

Leeds City Council

Leeds Flood Alleviation Scheme

**Justification for Change to Material
Finishes at Crown Point Weir**

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This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.

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Executive Summary

As part of the Leeds Flood Alleviation Scheme, the existing Grade 2 listed weir at Crown Point, known locally as Leeds Dam is to be replaced with a new weir on the same alignment as the older structure but with movable components below the water to allow reductions in the river level at times of flood. English Heritage have supported the grant of Listed Building consent on the basis that from the substantial harm from the alterations to the weir is outweighed by the wider public benefits protection from flooding to an area of wider area of heritage significance, along the city's historic waterfront.

It should be noted that there are also a number of different construction types and materials used in existing walls and structures in this area. These include sheet piles walls, original mass stone river walls, concrete copings and numerous brick types. Stone is only one of the materials utilised in this area with mixed character and a variety of modern buildings surrounding the site.

The new weir shall include piers and walls which will be visible above the water level in normal river conditions. The planning consent has conditioned the construction of the new weir to include stone masonry finishes. In practical terms this would mean, either solid masonry piers or a composite structure formed from a concrete frame and then clad with masonry would be required. **The use of solid masonry is not supported in terms of its increased maintenance and constructability requirements, whilst the use of cladding is not supported on maintenance grounds including longevity of the cladding and resistance to damage from impact debris.**

The piers are located within the middle of the river channel and as such are subject to peak river velocities with a significant risk of impact from flood bourn debris such as tree trunks which brings a significant risk that the masonry face is vulnerable to being broken off and damaged. Also the abrasive action of the river will mean that the masonry joints are vulnerable to erosion and colonisation by structurally damaging vegetation such as buddleia.

The suppliers of the moveable components of the weir estimate that the mechanical components will need maintenance and overhaul about once every 20 to 25 years, and this operation will require construction of extensive temporary access arrangements to ensure the safety of the operatives. With the use of masonry finishes it is estimated that the structure could require repair at least once every 10 years, also requiring temporary access within the river and not necessarily at a timing which coincides with the mechanical components overhaul. An increased maintenance regime will increase the Health & Safety Risk as more frequent in-river working will be required to inspect and repair the cladding and mortar.

Leeds City Council has an obligation under the Construction Design and Management Regulations (CDM) and as operators of the weir to minimise the health and safety impacts of maintenance. Also as designers, Arup have to consider and minimise through design, the risks on construction and maintenance. BAMNuttall as the appointed contractor for the weir construction do not favour masonry cladding either as it makes construction more complex, more vulnerable to damage and is on a prolonged construction timetable.

In particular, Leeds City Council as operators of the weir and Arup as designers therefore do not recommend the use of masonry in this location as it would require a more regular and extensive maintenance regime to include inspection, replacing lost stone, re-pointing, repair and treatment to prevent the establishment of vegetation.

The riparian owner of the weirs, the Environment Agency who have extensive experience in maintaining in-river assets are in agreement with this philosophy and have endorsed the use of concrete throughout the fixed parts of the weir structure. The Canal and Rivers Trust also identify the use of concrete as appropriate given that the new weir represents a modern addition to the waterway and requires the use of modern materials to avoid a pastiche development. It is noted that the new Leeds Southern Station Entrance has concrete piers which are exposed in the finish of the structure.

English Heritage have been consulted on the use of concrete finishes to the piers and do not object to the application to vary condition 18 of 14/01511/FU.

The use of high-quality concrete is supported as an appropriate material by the Environment Agency, Canal and Rivers Trust, Arup as LCC Technical Advisor, BAMNuttall as construction contractor. Concerns have been raised by these organisations in relation to the associated maintenance issues which would arise with the use of stone for the weir piers as outlined below in the report. The LCC project team have chosen the material based on the technical advice provided by the various technical and advisory parties engaged in the detailed design process.

This report therefore supports an application to amend the planning condition regarding the use of a masonry finish, instead recommending a more durable homogenous concrete structure with the exposed concrete surfaced being finished to a very high quality standard.

1 Introduction

As part of the Leeds Flood Alleviation the existing weirs at Crown Point (Leeds Weir) and Knostrop are to be replaced with new movable weirs. Other elements of the scheme include linear defences and the merging of the canal and river channels along the Knostrop Cut. Planning permission 12/04465/FU for two replacement movable weirs and associated infrastructure was granted on 1st May 2013.

