Navigation Committee

08 June 2023
Agenda item number 8

Water Plant Management

Report by Head of Construction, Maintenance & Ecology

Purpose

To describe the navigational issues posed by water plants to waterways users, the prioritisation of action by the Broads Authority, the consenting and permitting processes involved and how water plants are managed.

Broads Plan context

C3 - Manage water plants and riverside trees and scrub and seek resources to increase operational targets.

- Carry out annual regimes for water plant cutting in navigation channels in accordance with agreed criteria, and monitor impact on plant species, distribution, and abundance.

B1 - Restore, maintain, and enhance rivers and broads and use monitoring evidence to trial and implement further innovative restoration techniques.

- Seek funding to develop and implement river and broad restoration, maintenance and enhancement works for aquatic communities (incl. fish) at priority sites to meet WFD and SSSI objectives.

Contents

1. Introduction

1.1. Globally water plants occupy almost all freshwaters and are uniquely adapted to life in, or on, the water. Abundance and presence of water plant species in the Broads is driven by ecological and human factors including light (penetrating through the water); availability of nutrients and chemicals (influencing growth); substrate (gravel or silt); grazing by birds (swans, coot etc); salinity (species have different tolerances); and direct physical impacts from human activity (managed cutting, or those chopped up by boat propellers). The relatively shallow waters and slow-flowing waterways provide a home for many species of water plants to thrive.

1.2. Where water plant growth in the Broads impacts on navigational access within the public navigation area, then the approach on management of water plant growth is initiated. The navigation area is defined in the Norfolk and Suffolk Broads Act 1988 (legislation.gov.uk), part 2, paragraph 8, as "*those stretches of the rivers Bure, Yare and Waveney, and their tributaries, branches and embayments (including Oulton Broad) which, at the passing of this Act, were in use for navigation by virtue of any public right of navigation".* The Broads Authority's approach to water plant management is outlined in the Waterways Management Strategy & Action-Plan 2022-27 (www.broads-authority.gov.uk), section 4.2.

1.3. The benefits to navigation from removal of seasonal growth of water plants is that risks of vessels having propellers, keels and rudders caught up with vegetation are reduced. Navigational impacts such as loss or reduction of propulsion, steerage or headway can have serious safety implications in busy waterways; there is potential for costly vessel maintenance from lift-out requirements and any mechanical repairs; as well as reduced quality of experience for recreational users who may be inexperienced or not prepared for dealing with such situations.

1.4. The conservation designation of all the SSSI/SAC/SPA (also called designated sites) waterbodies in the Broads includes water plant species and communities, which in many areas either have targets monitored by Natural England for an increase in abundance and/or an increase in the geographic range of threatened species. The government target condition for SSSI's is "Favourable – recovering". Where water plant management occurs in the designated sites, the Authority is required to gain assent from the regulator, Natural England. This requirement is driven by elements of the Wildlife and Countryside Act 1981 (legislation.gov.uk), Countryside and Rights of Way Act 2000 (legislation.gov.uk) and The Conservation of Habitats and Species Regulations 2017 (legislation.gov.uk). Ecological impacts of such maintenance works need to be assessed for the potential to cause damage to or affect the condition of a designated site. Appropriate controls, monitoring and mitigation are therefore required to be put into place by the Authority. This approach ties in with also achieving the biodiversity objectives for the Broads, see Broads Biodiversity & Water Strategy 2019.pdf (www.broads-authority.gov.uk).

1.5. Similarly, the Environment Agency aims to achieve Water Framework Directive (WFD) targets of at least "good" ecological status in all the major broads, plus all of the rivers. The WFD assessment includes water plants as one of the ecological elements. Table 1 gives examples of some key waterbodies and their current ecological condition.

Table 1. Condition and status of some key broads waterbodies. (Source: Natural England Designated Sites Viewer: Environment Agency Catchment Data Explorer and Broads Authority data (accessed 23/5/23))

Site	Natural England unit condition (and date last assessed)	EA WFD lake status (and date last assessed)	Broads Authority water plant abundance score 1 = low, 10 = high (2022)	Broads Authority water plant abundance trend (2018-2022)
Target	Favourable - recovering	Good	N/A	N/A
Hickling Broad	Unfavourable – Declining (Dec 2013)	Moderate (2019)	7.47	Increase
Horsey Mere	Unfavourable – Declining (Sept 2010)	Moderate (2019)	1.64	No change
River Bure (Horstead to St Benets)	N/A	Moderate (2019)	7.23	N/A
Barton Broad	Favourable - recovering (Nov 2010)	Poor (2019)	1.19	No change
River Ant (Dilham to River Bure)	N/A	Moderate (2019)	4.67	N/A
Rockland Broad	Unfavourable - No change (Aug 2018)	Moderate (2019)	5.99	Increase
River Wensum (New Mills to Trowse Eye)	N/A	Moderate (2019)	1.69	N/A

Table 1 shows that the Natural England unit condition status is now out of date. Natural England are planning to move to SSSI condition assessment based on designated ecological features rather than whole units, so tracking of water plant condition in the SSSI broads shall improve once this new reporting is updated. Of the four sites shown in Table 1, only Barton Broad meets SSSI unit condition targets, which is more based on anticipated ecological recovery following reduction of nutrient inputs in the catchment. However, if should be noted that Barton Broad has very low water plant abundance. The Environment Agency ecological status is more up to date and reflects chemical as well as ecological (such as water plants) elements. None of the sites listed achieves "good" status, with waterbody status largely being driven by the negative influence the poor water quality has in the Broads. The Authority's own water plant monitoring gives an abundance score for each site, with 1 being low and 10 very high. Broads Authority water plant data is shared with partners on an annual basis so updating their assessments is possible.

