

# Updated Hoveton Wetlands Restoration WFD Compliance Assessment

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## Introduction

This assessment is an update to the 'Hoveton Wetlands Restoration WFD Compliance Assessment, March 2014'. It provides a concise update using the most recent WFD condition assessments and reviews the conclusions of the 2014 assessment. It should be read in conjunction with the 'Hoveton Wetlands Restoration WFD Compliance Assessment, March 2014' (submitted with FRAP application) and the 'Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA), January 2020' (submitted with FRAP application). The sediment removal works associate with the project have been completed. This updated assessment therefore focuses on the WFD impact of the biomanipulation of Hoveton Great Broad and Hudson's Bay, namely:

- the installation of three fish barriers on Hoveton Great Broad and fish removal
- biomanipulation - the removal of >75% of the fish biomass from Hoveton Great Broad and Hudson's Bay
- the introduction of the removed fish in to the River Bure

## Hoveton Great Broad Restoration Project update

The project has just completed the process of sediment removal and the establishment of fen vegetation areas. Sediment was dredged from the broad to a depth of 1.1m and used to fill geotextile bags to create new vegetation areas. Additional sediment was then taken to back fill the northern and western sites only. Fen vegetation was taken from woodbastwick marshes, adjacent to decoy broad, to help establish these new fen areas. Early signs of growth seen on these areas is encouraging.

The next phase of the project is to install water permeable barriers to carry out biomanipulation. These fish proof barriers are proposed to be placed on the openings to Hoveton Great Broad. They will allow water to circulate normally. Biomanipulation will then involve the removal of >75% of the fish biomass focusing on zooplanktivorous and benthivorous fish species. This should provide conditions for the clear-water state to be recreated and in turn allow macrophytes to re-establish. Once a diverse and abundant macrophyte community has been achieved it is anticipated the broad will maintain a stable clear water, macrophyte dominated state, and the barriers will be removed.

Simultaneously, the project continues to maintain and develop the Hoveton Great Broad Nature Trail, seeing a year on year growth on visitor numbers of around 10% a year. The project also delivers an extensive engagement and community outreach programme which worked with 3000 people last year across 55 events.

## WFD assessment

The following section considers the change in WFD condition since the 2014 assessment and reviews the conclusions of the 2014 assessment in light of the current information available. The project will no longer be undertaking the proposed marginal habitat works at Wroxham Broad therefore Wroxham Broad has not been included in this updated analysis. In addition sediment removal and creation of the new fen areas on Hoveton Great Broad has been completed, therefore this update assessment will focus on the isolation of Hoveton Great Broad from the system, via the installation of water permeable barriers, the removal of fish as part of the biomanipulation, and the introduction of these removed fish in to the River Bure.

## Hoveton Great Broad (waterbody ID: GB30535977)

Key activities to be assessed for Hoveton Great Broad:

- Broad isolation and fish removal

Table 1. Selected WFD data for Hoveton Great Broad waterbody. Quality elements are italicised, statuses are in bold and failing elements are in red and passing elements in green.

<b>Hoveton Great Broad</b>		<b>waterbody ID: GB30535977</b>	
Waterbody size:	0.37km		
Typology:	High Alkalinity, Very Shallow		
Hydromorphology designation:	Heavily modified		
	<b>2014 classification</b>	<b>2016 classification</b>	
<b>Overall Water Body:</b>	<b>Moderate</b>	<b>Poor</b>	
<b>Biological Status:</b>	<b>Moderate</b>	<b>Poor</b>	
<i>Macrophytes:</i>	<i>Moderate</i>	<i>Poor</i>	
<i>Phytoplankton Blooms:</i>	<i>Poor</i>	<i>Poor</i>	
<i>Fish</i>	Not assessed	Not assessed	
<b>Physio-chemical Status:</b>	<b>Moderate</b>	<b>Moderate</b>	
<i>Dissolved Oxygen:</i>	<i>High</i>	<i>High</i>	
<i>Total Phosphorous:</i>	<i>Moderate</i>	<i>Moderate</i>	
<b>Specific Pollutants:</b>	Not assessed	Not assessed	
<b>Morphology Status:</b>	<b>Good</b>	<b>Good</b>	
<i>Hydrology:</i>	<i>High</i>	<i>High</i>	
<i>Morphology:</i>	<i>Good</i>	<i>Good</i>	
<b>Chemical Status:</b>	Assessment not required	Assessment not required	