As further detail for the new weirs was determined, application minor material amendment to the original permission was sought under Section 73 of the Town and Country Planning Act updating a previous application on 17th March 2014 (LCC reference 14/01511/FU) and planning permission was granted on 26th June 2014 with a number of conditions.

Condition 18 states *“Prior to the construction of the external facing materials, full details of all external facing materials for the in channel piers, fish passes and turbines shall be submitted to and approved in writing by the Local Planning Authority with the agreed details implemented in accordance with the approved details and retained and maintained as such thereafter. **Such details shall include the use of stone for the in channel piers at Leeds Weir.**”*

Having undertaken more design development and having appointed a Contractor to undertake the works the Project Team, has a greater understanding of the implications attached to Condition 18, particularly with regards the technical feasibility, maintenance and cost and seek to amend this condition to allow for the use of high quality concrete finishes at Crown Point (similar to those accepted at Knostrop Weir).

The purpose of this report is to provide justification in support of an application to vary condition 18 to remove the requirement for the use of stone for the in-channel piers at Leeds Weir.

2 Background

2.1 Timescales for delivery

The Leeds Flood Alleviation Scheme (Leeds FAS) is funded from a number of sources including Leeds City Council, Regional Growth Funding; Flood Defence Grant in Aid (from the Environment Agency) and Economic Development Funding (from Defra).

A requirement of the various different funders is that work on the Leeds FAS is completed by March 2017 with £10M spent by mid-2015. This has meant that the project has required an accelerated approach towards planning and procurement.

Outline details have been presented to Plans Panel at pre-application presentations and further details have been presented as they have been developed throughout the development of the design. Engagement with Planning Officers and appropriate consultees has been undertaken throughout the development of the project.

A report by officers in relation to planning application 14/01511/FU for the two replacement weirs at Knostrop and Crown Point Weirs was presented to the City Centre Plans Panel in June 2014. The report included for the use of high quality concrete finishes for the piers at both locations.

At the time, high quality concrete finishes were promoted by the Project team at both locations based on the following reasons:

- The concrete option offered the lowest maintenance costs, as the surface finish would not promote the growth of vegetation such as buddleia.
- The concrete option offered the lowest health and safety risk associated with construction and maintenance.
- The movable weirs are a modern innovation and the concrete finish is deemed contemporary with this construction.
- A high quality concrete finish was estimated to be the most cost effective option, in terms of its simplicity to construct.

The case for concrete finishes was supported by the Plans Panel at Knostrop Weir as it was deemed a less sensitive area in terms of visual appearance of the weir and in a less prominent position on the outskirts of the City.

The proposal for concrete finishes at Crown Point however was not supported as this area is regarded as more sensitive in terms of the existing heritage context and it was requested that a condition that the weir piers should be finished in stone be specified.

3 Feasibility Review

Since the submission of planning application 14/01511/FU, LCC, Arup and BAM Mott Macdonald (BMM), the Contractor appointed to undertake the works have undertaken a feasibility review to establish how the masonry finishes might be achieved and whether the risks outlined could be mitigated.

This review included;

- Site Context
- Proposed Structure
- Options

The findings of this review are outlined in this report.

3.1 Maintenance

Concerns were expressed by the Project Team at Plans Panels in response to questions from members that the use of masonry at this location would increase maintenance liability for this critical piece of flood resilience infrastructure. This would include regular treatment to replace or repair stones hit by debris, to repair masonry joints and to remove vegetation.

The new weir will be owned by the Canal and Rivers Trust (CRT) and leased to Leeds City Council on a 250 year lease. Leeds City Council will be responsible for the maintenance of the weirs over this period. Both stakeholders have accepted the use of high quality concrete finishes and expressed concern over the potential maintenance issues associated with masonry.

It was agreed by the Project Board to review all the options and return to Plans Panel with more detailed justification for the Project teams preferred weir finish.

3.2 Site Context

The site combines a mixture of historic structures such as the recently widened Crown Point Bridge and original river walls, and more contemporary buildings such as Merchants Quay, Turlow Court, Fearn's Wharf, Royal Armouries and Clarence Dock.

There are also a number of different construction types and materials used in existing walls and structures in this area. These include sheet piles walls, original mass stone river walls, concrete copings and numerous brick types. A selection of these different materials and construction types are shown in the photographs below.



Photo1 - Existing walls around Crown Point Weir have various finishes.