1.6. Invasive species pose hazards to navigation through rapid infestation of waterways; negatively impacting vessel movements and routine maintenance. Species such as floating pennywort, already present in the Rivers Waveney (upstream of Bungay) and on the River Ant (Honing Lock to Wayford Bridge) require continuous removal effort if the worst impacts are to be avoided. Total eradication is the aim of removal operations, but the plant can regrow from very small fragments. This effort involves staff time from the Authority and numerous partner organisations.

1.7. The Authority itself has powers to conserve natural features of the Broads through control activities within the navigation area through the Norfolk and Suffolk Broads Act 1988 (legislation.gov.uk),

"13(1) The Authority may, for the purpose of conserving the natural beauty of any area—

(a) close to navigation any area at the edge of any waterway within the navigation area; or

(b) restrict navigation in any such area to specified classes of vessel."

In practice, this power is not typically directly applied. A collaborative approach with waterways users, landowners and regulators has led to the prioritisation and scope of water plant cutting and other maintenance activities, which considers the species and habitat impacts of all maintenance activities. This process is outlined in principles, aims and objectives of the Waterways Management Strategy & Action-Plan 2022-27 (www.broads-authority.gov.uk)

2. Where water plant management occurs

2.1. Where water plants have a significant impact on vessels making safe passage the Authority has prioritised these areas based on the channel width impacted, height of plants and volume of boat traffic.

2.2. The areas of the public navigation in the annual water plant cutting programme are: -

- Bure – Coltishall Lock to Belaugh
- Ant – Tyler's Cut to just downstream of Wayford Bridge
- Upper Thurne – Hickling Broad marked channel, Catfield Dyke, Waxham Cut, Meadow Dyke, West Somerton to Martham Ferry
- Wensum– New Mills to Trowse Eye
- Yare - Thorpe River Green, connecting dykes and channels through Rockland and Bargate Broads
- Waveney – Geldeston, Barsham to Beccles

2.3. Where cutting occurs in designated sites or where other constraints are required, the timing of cutting and the expiry of the current assent is listed in Table 2.

Table 2. Water plant cutting where permits are required.

River	Stretch	Type of Cut	Designated Site	Assent gained	Specific timings
Thurne	Hickling Broad channel & Catfield Dyke	In channel (& encroaching reed)	Yes	Yes - expiry (30/09/27)	Cut late May to 30th Sept
Thurne	Somerton – Martham Ferry	In channel (& encroaching reed)	Yes	No*1	
Thurne	Waxham Cut	In channel (& encroaching reed)	Yes	No*1	
Yare/Wensum	New Mills – Thorpe Island	In channel	No. Fish spawning area	Not required	Thorpe Island after 15th June
Yare	Bargate & Rockland Broad	In channel	Yes	Yes - expiry (30/09/27)	15th July to 30th Sept

*1 – HRA submitted to NE but refused on grounds of uncertainty. Cutting proceeds under BA as competent authority. HRA to be discussed & re-submitted as part of wider 5yr cutting plan covering all cut areas in 2023.

2.4. In recent years the volume and height of water plants has increased in more river stretches, and in areas outside the typical marked channels or popularly used areas of the open broads. This has also led to increased requests for cutting in areas not within the Authority's remit to manage, such as private dykes, marinas, and other adjacent waters. Where broads open to public navigation have experienced increasing amounts of water plant growth, this has led to impacts on some sailing club activities, which tend to use a greater area of the broads surface outside the marked channels.

2.5. Hickling Broad is the site with most current challenge in terms of multiple users experiencing difficulties with, or constraints on, their intended activities due to abundant growth of water plants. Hickling Broad Sailing Club has experienced reduced participation in some events in the plant growth season; some day-boat operators instruct hirers not to venture upstream of Potter Heigham Bridge; and several boatyards have reported regular callouts to Hickling Broad to recover hired vessels that have lost propulsion due to entanglement with water plants. The most abundant species currently growing in Hickling Broad is a species called intermediate stonewort. This is a very rare native species that within the UK only grows in the broads of the Upper Thurne. As such, the landowner Norfolk Wildlife Trust and the statutory bodies, Natural England, and the Environment Agency, all have targets to protect this species and the associated community of other water plants that grows alongside it.

2.6. The Authority manages the marked channel through the centre of Hickling Broad, the approach to Catfield Dyke and the dyke between the Pleasureboat Inn and Whispering Reeds boatyard that connects to the parish slipway. This allows access to the village, moorings, and associated facilities for all waterways users.