Hoveton Great Broad (HGB) (waterbody ID: GB30535977) consists of HGB itself as well as the smaller broad Hudson's Bay. It is connected to the River Bure (waterbody ID: GB105034050930) at various points where water exchange occurs. Water from the Hoveton Marshes also drains into this waterbody but the majority of the dykes on the marsh are silted up and the marshes themselves are scrubbing over.

### Macrophytes – **Poor**

Since the 2014 assessment macrophytes have deteriorated from moderate to poor despite improvements in water quality within the River Bure as discussed above. This decline occurred before the first round of sediment removal in August 2016 so is due to natural deterioration of the

water body. This decline is likely to be a consequence of continued high turbidity within Hoveton Great Broad associated with high algal load. Other mechanisms could include sediment suspension through wind action, or benthivorous fish feeding.

The installation of fish barriers and biomanipulation of Hoveton Great Broad and Hudson's Bay will help improve conditions for macrophyte growth and recovery, reduce sediment suspension by removal of benthivorous fish, and sedimentation from wind action as macrophytes stabilise the sediment. Any localised damage to macrophytes during the installation of the barriers will be minimal and short-term.

There is no change from the conclusion of the 2014 WFD assessment:

*'the central aim of this project is to improve the clarity of the water in the broad which will improve conditions for macrophyte growth. The project is using proven methods to restore the broad back to an ecologically favourable condition of clear water with lush macrophyte growth.'*

Indeed, the proposed works should deliver a significant improvement in the macrophyte WFD element.

### **Phytoplankton – Poor**

There has been no change in phytoplankton status since the 2014 assessment. The installation of fish barriers is not expected to suspend significant amounts of sediment. However, if some sediment is suspended the conclusion of the original assessment still stands, with improvements expected following biomanipulation:

*'The impact of the works will be of a temporary nature and will not impact the WFD status for phytoplankton blooms. An increase in blooms may occur for a short time after the works but when the lake is monitored for WFD these impacts should no longer be apparent. Phytoplankton is monitored in the summer between July-September. In the long-term the Phytoplankton bloom status should improve as the amount of phosphate in the waterbody will be less as a result of the sediment removal. Also, as part of this project, fish will be removed from the broad and the broad isolated for up to 10 years [permission for 10 years granted, complete restoration may take 15-20 years]. Removal of fish has been shown to reduce chlorophyll a, a proxy for phytoplankton abundance, in shallow broads (Moss et al., 1996). Fish predation of zooplankton can suppress zooplankton numbers so that they are no longer effectively grazing phytoplankton. This allows phytoplankton abundance to increase thus increasing turbidity and suppressing macrophyte growth. The removal of fish coupled with sediment removal can have an almost immediate positive impact on water clarity and macrophyte growth (Moss et al., 1996).'*

### **Fish – not assessed**

No tool is currently available to assess the WFD status of the fish communities in lakes, therefore the Environment Agency have not assessed the fish element for Hoveton Great Broad. Given the concern about the fish population a WFD assessment has been completed by Natural England using the best available evidence and is available in the 'Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA), January 2020' (submitted with FRAP application).

## Dissolved Oxygen – High

There has been no change in dissolved oxygen status since the 2014 assessment. Installation of fish barriers is not expected to suspend significant amounts of sediment. Monitoring of Dissolved Oxygen levels during sediment removal did not record any significant declines (i.e. danger to fish), and effects are short-term. There is no change from the conclusion of the 2014 assessment:

*‘High status is the top status under WFD and indicates that human activity is having no or limited impact on this element. DO will only be temporarily impacted by the [works] and therefore there will be no deterioration in the WFD status for this element.’*

## Total Phosphorous – Moderate

The status of total phosphorus has not changed since the 2014 assessment. Whilst the River Bure has seen improvements in phosphorous levels these improvements have not been seen in Hoveton Great Broad. The high levels of phosphorus in Hoveton Great Broad are attributed to in lake nutrient cycling caused by the presence of nutrient rich sediment. In lake cycling is expected to improve following the sediment removal.

