UUWR_11.1

PR24 Draft Determination: UUW Representation

Area of representation: Appendix - Davyhulme WwTW

August 2024

This document is a supporting appendix to accompany UUW DD representation document UUWR_11 – Gated mechanisms providing technical information on Davyhulme WwTW sanitary and P removal schemes.

Reference to draft determination documents: PR24 draft determination: Expenditure Allowances, section 4.7.3 Approach to large schemes, pages 177 - 184

United Utilities

Water for the North West

1. Key points

- **Negotiations with the Environment Agency have been complex, but now are clear:** We recognise that Environment Agency negotiations have been prolonged as we have optimised adaptive plans that deliver benefits for customers. Following agreement with the Environment Agency in May 2024 and formally in the WINEP published 5 July 2024 we have a clear need for Davyhulme WwTW. We have worked hard to optimise the scope, cost and delivery schedule. This has reduced AMP8 requirements by £188m for Davyhulme and avoids wasteful or abortive investments. We now have clarity and are ready to deliver at pace for customers and the environment based on the adaptive plan.
- **United Utilities is certain on the required solution and the associated cost to deliver all AMP8 and AMP9 regulatory drivers at Davyhulme WwTW –** a considerable site re-build is necessary to meet the challenging AMP8 and AMP9 WINEP requirements for the technically achievable limits (TAL) for BOD and phosphorus. We discuss further our observations on the cost assessment approach for phosphorus removal in *UUWR_33 - P Removal*. In this appendix to *UUWR_11 – Gated mechanisms* we present evidence for our cost assessment at Davyhulme WwTW.
- **The stringent permit drivers for Davyhulme set by the Environment Agency mean we will need to upgrade part of the treatment works –** existing assets are not capable of meeting the strict 6mg/l BOD driver within the existing works and will need to rebuild part of the activated sludge process. With the agreement to deliver 8mg/l in AMP8, with 6mg/l BOD in AMP9, this unlocks the opportunity to deliver a biological P removal process in an efficient way.
- **We consider chemical phosphorus removal at Davyhulme WwTW unsustainable –** our preferred solution is for biological phosphorus removal by AMP9 and our first phosphorus recovery process in AMP8, which we consider to be resilient and best value. The chemical volumes expected would result in tanker movements that could significantly impact our neighbouring communities and a chemical dosing solution would be higher whole life cost.
- **We have done a full bottom-up estimate assessing site specific risks:** We understand the construction complexity of the schemes and have included phasing, temporary treatment and land purchase costs as necessary.
- **Site specific constructability challenges have added additional risk and cost:** the particularly constrained nature of the site, ground conditions and a large biological P removal plant are aspects we consider are not well represented in Ofwat's cost assessment model.
- **Our proposal is securing a central part of our adaptive plan for Davyhulme which is key to the wider Manchester Ship Canal strategy:** with awareness of the long-term drivers in the Environment Act, we have included solutions for AMP8 that enable best overall value for customers and the environment considering the AMP8 and AMP9 drivers.

2. Introduction and Site Overview

This document is an appendix to DD representation document *UUWR_11_Gated mechanism*. Here we describe the development of the Davyhulme scheme in detail and provide additional information around the solution development and the constructability assessment and specific challenges to Davyhulme. We consider that this early detail is key to understanding the delivery schedule as well as supporting a robust cost estimate.

Our PR24 submission included four large wastewater projects at some of our largest treatment works; This appendix relates to the scheme at Davyhulme WwTW. Due to the scale of investment and perceived uncertainty of scope and costs, Ofwat has placed Davyhulme into the newly proposed large scheme gated process for added scrutiny and customer protection.

The Davyhulme schemes are driven by improving the status of the Manchester Ship Canal as part of a long-term adaptive plan agreed with the EA. In addition, we have considered future requirements and long-term planning principles to ensure there is no abortive short-term investment for customers.

We have developed the best value solutions through an optioneering process, and we have challenged ourselves on the need and solution. Based on the knowledge and experience of our capable engineering team and those of our experienced supply chain partners we have proposed solutions that meet the requirements of the Environment Agency as set out in the WINEP, deliver the necessary significant environmental improvements and are best value for customers.

Our proposal is to move the two schemes for Davyhulme to the enhanced engagement and cost sharing scheme as described in *UUWR_11_Gated mechanism*. On moving we recommend cost assessment is carried out as a deep dive cost assessment rather than through a modelled approach. The scheme for Davyhulme is part of an AMP8 and AMP9 adaptive plan to deliver a large biological phosphorus removal process with demonstrable constructability challenges that we expect to be viewed as an outlier against the model assessment. Our observations of the limitations of the phosphorus removal cost assessment models are discussed in detail in DD representation document *UUWR_33_Phosphorus Removal*, with a summary of relevant areas as follows:

- Ofwat has developed four econometric models to assess phosphorus removal costs. Two of these models are backwards-looking, using data on the AMP7 phosphorus removal programme, while two are forward-looking, using data on companies' proposed phosphorus expenditure within AMP8. These models perform well in terms of statistical significance, though there is a noticeable deterioration in the model fit of the backward-looking AMP7 models. PR24 is the first time Ofwat has used a scheme-level econometric approach.
- Ofwat assesses outliers separately. It identifies outliers using the Cooks Distance statistic. Outliers are subject to a deep dive assessment. 'Efficient' outliers receive the business plan value rather than the (higher) modelled value. 'Inefficient' outliers receive the modelled value if insufficient evidence has been provided to support higher cost forecasts.
- Ofwat does not distinguish between chemical and biological solutions, because it considers that biological solutions will only be adopted at a small number of sites in AMP8.

The final point of not distinguishing between chemical and biological solutions being key to Davyhulme, as biological phosphorus removal is the best value solution for this adaptive plan. We consider that large biological phosphorus removal solutions will not perform well through existing model assessments. In our solution development, we have considered chemical supply resilience, impact to customers from traffic movements from chemical tanker deliveries and whole life cost assessments that we propose are not considered in existing model assessments.

We are supportive of biological phosphorus removal techniques, along with the Environment Agency. However, if insufficient allowance to deliver biological phosphorus removal materialises, we may be guided towards the lowest capex solution and to what we consider to be a lower value and less resilient solution of chemical phosphorus removal and the disruption that the extensive tanker movements this will result in at these sites. Furthermore, we have carried out bottom-up estimates and considered the constructability challenges in detail. Further information on these issues is included in this appendix, but key to this scheme are issues such as

confirmed contaminated land and constructing in extremely close proximity to the M60 motorway and Barton high level bridge. These are considerable challenges and we have assessed the impact on the costs for these issues which we consider would not be well represented through standard cost assessment modelling.

Following the October 2023 business plan submission we have used the time wisely and have continued to carry out a further review of the scope and costs for the Davyhulme project. This document provides information around the technical and constructability challenges and presents additional evidence to demonstrate that the solutions and costs UU submitted are accurate and efficient.

2.1 Overview - Site considerations

Stretching Permit Limits

The drivers for Davyhulme are documented in the WINEP and summarised in Table 1.

As indicated in the table, the new permit levels are a significant progression in AMP8 towards TALs in AMP9. Stringent targets at significantly large WwTWs adds complexity and cost. We have applied adaptive planning principles to consider future drivers to minimise spend across AMPs and provide solutions that are resilient.

Our plans detail the best available technologies (BAT) for treating wastewater to low levels and how we arrived at our proposed solutions.

Table 1: Table showing drivers by site (red depicts new permit that will be at technically achievable limit)

Site	AMP 8 new drivers		AMP9 new drivers	
	BOD	Phosphorus	BOD	Phosphorus
	mg/l 95%ile	Annual average	mg/l 95%ile	Annual average
Davyhulme	8	3	6	0.25

Source: UUW analysis

The red coding in Table 1 shows where drivers include permit levels at the TAL for that driver. The term TAL is not an absolute number, but it is an indication of on average the minimum level for that driver. There will be examples of sites in the UK with permits lower than the TAL where companies have agreed to take on more onerous targets due to the nature of the assets on site or for use in a flexible permitting environment. However, the TAL limit indicates the minimum environmental standard expected for these determinands (BOD, ammonia etc).

As we are now clear on the long-term WINEP ambitions, we have deployed adaptive planning principles and explored the potential for a phased driver delivery, that we consider efficient and appropriate in seeking the lowest cost solution in AMP8 and for the whole life of the facility at Davyhulme.

Constructability challenges

As part of the company's approach to developing the submitted solutions for our major AMP8 projects we consulted with our external supply chain to ensure site specific constructability issues were identified and considered.

Two major constructability themes have been identified that apply to Davyhulme: constrained site conditions and the surrounding built environment. Adapting to and resolving these challenges has resulted in site specific cost increases when compared to a typical capital intervention. This may contribute to this project being viewed as an outlier.

Constrained Site Conditions

Davyhulme has already expanded to the site boundary in many areas. There are no substantial undeveloped areas for the construction of new build assets. This results in additional constructability requirements such as the need to demolish redundant assets, construct in challenging ground conditions (including building on brown field sites /

flood plains). This impacts programme sequencing and can necessitate temporary treatment to enable the continuity of existing treatment to be maintained during construction. Where construction within the site boundary is unachievable, we have identified the need to purchase land or rent land for the location of site compounds, plant storage and equipment laydown areas.