2.7. In 2017 the Authority conducted a trial of cutting stonewort outside the marked channel to establish the impacts of cutting on plant growth. The trial followed consultation with Natural England, who granted assent for the limited cutting, based on the Habitat Regulations Assessment the Authority was required to prepare. The trial area was monitored for three years to follow the impacts of the cutting event. The draft report was first presented to the Upper Thurne Working Group, as the key stakeholders with a direct interest in the trial and its findings. Following feedback from the group and a peer review process that was significantly hampered by COVID and staff changes, the report has now been finalised and is presented as Appendix 1 to this report.

3. Cutting specifications

3.1. Cutting water plants and removing the arisings aims to maintain a water depth that allows unrestricted passage for most boats. The Authority's water plant harvesters can cut at variable depths, up to a maximum depth of 1.5 m below the waterline. Variation in water levels needs to be considered at the time of cutting so that any drop in water level does not then cause issues from the remaining uncut plants. The environmental standard operating procedure (ESOP) which guides the Authority's maintenance work states that water plants will not be cut any lower than 30 cm from the bed of the channel (this is increased to 40 cm for some designated sites), to ensure some plant biomass and root networks are left in situ. See ESOP 1 – Cutting water plants

Environment standard operating procedures (broads-authority.gov.uk). Most areas of the Broads waterways are highly suitable for water plant growth, so a regular rotation of cutting is planned. However, water plants soon regrow when conditions are suitable, which leads to a requirement for multiple cuts which become more reactive as the season progresses.

3.2. Typically, water plants are cut between May and September, but are not removed entirely from the cut areas (see Figure 1). This ensures the biodiversity and sediment stabilisation benefits provided by water plants is preserved. Maintaining some viable habitat with the physical structure provided by water plants, the food it provides and the shelter for aquatic species is important for invertebrates, fish, and waterfowl. The root network and plant biomass above the channel bed reduces sediment transport downstream, by holding the sediment together and reducing the flow velocity across the sediment surface. Water plants growing at the margins of rivers help to reduce bank erosion decreasing the input of sediment into the waterways and provides nesting opportunities for waterfowl. For this reason, uncut margins are left intact. Periodic management of the uncut vegetation at the margins is tackled in the autumn either via the water plant harvester vessels, or through dredging operations. At Broads Authority 24-hour moorings, or other publicly accessible short stay moorings, the cutting specification is as close to the piled edge as is practicable.

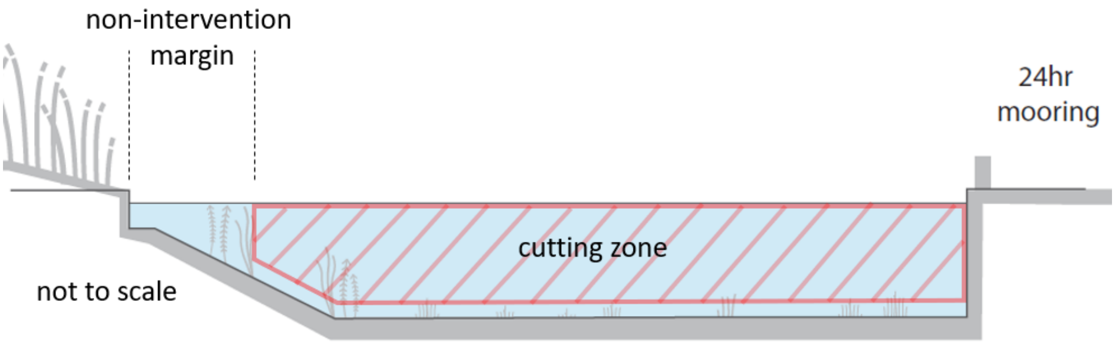

Figure 1. Example river profile showing water plant cutting zone (red hatching) adjacent to natural bank (left) and public moorings (right)

3.3. A method statement is produced to guide the cutting operations in each area. An example is given in Appendix 2 for the River Bure. The method statement covers instructions and maps for the operators including cutting height above riverbed, non-intervention margins, working procedure, disposal of cut arisings to land and ecological notes.

3.4. The Authority currently has three water plant harvesting vessels. Flexibility is required in how the staff resource is deployed, to meet the reactive demands of where and how well water plants are growing. The ranger team monitor the level of growth across the waterways and feedback to the maintenance team to help prioritise actions. This is also supported by reports from stakeholders and the public who contact Broads Control. As the internal staff resource is finite and a range of other waterways management tasks are needed to be performed throughout the year, fluctuations in the number of days spent of water plant cutting means reciprocal variations in the time spent on other tasks is required. This is a dynamic management task and is tracked through staff time sheets. Reporting on the annual figures for staff time spent on all the navigation maintenance activities is via the Construction, maintenance & ecology report presented at the Navigation Committee meeting each June (see Agenda item 14).

3.5. Arisings from cutting are typically placed in low heaps (less than one metre high) on the bankside of the manged waterways. Given the structurally weak stems and leaves of water plants, they quickly dry out and shrink. The waste disposal guidance provided by the Environment Agency aims to ensure that bankside habitat is not significantly impacted and that conditions that promote significant leaching of nutrients from the heaps of cut vegetation are minimised, this means disposal locations need to be assessed prior to use and not all bankside locations are suitable for disposal.