In addition stabilisation of the sediment through establishment of macrophytes should further reduce in lake cycling. Increased macrophytes are also likely to reduce phosphorous through direct absorption during growth.

There is no change to the 2014 assessment:

*‘Apart from a potential short-term increase in total phosphorous the long-term impact of these works will be to reduce total phosphorous concentrations.’*

## Hydrology – High

There has been no change in hydrology element since the 2014 assessment. The fish barriers being installed on Hoveton Great Broad will be constructed from 2mm screen and permeable to water. Therefore the conclusion of the 2014 assessment stands:

*‘No water level management works are planned for this project nor are any of the other works expected to have an indirect affect on hydrology. No abstraction of water is planned either therefore no deterioration in this element is to be expected.’*

## Morphology – Good

There has been no change in the morphology classification since the 2014 assessment. The installation of fish barriers will not have an impact on the morphology of Hoveton Great Broad, therefore there is no change in the conclusion of the 2014 assessment:

*‘There should be no long-term deterioration of this quality element’.*

## Reasons for not achieving good status

The Environment Agency provides reasons for not achieving good status (RNAGS) for each WFD body. Table 2 provides a summary of the RNAGS for Hoveton Great Broad (waterbody ID: GB30535977). The table indicates the main reason for HGB failing to meet its WFD objectives are diffuse sources, mainly from Agriculture and rural land management. The Environment Agency have asked the Hoveton Great Broad restoration project to evidence how biomanipulation will improve

the WFD status of Hoveton Great Broad, and why the focus of the project is not on diffuse sources of pollution from agriculture and urban sources (as per the RNAGS identified by the Environment Agency).

Whilst diffuse pollution from agricultural and urban run-off has played a part in the current WFD status of HGB, it is incorrect to identify it as the main driver for continued poor status. The science does not support the Environment Agency's conclusions, as discussed below, and evidenced in the 'Hoveton Project creating a sustainable future for the Bure system' report submitted to support this application.

Table 2. Environment Agency RNAGS for Hoveton Great Broad (waterbody ID: GB30535977).

SWMI	Activity	Category	Classification Element
Diffuse source	Poor nutrient management	Agriculture and rural land management	Phytoplankton
Diffuse source	Poor nutrient management	Agriculture and rural land management	Total Phosphorus
Diffuse source	Track/rural road	Agriculture and rural land management	Macrophytes and Phytobenthos Combined
Diffuse source	Poor nutrient management	Agriculture and rural land management	Macrophytes and Phytobenthos Combined
Diffuse source	Track/rural road	Agriculture and rural land management	Total Phosphorus
Diffuse source	Contaminated land	Urban and transport	Phytoplankton
Diffuse source	Track/rural road	Agriculture and rural land management	Phytoplankton
Diffuse source	Contaminated land	Urban and transport	Macrophytes and Phytobenthos Combined

The main source of diffuse pollutants in to HGB come from the River Bure. There is little land adjacent to HGB which would provide significant source of diffuse water pollution. Since the 1980's there has been a significant effort to reduce the diffuse pollution in the River Bure through phosphate stripping at sewage treatment works and engagement with farmers to reduce diffuse pollution through agri-environment schemes and the Catchment Sensitive Farming programme. This has delivered significant improvements in water quality in the River Bure, but despite these improvements the condition of HGB continues to deteriorate. Figure 1 shows the reduction in riverine phosphorus over the years. The rivers Bure, Ant and Thurne (but not the broads attached to them) are now generally at high WFD status for phosphorus, reflecting the historic and ongoing efforts to minimise point and diffuse sources of pollution.