Surrounding Built Environment

Davyhulme is located within the highly urbanised City of Manchester and is significantly constrained by its surrounding geography and adjacent land use. These factors present several challenges that drive increased costs and prolong construction timescales at each site.

The presence of a high density of third-party assets, such as overhead and buried HV Power, Gas and Telecom infrastructure, requiring service diversions and / or protection works.

The choice and design of our solutions are influenced by the need to give due consideration to limiting construction, noise, vibration and odour emissions that may impact the surrounding residential communities.

Construction activities and plant access is required in close proximity to a number of strategic transport assets such as the Manchester Ship Canal, the M60 motorway and Barton Bridge. There will be programme and cost impacts due the need to obtain specific permissions, such as National Highways Approval In Principle, (AIP), undertake monitoring works during construction and the need to employ specialist low impact construction techniques.

Davyhulme is located within a high density of sensitive residential properties and commercial premises immediately adjacent to the site boundaries and site access is though high traffic / congested areas. This requires the adoption of appropriate working practices, such as low noise and vibration techniques, dust and odour suppression measures and restricted working hours to ensure that disruption to customers is controlled to within acceptable levels.

Specific constructability requirements have been identified for each of the schemes discussed in this appendix, they significantly contribute to increased project costs.

3. The Need for the Project

Davyhulme is United Utilities' largest wastewater treatment works serving over 1.1m population equivalent in Greater Manchester and discharges into the Manchester Ship Canal. The WINEP drivers being implemented will support the Manchester Ship Canal to meet 'moderate' status (Table 2).

A layout of the existing Davyhulme WwTW site is shown in Figure 2, which depicts the complexity of the works including multiple stream activated sludge processes (ASPs), the restrictions on available space and the proximity to customers and significant local amenities.

Table 2: Existing permits and future drivers for Davyhulme WwTW

	Existing permit	1st Apr 2025 AMP8	31st March 2028 AMP8	31st December 2028 AMP8	31st March 2035 AMP9
BOD mg/l 95%ile	20	15	8		6
Ammonia mg/l 95%ile	1				
Phosphorus mg/l Annual average	-			3	0.25

Source: UUW analysis from WINEP

As shown in Table 2, achieving 'moderate' status in the Manchester Ship Canal requires Davyhulme final effluent to reduce from 20 to 6mg/l BOD and brings in a new phosphorus permit, targeting 3mg/l in AMP8 and then tightening to 0.25mg/l in AMP9. The existing works is not capable of achieving the required BOD and phosphorus performance and requires additional interventions and associated funding to enable these new permit limits to be met. It should be noted Davyhulme already has a stringent 1mg/l ammonia permit which will be maintained.

The WINEP requirements represent the lowest TAL of BOD and phosphorus. At Davyhulme these limits cannot be achieved through the sites existing treatment process. The detailed reasons for this are discussed in the following sections along with the proposed solution and associated costing for delivery.

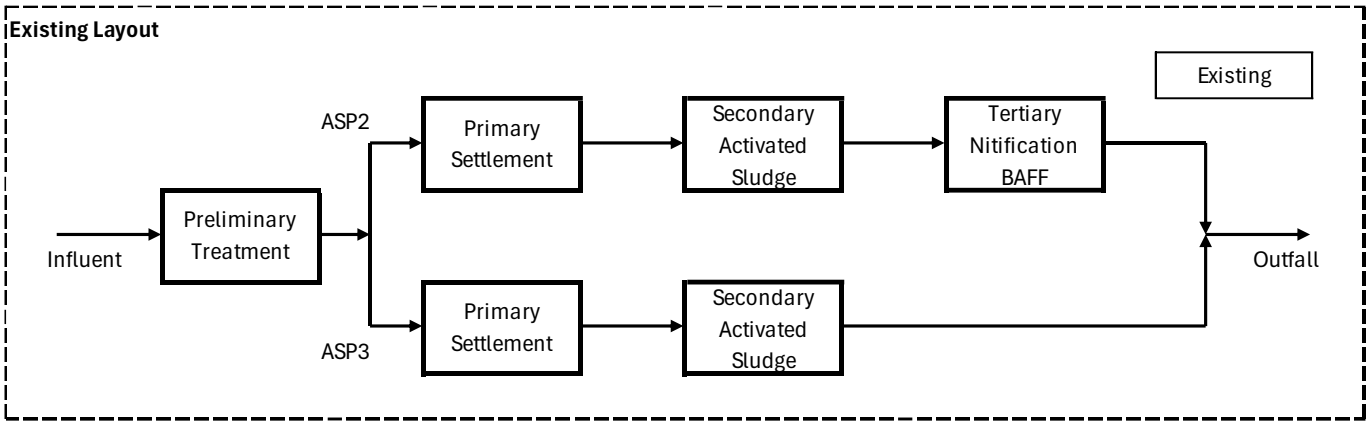
Achieving the most stringent BOD and phosphorus levels at United Utilities' largest works is a significant challenge and our options assessment showed it was not possible to deliver this in a single AMP. United Utilities proposed a phasing of the drivers across AMP8 and AMP9 to comply with a more achievable regulatory programme (Table 2). With this new agreement we were able to develop an adaptive plan, phasing the delivery of the stringent 6mg/l and 0.25mg/l phosphorus drivers into AMP9, minimising abortive spend and delivering best value for customers.

Davyhulme Existing Process

Flows to Davyhulme WwTW pass through preliminary treatment comprising screening and degritting processes. Flows are then treated through the activated sludge process (ASP), with flows dividing in the proportion of 60% to ASP3 and 40% to ASP2 (Figure 1 and Figure 2). The measured flow to treatment is used to calculate a 60% set-point for an inter-stage pump station which lifts flows to ASP3. Remaining flows gravitate through ASP2. ASP3 includes primary settlement to remove gross solids prior to secondary activated sludge treatment. ASP3's secondary treatment achieves the required BOD and ammonia removal in one step. The settled final effluent passes forward to a common effluent discharge point. ASP2 includes primary settlement and secondary treatment similar in principle to ASP3 but is only designed to remove BOD. Ammonia removal is achieved by passing secondary treated effluent through a tertiary biological aerated flooded filter. The final effluent from ASP2 joins ASP3 final effluent and flows to the Manchester Ship Canal.

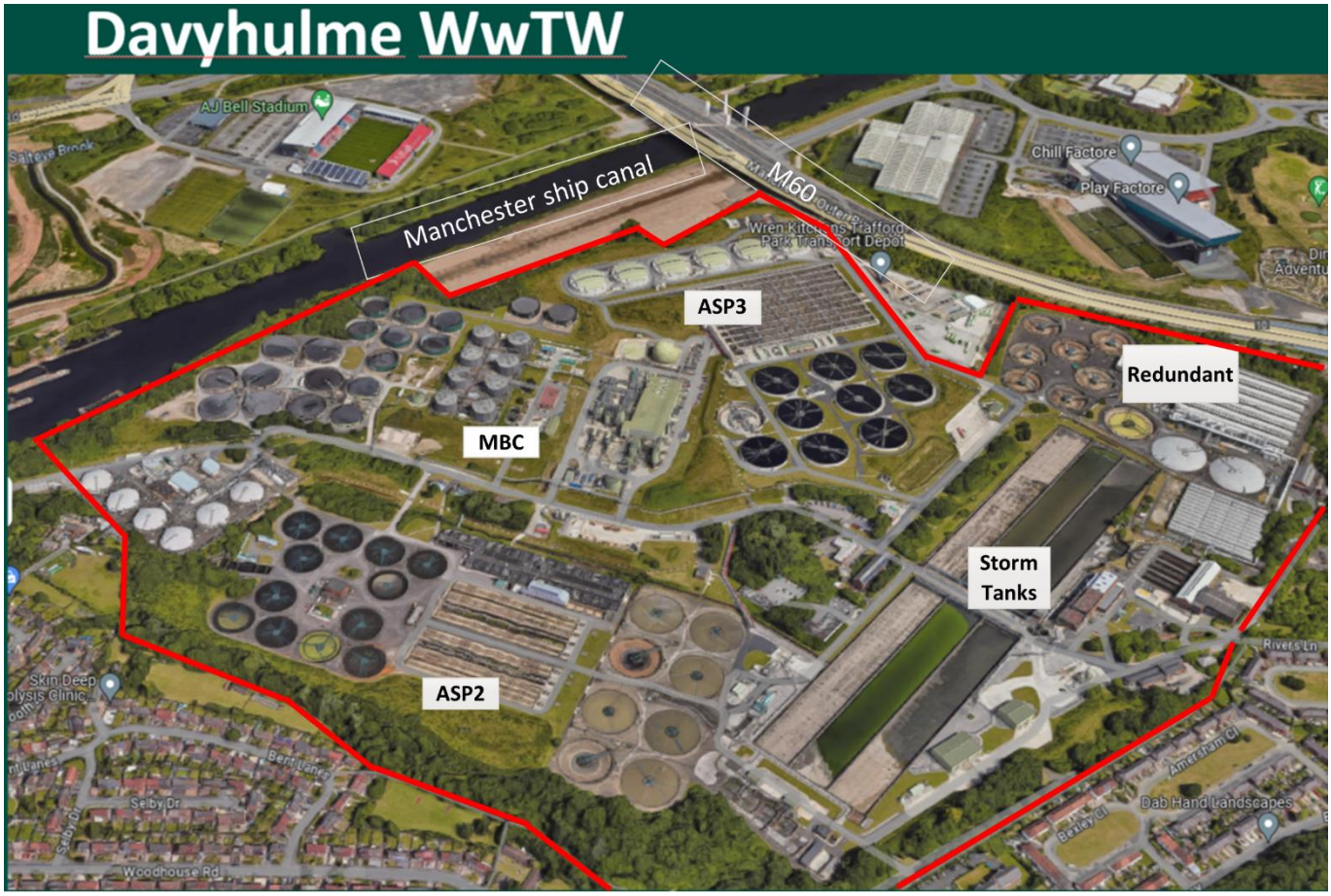
In addition to the wastewater treatment process Davyhulme WwTw is co-located with the Manchester Bioresource Centre, a regional biosolids processing facility that incorporates a thermal hydrolysis process. As a result of the thermal hydrolysis process the centrate generated from raw sludge thickening and digested sludge dewatering causes elevated loads of phosphorus to return to the wastewater process.