3.3 Existing Finishes at Crown Point

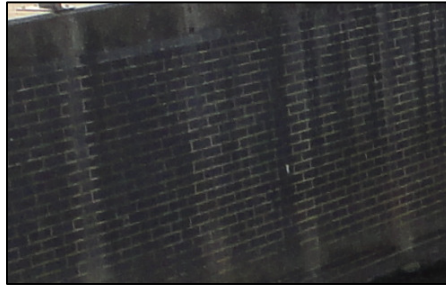


Photo 2: Fearn's Island River Wall, adjacent to weir
Photo 3: Turlow Court River wall, adjacent to weir
Photo 4: Fearn's Wharf River Wall



Photo 5: Buildings on the right bank – Clarence Dock, Royal Armouries



Photo 6: Buildings on the left bank – Merchants Quay, Turlow Court, The Gateway (Background)

3.4 Environmental Context

The river channel is approximately 70m wide at the location of the weir. River velocities vary quite significantly across the width of the weir with maximum velocities in the centre of the channel and lowest velocities adjacent to Fearn's Island. The hydraulic drop across the weir is approximately 1.5m. This means there is a significant amount of energy within the river as it passes over the weirs.

Large debris such as tree trunks often pass over the weir particularly during high flow events and the existing baffle boards are frequently damaged or dislodged.



Photo 7: Leeds Dam – debris and damage to boards

3.5 Proposed Structure

The existing Crown Point weir is a Grade II listed structure. A Listed Building Consent has been granted for the removal of this structure. A portion of the existing weir is to be retained as part of a planning condition and a site interpretation board is provided in the vicinity explaining the heritage of the site.

The proposed new weir consists of two movable flood gates, a fish pass and a portion of retained remnant weir. The weir gates comprise painted steel panels supported on rubberised air bladders founded on a concrete apron (refer to the diagram below).

The new weir will be owned by the Canal and Rivers Trust (CRT) and leased to Leeds City Council on a 250 year lease. Leeds City Council will be responsible for the maintenance of the weirs over this period.

The gates will be predominantly submerged and in normal conditions (Q95) the downstream face and upper 420mm of the dividing piers will be visible (refer to figure 1). **That is to say, under normal river conditions only a limited portion of the pier would be visible.**

A stainless steel panel is inset into the pier to provide a sound interface between the fixed and moving components.

In a high flow event, the piers would be overtopped before lowering the movable gates to drop river levels and prevent flooding at flood events up to a 1 in 100 year return period.

The design criteria for the pier and weir gates against accidental impact is 550kN based on a 20 tonne boat impacting the piers at 4.0m/s. This is a low risk event, however debris impact loads are a more likely event with loads in the region of 100kN. This is sufficient to cause damage to masonry finishes.

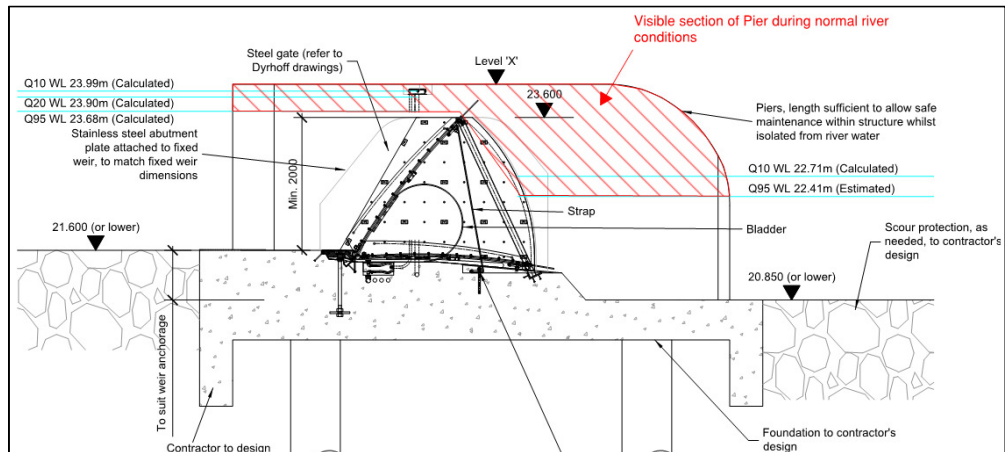


Figure 1: proposed cross section through the weir.