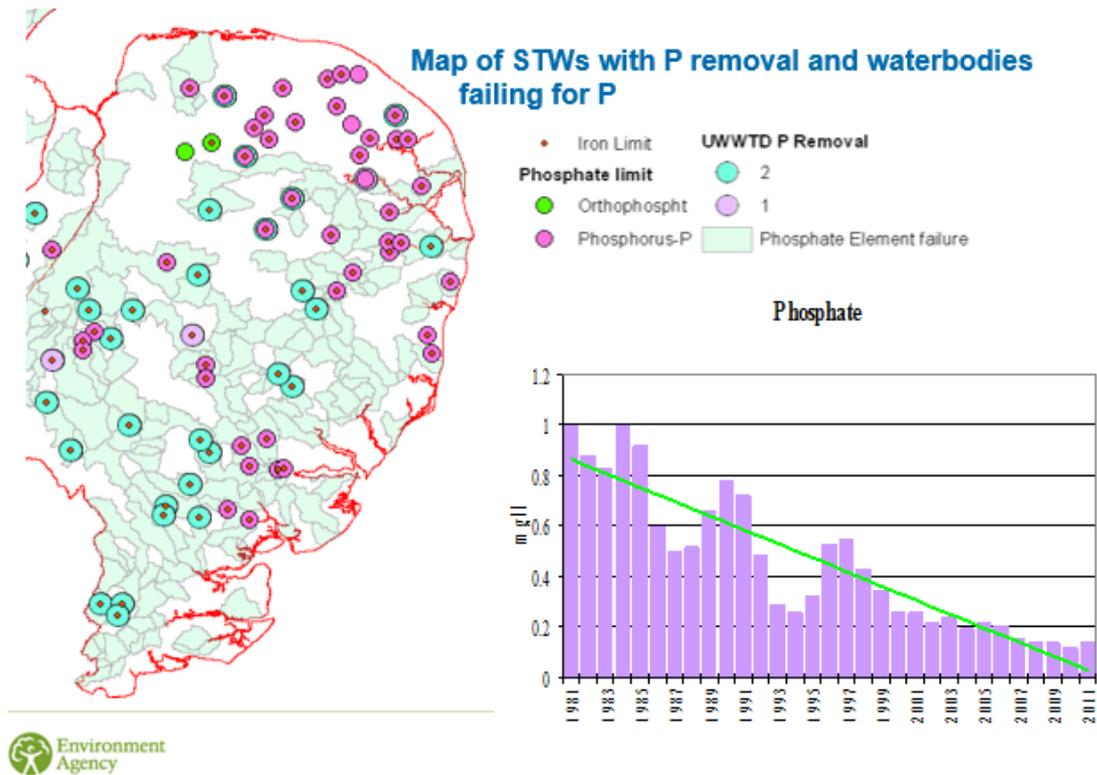


Figure 1. Reduction on phosphorus loading from STWs 1981 to 2011 (EA presentation, date unknown).

It is well known that shallow lakes can exist in two states, both of which are considered stable states (Sheffer et al, 1993). The idea was first proposed in the 1960's (Lewontin, 1969) and described mathematically within ecological communities in the 1970's (May 1977). This means that it is difficult to move from one state to another without certain switching mechanisms being applied. The two states of shallow lakes are:

1. clear-water macrophyte dominated state
2. algal dominated turbid state

Figure 2 below shows that the two states can exist over a wide range of overlapping nutrient concentrations. They are essentially stable owing to ecological feedback mechanisms (food chain relationships such as top down predation that aid grazing on plankton and bottom up relationships such as algae shading light and thus stopping plant growth). These controlling relationships both maintain the current state and prevent it switching to the other state. The effort required to switch between states is dependent on the nutrient status of the lake. The role fish play in maintaining a feedback loop are addressed in the 'Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA), January 2020' (submitted with FRAP application) and will not be covered further in this section.