Figure 1: Simplified existing process flow at Davyhulme



Source: UUW analysis

Figure 2: Existing Davyhulme WwTW layout (red line depicts the site boundary)



Source: UUW analysis with Google Maps

4. Development of the technical solution

The following technical sections detail the technical review and optioneering undertaken to determine the viable options and the reasoning behind the selected solution, that is the basis of the proposed adaptive plan for Davyhulme across AMP8 and AMP9.

Davyhulme Current Performance

As stated there are two types of activated sludge plant (ASP) technology currently in operation at Davyhulme (Figure 1):

(1) ASP2 is a two-stage treatment process comprising a surface aerated carbonaceous ASP followed by a biological aerated flooded filter (BAFF). It was constructed circa 1950. Since the construction of ASP2, advances in technology mean that it is no longer the best and most viable available technology.

(2) ASP3 is single stage nitrifying ASP utilising fine bubble diffused air for aeration. It takes 60% of the flow to treatment plus all the internally generated return liquors and was constructed in 2018. ASP3 was and is still best available technology.

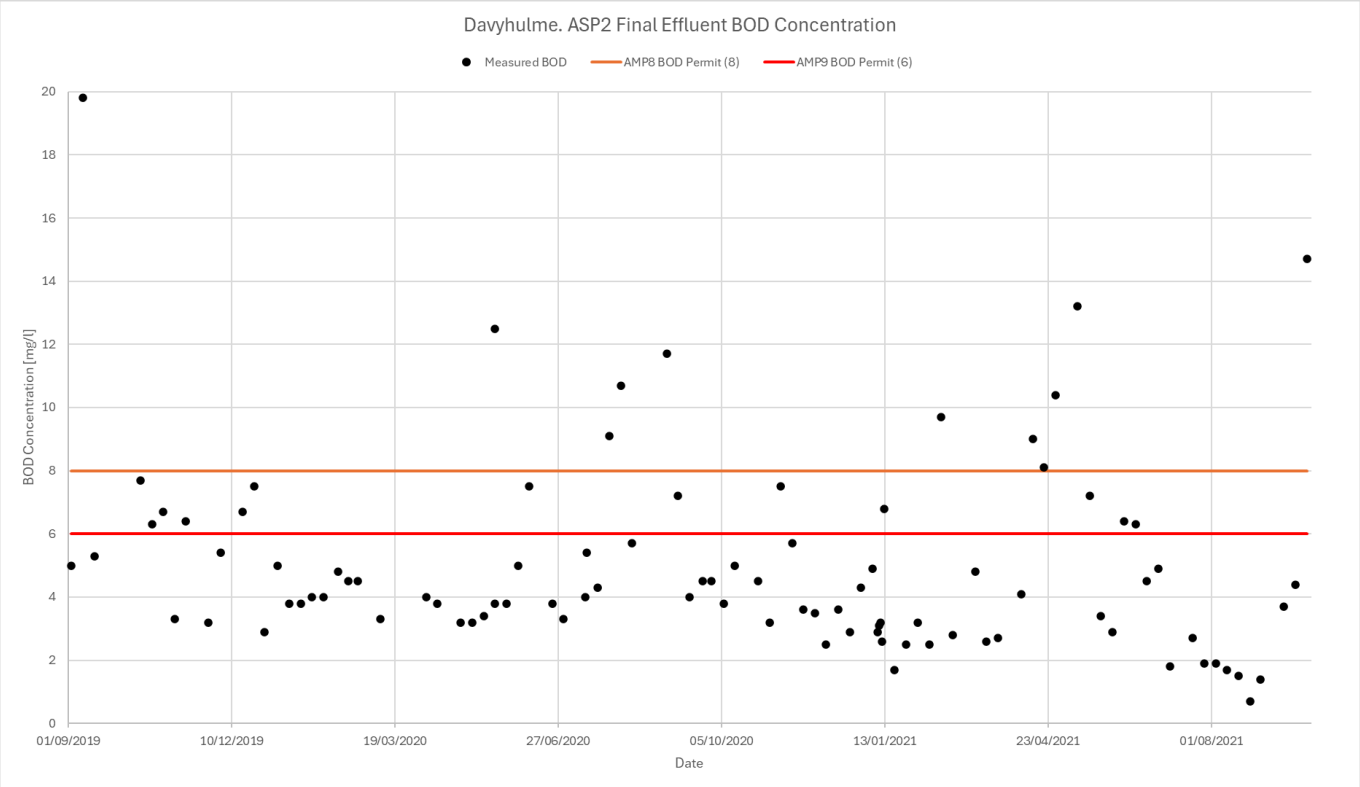
Prior to the installation of ASP3 there was a, now redundant, ASP1 stream with a similar design to that of ASP2.

BOD Performance

The introduction of ASP3 during delivery of the Davyhulme Modernisation project in AMP6 allowed the flow to treatment to ASP2 to be reduced from 60% to 40% with the aim of allowing ASP2 to meet the 1 mg/l ammonia WINEP driver at that time. As discussed above ASP2 is no longer best available technology and the 1 mg/l ammonia presented a challenge that required a change in configuration to be achieved.

Despite the reduction in flows ASP2 cannot meet the 8mg/l and/or the 6mg/l BOD requirement (Figure 3). The figure demonstrates that it operates below the current permit of 20 mg/l, and this has allowed a short-term reduction to 15 mg/l BOD to be proposed as part of the phased delivery.

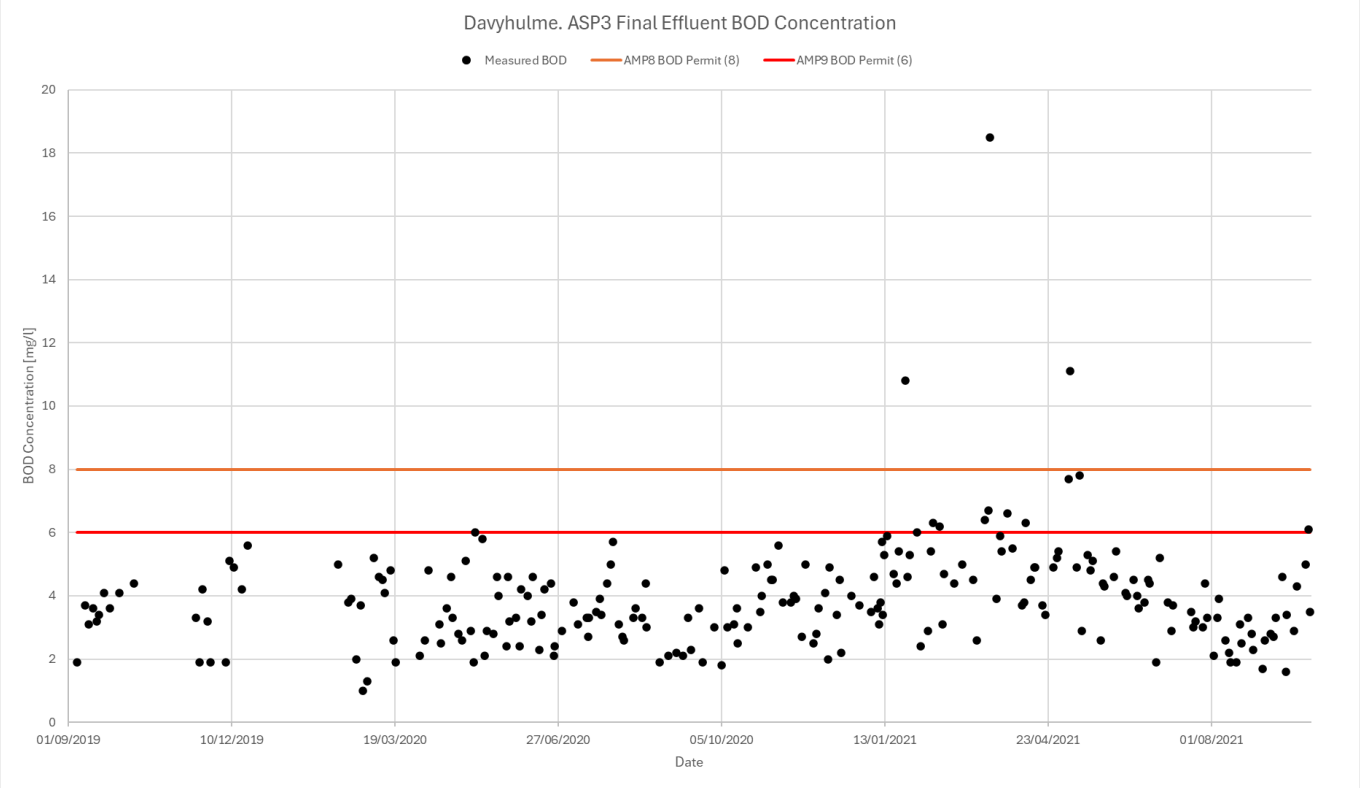
Figure 3: Davyhulme ASP2 Final Effluent BOD Performance (post BAFF)