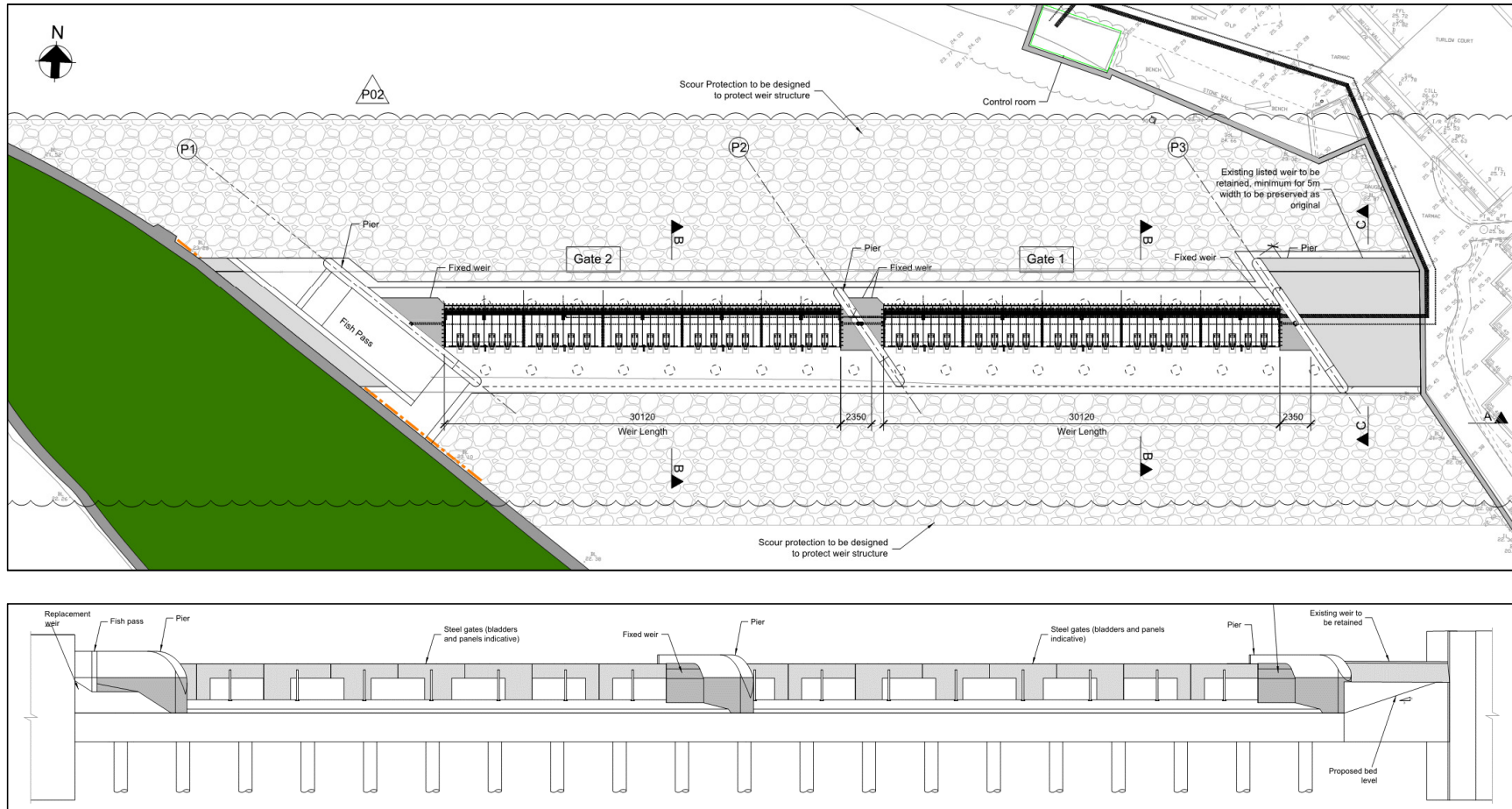


Figure 2 and 3: Plan and front elevation of proposed movable weir at Crown Point

4 Options

The Contractor appointed to undertake the works has reviewed how the masonry finishes might be achieved. Several options have been assessed including;

- Reclaimed stone masonry from Knostrop Cut
- Stone facing
- Pigmented concrete with masonry imprint to replicate a masonry finish.

The impacts on construction and maintenance of the options have been compared against the use of concrete with high quality finishes.