3.6. Ecological monitoring of the water plant species in the actively cut river stretches (see section 2.2) is cyclical. Typically, two rivers are monitored per year by Broads Authority ecologists. However, in 2023 all the river stretches managed for water plants will be surveyed. This additional effort reflects the increasing plant biomass in all of the cut stretches and the need for more information prior to considering extending the cutting areas. Annual hydroacoustic monitoring is carried out in August and October in Hickling Broad, each year to determine the overall percentage of plant cover as per the Natural England assent conditions for this site. The Broads annual water plant survey, which takes in some of the broads sites where plant cutting occurs in marked channels (Hickling, Martham North, Rockland) has some points that fall within the cut areas. The scope of the Broads annual survey is for a variety of purposes but is frequently referenced in terms of ecological conditions within sites where cutting occurs. All three of these survey types are reported here for 2022 Broads Annual Water Plant Monitoring Report 2022.pdf (www.broads-authority.gov.uk)

4. Financial implications

4.1. The total costs of maintaining the water plant cutting operation across the navigable area are comprised of the capital cost of the water plant harvesters, the annual maintenance costs of the vessels, staff time operating the harvesters during cutting and monitoring the water plant communities.

4.2. Over the past six years, the operational staff time spent on the cutting activity has varied as per the demands of water plant growth. Figure 2 shows a graph of staff time and how it has varied. The peak in 2022/23 was the greatest amount of time spent by the Authority in any one year. The mild spring in 2022, exceptionally clear water in most rivers and the low river levels due to drought, all contributed to generating a large growth of water plants across the Broads.

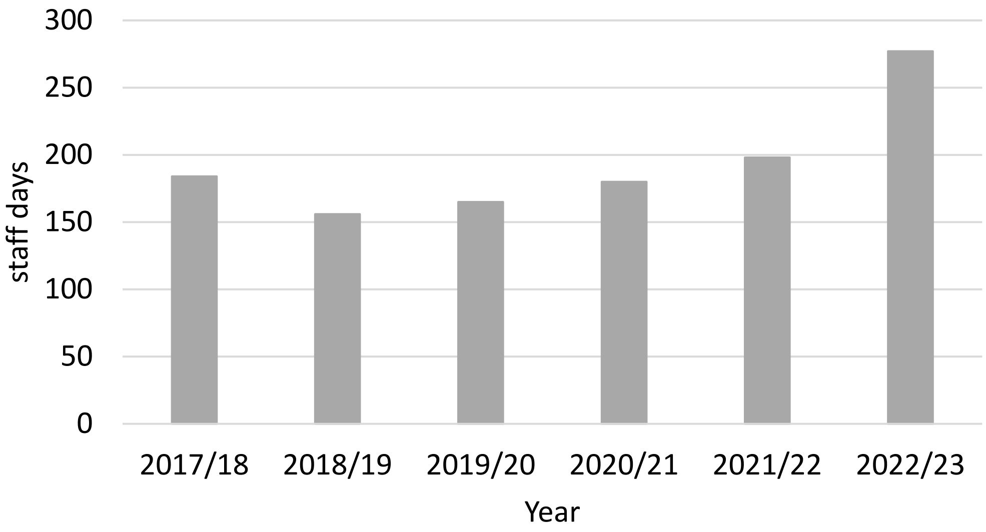

Figure 2. Total staff days per year spent on water plant cutting.

During the financial year 2022-23, there was a total of 277 days spent by the operations technicians on the water plant cutting and disposal activities on the navigation area. This was just over 10% of the total working time available for the operations technicians for all navigation management activities in the year. The ecologists spent 25 days on tasks directly related to water plant cutting, including preparing method statements, gaining permissions and plant monitoring in cut areas. The plant & equipment team spent 80 days on the maintenance and annual refit requirements for the two harvesting vessels in the fleet at that time. Taking into consideration the staff time actual cutting and all associated operational overhead calculations for transport, premises and staff management, the value of the work in 2022/23 was £64,500.

4.3. Total cost of invasive species removal work from the navigable waterways by Broads Authority operational staff in 2022/23 was approximately £19,900. This included input from ecologists, rangers, and operations technicians. In addition to these staff costs, the Authority makes regular budget contributions to partnership removal programmes.

5. Risk implications

5.1. Within the Operations Directorate Risk Register water plant cutting activity is relevant to the following risks: -

5.2. Loss of navigation due to engineering or environmental issue (Performance). Initial risk level “medium”. Controls identified to manage this risk includes: -

- Monitor and review aquatic plant cutting regime to ensure it is fit for future demands and a changing seasonal climate.
- Purchase of one an additional brand new Berky water plant harvester vessel
- Annual winter refit programme for each water plant harvester by the plant & equipment team at the Dockyard

Residual risk following these controls is “medium”.

5.3. Ecological degradation (Reputation). Initial risk level “high” – controls identified to manage this risk includes: -

- Regular review of Environmental Standard Operating Procedures to ensure work processes cover all significant hazards to the environment.
- Consultation with stakeholders and regulators on the water plant cutting activities in Protected Sites like Hickling Broad
- Complete the actions listed in the Waterways Management Strategy & Action Plan 2022-27 – (see Table 5. Water plant management objectives, page 35)

Residual risk following these controls is “medium”.

