteriorate, and therefore a solution is required to address the risks to water supply and water quality.

6) The need for the Proposed Bowland Section is driven by the same need as the overall Proposed Programme of Works i.e. there is a requirement to replace part of an ageing asset to secure a water supply into the future, and to mitigate potential risks to drinking water quality.

3.1.1 The Existing Bowland Section

7) The existing Haweswater Aqueduct is a major feat of engineering. The pipeline, built between 1933 and 1955, has successfully served customers in Cumbria, Lancashire and Greater Manchester for over sixty years (see Illustration 3.1 below).

8) To maintain the integrity of the network, United Utilities is proposing to replace all five tunnel sections along the length of the aqueduct from Cumbria to Greater Manchester.

9) The third of the five tunnel sections (when viewed from north to south), known as the Proposed Bowland Section, extends from Lower Houses, near Wray in the north, below the Bowland fells, to Newton-in-Bowland in the south (Illustration 3.2 below).

10) The Proposed Bowland Section would be constructed by tunnel boring techniques below ground level, with short open-cut surface trenching sections at each end making connections back to the existing aqueduct. The new tunnel would be bored north from a launch compound at Newton-in-Bowland, with a reception shaft at Lower Houses. Further details on the tunnel boring technique and associated construction works are provided in this chapter. It is important to note that the replacement section of tunnel needs to connect into the existing aqueduct at the end of each existing multi-line siphon section. The location of the proposed tunnel shafts, and associated compounds, is therefore determined by the

location of the existing connection points between the single line sections and the multi-line siphons sections.

11) Once the Proposed Bowland Section has been constructed, it would be tested and commissioned before the existing tunnel sections of the Haweswater Aqueduct are decommissioned.

Illustration 3.1: The existing Haweswater Aqueduct

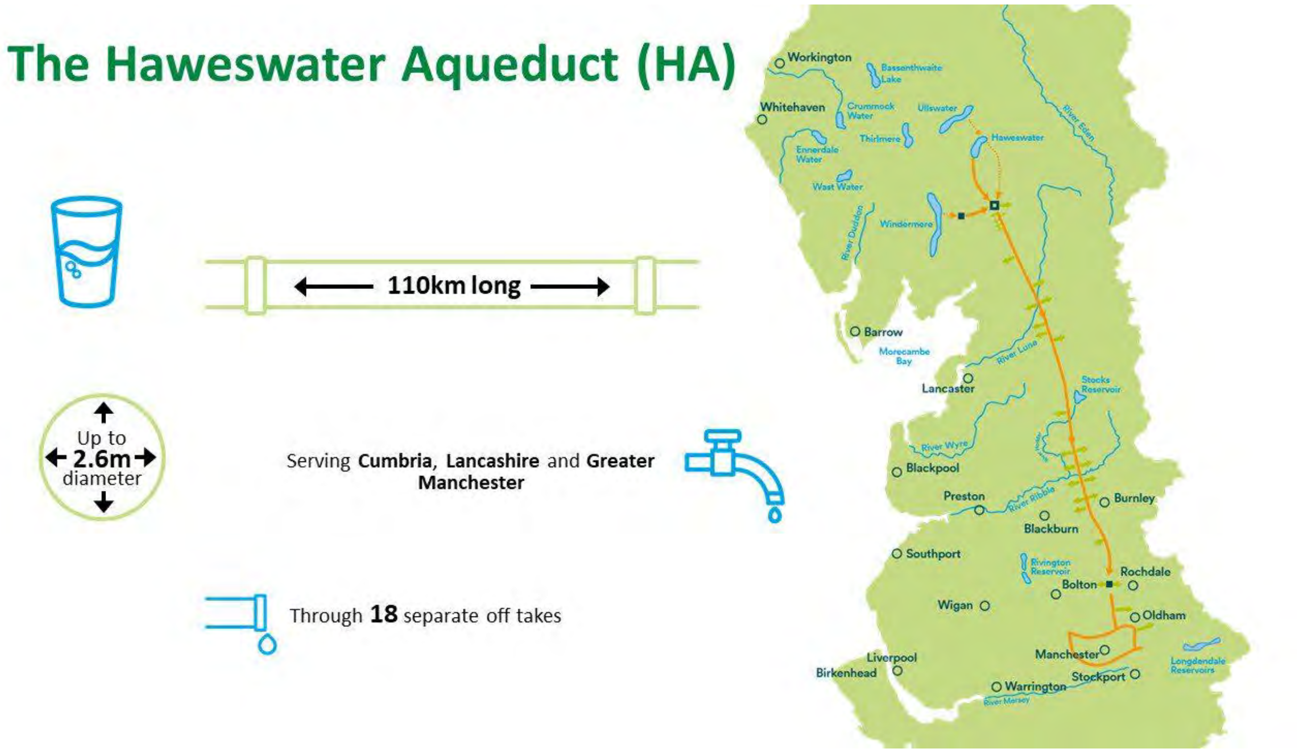
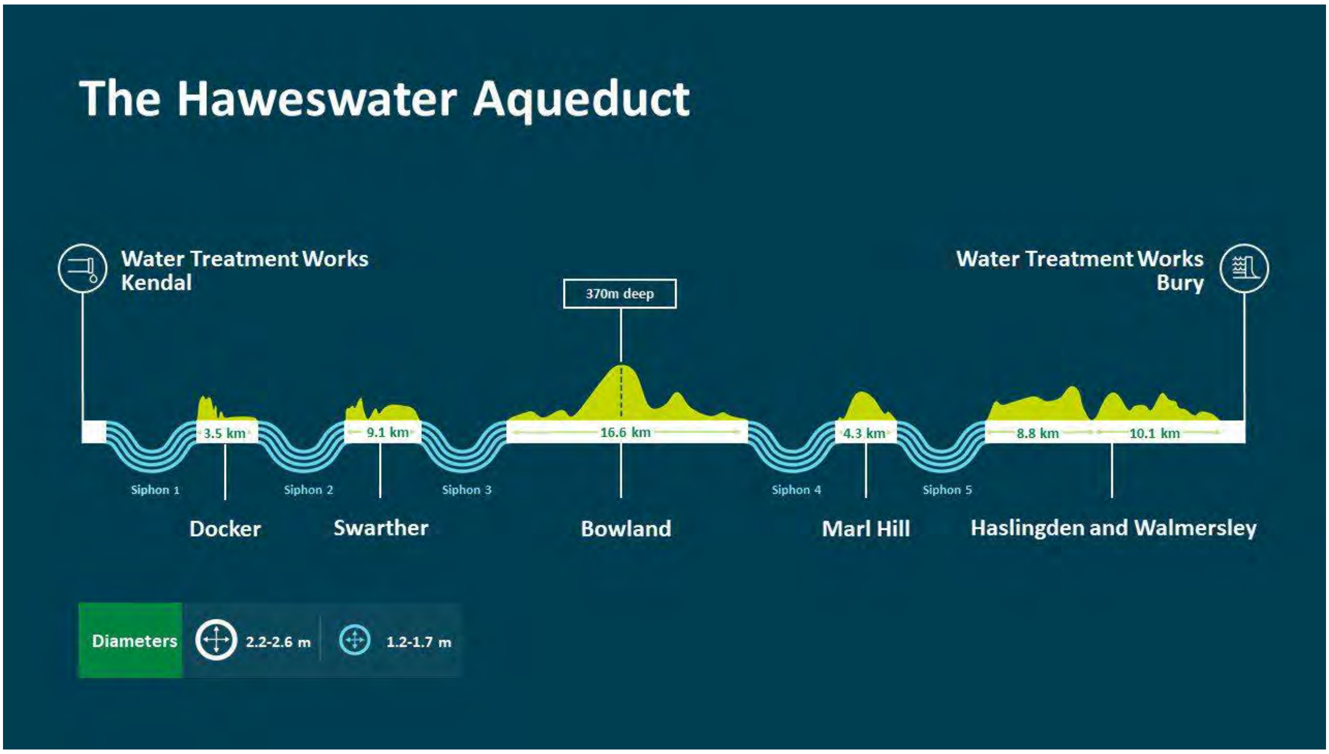


Illustration 3.2: The existing Haweswater Aqueduct outlining the different sections