4.1 Option 1 Reclaimed Stone Masonry from Knostrop Cut

This option considers construction of the piers from solid masonry acting structurally. A concrete “pillar” would be required to facilitate the fixing of the stainless steel plate described in section 3.5.

The photograph below shows the size and type of stone that could be reclaimed from the Knostrop Cut when the river and canal channels are merged. This stone would appear to be a good match for similar stone that is used in the construction of Fearn Island.



Photo 7: Typical material along Knostrop Cut

On closer inspection much of the visible masonry is weathered and some has deteriorated and is unsuitable for re-use. The stone below the waterline has not been examined and therefore its' condition is unknown but it can be expected that a significant proportion of it will not be suitable for re-use. It is however considered technically feasible that sufficient quantity of material could be recovered for use at Crown Point subject to inspection of the material once recovered. The recovery of this material would be time consuming and require special lifting equipment to remove each masonry block rather than simple

demolition and excavation techniques. Given the likely deterioration of the stone below the waterline, it is unclear as to whether this would be structurally adequate and the integrity of the stone would under the Contract be a project risk borne by LCC.

The stone would then have to be treated and dressed to fit the dimensions of the weir piers and transported to the Crown Point site. The masonry would require extensive dowelling to ensure the integrity of the pier.

The photograph below shows the deterioration of the stone and varying condition of the masonry at Knostrop Quay which has been discovered during preliminary investigations for the Flood Alleviation Scheme.



Photo 8: Masonry condition at Knostrop Quay

The construction of the piers using this material would be a slow task as the stone would have to be lifted in and require extensive fixing. This would extend the duration of the works within the river. The Contractor has estimated a prolongation of the works in the region of 70 days. The increased cost is primarily related to the longer periods for hire of cofferdams, props, craneage, plant and pontoons.

The costs associated with this option are in the region of £1,200,000.

Significant ongoing maintenance would be required to maintain the masonry, the bed-joint and mortar to ensure the material does not prematurely weather under the action of the river and ensure vegetation was unable to grow and damage the pier further. **Both Canal and Rivers Trust as riparian owner and the Environment Agency have been consulted and expressed a concern at the ongoing maintenance liability of providing a masonry solution at this**

location. This option is not supported by the contractor or the Client's technical advisor given the nature of ongoing maintenance and the risk of sufficient re-useable stone.

Option 1: Construct the piers from reclaimed masonry from Knostrop Cut	
Time Impact on Programme: 70 days Initial estimated cost: £1,200,000	
Advantages	Disadvantages
Meets with planning condition no 18.	Risk that reclaimed material will not be of suitable strength to survive demolition and rebuilding, or continued scour.
	Complex construction methods and temporary works required – blocks would require dowelling into the concrete below
	Method would present significant H&S issues during construction and maintenance.
	Increased maintenance requirements to ensure material integrity
	More vulnerable to vegetation growth

4.2 Option 2 - Stone Facing

An alternative to the use of mass stone would be to construct the piers in structural concrete and face them in masonry cladding to give the appearance of a masonry pier. There are a range of different cladding alternatives such as the ones shown below.



Photos 9 and 10: masonry cladding at Burley Mill Fishpass

In order to incorporate the cladding, it is likely that the width of the piers would have to be increased by approximately 200-250mm per face as the cladding would not act structurally. This option would also require a simpler nosing and coping detail as the rounded bullnoses could not be accommodated with cladding.

This type of cladding is often used on structures which are located at the rivers edge rather than in the middle of the channel, where river velocities are lower and the risk of damage from impact from debris is much reduced. The copings shown in the example above are unlikely to sustain a significant impact load without damage. This risk is likely to be exaggerated as the piers are designed to be overtopped on a regular basis. **The examples identified at Burley Mills are not considered to be a comparable example to the Leeds Weir where piers are proposed in the middle of the channel and there is likely to be associated risk of damage from debris.**

The use of cladding could potentially reduce the programme however again the fixing of cladding would not be a simple task. The Contractors' estimate for programme prolongation is approximately 34 days. The increased cost is primarily related to the longer periods hire of cofferdams, props, craneage, plant and pontoons.

The costs associated with this option are in the region of £510,000.