Source: UUW developed chart

ASP3 receives 60% of the flow to full treatment and all thickening and dewatering liquors. ASP3 presents an opportunity to avoid delivery of a tertiary treatment stage which would typically be included for a 6 mg/l BOD requirement in the absence of actual operating data to show it is not required. ASP3 is outperforming the general case and is very close to the 6mg/l BOD requirement (Figure 4).

Figure 4: ASP3 Final Effluent BOD Performance



Source: UUW developed chart

Phosphorus Performance

Neither ASP2 nor ASP3 currently include any treatment capacity for removing phosphorus as Davyhulme has not historically had a phosphorus driver. Phosphorus concentrations in the crude flow to treatment are approximately 5 mg/l and whilst there is some natural sedimentation and biological uptake of phosphorus in the sludge this is variable and not controllable (Figure 5). It is crucially also not sufficient to meet the WINEP requirement of 3 mg/l phosphorus in AMP8 as shown in Figure 6.

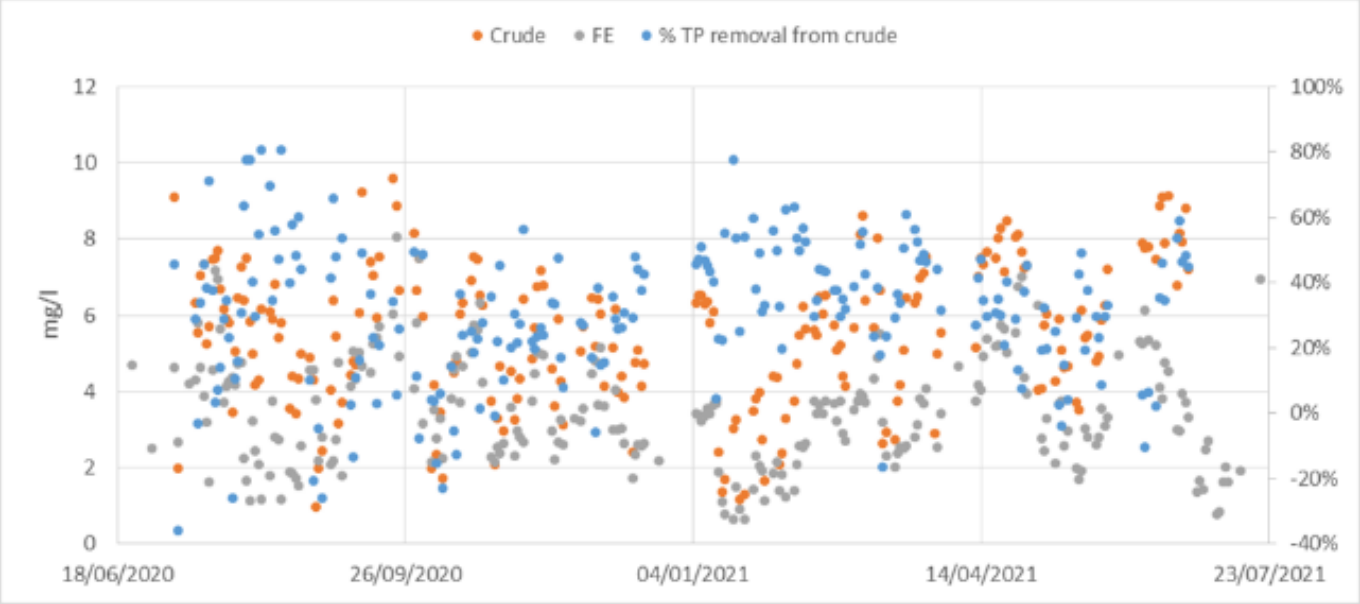
As previously mentioned Davyhulme WwTW is connected to the Manchester Bioresource Centre and the wastewater side of the works receives the return sludge liquors from this regional sludge processing facility. The return liquors contribute a significant return phosphorus load and the impact of this clearly has a direct influence on the final effluent phosphorus concentration as detailed in Figure 7.

Our optioneering process for Davyhulme

During development of United Utilities' PR19 submission an AMP7 WINEP phosphorus driver was identified for Davyhulme to address a no deterioration driver for chemical status in the Manchester Ship Canal. Initial investigations showed that delivering this new permit in AMP7 would not represent the best long-term value for money, and so it was agreed with the EA that an in-depth study of the Manchester Ship Canal would be delivered, with a particular focus on Davyhulme WwTW and its catchment, along with the delivery of several other low phosphorus permits on the other sites that feed the Manchester Ship Canal during AMP7 (United Utilities, 2021).

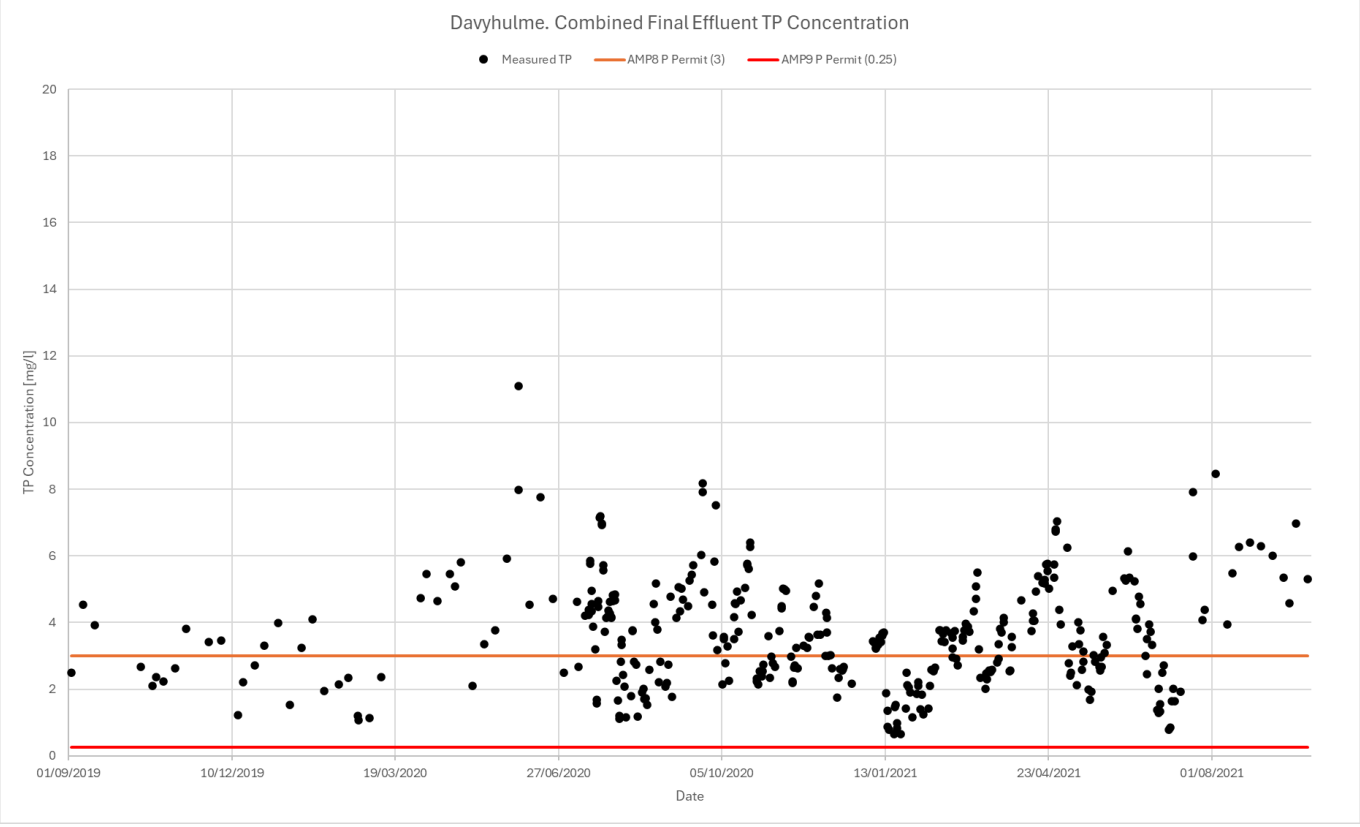
The study carried out an optioneering exercise comparing over 20 different solutions to meet the AMP8 and AMP9 drivers for phosphorus and BOD and a summary of some of the key outcomes from this optioneering is detailed below.