6. Conclusion

6.1. Going forward, if water clarity continues to improve, as it has most notably in the River Bure, River Yare and in Hickling Broad/Heigham Sound, then the proportion of Authority operational time in managing water plants is not likely to drop back down below 10%. This level of commitment in 2023/24 is achievable with some in-year reprioritisation of other tasks, such as dredging or riverside tree management. Any longer-term increases in annual water plant cutting requirement or any expansion of the areas to be regularly cut, would demand a more fundamental rethink. Options to release more operations technician time for water plant cutting includes permanently reducing the duration of time spent on other tasks or requesting additional revenue budget to allow procurement of additional external resource to back fill in other areas. The most likely areas to reduce would be dredging and riverside tree management. Dredging currently occupies about 60% of all operations technicians’ time, so can most afford some time reduction. Riverside tree management can be shifted to delivery by rangers in the winter and/or using additional revenue budget to contract in external resource.

6.2. With three harvesters now in the fleet, making the most efficiency of the operator’s time available has increased slightly. Typically, the cutting is carried out by two members of staff who move their vessels between sites as demand requires. Two vessels will now be stationed in the northern rivers and one in the south, which reflects cutting requirement and waterways users’ needs. Vessel travel time between sites will reduce in the northern rivers, which will allow greater flexibility and reactivity to issues that arise and will also reduce any downtime in cutting if a vessel requires repairs during the season. The brand-new vessel did not unfortunately come with an additional operator, so the likelihood of operating three harvesters at one time is very low. There will as be an additional burden on the plant & equipment team each year, as there are now three vessels to maintain.

6.3. The current challenge is how does the Authority meet all its statutory obligations and maintain accessible waters within the public navigation, for as many different user groups as possible. Ecological conditions in the Broads are steadily improving because of decades of investment in nutrient reduction from point sources, such as sewage treatment works, and more diffuse sources, such as from agricultural practice in the wider Broadland catchment. The is also risk of increased occurrence of invasive non-native plant species in the Broads waterways. Waterways users have experienced navigation in waters that were relatively free of water plants, and now have genuine safety concerns and expectations that all aspects of the navigable space will be managed to meet those expectations. The Authority is open to managing the navigable waterways of the Broads for all purposes, but financial, ecological, and legal constraints all combine to shape the water plant cutting programme that has developed to this point. If deviations from the current approach are decided as a priority by the Authority, then staff resource will need to be redirected to tackle those financial, ecological, and legal constraints.

6.4. If changes to the current approach to water plant management are required, it is proposed that there will be prior consultation with the Navigation Committee.

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Date of report: 22 May 2023

Background papers:

Norfolk and Suffolk Broads Act 1988 (legislation.gov.uk)

Waterways Management Strategy Action Plan 2022-27.pdf

Broads Annual Water Plant Monitoring Report 2022.pdf (www.broads-authority.gov.uk)

Broads Plan strategic objectives:

C3 - Manage water plants and riverside trees and scrub, and seek resources to increase operational targets

Appendix 1 – Experimental cutting of stonewort in Hickling Broad, 2019-2019

Appendix 2 – Water plant cutting method statement for the River Bure

EXPERIMENTAL CUTTING OF STONEWORT IN HICKLING BROAD, 2017-2019

May 2023

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Experimental Cutting of Stonewort in Hickling Broad, 2017-2019
Final Report 2023

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Origination

Version	Author	Date	Detail	Approved by
1.1	AL	07/05/20	Initial Draft	SS
1.2	AL	25/06/20	incorporation of internal comments	SS
1.3	AL	11/08/20	incorporation of internal comments	SS
1.4	AL	08/09/20	incorporation of internal comments	SS
1.5	AL	16/09/20	incorporation of internal comments	DH
1.6	AL	10/11/20	updated with steering group comments	DH
1.7	AL	08/5/23	updated following Prof. G. Phillips review	DH

Acknowledgements – Thank you to members for the Upper Thurne Working Group who provided comments on an early draft and to Prof. Geoff Phillips, who provided detailed commentary and advice on the statistical testing and conclusions.

1. Introduction

1.1 Background

Hickling Broad is the largest broad within the Norfolk and Suffolk Broads system, with approximately 120 hectares of open water. Recent Broads Authority hydrographic surveys show a water depth outside the marked channel of less than 1.2 m at mean low water level. The bed of the broad is mostly comprised of soft mud overlain with a layer of fluidised sediment. Hickling Broad contains species and habitats of high conservation importance, including several rare and important species of charophyte, or stonewort (Barker et al., 2008). Hickling Broad is also an important recreational and race sailing waterbody, popular with a broad spectrum of water user groups. However, plant growth outside of the marked channel can impede sailing vessels, and improvements in water quality have led to increases in water plant growth which can exacerbate this issue. This then creates a challenge for year-round access for all craft to the whole of the broad, without compromising the biodiversity, or breaching the legislation designed to protect it.