Similar maintenance issues as those described for the solid masonry option exist with the use of stone cladding. The cladding and coping stones are relatively thin (200 to 250mm) and can be prone to damage particularly in a location where continuous impact from river debris can be expected. **Replacing any damaged masonry would present a significant health and safety risk. Both Canal and Rivers Trust as riparian owner and the Environment Agency have been consulted and expressed a concern at the ongoing maintenance liability of providing a masonry solution at this location. This option is not supported by the contractor or the client's technical advisor given the extent of ongoing maintenance required and the risk of damage to the cladding as a**

consequence of the location within the middle of the Channel where risk from damage is substantial.

Option 2: Construct piers using stone cladding	
Time Impact on Programme: 34 days Initial estimated cost: £510,000	
Advantages	Disadvantages
Meets with planning condition no 18, although the appearance would be affected by the block size	The texture and size of blocks available would not match the existing larger smooth blocks of the river walls
	Complex construction methods and temporary works required
	Increased maintenance requirements
	More vulnerable to damage from floating debris
	More vulnerable to vegetation growth
	Requires a coping to complete appearance – this would mean the current downstream shape of the piers would not be appropriate. A vertical end with a bull nose radius could be provided

4.3 Option 3 – The use of pigmented concrete imprinted with a masonry finish

The appearance of masonry with the robustness and ease of construction of concrete can be achieved to a certain degree of success by the use of pigmented concrete which is cast against a textured form liner. This type of construction is typically used where long lengths of regular walls are required.

The imprinted texture can be either random or regular. The images below show a couple of examples where imprinted concrete finishes have been used.



Photos 11 and 12: Pigmented Concrete with masonry imprint (Derwent Water and Linguen Weir)

This option would also require a simpler nosing and coping detail as the rounded bullnoses could not be accommodated with the imprint. The copings shown in the example above are unlikely to sustain a significant impact load without damage. This risk is likely to be exaggerated as the piers are designed to be overtopped on a regular basis.

This option would have very limited impact on the programme and is likely to be similar to the option of high quality concrete finishes. The liners used to form the imprint are more expensive than standard liners and therefore the estimate for the use of this option is in the region of £250,000.

This construction method is best used on random or rough finished stone and it is unlikely that the existing masonry appearance, which consists of large blocks of smooth faces with close bed-joints could be satisfactorily replicated. Both Canal and Rivers Trust as riparian owner and the Environment Agency have been consulted with regards this option and have not expressed any concerns with this option. It is understood that this option is not supported by LCC Conservation on heritage grounds or by English Heritage who would prefer a smooth finish should concrete be used.

Option 3: Construct the piers using high quality concrete with masonry imprint Time Impact on Programme: 0 days Initial estimated cost: £256,000	
Advantages	Disadvantages
Meets with planning condition no 18, although the appearance would be affected by the masonry liner.	Requires a coping to complete appearance – this would mean the current downstream shape of the piers would not be appropriate. A vertical end with a bull nose radius could be provided.
Efficient construction method	Difficult to maintain continuous and consistent colour shading throughout.
Relatively low maintenance requirements.	Coping detail is more vulnerable to damage from floating debris
Robust construction	
Prevents vegetation establishment	

4.4 Option 4: Use of high quality concrete finishes

The proposal submitted in the amendment to the planning application included piers constructed using high quality concrete finishes. Concrete is frequently used as an architectural material and high quality finishes can be achieved through the use of the appropriate formwork and good working practises. Concrete is the most common material used in bridge piers, particularly those sited within rivers.

Concrete offers an efficient, robust option which is also flexible in terms of the shapes that can be cast. Algal staining can be reduced through the application of additives and transparent membranes. The finish can be softened by the use of exposed aggregate as used at St Anns Weir, R Aire. Concrete is the most durable of the options considered which is why it is frequently used in marine environments such as those at Castleford Weir (R Aire). It is noted that the pillars for the new Southern Station Entrance to Leeds Rail Station are Concrete.

A small selection of photographs of different concrete fishpasses and bridge pier structures are shown below. Castleford fishpass is located within the middle portion of the river and therefore is subject to the peak river velocities.