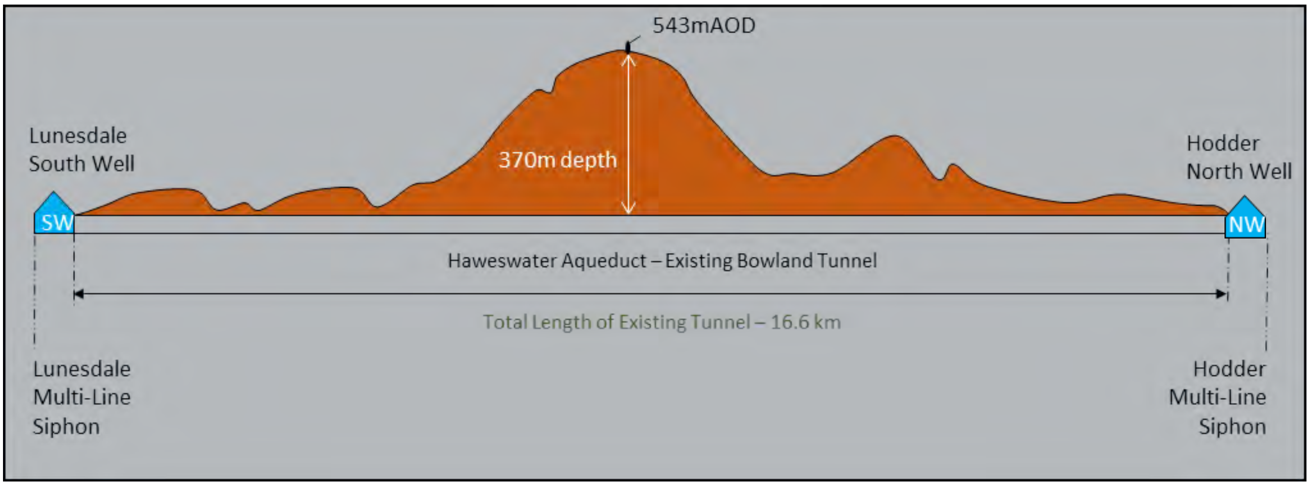
12) The total length of the existing Bowland Tunnel is 16.7 km comprising:

- Summer House Conduit (0.1 km)
- Bowland Tunnel (16.6 km).

13) The existing Lunesdale multi-line siphon is located to the north of the Proposed Bowland Section, while the existing Hodder multi-line siphon is located to the south of the Proposed Bowland section.

14) At its deepest point the existing Bowland Tunnel is approximately 370 m below ground level (Illustration 3.3).

Illustration 3.3: Cross section for the existing Bowland Section of the Haweswater Aqueduct



3.2 Consideration of Alternatives

15) This section describes the alternatives that were considered to address the identified need to protect the water supply provided by the existing Haweswater Aqueduct. Given that maintaining water supply is a necessity, these considerations focused primarily on the level of intervention required, such as whether there were opportunities for repair and protection instead of replacement.

16) During 2017 United Utilities undertook an extensive process to identify and assess a full range of options to provide a reduction in the risk to customer supplies. These options were appraised against cost, environmental and technical considerations, and additionally a range of proposals were tested through extensive customer and stakeholder engagement.

17) The Proposed Programme of Works (namely replacement of five tunnel sections) was chosen as the preferred baseline solution following an exhaustive three stage optioneering exercise which considered many potential combinations of engineering and operational solutions. The optioneering process followed three steps:

- Coarse option screening
- Coarse solution screening
- Fine solution screening.

18) *Coarse option screening* aimed to remove unviable options through application of the following three criteria:

- Technical feasibility – Options were reviewed in respect of whether they would be technically possible and buildable in Asset Management Period (AMP) 7 / 8. Each AMP is a five year period with AMP7 presently running from 2020 to 2025 and AMP8 from 2025 to 2030
- Statutory / Environmental Feasibility – Options were reviewed to evaluate the likelihood of permission being granted for the works to be constructed. United Utilities considered whether each proposed option had the potential to impact on important designated sites such as Special Areas of Conservation (SAC)

- Addressing the need – An assessment was made of the impact that the option could have in supporting the need for improving the resilience of the Haweswater Aqueduct's supply through Cumbria and Lancashire and into Greater Manchester.

19) *Coarse solution filtering* grouped options into solutions, calculated simplified bill impacts, assessed risk reduction and screened out solutions using a dominance criterion (i.e. solutions with lower risk reduction for higher bill impact were removed).

20) *Fine solution filtering* of the options considered Ofwat's resilience principles, most notably: 'resilience in the round' (Principle 1); 'Naturally resilient' (Principle 2); 'Customer engagement' (Principle 3); 'Broad option set' (Principle 4); and 'Best value solution' (Principle 5).

21) The approach to Robust Decision Making (RDM) was to consider three main areas to inform selection of a preferred solution that would provide best value for customers. The three areas were as follows:

- Customer engagement: focused customer research to understand customer preferences for risk reduction and associated costs via the impact on their bills
- Cost benefit assessment (CBA): a detailed CBA using specific and standard economic metrics
- Multi-criteria Decision Analysis: a wider analysis looking at resilience in the round covering metrics beyond those provided by customers and included within the CBA. The five 'Decision Metrics' used in the multi-criteria analysis were:
  - Bill impact
  - Economic impact
  - Resilience risk
  - Environmental impact
  - Willingness to pay benefit.

22) Every five years, statutory Water Resources Management Plans (WRMPs) set out a water company's intended approach to managing water resources for at least the next 25 years. Five solutions were chosen as part of the fine filtering process and were presented in United Utilities' final WRMP, which was published in 2019.[1] These five solutions are described in Table 3.1. An additional four solutions, informed by customer preference and forming the nine referred to in Table 3.1, were tested in the CBA and multi-criteria analysis.

Table 3.1: Outcome of the Robust Decision-Making Process

Solution	Description	Evaluation/Reasoning
A	Volumetric (new and / or modified alternative supply) and targeted repairs of the Haslingden and Walmersley tunnel section (with a new and / or modified treatment installation).	Unrepaired sections of Haslingden and Walmersley and all upstream tunnel sections continue to deteriorate with associated risk to quality and supply. Insufficient risk reduction to water quality and risk of supply interruptions.
B	Replacement of the Haslingden and Walmersley tunnel and UV/Metals Treatment (new and / or modified treatment installations).	Unrepaired upstream sections continue to deteriorate with associated risks to supply. Insufficient risk reduction to water quality and risk of supply interruptions.
C	Turn Haweswater Aqueduct to raw water and provide three new and / or modified treatment installations at strategic supply points. Solution included new and / or modified alternative supplies and new and	Solution included new and / or modified alternative supplies and new and / or modified service reservoirs – addresses quality issues, however, all sections continue to deteriorate with associated risk to supply.

[1] https://www.unitedutilities.com/globalassets/z_corporate-site/about-us-pdfs/wrmp-2019---2045/final-water-resources-management-plan-2019.pdf [Accessed: June 2021]

Solution	Description	Evaluation/Reasoning
	/ or modified service reservoirs.	
D	**Replacement of all single line (tunnel) Haweswater Aqueduct sections**	**Addresses the risk to water quality and of supply interruptions**
E	Volumetric (new and / or modified alternative supplies and new and / or modified treatment installations) and replacement of all Haweswater Aqueduct tunnel sections.	Addresses the risk to water quality and of supply interruptions but significant increase in bill impact to achieve nominal increase in risk reduction compared to preferred Solution D.
F	Replacement of the Haslingden and Walmersley tunnel section, conversion to raw water aqueduct and provide three new and / or modified treatment installations at strategic supply points.	Addresses quality issues however, sections not replaced continue to deteriorate with associated risk to supply. Greater cost and less risk reduction than the preferred Solution D.
G	Haweswater Aqueduct volumetric (new and / or modified alternative supply) and lining of all tunnel sections.	Addresses quality and supply issues. Significant increase in bill impact and lesser risk reduction compared to preferred Solution D. Thickness of lining reduces diameter and capacity of Haweswater Aqueduct.
H	Haweswater Aqueduct volumetric (new and / or modified alternative supply), targeted repair of all single line aqueduct sections and conversion to raw water aqueduct.	Addresses quality issues however unrepaired tunnel sections continue to deteriorate with associated risk to supply which is largely mitigated by the new sources. Greater cost and less risk reduction than the preferred Solution D.
I	Over-pumping and lining of all Haweswater Aqueduct tunnel sections.	Addresses quality and supply issues. Significant increase in bill impact and lesser risk reduction compared to preferred Solution D. Thickness of lining reduces diameter and capacity of the Haweswater Aqueduct. Insufficient risk reduction as preferred by customers.

23) To support United Utilities' decision making, the solutions were subject to Environmental and Social costings, Strategic Environmental Assessment, Habitats Regulations Assessment and Water Framework Directive Assessment. The outcomes of these assessments, together with consultees' views on the Draft WRMP19, were used to inform the selection of the preferred solution.