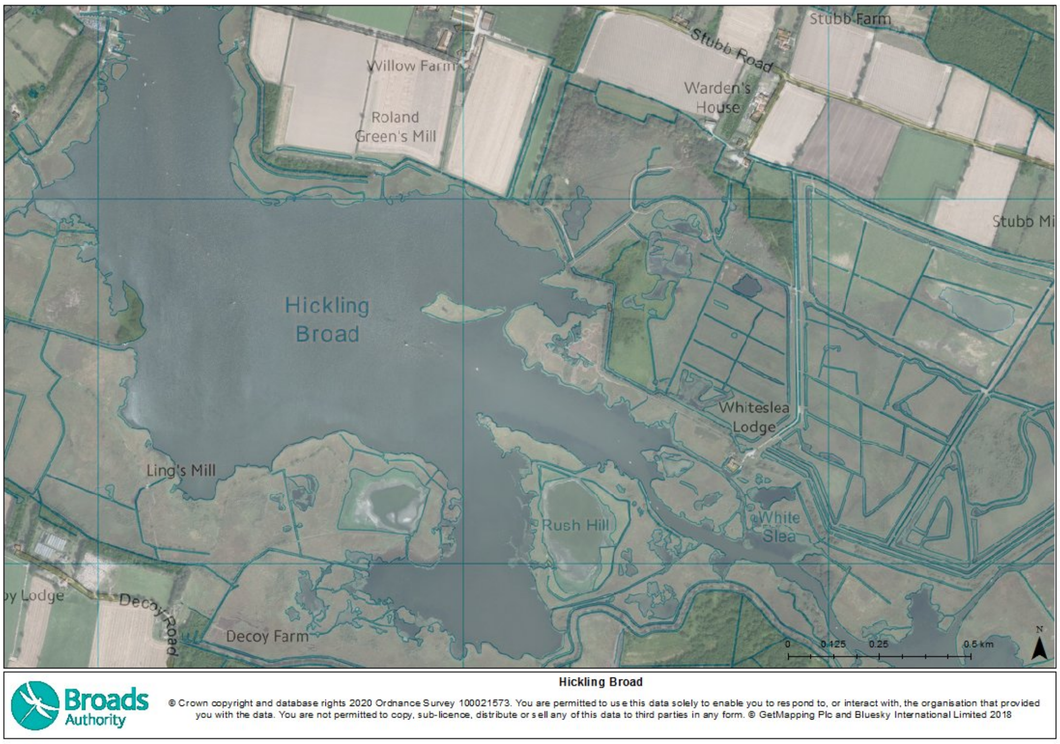

Figure 1: Map of Hickling Broad

The Broads Authority has a duty to maintain the navigation area for the purposes of navigation to such standard as appears to it to be reasonably required; and to take such steps to improve and develop it as it thinks fit. Vigorous plant growth in recent years has therefore presented a number of challenges around managing navigational access on a site dominated by a protected water plant community (Jackson et al., 2001).

The water plant growth in Hickling Broad has been managed within the marked channel through a programme of dredging projects and routine water plant cutting in the growing season (Table 1). Outside of the marked channel, dense growth of water plant near to the water surface has implications for boat handling and safety; sailing boats with deeper keels (typically drawing 90 cm) may become impeded by the plants. Not only sailing boats but windsurfers, canoers, paddleboarders and anglers also utilise a much greater proportion of the open water of the broad, compared with motor vessels which largely stay within the marked channel.

Table 1: History of Broads Authority water plant management across Hickling Broad (1994 - 2017)

Period	Description
1994 - 1998	A cutting and monitoring programme for Spiked water-millfoil (*Myriophyllum spicatum*) and pondweeds (*Potamogeton* species) which covered approximately a third of the open water area of the broad
1998	An experimental 50 x 50 m plot of Intermedia stonewort (*Chara intermedia*) cut and monitored.
1999	Trial plots of Intermediate stonewort cutting extended (38 ha).
2000 - 2006	Trial of Intermediate stonewort cutting suspended due to lack of growth.
2016 onwards	Annual cut of all plants within the marked channel when certain criteria are met was initiated as water plant abundance increased.
2017	Criteria met for experimental charophyte cut in small plots. One cut was carried out and then monitored for three seasons (this report)
2017-2019	Cutting of non-Chara species outside of the main channel in a limited strip either side of the marked channel

In most years prior to 2020, there has been limited plant growth in the central area of the broad, and within the marked channel; probably as a consequence of lower water clarity and poorer light conditions at the sediment surface in this deeper part of the broad. This central area is likely to be subject to greater sediment disturbance by motorboat traffic as well as wind generated wave action. These forces act on the mobile, unconsolidated sediment that tends to focus in the centre of the waterbody, and therefore creating poorer water quality conditions. Increased plant growth in recent years however, extending out from the broad margins and towards the marked channel, has resulted in significant impacts on water user groups who access areas outside the marked channel. Between 2017 and 2019, low water levels exacerbated the issue, with water plants being brought closer to the water surface.

In 2017 abundant plant growth, in conjunction with unresolved issues for recreational users of the broad, gave rise to a proposal for an experimental water plant cut, outside of the marked channel. This trial was developed in consultation with Natural England (NE), Environment Agency (EA) and the landowner, Norfolk Wildlife Trust (NWT), brought together under the Hickling Broad Enhancement Project. Given the uncertainty and limited international scientific literature around the impacts of cutting stonewort, the proposal included a specific trial of cutting stonewort in Hickling Broad.