Figure 5: Davyhulme WwTW Historical Phosphorus Removal Performance



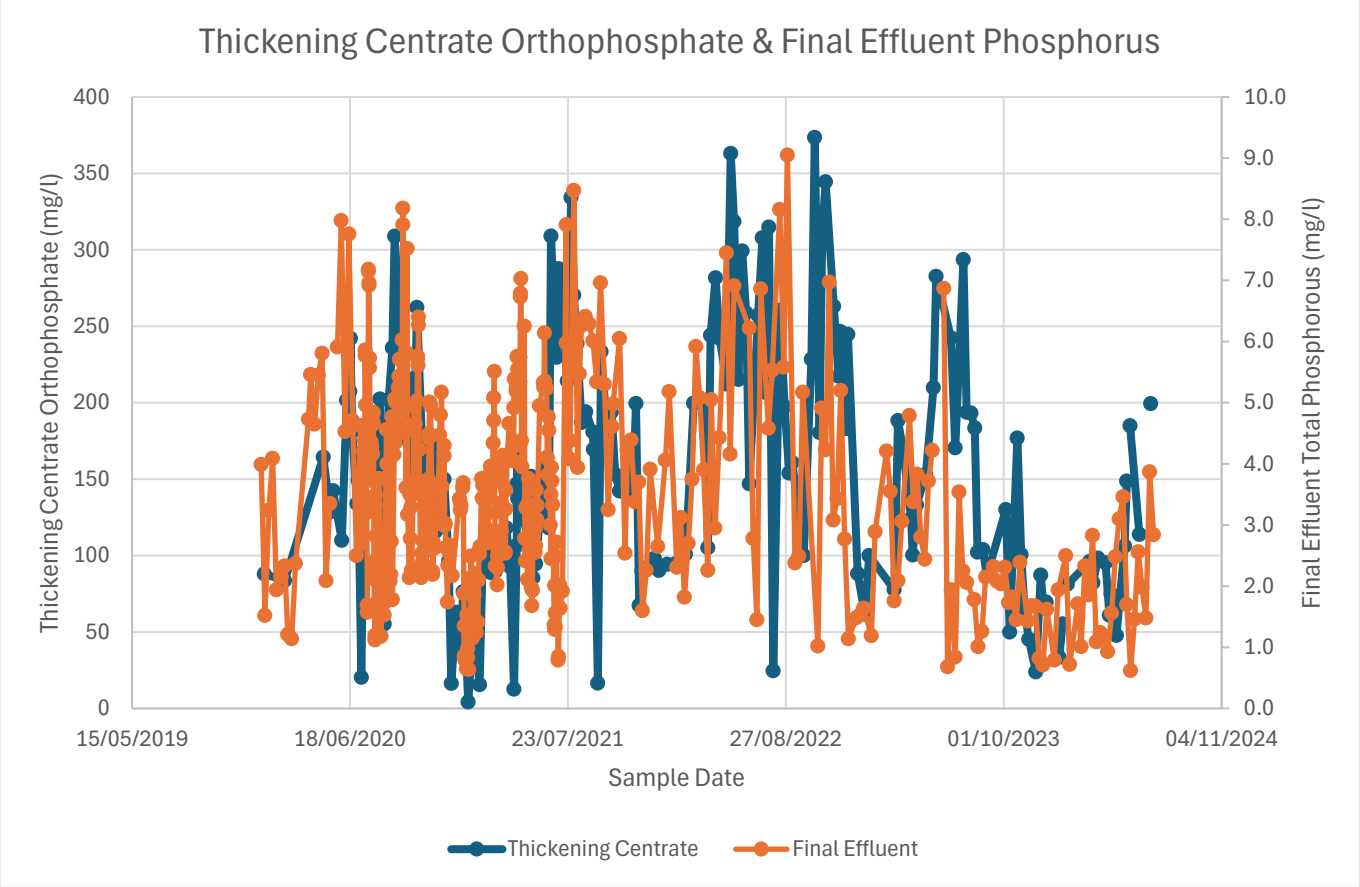
Source: Manchester Ship Canal Phosphorus Deterioration, Davyhulme WwTW – Phosphorus Investigations, September 2021

Figure 6: Davyhulme Measured Phosphorus in Effluent from Existing Assets



Source: UUW analysis

Figure 7: Davyhulme Measured Thickening Centrate Orthophosphate influence on Final Effluent Total Phosphorus



Source: UUW analysis

Options for enhancing BOD Removal

The driver for 6mg/l BOD is a significant challenge to deliver at any wastewater treatment works, being the current TAL. We challenged ourselves to incorporate the use of the existing assets; we assessed the current performance, the optimisation potential and the potential to add on additional treatment to meet the requirement for 6mg/l BOD.

ASP2 and ASP3 have differing BOD removal performance. ASP2 can outperform the current BOD permit (20mg/l) but cannot match the performance that the BAT ASP3 can achieve (Figure 3 compared with Figure 4). ASP2 relies on relatively short solids retention time and shallow final settlement tanks. This ASP was designed for carbonaceous removal only, unlike ASP3 which was designed for full nitrification to meet the 1mg/l ammonia permit in AMP6. The introduction of ASP3 during delivery of the AMP6 project allowed the flow to full treatment to ASP2 to be reduced from 60% to 40% with the aim of allowing ASP2 to meet the 1 mg/l ammonia WINEP driver at that time. Figure 3 shows that despite this reduction in flow ASP2 cannot meet the 6mg/l nor 8mg/l BOD requirement, it has however allowed it to operate below the existing 20mg/l BOD permit and this has allowed a short-term reduction to 15mg/l BOD to be proposed as part of the phased delivery.

BOD exists in both soluble and insoluble (particulate) form and both forms must be minimised to achieve a TAL of 6mg/l BOD. Solids retention time represents the time spent by the biomass in the ASP and is a key measure for understanding the potential of the ASP to complete removal of BOD. The ASP2 short solids retention time (approximately one third of ASP3) gives suitable soluble removal for the current permit but cannot achieve the minimum levels achieved by ASP3. Furthermore, ASP3 has 5.5 m deep side walls in each final settlement tank while ASP2 has only 2.1 m deep side walls.

Solids separation performance in final settlement tanks improves with increasing side wall depth. The greater depth of the ASP3 final tanks has the advantage of being able to retain settled solids more readily within the tanks even when there are large flow changes such as in a storm event. The design of ASP2 means that the settled

solids are much nearer the top of the tank and more likely to be re-suspended in the event of a significant increase in flows which would impact our ability to meet a 6mg/l BOD permit.

As a result of this, we have determined how low we can take the BOD permit with the existing design of the ASP2 final tanks, and this is why we have proposed an interim step of changing the permit limit to 8mg/l BOD in AMP8 ahead of the step change in solution that would be required for AMP9. This means we can carry out some targeted interim capital interventions to achieve the 8mg/l BOD, but this is the maximum extent of enhancement that can be undertaken without wholesale significant interventions which would incur abortive costs for customers when considering the wider drivers for Davyhulme in AMP9.

As a result of our optioneering process for Davyhulme we determined the need to significantly modify our treatment approach on ASP2 which would likely include significant capital intervention to achieve 6mg/l BOD, we were also conscious of the phosphorus drivers and so determined the need to consider a wider solution that would present best value for customers delivering an overall solution to meet both TALs for BOD and phosphorus.

Phosphorus Removal: Chemical Phosphorus Removal Options

Phosphorus removal at wastewater treatment works is often achieved at minimum capital cost by chemical precipitation, which involves dosing metal coagulants and removing the phosphorus-rich solids that this chemistry creates. Davyhulme is the largest wastewater site in United Utilities' region and presents a unique challenge for this more traditional approach. At Davyhulme, chemical precipitation would require unprecedented quantities of chemicals to be delivered and stored on site. Calculations have determined the need for a minimum storage of 950 tonnes of ferric chemical and 652 tonnes of caustic chemical. These calculated figures are based on only 7 days storage at average consumption rates, which would equate to only 3 days storage at peak dosing conditions. The standard storage to manage the risk of delivery delays and peak consumption is 14 days, which is just too large to be accommodated at Davyhulme. The total tanker movements per day are calculated to be 7 per day at average conditions, which would have a significant and what we consider to be unacceptable impact on neighbouring communities.

A phosphorus permit of 0.25 mg/l is at the TAL for this determinand and security of supply of chemicals is critical to consistently meeting this stringent level of permit. The supply chain indicate significant risk to uninterrupted supply of these quantities of chemicals and therefore chemical precipitation presents an intolerable risk to delivery of the phosphorus driver.