24) Of the five solutions considered, only Solution A (and the associated Solution F) involved no development works in an area designated as AONB or National Park. Solution A, however, was assessed as being insufficient in reducing the risk to water quality and supply interruptions. Only Solutions D and E addressed both the water supply and water quality resilience concerns of the deteriorating condition of the tunnel sections of the Haweswater Aqueduct. The Programme of Works is common to both Options D and E and there is no other feasible way of securing a resilient water supply. Replacing all of the tunnel sections of the aqueduct requires connecting into the existing infrastructure at locations within the designated areas of the Yorkshire Dales National Park and Forest of Bowland AONB and these designated areas cannot be avoided.

25) Option D was ultimately selected as the preferred option as it delivers the long-term resilience benefits and delivers the best value to customers. It comprises a full replacement of each single line tunnel section of the existing aqueduct conveying drinking water from a water treatment works near Kendal (Cumbria) downstream to a water treatment works near Bury. The additional costs of Option E were considered not to be justified.

26) This was presented in the draft Water Resources Management Plan (WRMP) (February 2019), submitted to the Secretary of State for Environment, Food and Rural Affairs. After receiving approval from the Secretary of State on 23 July 2019, the final Water Resources Management Plan was published in August 2019, including the intention to proceed with the Proposed Programme of Works.

27) United Utilities' comprehensive option identification and appraisal process means that, from a very large pool of options, only the most appropriate has been selected in the final WRMP. This has been through Strategic Environmental Assessment and an extensive consultation process with regulators and customers, and has been included within a WRMP approved by the Secretary of State and OFWAT. It has shown that alternative options outside the Forest of Bowland AONB offered insufficient risk reduction to water quality and risk of supply interruptions. The only feasible means of securing a long term resilient water supply is therefore through replacement all of the tunnel sections of the existing Haweswater Aqueduct, which requires connection into the existing infrastructure at locations within the designated areas of the Yorkshire Dales National Park and Forest of Bowland AONB.

3.3 General Approach to Design

28) United Utilities started the initial design in 2018 and commenced ground investigation (GI) and environmental surveys in 2019. The various planning applications for the Programme of Works will be submitted in 2021. Pending the timing and outcome of the planning decision by Ribble Valley Borough Council, construction of the Proposed Bowland Section could start in 2023.

29) There are various technical requirements that have influenced the design of the Programme of Works, including:

- A need for all new tunnel sections to be connected to the existing Haweswater Aqueduct
- To maintain a gravity flow along the entire length of the Proposed Bowland Section and, ultimately, along the full length of the Haweswater Aqueduct
- A need for the Proposed Programme of Works to be designed, built and operated safely
- A potential requirement for an aqueduct outage to enable connection of the newly-built tunnels into the existing infrastructure. This is potentially a considerable undertaking and one that could only be delivered over a short timescale, nominally four weeks during the month of October. There is an alternative to full outage; periods of reduced aqueduct flow when individual multi line siphon pipes can connect the new tunnel sections to the existing aqueduct.

30) Extensive site investigations were undertaken along the route of the Proposed Programme of Works in 2019 and 2020 to characterise the underlying geology and ground conditions. Boreholes were drilled to considerable depths below ground level, reflecting the depth at which tunnel sections of the aqueduct would be constructed. To supplement intrusive investigations, geophysical surveys were carried out and geotechnical models were constructed to describe the ground conditions. Areas where there are believed to be high groundwater pressures were also identified. Ground investigations have continued into 2021 to inform the detailed design stage.

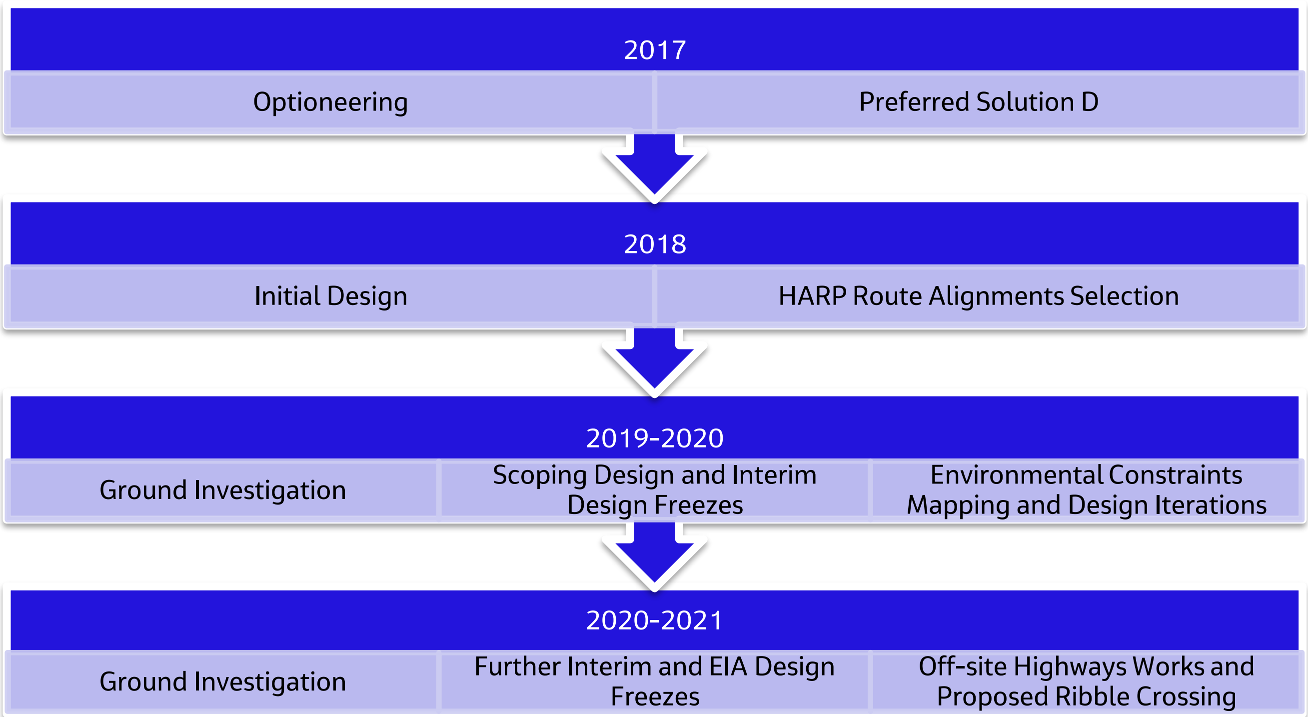
3.4 Design Evolution of the Proposed Bowland Section

31) The Proposed Bowland Section has been subject to an iterative design process, whereby engineering design has evolved in response to engineering/technical, stakeholder and EIA inputs. Alternatives have been considered through this process where feasible to reflect enhanced design and construction knowledge, respond to stakeholder feedback, or to avoid or reduce environmental impacts.

32) The design evolution of the Proposed Bowland Section and the way in which environmental considerations and comments received during consultation have influenced the decision-making are described in this section, with a timeline included as Illustration 3.4 below.

33) Route alignment was defined though an assessment process as described in Section 3.4.1, followed by refinement of the design as described in Section 3.4.2.

Illustration 3.4: Design Change Timeline



3.4.1 Route Alignment Refinement

34) Following the selection of the preferred solution (Solution D) for the Programme of Works, five route alignment options were developed for the Proposed Bowland Section (Table 3.2).

Table 3.2: Route alignment options for the Proposed Bowland Section

Route Option	Proposed Alignment
Option 1	Option 1 was aligned to the west of the existing Haweswater Aqueduct. An intermediate shaft was proposed to provide an opportunity to reduce the overall drive length from the Newton-in-Bowland compound and in doing so, offering a means for personnel egress from the tunnel during construction, and / or for servicing the tunnel during construction.
Option 2	For this option, shaft Construction Area A was located to provide a minimum cover of two tunnel diameters to the crown.[2] The tunnel had a slight curve south off Construction Area A to allow minimum cover to be maintained where the tunnel passed through a low point in a valley. It then continued on a straight alignment to Construction Area E.
Option 3	This option was a variation of Option 2 with an intermediate shaft (TR3-D) proposed to reduce the overall tunnel drive length. The curved tunnel between Construction Area A and Construction Area E was proposed to maintain a minimum cover of two diameters .
Option 4	For this option, the proposed tunnel alignment closely followed the existing Haweswater Aqueduct alignment, with an intermediate shaft located adjacent to Croasdale Beck. The proposed alignment would have needed to be offset by sufficient clearance to ensure that there was no impact on the existing Haweswater Aqueduct from tunnelling activities.
Option 4B	The option between Construction Area A and Construction Area E closely follows the alignment of the existing Haweswater Aqueduct, but at the north end followed the ground profile to maintain minimum cover of two tunnel diameters. There were three intermediate shafts proposed: Construction Areas B, C and D. These were included to reduce the overall length of a single tunnel drive to provide emergency egress or safe refuge for construction staff.