1.2 Aims and Objectives

The trial was built upon a significant body of earlier research into stonewort growth in Hickling Broad (Harris, 2000; Jackson, Georgiou & Crooks, 2001). The purpose of this trial was to provide a better understanding of the impact of repeat cutting on the height, density and overall integrity of the stonewort bed; the stonewort species composition within the bed; and to generate robust data to inform discussions around the future management of water plants.

To focus the data gathering and statistical analysis, it was hypothesised that, in comparison to control areas, cutting would result in a:

a) reduction in overall plant height,

b) reduction in overall plant cover,

c) decrease in charophyte prevalence within the plant community.

The aim of this report is to summarise the findings of the three years of water plant monitoring conducted after cutting and produce recommendations for the future management of the water plant communities in Hickling Broad.

1.3 Project constraints

1.3.1 Cutting and collecting water plants

Routine cutting and collecting of water plants across the Broads is carried out with Berky type-6520 water plant harvesters; a work vessel with adjustable cutting bar height, reciprocating blades and integral conveyor belt system to collect the cut material. In terms of planning specific cutting operations, the geo-positioning of this type of vessel is highly influenced by wind; the overall limitations in manoeuvrability of a long vessel with a submerged and heavy cutter head attachment; and the absence of permanent marks by which to accurately locate in an open water environment. Typically, this type of vessel operates best in straight lines, with the ability to raise and lower the cutter head. Given these constraints, the size, shape and location of the cut areas needed to be as simple and repeatable as possible, without demanding complicated locating by the operator.

1.3.2 Criteria for permission for cutting stoneworts

There are legal restrictions, as regulated by Natural England, on activities and developments that might affect a designated site such as Hickling Broad. Central to the project was the set of ecological criteria and thresholds, established in consultation with the Hickling Broad Enhancement Project board, which had to be achieved before any cutting could take place. These criteria were:-

- Water plants were causing problems reported by water users,
- "favourable condition" (as defined within the Conservation Regulations 2010) for stoneworts was being achieved within the open water unit of the Hickling Broad SSSI. This was specifically defined for this SSSI unit by Natural England as characteristic Chara species present at >60% of plant survey sample points in the Broads Authority's June plant survey,
- A dense stonewort bed covered the study area,
- Plant growth reached within 60 cm of the water surface (at mean low water (MLW)).

2. Methodology

2.1 Experimental Design

Hydroacoustic and rake based water plant survey methods routinely used in Hickling Broad were reviewed and considered when developing this project's experimental design (see Broads Annual Water Plant Survey Report 2016 (broads-authority.gov.uk). In 2016, hydroacoustic surveys identified a dense stonewort bed in the north western section of Hickling Broad. A central 2.4ha (100 x 240m) study area was designated across this area, this was then apportioned into discrete 'cut', 'non-cut' and 'control' plots. Ten cut and ten non-cut plots of 20x20m in size, were alternated in two parallel rows, giving a 'checkerboard' effect. Twenty adjacent 20x20m plots were treated as the control (see Figure 2).

2.2 Stonewort Cutting

In early summer 2017, the criteria for permission to cut stonewort were met. The experimental cut was undertaken on 26th July 2017. This mid-season cutting date was chosen to minimise the impact of cutting on the ability of the plants to over-winter successfully. Before cutting began, mean water level was obtained from Environment Agency water level telemetry data and referenced to gauge boards on the broad. This level was then used to set the cutter bar to the appropriate depth of 40cm above the bed. The Environmental Operating Procedure 1: Water Plant Cutting governed the cutting methodology and outlined operational safeguards for this experiment. The ten cut plots were mapped to generate GPS coordinates and provide clear operational instructions for the harvester operator. Hydroacoustic survey was conducted to gather the "before cutting" data. The water plants removed from each cut plot were sampled, with species identified, relative composition of the plant community estimated and wet weight measured.

Over 2018 and 2019 the ecological criteria (see Appendix 1) were not met that would permit repeat annual cutting, and the project was limited thereafter to monitoring only. The project concluded at the end of growing season in 2019.