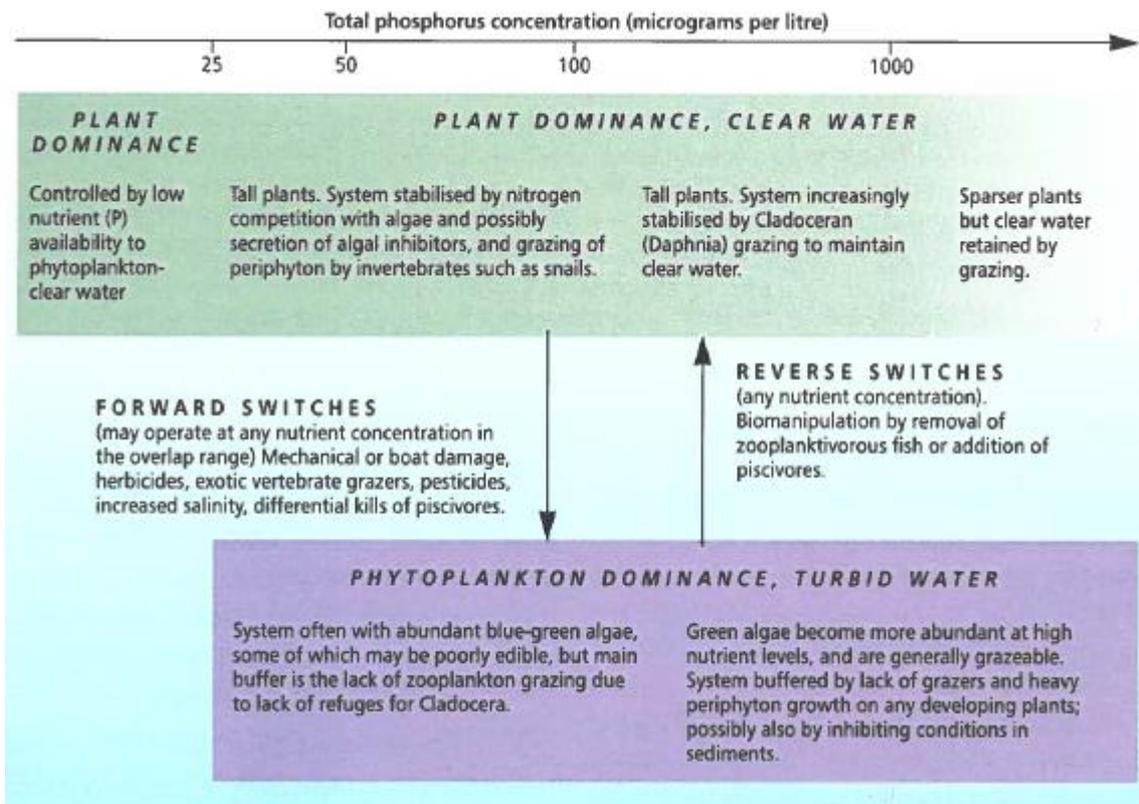


Figure 2. The alternative stable states model for dominance by aquatic plants or phytoplankton in shallow lakes, over the gradient of total phosphorus concentrations that includes both pristine values and those encountered in polluted conditions (Moss et al. 1996)

Phosphorus concentrations of <0.03mg/l are required for Hoveton Great Broad, Hudson's Bay, and the other broads to recover naturally (Moss et al. 1996).

The Diffuse Water Pollution Plan (DWPP – still in draft and unpublished) has modelled the current sources of P in the river Bure as shown in figure 3. This shows that the major contributors are Sewage Treatment Works (STWs), livestock, and urban run-off. In order to achieve the target of 0.03mg/l in the Bure the DWPP has modelled that 12 STWs will need further P stripping up to the technical achievable limit, and 100% uptake of P reduction methods across agriculture.

Whilst Anglian Water have committed to delivering their fair share reduction in P by 2030 this would only deliver a P concentration within the River Bure of 0.052mg/l. The Catchment Sensitive Farming review 2006 -2018 shows that since 2006, 34% of the farmed area in England is managed by CSF engaged farmers with an uptake of 59.6% uptake of advised measures. This has seen a modelled decrease of 2.4% for total P in rivers from farm sources within target areas up to January 2018 (EA 2019). It is evident from this data that a 100% of uptake for all agriculture methods on all agricultural land within the Bure catchment is not going to be achieved within the short to medium term. Therefore P concentrations of <0.03mg/l will not be achieved, and biomanipulation of the fish community is the only option to restore the WFD status of the broads to favourable condition and good ecological status.