[2] The 'crown' of a tunnel relates to its 'roof', or top half of the structure. The invert level refers to the bottom of a tunnel.

35) Prior to the 2019 Scoping Report submission (refer to Chapter 4: EIA Methodology), an appraisal of the route alignment options was undertaken. This included a review of the information from an environmental, engineering, safety and cost perspective. The environmental considerations comprised:

- Biodiversity
- Land use allocations and committed developments
- Woodlands, arboriculture, landscape and visual amenity
- Community and human health
- Water environment and flood risk
- Land quality, soils, agriculture
- Noise and vibration
- Site access, materials and haulage routes.

3.4.2 Design Refinement

36) The engineering design process for this scale of project requires ongoing development and refinement to achieve the design finally submitted with the planning application. To assist the EIA process and provide a mechanism for environmental input into design, several 'design freeze' milestones were established. These milestones enabled the EIA team to review the proposals at key points in the process and provide feedback to the engineering design team to inform design refinement. The four key design points were:

- Design and construction outlines used in the 2019 Scoping Reports
- Interim Design Freeze in late 2019 / early 2020
- EIA Design Freeze 1
- EIA Design Freeze 2.

Scoping Design

37) As described in Chapter 4: EIA Methodology, EIA scoping was undertaken in two stages, with initial design work undertaken in 2019 leading to submission of the Scoping Report in October 2019[3]. Engineering design and access studies continued through 2020 and some significant changes were made to the Proposed Bowland Section. As a result, it was decided to submit an addendum to the Scoping Report in February 2021[4], describing the changes and the implications for the EIA. The text in this section refers to the content of the original Scoping Report, with the changes reflected in the Scoping Addendum covered in Section 3.4.3: EIA Design Freeze 2 below.

38) The proposed Bowland Section would be constructed in tunnel below ground level over approximately 16.4 km with a very small additional distance (approximately 465 m) of open-cut trenching at the surface to transition from the new tunnel to the retained multi-line sections. The total length would therefore be approximately 16.9 km.

39) The development envelope[5] for surface-based activities associated with the Proposed Bowland Section would encompass some 78 ha of predominantly agricultural land. This includes land required for construction accesses, construction areas and proposed discharge pipes.

40) The design submitted at scoping followed Option 4B with a total of five construction area locations, including three intermediate shafts:

- Construction Area A (Lower Houses Compound) was a reception shaft

[3] Haweswater Aqueduct Resilience Programme Proposed Bowland Section - EIA Scoping Report (October 2019)
[4] Haweswater Aqueduct Resilience Programme Proposed Bowland Section - EIA Scoping Report Addendum (February 2021)
[5] The area of land encompassed within a planning application boundary

- Construction Areas B, C and D were intermediate shafts generally situated on fell-top locations along the route to provide refuge or emergency egress for the construction staff
- Construction Area E (Newton-in-Bowland Compound) was a launch shaft, with an overflow included to the south of the proposed connection leading to the River Hodder.

Interim Design Freeze

41) As the design of the development evolved with further detail from the ground investigation, field surveys and consultation responses, there was an interim design freeze involving further refinement of the development envelope boundaries. At the time of the interim design freeze, the preferred base option for United Utilities was Option 4B. This option was consistent with the design submitted with the scoping reports, including the intermediate shafts, but included the following updates:

- Construction Area A boundaries were revised to reduce the area of land take, and included the alignment of the proposed access track
- For Construction Area E an overflow was removed from the development envelope. A dedicated haul route over the River Hodder to bypass the village of Newton-in-Bowland was introduced to the south and west of the village.

42) Shortly after conclusion of the Interim Design Freeze, consultation and agreement with the Health and Safety Executive enabled the discounting of Construction Areas B, C and D from the proposals. This allowed for a revised tunnel route alignment to be proposed, following a largely direct and straight alignment from Construction Area A to Construction Area E.

43) At Construction Area A (Lower Houses Compound) no changes were proposed to the boundaries of the construction compound or access track.

EIA Design Freeze 1

44) For EIA Design Freeze 1, the alignment of the access track from the Lower Houses Compound to Helks Brow was moved further south away from Cod Gill, the compound itself was further reduced in size (on the southern boundary), and a new access track from Park House Lane was added to the compound to enable a 'one way system' that would facilitate the safe movement of construction vehicles on the local public highway when entering and leaving the compound.

45) At the Newton-in-Bowland Compound, the construction area to the north of Newton / Dunsop Bridge Road was reduced in size along its eastern boundary avoiding historic landscape features and reducing potential noise impacts on Newton. The construction compound laydown area was removed from the haul route over the River Hodder and the width of the corridor for the haul route was reduced. The surplus material laydown area north of the Newton-in-Bowland compound was removed from the design.

3.4.3 EIA Design Freeze 2

46) Due to the technical limitations described in Chapter 4: EIA Methodology, and ongoing stakeholder consultations, decisions around some elements of the Proposed Bowland Sections were taken at a late stage in the EIA process. This led to a further design freeze, EIA Design Freeze 2, which introduced several new aspects of the proposed development:

- Off-site highways works, involving road widening, passing places and junction improvements on the public highway to enable to safe movement of construction vehicles and other road users
- Satellite compounds, located remotely from the main construction compounds, were proposed to facilitate general construction logistics, for example, construction vehicle holding areas, park and ride compounds and temporary residents' parking
- The Proposed Ribble Crossing; a newly-constructed, dedicated haul route across open countryside in the Clitheroe area designed to reduce or avoid high volumes of construction traffic through local communities.

3.4.4 Selection of Transport Routes

47) While not strictly design development, the selection of transport routes to the main construction compounds from the strategic road network was also developed through a combination of engineering considerations, environmental constraints and community feedback during the consultation process. A description of how public highway transport routes was selected is presented in Appendix 3.1.

3.4.5 Embedded Mitigation and Design Development

48) Throughout 2020, development envelopes and proposed compound layouts were further refined to deliver embedded mitigation solutions. Additionally, the design team responded to feedback from online consultations with stakeholders. Various design optimisation and environmental mitigation workshops were held throughout the design development process, with technical inputs from landscape architects, arboriculturists, water environment specialists, ecologists, cultural heritage specialists, acousticians and air quality scientists. The positive outcomes of the embedded mitigation and design enhancement workshops are described in the respective topic chapters of the ES.

3.5 Development Description

49) This section describes the Proposed Bowland Section, as assessed and reported in the technical Chapters 6-19 of this ES and presented on Figure 3.1:

- Section 3.5.1 provides an overview of the replacement aqueduct, described from north to south, while Section 3.5.2 summarises the activities associated with the three main phases of construction works – enabling, main construction works and commissioning
- Associated above- and below- ground structures are described in Section 3.5.3 to 3.5.5
- Sections 3.5.6 to 3.5.8 describe the establishment of the proposed construction compounds and proposed activities within them, tunnel construction and open-cut connections to the existing aqueduct
- Section 3.5.9 outlines the off-site highways works, including a park and ride facility and construction vehicle holding area in the Clitheroe district, noting that this element of the Proposed Bowland Section is reported in Volume 5 of the ES
- Section 3.5.10 describes the Proposed Ribble Crossing, noting that this element of the Proposed Bowland Section is reported in detail in Volume 6 of the ES.

3.5.1 Route of the Proposed Bowland Section

50) The route of the replacement aqueduct runs south to north, starting in an upland area of semi-improved pasture under livestock, passing at depth below the Bowland Fells before emerging in the Hodder river valley to the west of Newton in Bowland. The Proposed Bowland Section is located within Lancaster City Council authority area in the north and Ribble Valley Borough Council authority area in the south.

51) The Proposed Bowland Section would replace an existing 16.7 km section of aqueduct. It would be constructed by a Tunnel Boring Machine (TBM) below ground level with short, open-cut surface trenching sections at each end making connections back to the existing aqueduct. The new tunnel would be bored in a northerly direction from a portal at the southern end of the tunnel. The Bowland tunnel would have a launch compound approximately 850 m to the west of Newton-in-Bowland with a reception shaft near Wray (referred to as the Lower Houses compound). Further details on the tunnel boring and associated works are provided within this chapter.