Phosphorus Removal: Biological Phosphorus Removal Options

As discussed above, the chemical phosphorus removal options reviewed presented a significant challenge in terms of sustainability, operation and supply chain. An alternative option to chemical treatment is biological phosphorus removal, which can significantly reduce reliance on chemical deliveries managing the risk of chemical supply and making delivery of the WINEP requirements sustainable. Davyhulme's unique challenge therefore results in biological phosphorus removal being critical to delivering the phosphorus driver for this project.

In addition, we knew that we needed to significantly intervene on ASP2 to achieve the 6mg/l BOD, combining the two drivers together allowed us to develop the best value intervention as a combined solution. As discussed in our representation for our phosphorus programme (*UUWR_33_Phosphorus removal*), when a new secondary treatment process is part of the solution for sanitary drivers, the best value sustainable solution is to deliver biological phosphorus removal at the same time for phosphorus drivers.

We were also conscious of the PR24 WINEP driver guidance – nutrients and sanitary determinands (surface waters) which states on page 18 that "*Water companies are encouraged to take opportunities, where possible, to make greater use of biological phosphorus removal techniques and to recycle or recover phosphorus from WwTW when designing actions to meet environmental targets*". In the case of Davyhulme the biological phosphorus removal solution became the only way to effectively and sustainably deliver the project drivers at best value to customers.

Phosphorus recovery was identified as a key part of the biological phosphorus solution for Davyhulme for the longer term 0.25mg/l permit as without recovering phosphorus from internal recirculation flows phosphorus would continue to loop around the site. This is exacerbated by the co-location of the regional sludge facility which

imports sludges from around United Utilities' region, bringing a significant import phosphorus load to Davyhulme WwTW.

Figure 7 depicts the significant contribution of phosphorus from the return liquors from the Manchester Bioresources Centre (delivered back to the WwTW via the returned sludge liquors) which directly impacts the final effluent P concentrations.

Considering the need to include phosphorus recovery for the AMP9 solution and the significant impact seen to the final effluent directly from the return liquors. Our engineering team determined an opportunity to deliver the phosphorus recovery early targeting this low flow, high concentration stream to achieve the 3mg/l permit as part of an adaptive plan, ensuring a no regrets intervention.

Options carried forward for detail review

Following on from the Davyhulme Phosphorus Study (United Utilities 2021), two options were taken forward for review. Whole life cost over 30 years was calculated for the two options: chemical dosing only and biological treatment with a trim dose of chemicals. The best value solution was found to be the option including biological phosphorus removal as detailed in DD representation document *UUWR_33_Phosphorus removal* and allows us to deliver an adaptive plan whilst making early environmental benefit from the inclusion of phosphorus recovery early in our delivery.

This results in the following process to be delivered at the end of the phased delivery:

- Phosphorus recovery from the liquor return stream
- Enhancement of ASP3 to full biological phosphorus removal
- Replace ASP2 with a new ASP4 designed for full biological phosphorus removal (retaining the existing ASP2 primary tanks to minimise additional investment)
- Chemical trim to ensure 0.25mg/l P consent met year-round.

Considering the lower whole life cost of the biological solution, the guidance from the EA on preferred use of biological solutions along with the complexity of chemical dosing at Davyhulme WwTW, UU is certain that the proposed option for delivering the WINEP drivers at Davyhulme should be a full biological phosphorus removal process with phosphorus recovery. Investment in a BAT biological phosphorus ASP will ensure the long-term sustainability, efficiency and regulatory compliance of Davyhulme WwTW.

4.1 The Adaptive Plan

As discussed in Section 3 we propose to deliver the project needs as part of an adaptive plan in three phases. The phases are outlined below.

Phase 1: 15mg/l BOD (April 2025, AMP8)

Davyhulme is currently successfully outperforming the design intent of the existing assets. As part of our agreed adaptive plan, we have agreed with the Environment Agency a reduction in permitted BOD from 20 to 15mg/l as we consider we can manage this risk and deliver the improvement without additional enhancement funding. Managing further reductions from operational outperformance is not possible and intervention is required in subsequent phases described below.

Phase 2: 8 mg/l BOD and 3 mg/l Phosphorus, AMP8

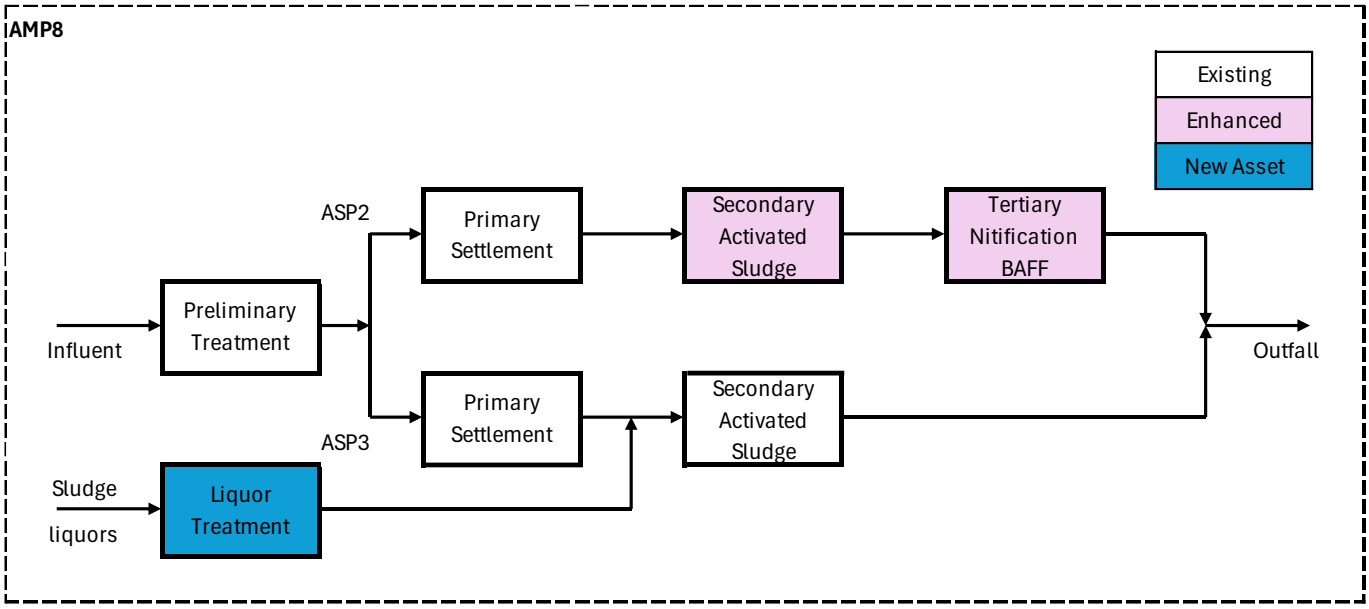
In relation to BOD, our experience with the new activated sludge plant, ASP3, demonstrates that deep final tanks are required to be able to meet 6mg/l. This provides an opportunity to meet this driver without tertiary treatment, which would normally be required. ASP2 has shallower tanks (2.1 m versus 5.5m) and cannot deliver the same performance as ASP3. From our process assessment and modelling, ASP2 is predicted to be able to perform to 8mg/l BOD at best with enhancement of the activated sludge plant (Figure 8). Abortive work is kept to a minimum by enhancing ASP2 to meet an interim 8mg/l BOD driver which was agreed with the Environment Agency based on our plan for delivery of the drivers as an adaptive plan.

In relation to phosphorus, the Phase 2 driver of 3mg/l cannot be achieved with the existing treatment works as it is not designed to remove phosphorus and we have verified this through a significant sitewide phosphorus survey and study (*Manchester Ship Canal Phosphorus Deterioration, Davyhulme WwTW – Phosphorus Investigations, September 2021, Figure 28*).

Phosphorus recovery was identified as a key part of the biological phosphorus solution for Davyhulme for the longer term 0.25mg/l permit as without recovering phosphorus from internal recirculation flows phosphorus would continue to loop around the site. We thought about this differently and identified that implementing the phosphorus recovery as the first step would allow us to achieve the 3mg/l P permit. This alternative solution was shown to be the best value whilst also representing a no regrets alternative option to achieving the interim permit. This phosphorus recovery solution enabled an adaptive plan to delivery of the AMP9 driver needs, avoiding abortive investment from AMP8 to AMP9 (Manchester Ship Canal Phosphorus Deterioration, Davyhulme WwTW – Phosphorus Investigations, September 2021).

Phase 2 is therefore a cost-effective solution for the interim drivers in AMP8 and a key step in our adaptive plan to ultimately achieve the stringent drivers in AMP8.