A significant advantage of concrete over the other options, is that concrete is generally maintenance free with no need to re-point or remove vegetation. **This option is endorsed by the Environment Agency and supported by Arup and BAMNuttall as the most appropriate option for facing of the weir piers. The Canal and Rivers Trust in their planning response identify a high quality concrete finish could be appropriate as an alternative taking into account that the new weir represents a modern addition to the waterway and requires the use of modern materials to avoid a pastiche development.**



Photos 13 and 14: St Anns Weir and Castleford Fish Pass, (both R Aire)



Photos 15, 16, and 17: High Quality Concrete finishes on bridge piers

Option 4: Construct the piers using high quality concrete

Time Impact on Programme: 0 days

Estimated Additional Cost: **£0.00**

Advantages	Disadvantages
Efficient construction method	Does not meet the planning condition 18.
Robust construction	
Low maintenance requirements	
Prevents vegetation establishment	
Colour matches surrounding materials e.g. Meanwood Beck outlet, the adjacent cantilever footway and the Royal Armouries.	
Flexible in terms of the finishes and forms	

5 Visualisations

In this section a number of visualisations have been prepared to provide an indication of how the weir would fit in its surrounding based on masonry and concrete finishes.

The visualisations show a couple of different forms of Control Buildings which are separately being considered at this location. Both forms include a brick finish similar to those that are proposed for the linear defences.

The Control Building form has yet to be confirmed and will be subject to discussion with LCC officers prior to submission of the details for planning approval.



Figure 4: Upstream visual representations of masonry finishes



Figure 5: Downstream visual representations of masonry finishes



Figure 6: Upstream visual representations of Concrete finishes



Figure 7: Downstream visual representations of Concrete finishes

6 Conclusion/ Recommendation

In response to the planning condition, the project team has examined the feasibility of masonry finishes and how they could be accommodated or amended within the design presented in mid-2014, which was for high quality finish homogenous concrete construction. **The use of solid masonry is not supported in terms of its increased resource for maintenance and constructability, whilst the use of cladding is not supported on maintenance grounds including longevity of the cladding and resistance to damage from impact debris.**

The piers are located within the middle of the river channel and as such are subject to peak river velocities with a significant risk of impact from flood bourn debris such as tree trunks which brings a significant risk that the masonry face is vulnerable to being broken off and damaged. Also the abrasive action of the river will mean that the masonry joints are vulnerable to erosion and colonisation by structurally damaging vegetation such as buddleia. No scheme examples have been identified, which are comparable to the current proposals as they generally are located at the river edge where velocities and risk of damage is lower.

The use of stone is therefore not supported in terms of technical feasibility and ongoing increased maintenance regime and liabilities for Leeds City Council as operators of the weir. This is consistent with advice from the Environment Agency and Canal and Rivers Trust as experienced organisations in weir operation and River maintenance who support the use of a concrete finish. We note that concrete has previously been chosen as an appropriate option for the piers for the new Leeds Southern Station Entrance against the backdrop of the Railway Arches.

English Heritage have been consulted on the use of concrete finishes to the piers and do not object to the application to vary condition 18 of 14/01511/FU.

The use of high-quality concrete is supported as an appropriate material by the Environment Agency, Arup as LCC Technical Advisor and BAMNuttall as construction contractor. Concerns have been raised by these organisations in relation to the associated maintenance issues which would arise with the use of stone for the weir piers as outlined below in the report. The Canal and Rivers Trust consider a high quality concrete finish could be appropriate as an alternative taking into account that the new weir represents a modern addition to the waterway and requires the use of modern materials to avoid a pastiche development. The LCC project team have chosen the material based on the technical advice provided by the various technical and advisory parties engaged in the detailed design process. In summary concrete is supported for the following reasons below.

- English Heritage have supported the grant of Listed Building Consent to remove the existing weir and have raised no objections to the proposal to use concrete in the replacement structure.
- The masonry options have additional maintenance liabilities for LCC which have both financial and health and safety impacts over the life of the asset. There would be a need for more regular inspection of the weirs and an increased maintenance regime to ensure any ongoing damage to the

stone face would be repaired and cladding replaced as necessary. This would increase project risk as well as having ongoing budgetary implications for LCC throughout the life of the weir.

- Canal and Rivers Trust and the Environment Agency are supportive of the use of concrete finishes as they regard concrete as the most durable and appropriate material in terms of maintenance in this location and given the modern structure being proposed.
- BMM, the Project Contractor has assessed that the concrete option optimises the health and safety issues during construction and provides the most economic solution as well as being recommended in terms of ongoing maintenance.
- Arup, LCC's technical advisor recommend that the use of concrete with high quality finishes provides the most durable solution with the least ongoing maintenance liability. It also mitigates the H&S risks during construction and maintenance.