52) The tunnel between the Lower Houses and Newton-in-Bowland compounds would be approximately 3.5 m internal diameter (4.1 m external diameter) and approximately 16 km in length. The tunnel route runs in a south by south east direction with a slight curve below Thrushgill Fell before running in a straight line to Gamble Hole farm where another slight curve brings the tunnel to a portal trench at the Newton-in-Bowland Compound. The maximum depth of the tunnel would be approximately 380 m below ground level.

3.5.2 Construction Activities

53) Table 3.3 lists the construction–related activities which are expected during each of the three phases of the proposed construction works.

Table 3.3: Split of construction activities per phase

Works Phase	Activities
Enabling Works	▪ Off-site highway works and satellite compounds ▪ Establishing construction access ▪ Watercourse diversions, as required[6] ▪ Vegetation clearance ▪ Soil stripping and storage ▪ Public Rights of Way diversions ▪ Earthworks, including the creation of working areas for static plant and machinery ▪ Establishing plant, machinery and other facilities at the within the working areas.
Main Construction Works	▪ Shaft and portal construction ▪ Management of material/ waste arisings ▪ Tunnel construction ▪ Open-cut pipework construction
Commissioning Works	▪ 'Turning' of flows from the old to the new aqueduct ▪ Land reinstatement.

3.5.3 Overflows

54) The existing overflow structures and pipelines protect the siphon sections from excessive flows by allowing water flows to pass over an overflow weir. The weir is located at the Hodder north well and, passes to the River Hodder. A new flow distribution structure would be constructed with a connection to the existing overflow chamber and this would continue to serve the same purpose for the new aqueduct. Ingress flows to the decommissioned asset would also flow down this overflow pipe with measures in place to prevent cross contamination between the ingress flows and the flows in the aqueduct.

3.5.4 Valve House Buildings

55) At each end of the Proposed Bowland Section, there would be a transition from the existing United Utilities infrastructure via buried pipework and underground chambers to the proposed tunnel. These transitions would take place in valve house buildings, single storey structures approximately 11 m wide and 12 m long. Valve houses on the Proposed Bowland Section would be required at the Lower Houses and Newton-in-Bowland compounds. New valve house buildings would be similar in size and appearance to the existing structures.

56) Existing valve houses would be retained at each location. An existing valve house building in a rural location is shown in Illustration 3.5 below.

[6] The need for temporary drainage and drainage strategies has been explored for the main compounds. Temporary watercourse diversions or crossings, if unavoidably necessary, would be developed in consultation with the regulatory authorities. Further details are provided in Chapter 7: Water Environment, and outline Drainage Strategies are presented in support of the Planning, Design and Access Statements for both planning applications.

Illustration 3.5: Typical valve house building – rural setting

3.5.5 Air Valves on the Proposed Aqueduct

57) Air valves would be local to the proposed valve house buildings to release any trapped air in the below ground connection pipework. Access to these would be restricted to routine maintenance with access by foot or light vehicles. Air valves would be installed in buried chambers with localised ground raising and grass banking around an access cover.

3.5.6 Construction Compounds

58) Two main construction compounds would be required for the Proposed Bowland Section, and the following text provides an overview of these compounds, with more detailed supporting information provided in Appendix 3.1. Satellite compounds are addressed in Volume 5 of the ES, being reported as part of the off-site highways works.

59) Main construction compounds would be located at the start and end of the tunnelled sections, and as such would be the main hubs of construction activity. The establishment of compounds would typically require:

- Creation of site access
- Vegetation clearance, including felling of trees and hedge removal outside ecologically sensitive times of the year
- Topsoil stripping, with storage for reinstatement
- Earthworks to create level areas in the sites
- Creation of platforms for working machinery where necessary
- Site drainage installed where required
- Site fencing, hoarding and lighting
- Provision of offices, workshops and welfare cabins
- Delivery and storage areas for materials.

60) From the Newton-in-Bowland compound a TBM would be directed into the hillside from a horizontal 'launch portal' and, after some 16 km of tunnelling, would be received at a 'reception shaft' within the

Lower Houses Compound.[7] To facilitate this, a portal would be created at the launch compound and a shaft would be excavated at the reception compound to, respectively, launch the TBM at the start of tunnelling, or to remove it after completion of tunnelling.

61) The specific activities undertaken at both main construction compounds would vary according to construction techniques and local requirements. Table 3.4 provides a summary of the key activities and features, with further detail provided in Appendix 3.1.

Table 3.4: Key Activities/ Works at Main Construction Compounds

Key Activities/Works		Lower Houses	Newton-in-Bowland
Shaft construction and tunnelling activities	TBM reception shaft	One	n/a
	TBM launch portal	n/a	One
	Rock blasting potentially required?	No	Yes
Reception and Launch Structures	Approximate measurements	Shaft 15 m diameter by approximately 10-15 m deep.	Portal -
Material / waste arisings	Surplus material arisings	Approximately 6,000 m^3	650,000 m^3
	Material destination	Suitable material from arisings would be retained with the planning application boundary and reinstated to agreed final levels.	Waddington Fell Quarry (subject to separate planning permission)
	Slurry treatment	No	No
	Grout batching / mixing	Yes	Yes
Water	Removal of suspended solids	Excess water from tunnelling activities would be pumped to temporary attenuation / storage lagoons. Here, suspended solids would be removed prior to water being discharged to local receiving watercourses.	Excess water from shaft construction activities would be pumped to temporary attenuation / storage lagoons. Here, suspended solids would be removed prior to water being discharged to local receiving watercourses.
	Site drainage	Yes	Yes
	Watercourse modification / 'in channel' works	Culverting of two watercourses	Culverting of nine watercourses (including access route)
Public & Private Access	Maintained	One (PRoW footpath 11-38-FP 23)	Two (PRoW footpaths 3-29-FP 26, 3-29-FP 35)
	Proposed temporary closure/ diversion	One (PRoW footpath 1-38-FP 22)	One (PRoW footpath 3-29-FP 31)

[7] The launch portal at the Newton-in-Bowland compound would be a unique feature within the proposed Programme of Works; the launch locations on other proposed sections would comprise a vertical shaft. It is the local topography at the Newton-in-Bowland compound which enables the adoption of a launch portal.

Key Activities/Works	Lower Houses	Newton-in-Bowland
Access to compound[8]	From the M6 Junction 34 *via* the A683 Access to the Lower Houses construction compound for general construction traffic would be via a partial one-system passing through Weddington and the outskirts of Low Bentham which would avoid the centre of Wray. Abnormal loads would access the site through Main Street, Wray, and Helks Brow.	From the M6 Junction 31 *via* the A59. Vehicles under 3.5 m in height would access *via* Pimlico Link Road and Chatburn Road/ Clitheroe Road, through Chatburn and along West Bradford Road. Vehicles over 3.5 m in height would use Pimlico Link Road and Chatburn Road / Clitheroe Road through Chatburn, Grindleton and along West Bradford Road.
Power supply	Diesel generating sets.	Diesel generating sets.
Utilities	Water for the compound would be drawn from the existing aqueduct. Wastewater from welfare units would be removed by tanker off site for treatment elsewhere. No other utility diversions are anticipated.	Water for the compound would be drawn from the existing aqueduct. Wastewater from welfare units would be removed by tanker off site for treatment elsewhere. A diversion of existing overhead electric cables may be required to facilitate the shaft construction.
Artificial Lighting	Lighting during evening and night-time hours local to reception shaft required to facilitate 24 hour working. Lighting in wider compound area to be limited to security lighting and sufficient to enable general safe working on an 'as required' basis, rather than higher level construction lighting.	Lighting during evening and night-time hours local to launch shaft required to facilitate 24 hour working. Lighting in wider compound area to be limited to security lighting, and sufficient to enable general safe working on an 'as required' basis rather than higher level construction lighting.
Connection to existing aqueduct and permanent works.	Open-cut connection from new tunnel to existing Haweswater Aqueduct. A new permanent valve house building served by a permanent access track.	Open-cut connection from new tunnel to existing Haweswater Aqueduct. A new permanent valve house building served by a permanent access track.

3.5.7 Tunnel Construction

62) The Proposed Bowland Section would be constructed using a Double Acting Shield TBM. This type of TBM could manage anticipated groundwater incursions during construction because the TBM is able to maintain free-draining capacity and control water flow at all times. The tunnel between the Lower Houses and Newton-in-Bowland Compound, would be approximately 3.5 m internal diameter and 4.1 m external diameter.