Figure 8: Simplified proposed process flow at Davyhulme for AMP8



Source UUW analysis

Phase 3: 6 mg/l BOD and 0.25 mg/l Phosphorus

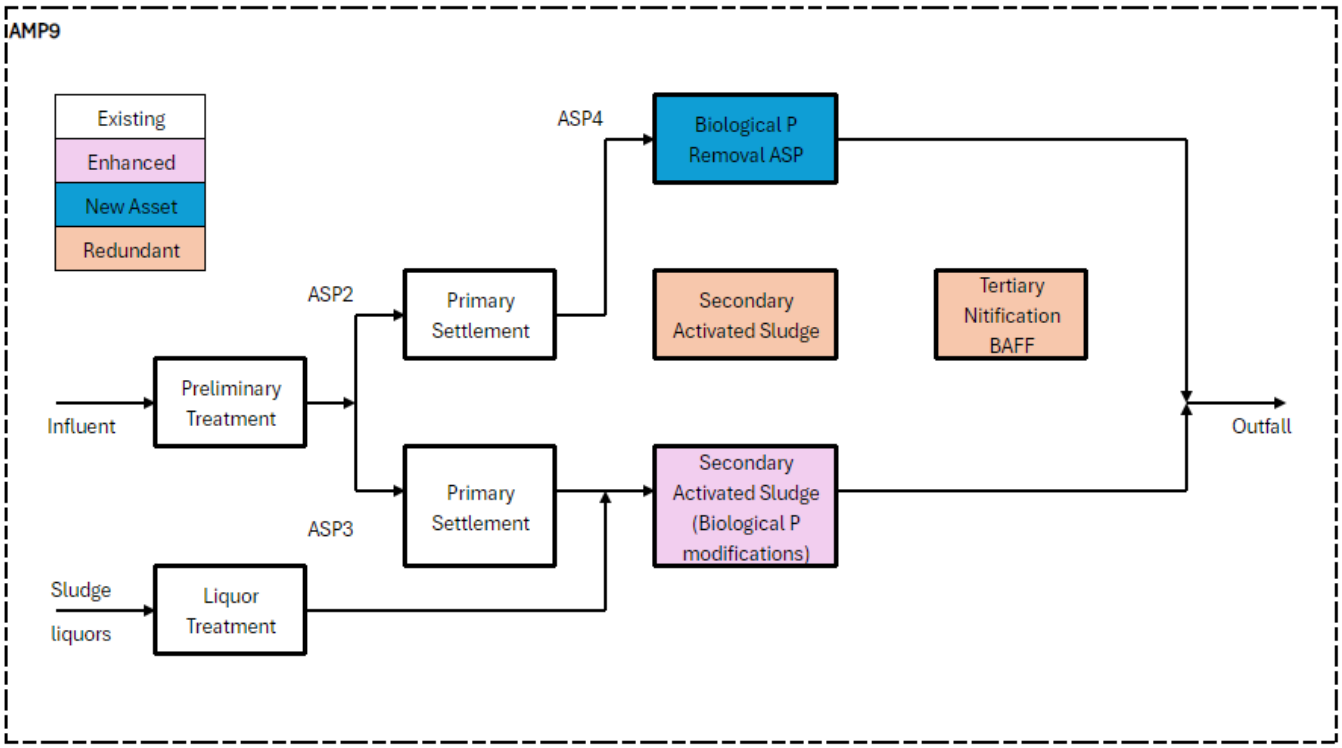
Delivery of Phase 2 enhancement of ASP2 will enable treatment to 8mg/l BOD, however through our process modelling and calculations, it is determined that this is the limit of the capability and capacity of these assets, they cannot achieve 6mg/l BOD and for Phase 3 and combined with the need to deliver further phosphorus reductions led to the need to rebuild this stream.

Our Phase 3 solution is therefore to deliver a new biological phosphorus removal ASP (ASP4) capable of meeting the 6mg/l BOD and 0.25mg/l phosphorus drivers, along with meeting the existing 1mg/l ammonia permit. This will be built on the footprint of the redundant ASP1 (Figure 9). ASP2 would then be decommissioned, and the primary tanks associated with ASP2 will be re-used (Figure 9). ASP3 is already achieving the 6mg.l BOD driver but would then be adapted to deliver biological phosphorus removal, so we are able to deliver 0.25mg/l phosphorus across Davyhulme.

The plant will still need a small chemical trim coagulant (ferric) dose (and associated alkalinity correction) to meet the extremely stringent 0.25mg/l P permit all year round. This is quite normal for larger biological phosphorus removal sites and has still been calculated to be the best value solution overall whilst creating a more sustainable solution for the removal of phosphorus at our largest works.

Following completion of Phase 3, Davyhulme will meet the stringent 6mg/l BOD, 1mg/l ammonia, 0.25mg/l phosphorus permit.

Figure 9: Simplified proposed process flow at Davyhulme for AMP9



Source: UUW analysis

5. Constructability challenges and influence on cost

Davyhulme WwTW is a highly constrained site with a limited footprint for construction of new assets. Our review of the construction plan for the Davyhulme solution identified a number of areas of site-specific challenges which have led to an impact in the total project cost for the scheme (Table 3).

Table 3: Davyhulme WwTW - Key Site Constructability Challenges

Item	Total Capex (£m)
Demolition of ASP1	50.8
Disposal of Contaminated Material	44.3
Piling	43.3
Land Purchase	20.0
Prolonged programme due to sequencing (12 months additional)	14.7
Total	173.1

Source: UUW analysis

The largest impact on the construction cost is the demolition of ASP1 (Section 5.1). This is closely followed by the impact of disposal of contaminated land and gas protection measures along with the need for deep piling (Section 5.2). The following sections will describe these plus other site-specific constructability challenges in more detail.

5.1 Demolition

To free land for the construction of the proposed activated sludge plant (ASP4), demolition will be required of the redundant ASP1, its associated primary tanks, and final settlement tanks (approximately 15 acres). As part of our optioneering process we did determine the potential to reuse the assets on the redundant ASP1 stream, but this was not viable, due to being similar in design to ASP2 including the shallow nature of the final settlement tanks. Demolition activities will take approximately 24 months and incur significant cost.

Prior to commencing demolition, significant service diversions will be required to the site high voltage ring main, in the vicinity of redundant ASP1.

5.2 Ground Conditions

Ground information from both historic ground investigations and the recent AMP6 modernisation projects evidence's that several significant factors are present that will increase the cost and schedule for ground works:

- Gound conditions are poor and structures will require deep piling (7,500 piles up to 25m)
- There is significant congestion of existing services on site, which will require an extensive diversions and protection work with an associated cost and schedule impact,
- Permeable granular deposits close to the Manchester Ship Canal will require temporary works dewatering to enable the construction of buried structures
- Aggressive soil conditions (high acidity and sulphur) are present on site that will necessitate the use of specialist concrete.

5.3 Surrounding built environment

The site at Davyhulme is extremely constrained, with the high-level motorway bridge over the Manchester Ship Canal (M60 Barton Bridge) immediately to the North, a retail park to the East, to the South by residential properties and by the Manchester Ship Canal to the West (Figure 2).

Additional costs and programme impacts will be incurred related to adapting construction methodologies and working times to reduce impact of works on customers and third-party assets.

The overview of Davyhulme following completion of AMP8 and AMP9 interventions is demonstrated in (Figure 10). As shown the level of change is significant, which is central to our desire to phase interventions over AMP8 and AMP9. While significant in size of build, we are confident we have a plan that is now deliverable over the two investment periods and we are ready to enter the delivery phase crucial to improving the Manchester Ship Canal for customers.

5.4 Land and Planning

There is insufficient land available for construction, logistics, welfare and construction facilities and land will need to be purchased adjacent to the site at premium cost (based upon GL Hearn Limited valuation December 2022).

There is also limited land available for the reuse of excavated material on site. Off-site disposal costs will be incurred for significant volumes of excavated material (65,000m3).