In contrast Phillips et al. 2015 concluded that mean total Phosphorus concentrations of <0.055mg/l are likely to be required to achieve successful biomanipulation. Therefore the modelled reduction to 0.052mg/l by 2030 (within the life span of the barriers) will be sufficient to see successful

biomanipulation and the improvement in WFD status, which would not be achieved by focusing only on diffuse pollution for agricultural and urban sources.

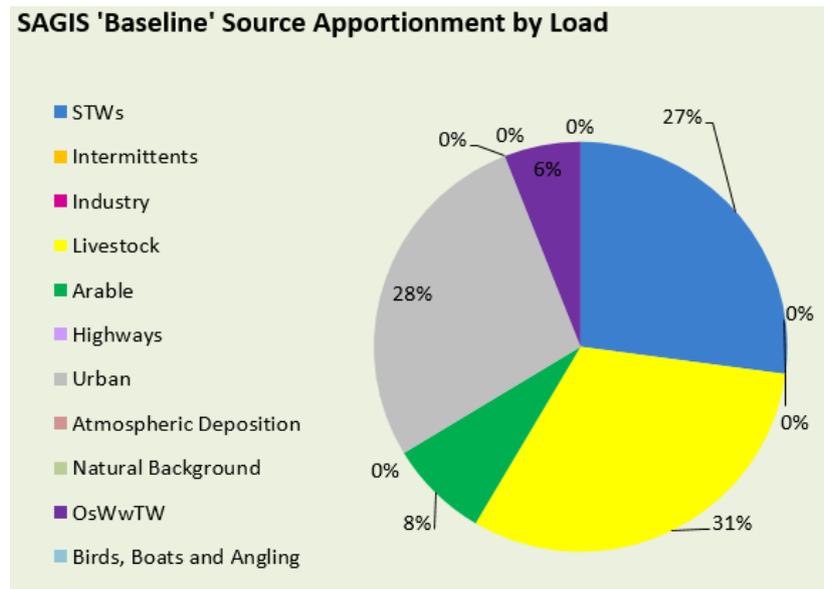


Figure 3. Source apportionment of phosphorus within the river Bure catchment.

Whilst continued improvement in water quality is required to aid stable recovery of HGB we recommend the RNAGS are updated for HGB (waterbody ID: GB30535977) to reflect the scientific evidence and modelling available, and that biomanipulation is added to the required measures to achieve good ecological status of HGB (waterbody ID: GB30535977).

## River Bure

The original 2014 assessment used the WFD classifications for River Bure (waterbody ID: GB105034050930). This waterbody has since been divided for WFD reporting and therefore data is no longer available for the river Bure under this waterbody ID. As such, this assessment has used River Bure (Horstead Mill to St Benet's Abbey) (waterbody ID: GB105034050931) which represents the section of the river Bure adjacent to Hoveton Great Broad. The 2014 values in table 2 have been updated accordingly.

Key activities to be assessed for the River Bure:

- Installation of fish barriers on HGB – associated suspended sediment
- Fish introduction from the HGB

Table 3. Selected WFD data for the River Bure waterbody. Quality elements are italicised, statuses are in bold and failing elements are in red and passing elements in green.

### River Bure

	Waterbody ID: GB105034050930	Waterbody ID: GB105034050931	
Waterbody size:	54.47km	29.799 km	
Typology:	Low, medium, calcareous	River	
Hydromorphology designation:	Heavily modified	heavily modified	
	<b>2014 classification</b>	<b>2014 classification</b>	<b>2016 classification</b>
<b>Overall water body:</b>	<b>Poor</b>	<b>Good</b>	<b>Moderate</b>
<b>Biological Status:</b>	<b>Poor</b>	<b>Good</b>	<b>Good</b>
Diatoms	<i>Moderate</i>	<i>Not assessed</i>	<i>Not assessed</i>
Macro-invertebrates	<i>Good</i>	<i>Good</i>	<i>Good</i>
Macrophytes	<i>Moderate</i>	<i>High</i>	<i>High</i>
Fish	<i>Poor</i>	<i>Not assessed</i>	<i>Not assessed</i>
<b>Physio-chemical Status:</b>	<b>High</b>	<b>Good</b>	<b>Moderate</b>
pH	<i>High</i>	<i>High</i>	<i>High</i>
Ammonia	<i>High</i>	<i>High</i>	<i>High</i>
Dissolved Oxygen:	<i>High</i>	<i>Good</i>	<i>Moderate</i>
Phosphate	<i>High</i>	<i>High</i>	<i>High</i>
<b>Morphology Status:</b>	<b>Moderate</b>	<b>Good</b>	<b>Good</b>
Hydrology:	<i>Moderate</i>	<i>Good</i>	<i>Good</i>
Morphology	<i>Moderate</i>	<i>Not assessed</i>	<i>Not assessed</i>
<b>Chemical Status:</b>	<b>Good</b>	<b>Good</b>	<b>Good</b>