63) The Bowland tunnel would be driven from the Newton-in-Bowland compound with above-ground temporary works to support the operation and maintenance of the TBM. The above-ground activities may require 24 hours per day working. The temporary construction works areas would provide an area

[8] An alternative transport route to the Newton-in-Bowland compound would be provided by the Proposed Ribble Crossing. This route is considered in Volume 6 of the ES.

for plant, machinery, equipment, welfare, offices and vehicle movements. Surplus excavated material from the tunnelling works would be brought to the surface and dewatered prior to being transported to the nearby Waddington Fell Quarry for final placement. Tunnel segments and consumables would enter the tunnel at the portal. The different tunnel components including connections to the existing aqueduct are summarised in Table 3.5 below.

Table 3.5: Tunnel Components and Connections

Tunnel Section	Description	Construction Technique	Approx. Length
Lower Houses connection	Connection from new tunnel shaft to existing Haweswater Aqueduct	Pipe laying into open-cut trench	165 m
New aqueduct	Tunnel from Lower Houses compound to Newton-in-Bowland compound	TBM	16 km
Newton-in-Bowland connection	Connection from new tunnel to existing Haweswater Aqueduct	Pipe laying into open-cut trench	300 m

3.5.8 Open-Cut Connections

64) Open-cut trenching would be required only when connecting the new section of tunnel into the existing Haweswater Aqueduct. Topsoil and subsoil would be carefully stripped from the land (if not already removed during preparation of the main compound) and stored appropriately within the planning application boundary for later reinstatement of the connection easement.

65) The construction area would be fenced off and used for storage of excavated material and pipes, with temporary access being constructed to move equipment, vehicles, personnel and materials along the length of the pipeline. At both main compounds, trenches would be excavated within the planning application boundary and connecting pipes laid in them prior to backfilling with imported and / or appropriate excavated material.

66) Illustration 3.6 below shows an aerial photograph of an open-cut section of the Haweswater Aqueduct under construction in Cumbria in 2019.

Illustration 3.6: Example of an open-cut construction area

67) At the Lower Houses site, the new connection could comprise four pipes (each approximately 1.2 m internal diameter) laid in a single trench connecting the existing multiline pipeline to a new valve house. While other connection options are available this construction approach has been adopted as the basis of assessment for the EIA. In the valve house water flow would transition into a single pipeline (circa 3.5 m internal diameter) that would connect to the new tunnel.

68) At the Newton-in-Bowland site the new aqueduct would consist of a single pipeline (approximately 3.5 m internal diameter) that would convey flow to a new Newton-in-Bowland valve house. The new aqueduct would be laid in the tunnel portal upon completion of tunnelling. At the new valve house flow would transition into four pipes (each some 1.2 m internal diameter) laid in single trench connecting the new valve house to the existing multiline pipeline.

3.5.9 Off-site Highways Works

69) In consultation with the highways authority, Lancashire County Council, off-site highways works have been included as part of the design of the Proposed Bowland Section, to enable the safe movement of construction vehicles and other road users on the public highway over the lifetime of the project. The planning application for the Proposed Bowland Section makes reference to a total of 58 separate highways works[9] associated with the Proposed Bowland Section. This total comprises 48 road widening sections, eight passing places and two junction modifications. In addition, there would be one parking restriction in Chatburn village.

70) The total number of off-site highways works that could be required is, however, dependent on the outcome of the decision-making around construction traffic routes in the Clitheroe area. In the event that the Proposed Ribble Crossing is selected as the preferred construction traffic route (refer to Appendix 3.1 for construction traffic route options), fewer off-site highways works would be required. A final decision on the construction traffic route(s) in the Clitheroe area would be taken during the planning determination phase.

71) Within the scope of the off-site highways works, two satellite compounds in Clitheroe are proposed. One is a proposed construction vehicle holding area within the curtilage of the Ribblesdale Cement Works. It is proposed that here some construction vehicles would be held for short periods of time before being released back onto the construction traffic routes towards the Newton-in-Bowland compound. This could be in response to alleviating traffic flows on the local road network during busier times of the day or delivering plant and materials on a 'just in time' basis. The second satellite compound would be a park and ride facility making use of the existing Ribblesdale Cement Works staff car park on the west side of West Bradford Road. The purpose of the park and ride facility would be to reduce flows of private cars and light good vehicles further north on the local road network by offering a shuttle bus service to and from the Newton-in-Bowland compound.

72) A temporary satellite compound is also proposed to the west of Wray, off the B6480. The proposed satellite compound would allow vehicles seeking access to the Lower Houses Compound to be held until being cleared to proceed via a communication system. In addition, the compound would act as a park and ride facility, enabling construction personnel to park before being shuttled to the Lower Houses Compound, thus reducing the volume of light vehicles on the local road network surrounding Wray. A temporary residents parking area is also proposed at Bridge House Farm Tea Rooms at the southern end of Main Street to provide alternative parking during the imposition of necessary temporary restrictions on Main St, Wray.

73) Further engineering details on off-site highways works are presented in Volume 2 Appendix 3.1, while an environmental assessment of the works is presented in Volume 5 of this ES. To ensure comprehensive and robust reporting in the ES, the cumulative effects of the off-site highways works (Volume 5), the

[9] This total comprises 22 road widening sections and six passing places for vehicles serving the Lower Houses compound. Twenty of these 22 proposed Lower Houses works are in the Lancaster City Council area, and two are in Craven District Council's administrative area. The total of 58 Proposed Bowland Section works also comprises 30 highways proposals in Ribble Valley Borough Council's administrative area, of which 26 works are road widening, two are passing places and two are junction modifications. The 30 Ribble Valley Borough Council highways works and one traffic restriction serve both the Bowland and Marl Hill compounds, with the exception of five road widening sections and one passing place which would be constructed for construction vehicles accessing the Newton-in-Bowland compound only.

Proposed Ribble Crossing (Volume 6) and the Proposed Bowland Section (Volume 2) are considered in Volume 2 Chapter 19. Similarly, a summary of the likely significant effects associated with the Proposed Bowland Section, the Proposed Ribble Crossing and the off-site highways works is presented in Volume 2 Chapter 21.

3.5.10 Proposed Ribble Crossing

74) The Proposed Ribble Crossing provides a means of allowing construction traffic to access the Slaidburn Road towards the Newton-in-Bowland compound without passing through most of the communities in the local area that would otherwise be affected by traffic using the public highway.

75) The proposal is for a dedicated haul route crossing open countryside to the north of Clitheroe, leaving the West Bradford Road near the Ribblesdale Cement Works and crossing the River Ribble *via* a temporary bridge in proximity to the existing West Bradford Bridge. The route would head west and then north to re-join West Bradford Road between Waddington and Waddington and West Bradford Primary School.

76) The Proposed Ribble Crossing would be a two lane carriageway approximately 7.7 m wide and approximately 1.45 km in length. The road and bridge would both be temporary structures in place for the duration of the construction of the Proposed Bowland Section. The road would be fully removed, and the land reinstated once the tunnel construction works have been completed. During the construction works the road would be reserved for the use of all construction traffic, and would be suitable for heavy goods vehicle use, including exceptional loads. No vehicles other than those associated with construction of the Proposed Bowland Section (and the Newton-in-Bowland compound of the Proposed Bowland Section) would be permitted to use the Proposed Ribble Crossing.

77) Further engineering details on the Proposed Ribble Crossing can be found in Volume 6, while an environmental assessment is presented in the same volume. To ensure comprehensive and robust reporting in the ES, the cumulative effects of the Proposed Ribble Crossing (Volume 6), the off-site highways works (Volume 5), and the Proposed Bowland Section (Volume 2) are considered in Volume 2 Chapter 19. Similarly, a summary of the likely significant effects associated with the Proposed Bowland Section, the Proposed Ribble Crossing and the off-site highways works is presented in Volume 2 Chapter 21.

3.6 Construction Code of Practice

78) The following section outlines the structure and content of an outline Construction Code of Practice (CCoP) which has been developed by United Utilities. The outline CCoP describes the nature and scope of good practice techniques and management approaches that would be adopted during construction of the Proposed Bowland Section.

79) The information contained in the CCoP has supported the EIA process and the assessment of environmental effects, but it also provides a framework for the planning authorities to develop planning conditions based on the mitigation measures proposed in the ES. It is also intended that the CCoP would be used by United Utilities in directing its contractors towards sustainable construction approaches, and providing a basis for the development of further, site-specific mitigation proposals.

80) The outline CCoP is presented in Appendix 3.2 of the ES and is structured as follows:

- Introduction (Section 1) – Purpose of the document and structure
- Environmental Management (Section 2) - Outlines how environmental protection and the control of pollution would be managed from EIA through to construction and implementation
- Communications and community / stakeholder liaison (Section 3) – Outlines the communications strategy during construction with the affected communities and relevant stakeholders
- General Site Operations (Section 4) – Outlines general management standards/procedures to be applied across all construction sites

- General Requirements by environmental topic (Section 5) – Sets out the measures that would be implemented to limit the disturbance from construction activities and reduce environmental impacts, as far as reasonably practicable. For ease of reference and consistency this follows the chapter structure outlined within the supporting ESs.