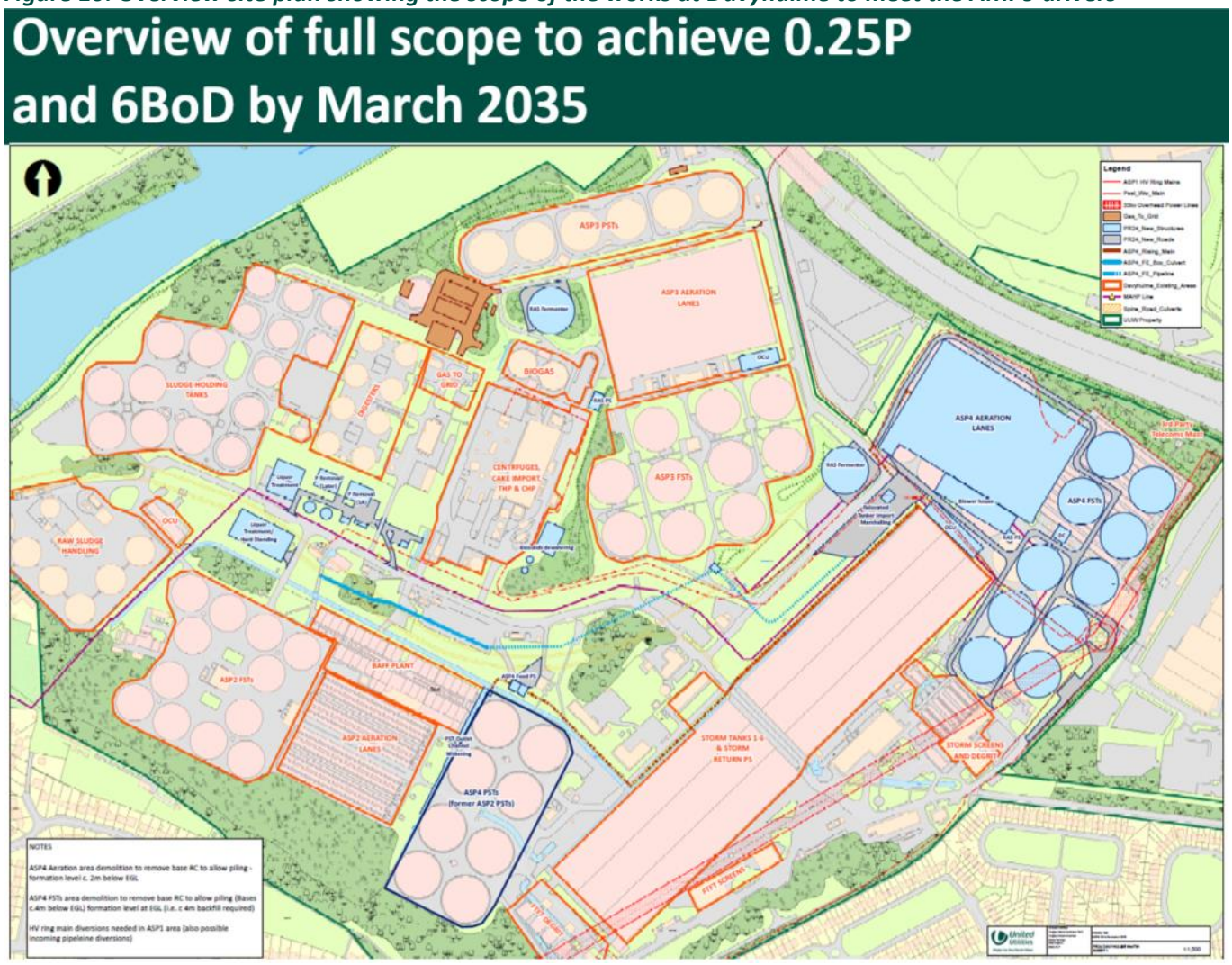
The proposed works are extensive and will require an Environmental Impact Assessment (EIA) Screening Opinion. There is a risk that should a full EIA be required; this will add 12 to 18 months to the project programme (in addition to the prolonged programme due to sequencing identified in Table 3). Full planning is required and based upon advice of our planning consultants will require a minimum of 18 months to obtain the required approvals given the scale and impact of the scheme.

5.5 Sequencing of programme

The phased consented approach results in the need for a sequenced project build programme, with early AMP8 work becoming redundant in AMP9 (Figure 11). To achieve the 8mg/l BOD requirement in 2028, enhancement of ASP2's primary settlement tanks and final settlement tanks is required. These works will become redundant (other than enhancement of the primary tanks) once the ASP4 stream is commissioned in 2035 to meet the 6mg/l BOD requirement.

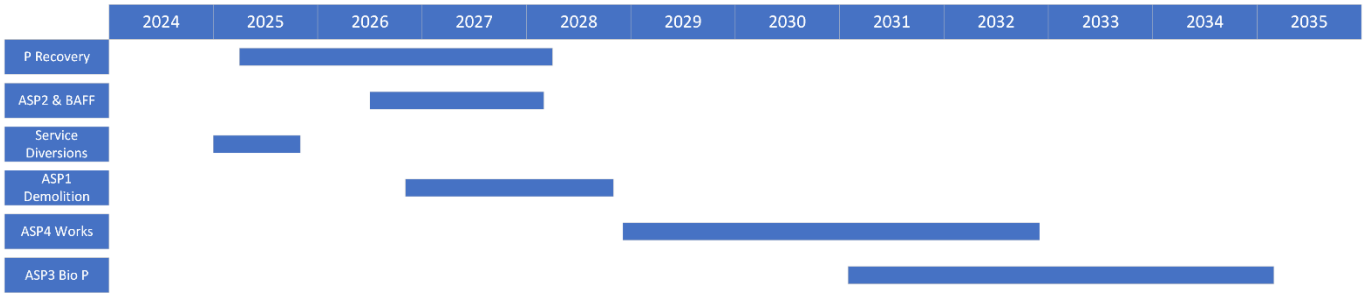
The scale and complexity of the existing site assets requires a phased delivery approach which will add significant cost and prolongation to the project programme (approximately 12 months in aggregate). The main ASP3 and ASP4 will need to be commissioned sequentially and operate in tandem with existing assets until the new operation has been established.

Figure 10: Overview site plan showing the scope of the works at Davyhulme to meet the AMP9 drivers



Source: UUW analysis

Figure 11: High-level programme illustrating the sequencing of the construction activities.



Source: UUW analysis

Figure 11, a simplified delivery schedule, demonstrates that construction activities are planned to be delivered over a number of years. This is to allow for maintaining service while construction continues, and assets are decommissioned and others brought on line. This AMP8 and AMP9 plan is significant, but now also deliverable, following the agreement of regulatory dates with the Environment Agency.

6. Challenging our own costs

Prior to the submission of our business plan, we challenged our solutions to ensure they were efficient and best value for customers. In the case of Davyhulme significant efficiencies were adopted including the removal of a tertiary solids process, which was included to ensure robust 6mg/l BOD and 0.25mg/l P. We are confident that this is the most efficient solution, however it will leave us with some operational risk to manage to achieve the tight phosphorus permit. Unlike Eccles there is not a stringent iron limit which is allowing us to make this efficiency and manage this risk and therefore not burden customers with additional costs in this instance.

The cost challenge generated significant efficiency for Davyhulme, which was removed from our costs prior to the submission of our business plan.

6.1 Efficiencies Identified since submission

Post business plan submission we have continued to develop the technical solution through our transitional investment funding. We appointed Jacob's as our Strategic Solution Partner in February 2024, and since then we have been working with their global experts to leverage advancements in technology and identify efficiencies.

Through this we have identified a further £169m of efficiency savings across the AMP8 and 9 drivers.

This results in a revised business plan of £618m, with £292m required in AMP8 which is included in our Draft Determination response. The key efficiencies identified since October 2023 submission are as follows:

- An alternative phosphorus recovery technology has been identified that reduces capital and operational costs. This change in solution has also allowed us to reduce the scope associated with the odour control plant;
- Alternative technology for phosphorus recovery has modular options which are complementary to our adaptive plans over AMP8 and AMP9;
- Existing odour control optimisation reducing the need for additional odour control for the new interventions, and
- Optimisation of existing ASP processes which supports a lower cost new ASP.

7. Conclusion

Davyhulme WwTW is our largest WwTW with a significant step change in AMP8 on the way to the stringent TAL drivers of 6mg/l BOD and 0.25mg/l phosphorus in AMP9. We are committed to deliver this in agreement with the Environment Agency through the adaptive plan for the area, however these significant improvements are not possible with the existing asset base. The information outlined within this document provides evidence of the need for intervention at Davyhulme WwTW, how we are confident in the scope, cost and delivery schedule. The bottom-up assessment, large biological P removal process and the many site considerations are aspects that we consider would not be well represented through standard cost assessment models.

Through AMP7 we have worked closely with the Environment Agency and have carried out a comprehensive study of phosphorus in the extensive catchment served by Davyhulme WwTW. This has given us a much better understanding of the challenges to meet the 0.25mg/l phosphorus TAL in conjunction with the 6mg/l BOD TAL and we have since undertaken significant engineering design work to develop our solution for Davyhulme WwTW.

We have carried out a comprehensive solution identification process and this has been estimated in detail as part of a bottom up estimating approach whilst considering the site-specific constraints. By considering solutions which complement both the 6mg/l BOD and 0.25mg/l phosphorus drivers we consider we have developed the best value solution for customers and the environment. This is validated by putting forward the lowest whole life cost solution of biological phosphorous removal for ASP3 and the inclusion of a new ASP4 stream.

In conjunction with the Environment Agency, we have developed and agreed an adaptive plan for Davyhulme. This provides the best value for customers and allows us to make incremental environmental improvements as early as possible before achieving the TAL drivers of 6mg/l BOD and 0.25mg/l P in 2035.

By forming an adaptive plan, we identified early interventions that could be implemented in AMP8 to facilitate Davyhulme WwTW to operate at tighter standards for BOD and phosphorus and this is reflected in the WINEP. Despite Davyhulme WwTW being extremely congested and land-locked by the M60 motorway, the Manchester Ship Canal, customer's properties and a retail park, along with the other constructability issues identified in this document, the solution we have put forward is deliverable and considers all these challenges.

Since we submitted our plans in October 2023, we have continued to work on developing our solutions for Davyhulme challenging ourselves on the costs we have put forward. Following the appointment of our Strategic Solutions Team partner Jacobs, we have been able to provide a more efficient solution for biological phosphorus removal which is reflected in the revised cost.

Our solution secures a central part of our adaptive plan for Davyhulme which is key to the wider Manchester Ship Canal strategy. With awareness of the long-term drivers in the Environment Act, we have been able to include solutions for AMP8 that enable best overall value for customers and the environment considering both the AMP8 and AMP9 drivers, minimising abortive investment.

8. References

United Utilities (2021) Davyhulme WwTW – Phosphorus Investigations, September 2021