The following assessment reviews the conclusions of the original WFD assessment (submitted with FRAP application) in light of the new WFD waterbodies and their changed condition status.

### **Diatoms – not assessed**

Diatoms have not been assessed as part of the new waterbody (Waterbody ID: GB105034050931). As per the original assessment diatoms respond to phosphate levels. The only impact on diatoms from the project could be caused by a short-term increase in suspended sediment and available phosphate. It's not anticipated that sediment suspension will be significant during the installation of the barriers. Any small amounts of suspended sediment released will be diluted by the flow of the River Bure and will only be temporary in nature. The mitigation measures proposed in the original assessment and conclusion are still appropriate, as below:

#### *Mitigation Measures*

*Silt curtains will be placed at points around the exit points around HGB to reduce suspended sediment flushing into the River Bure.*

#### *Conclusion*

*This project will cause no long-term deterioration for this element.'*

### **Macrophytes - High**

Macrophytes have been assessed as having high status as part of the new waterbody (Waterbody ID: GB105034050931). However, this does not affect the conclusion of the original assessment, as below:

*'Long-term inputs of phosphate can impact on the macrophyte element. Any inputs of suspended nutrients and thus phosphates into the River Bure from HGB will be small and of a temporary nature, therefore no deterioration in this element is to be expected because of the installation of fish barriers.'*

### **Macroinvertebrates - Good**

There has been no change in the WFD status from the original WFD assessment. The conclusions of the original WFD assessment stand, as below:

*'The Macroinvertebrates are good indicators of habitat quality, flow dynamics and oxygen levels, as well as being useful indicators of acute and chronic pollution incidents. Sediment is a natural part of a river but a small input of sediment from works on HGB may cause a localised short-term impact on macroinvertebrates. Excessive sediment can alter the macroinvertebrate community as different taxa have varying tolerances to sediment. However, the inputs from these works will be negligible.'*

#### *Mitigation Measures*

*Silt curtains will be placed at points around the exit points around HGB to reduce suspended sediment flushing into the River Bure.*

#### *Conclusion*

*The small, short-term and localised input of sediment from the sediment removal works will not alter the macroinvertebrate community and will therefore not have a negative impact on this element.'*

## Fish – not assessed

Fish have not been assessed as part of the new waterbody (Waterbody ID: GB105034050931). The impact of works on the River Bure fish community has been addressed in the 'Addendum to Hoveton Wetlands Restoration Project Water Framework Directive Assessment (WFDA), January 2020' (submitted with FRAP application).

## Physio-chemical – Moderate

The overall physio-chemical status of the River Bure has declined since the 2014 assessment from high to moderate due to a change in dissolved oxygen status:

Dissolved Oxygen *Current status:* **Moderate**

Phosphate *Current status:* **High**

pH *Current status:* **High**

Ammonia *Current status:* **High**

Significant levels of suspended sediment are not anticipated from the installation of the fish barriers and will not be sufficient to impact on dissolved oxygen levels. Use of silt curtains will remove any potential impact further. Conclusion of original assessment stands, as below:

*'The small potential input of suspended nutrients as a result of the dredging works may lead to a short-term increase in phosphate levels but this will only be temporary and will not be sufficient to affect this element.*

*The River Bure is a calcareous river and pH will not be impacted by these works.*

### *Mitigation Measures*

*Silt curtains will be placed at points around the exit points around Hoveton Great Broad to reduce suspended sediment flushing into the River Bure*

### *Conclusion*

*None of the physio-chemical elements will deteriorate as a result of this restoration project.'*

## Hydrology – Good

The hydrology status has changed to good since the 2014 assessment as part of the new waterbody (Waterbody ID: GB105034050931). No water level management works are planned for this project and the installed fish barriers will be permeable with regular maintenance to ensure permeability is maintained. No abstraction of water is planned either. Conclusion of original assessment still valid, as below:

*'no deterioration in this element is to be expected.'*

## Morphology - Not assessed

Works are limited to Hoveton Great Broad and will not impact the morphology of the River Bure.