81) The CCoP is supplemented by site-specific environmental mitigation measures as follows:

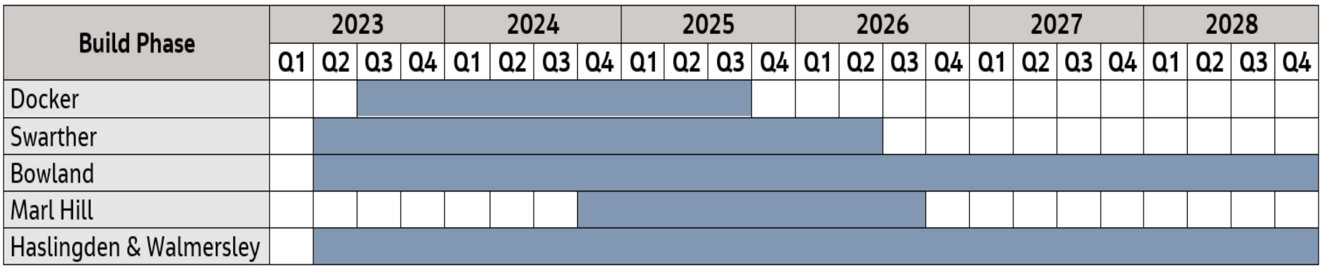
- Schedule of Mitigation (as per Appendix 20.1)
- Environmental Masterplan (illustrating the locational requirements of the mitigation as per Figure 20.1).

82) The Schedule of Mitigation comprises a compilation of the measures proposed in each of the topic chapters of the ES. Some of the mitigation measures are site-specific and relate to actions proposed at particular locations in connection with discrete environmental resources or construction or operation activities.

3.7 Construction and Commissioning Programme

83) An indicative construction programme for the Proposed Programme of Works is shown in Illustration 3.7. This presents a high-level overview of when proposed construction works might be undertaken, subject to planning permission.

Illustration 3.7: Indicative construction programme



84) The construction programme for the Proposed Programme of Works would be phased so that some of the proposed new sections of aqueduct could start later and / or be completed sooner than others. Illustration 3.7 indicates that construction of the Proposed Bowland Section could commence in 2023 with enabling works, ultimately reaching completion and commissioning in 2028. The indicative programme does not include reinstatement works, which may continue for several years beyond the completion of construction. The dates and durations are indicative and would be further developed once a contractor is appointed.

85) Connection and commissioning works would be undertaken following completion of the main construction works, although the precise timing of when these works would be undertaken would depend on the commissioning approach adopted by the Contractor. Section 3.8 describes the two connection and commissioning options available.

86) Land reinstatement would be carried out progressively, starting as early as practicable at each of the construction compounds. This may involve land restoration activities being commenced in appropriate locations at the main compounds whilst construction and commissioning activities are still underway. Land reinstatement works would continue for a number of years beyond the completion of construction works.

87) Decommissioning of the existing section of Haweswater Aqueduct would commence as early as feasible following completion of the connection and commissioning works. Decommissioning could extend beyond the end of 2028 for those HARP sections where the connection and commissioning works are undertaken towards the end of the overall programme, such as on the Proposed Bowland Section.

3.7.1 Hours of Working

88) Tunnelling and above-ground activities at the launch site would require 24 hours a day, seven days a week (24/7) operations. This would include soil and rock arisings being transported to the surface, handling of materials and water works operation. Other round-the-clock works would include:

- Above ground activities to support tunnel works at construction compounds
- 24/7 above ground support to tunnelling including maintenance, security, ventilation, refuelling
- Vehicle movements associated with tunnel shift changes based on a 12-hour shift pattern.

89) Commuter movements, would take place between 07:45 to 08:15 and 18:45 to 19:15 (two shifts) for the Lower Houses Compound and 06:45 to 08:00 and 18:45 to 20:00 (two shifts) for the Newton-in-Bowland.

90) At the Lower Houses Compound movement of HGVs and abnormal loads would be between 08:15 to 18:45 (without any restriction on movements during school drip off or pick up times).

91) For the Newton-in-Bowland Compound HGVs and abnormal load movements would be between 09:00 to 14:45 and 16:00 to 18:45. Construction traffic would be restricted between 08:00 to 09:00 and 14:45 to 16:00 to avoid possible conflicts with school drop-off and collection periods. These times would be reviewed and agreed with the relevant highways authority nearer to the start of construction activities to consider the most up-to-date school schedules.

92) It is anticipated that above ground activities at the launch sites and all other surface locations would adopt the following working hours:

- Monday to Friday 07:00 to 19:00
- Saturday 07:00 to 13:00
- Sunday by exception, no deliveries
- Bank Holidays by exception, no deliveries
- 24/7 during four week connection outages including two, four week outages with 24/7 working at each point of connection to the existing Haweswater Aqueduct between April and October
- Exceptions to the above by agreement with the planning authority e.g. full day Saturday, Sundays and Bank Holidays by exception.

3.8 Commissioning

3.8.1 Connection of New Sections to Existing Aqueduct

93) There are two options for connecting the new infrastructure to the existing Haweswater Aqueduct, depending on the construction technique to be adopted by the contractor. The two options are either a '*non-outage approach'* using a multi-line to multi-line connection, or a *'full outage approach'* using a single-line to single-line connection. These are shown in illustrations 3.8 and 3.9.

94) At the current stage of design development, it is not known which of these connection and commissioning options would be adopted by the contractor for the Proposed Bowland Section, and this would only be confirmed during the detailed design stage. However, for the purposes of the planning application and EIA, a multi-line to multi-line connection has been assumed on the basis that it represents the reasonable worst-case scenario with regard to area of land required and depth of excavation.

95) In relation to the commissioning of the new infrastructure following connection, it has been concluded that there are no material differences between the non-outage and full outage approaches from an environmental perspective – this is because the scale, intensity and duration of works, and discharges to the water environment would be similar. The only notable difference between the two commissioning options is the timing of when the connection and commissioning works can take place:

- For the non-outage approach connection and commissioning could take place during June / July or September / October each year (eight-week periods)
- Alternatively, for the full outage approach connection and commissioning could take place only during September / October every two years (during a four-week period) due to operational constraints on other parts of United Utilities' regional supply network.

96) This means that the non-outage approach allows four opportunities every two years for connection and commissioning, whereas the full outage approach only allows a single connection and commissioning opportunity every two years. The non-outage connection and commissioning approach therefore has programme benefits over the full outage connection and commissioning approach due to the increased flexibility of when the works can take place, potentially allowing earlier completion.

97) As it is not possible at this stage of design development to confirm which of the two approaches might be adopted; both are described below as well as being incorporated into the indicative construction programme included in Section 3.7.

3.8.2 Commissioning of the Tunnels and Connections

98) Whichever of the two connection approaches is adopted, the same three-phase approach to cleaning the new tunnel and connections would be adopted prior to the commencement of connection, as summarised below:

- Strip out of tunnelling infrastructure to include all rails, communication lines, debris and surface contamination on retreat from the tunnel
- Vehicle mounted deep clean of the internal surface of the pipe
- Final disinfection and sampling.

99) Once commissioned, cleaned and tested to meet the required Water Quality standards, the new tunnel and connecting pipelines would be connected to the existing aqueduct. The connection work would commence and be completed within 14 days of final disinfection to comply with Mains Hygiene principles.