## Chemical - Good

Good practice by contractors throughout the project, such as limiting any oil or petrol spills from machinery, should ensure that no deterioration in this element occurs.

## Other broadland lakes

The following section summarises the WFD status of other key broads in order to:

- Put the condition of Hoveton Great Broad in to context
- Highlight the WFD improvements which will be delivered by the work

Table 4. Selected WFD data for key broads. With poor elements in red, moderate in orange, and good/passing elements in green.

	Overall	Ecological	Chemical	Phytoplankton	Macrophytes	Total P	Ammonia
<b>Wroxham Broad</b>	Poor	Poor	Fail	Moderate	Poor	Moderate	High
<b>Decoy Broad</b>	Poor	Poor	Good	Moderate	Poor	Moderate	Not assessed
<b>Cockshoot Broad</b>	Moderate	Moderate	Good	Good	Moderate	High	Not assessed
<b>Ranworth Broad</b>	Poor	Poor	Good	Poor	Poor	Moderate	High
<b>Barton Broad</b>	Poor	Poor	Good	Poor	Poor	Moderate	High

## WFD status of broadland lakes

Table 4 highlights the poor WFD status of some key broadland lakes and how much improvement is still required to meet WFD targets.

It is clear from this table that the lake nearest to meeting these target is Cockshoot Broad which was biomanipulated in 1990. The only element failing to meet WFD targets is macrophytes (ecological and overall status moderate due to moderate status of macrophytes). Data from the Broads Authority annual water plant surveys (Broads Authority, 2018) indicates that a lack of diversity not abundance of macrophytes is the reason Cockshoot fails to meet good status for macrophytes. It is unclear why there is low diversity but it could be a result of poor propagule availability or potentially unique site conditions. Despite this single failing element on Cockshoot Broad it is clear the benefits biomanipulation can bring.

It is thought that by maintaining hydrological connection with the Bure during biomanipulation, and by removing the barriers once sufficient abundance and diversity of macrophytes has been achieved on HGB, a lack of macrophyte diversity will not be an issue on HGB. Even so, a moderate macrophyte community would still represent a WFD status improvement for HGB.

It should be noted that Cockshoot Broads RNAGS are also diffuse sources from agriculture & STWs despite limited connectivity to the river which were blocked for biomanipulation, and a 'high' total P WFD status. This highlights that the RNAGS need reviewing if they are going to be used to assess management interventions.

## References

Broads Authority (2018) The Broads Annual Water Plant Monitoring report 2018. The Broads Authority.

Environment Agency (2019) *Catchment Sensitive Farming Evaluation Report – Water Quality, Phases 1 to 4 (2006-2018)*. Natural England publication, June 2019.

Lewontin R. C. (1969). The meaning of stability. *Brookhaven Symp. Biol.*, 22, 13-23.

May R. M. (1977). Thresholds and breakpoints in ecosystems with a multiplicity of states. *Nature*, 269, 471-477.

Moss, B., Madgewick, J and Phillips, G. (1996). A guide to the restoration of nutrient-enriched shallow lakes. Environment Agency, Broads Authority, LIFE.

Phillips, G.1, Bennion, H.2, Perrow, M.R.3, Sayer, C.D.4, Spears, B.M.5, Willby, N6. (2015) A review of lake restoration practices and their performance in the Broads National Park, 1980-2013. Report for Broads Authority, Norwich and Natural England.

Sheffer M., Hosper S.H., Meijer M-L., Moss B. and Jeppesen E. (1993). Alternative equilibria in shallow lakes. *T.R.E.E.*, 8(8), 275-279.