Illustration 3.8: Non-outage connection

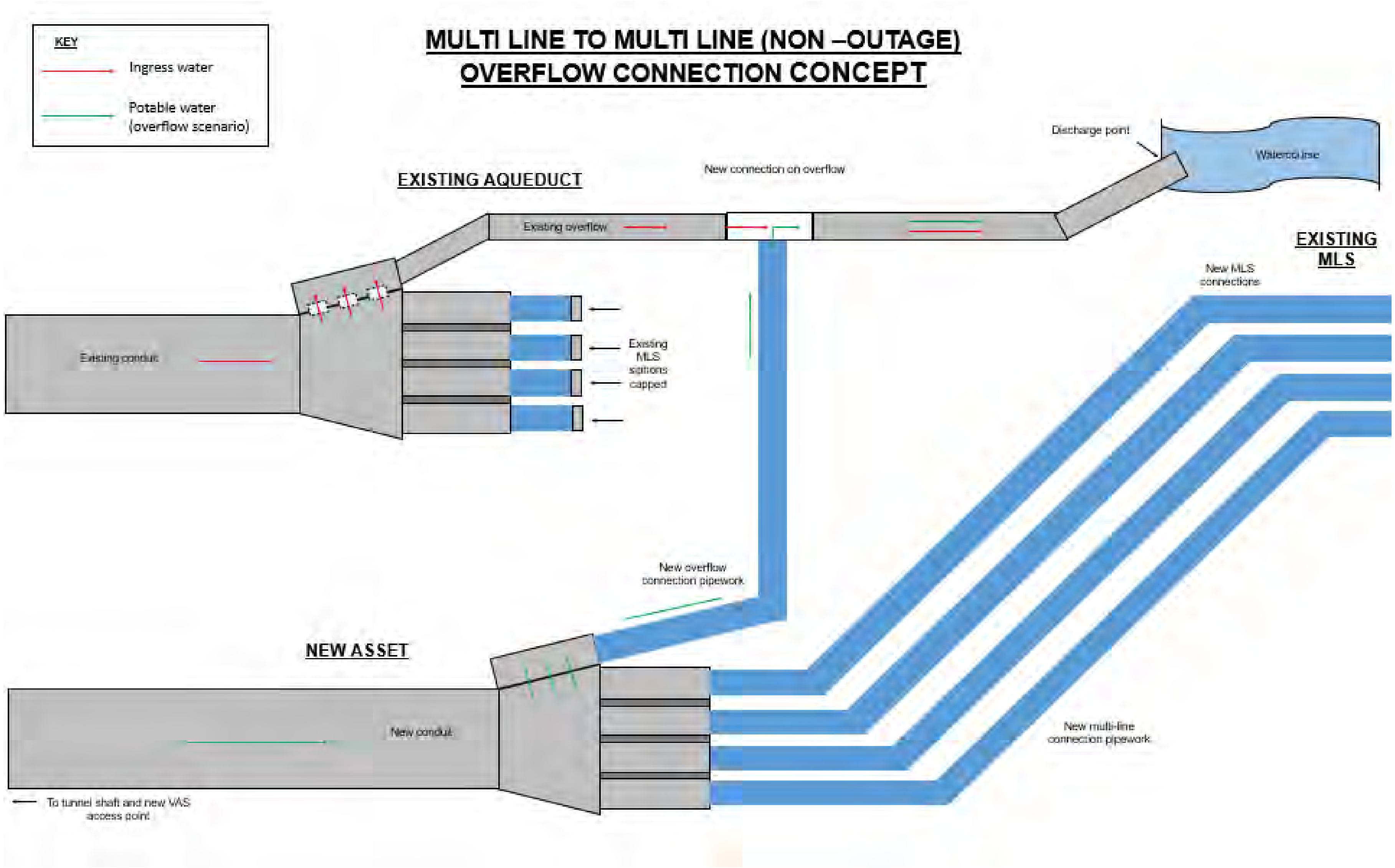
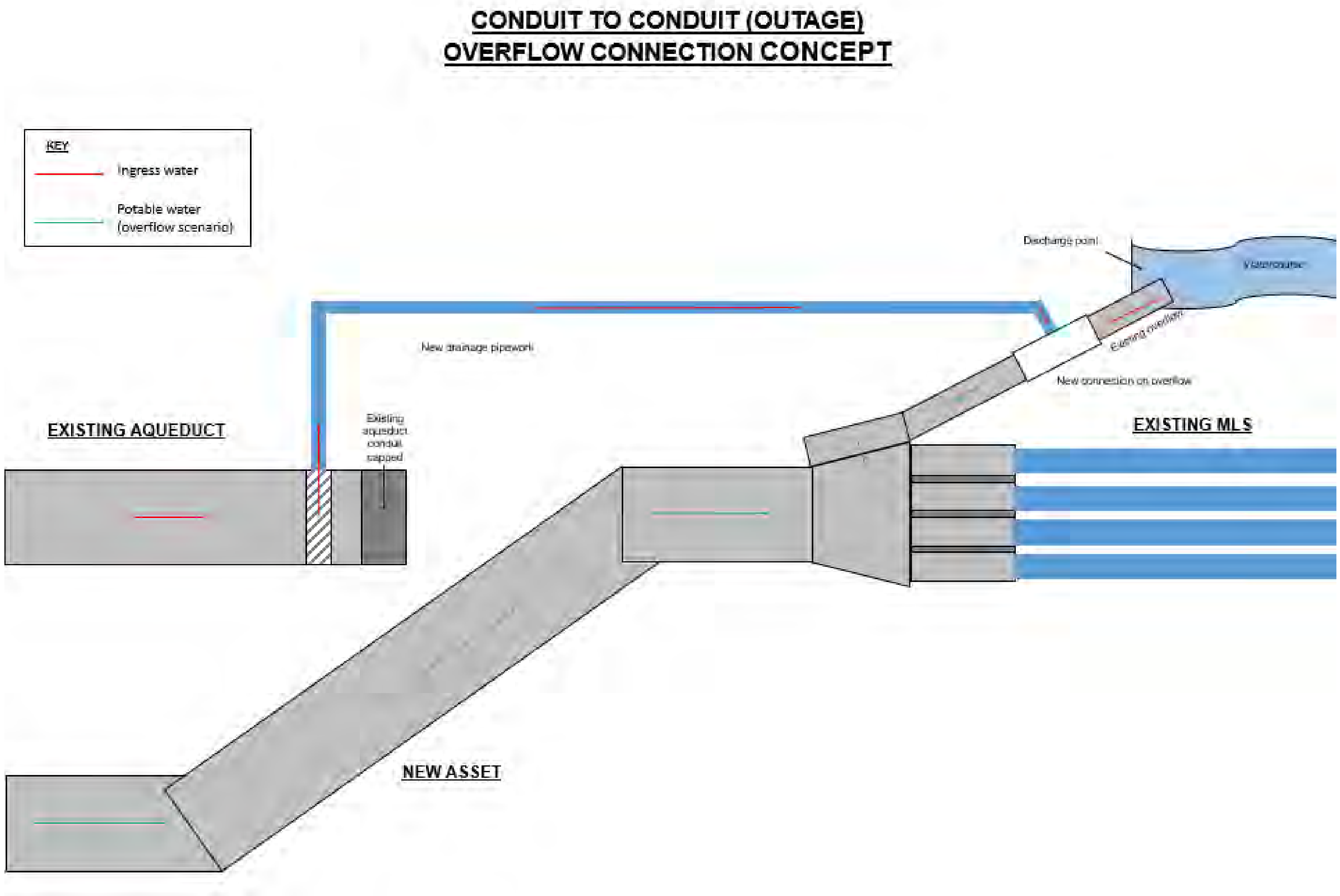


Illustration 3.9: Full outage connection



3.8.3 Land Reinstatement

100) Land used for temporary compounds and open-cut pipeline construction would be reinstated after completion of construction works, with temporary access roads being removed. Where launch and reception facilities (e.g. shafts) are present, these would be covered and reinstated at ground level.

101) Access tracks would be reinstated to the original land on completion of the commissioning works with agreement of the landowner.

102) Each of the proposed compounds are located on third party land which may be acquired or entered under the land entry powers afforded by the Water Industry Act.

103) At Lower Houses approximately 6,000 m^3 of excavated material would be retained on site and used in the reinstatement of the temporary compound area. The material would be placed on a section of land currently used for grazing within the planning application boundary. The surplus material would be placed to tie in with existing landform, extending an existing slope, rather than creating a distinct mound that may detract from landscape character. The reuse of the material in the landscaping of the site would remove the need for additional vehicle movements on the constrained local highway network, mitigating potential for disruption to the local community and reducing carbon emissions.

3.9 Operational Activities

3.9.1 Operational Access

104) Operational access along the line of the new aqueduct would be similar to the existing asset. Stiles or access gates would be provided at field boundaries to enable a walk over survey along the route of the aqueduct to take place.

105) Operational activities in relation to the valve house buildings and access buildings would generally be restricted to light vehicle access to service valves and to take water quality samples. The operational phase of the new aqueduct would give rise to very low volumes of traffic. Further details surrounding approaches to the transport planning study are presented in Chapter 16: Transport Planning.

3.9.2 Decommissioning of the Existing Asset

106) Following completion and commissioning of the new aqueduct, sections of the existing aqueduct would be taken out of service. A future maintenance and usage strategy for the redundant sections of aqueduct is being prepared. This strategy would include protection of existing structures above the redundant sections and dealing with any flows arising from the decommissioned aqueduct.