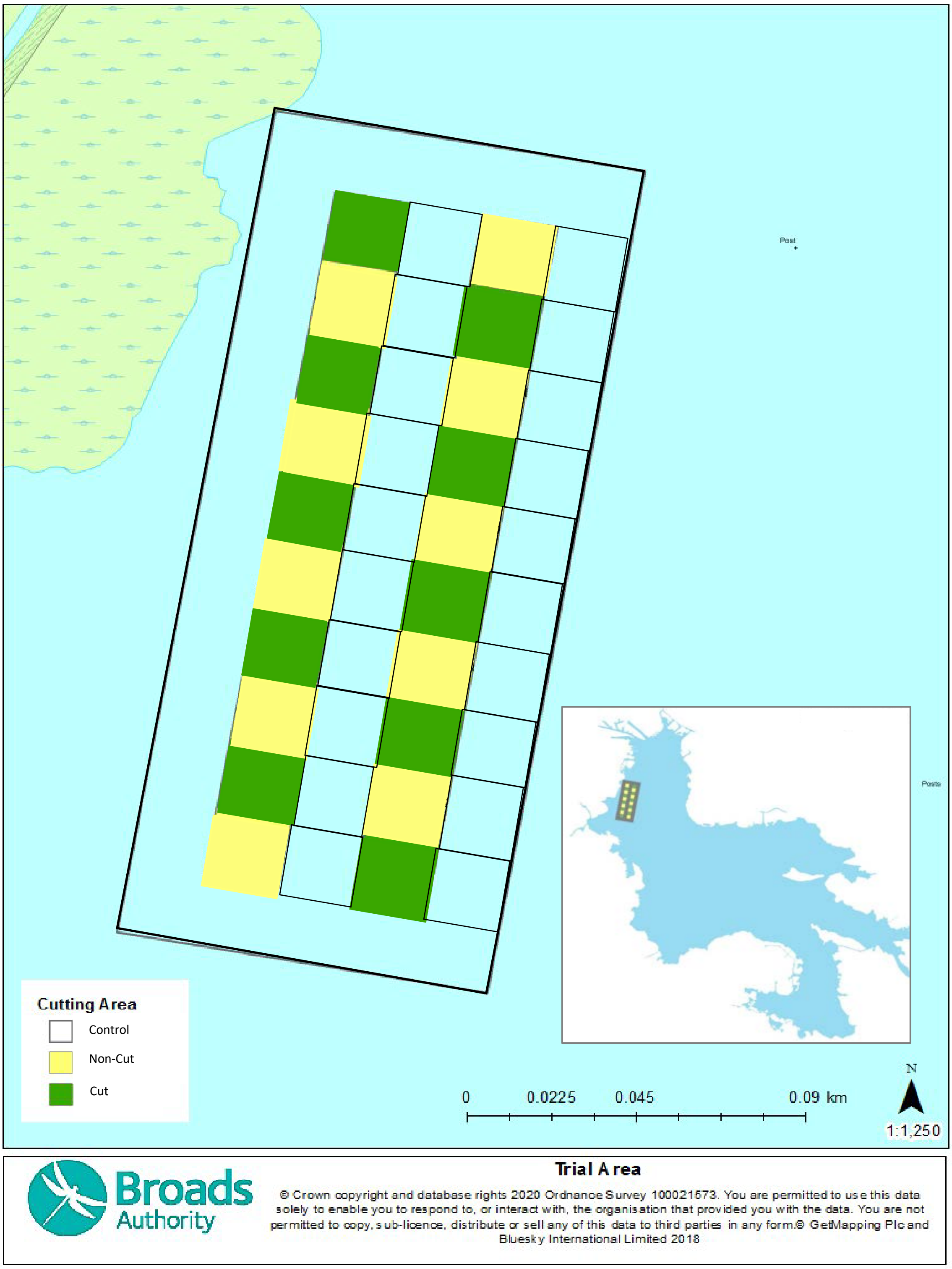

Figure 2: Checkerboard trial cut layout with control (light blue), non-cut (yellow) and cut plots (green) detailed

2.3 Monitoring

2.3.1 Hydroacoustic Surveys

Once the first water plant cutting had been completed, repeat hydroacoustic monitoring was undertaken, to quantify overall plant height, area covered and volume.

Hydroacoustic survey equipment, utilising sonar technology, is commonly used for detection, assessment, and monitoring of underwater physical and biological objects. Boat-mounted hydro-acoustic equipment can be utilised to detect the depth of a water body (bathymetry), as well as the presence or absence, distribution and size of underwater plants. Such survey equipment measures the range to an object and its relative size by producing a pulse of sound and measuring the time it takes for an echo to return from the object and the amplitude of the returned echo. The range is calculated as a function of the speed of sound and the time it takes for the echo to return.

The hydroacoustic surveys were conducted by navigating a survey boat along set transects across the study area, maintaining a constant speed. The equipment used in the surveys included a BioSonics DT-X, single beam (10°), 420 KHz transducer, with an on-board control unit and operating laptop. All data recorded was geo-referenced through connection to an external GPS receiver. This allowed subsequent quantitative analysis of the data using Sonar5-Pro post-processing software, developed specifically with a vegetation analysis component. The survey dates are presented in Table 2.

Using the Sonar5-Pro software, the sediment surface of each transect file was identified, as well as the less intense return derived from the upper surface of the water plants. Transects were divided into 1m sections to enable identification of the cut areas within the data and exclude any uncut areas on the boundaries of the Cut plots or where patches of plants had been missed by the cutter.

All features taller than 9 cm above the inferred sediment surface were recorded as water plants during data processing in order to reduce the likelihood of recording false positive results. This level was selected by adjusting the heights at 1 cm increments between 5 and 15 cm during the processing of the initial May survey. The outputs (frequency distribution) for cover (5% increments) at the different heights were assessed, with 9 cm the lowest value considered to produce a normal distribution pattern. The 9 cm threshold was then used for all surveys for consistency.

The derived results from the processing of the hydroacoustic data were then used to calculate water plant height, percentage cover (PAI) and percentage volume of plants within the water column (PVI). All water depth data was corrected for variation through reference to local water level datums. Overall means were calculated for each survey for the study area, the ten cut treatment plots (combined), the ten non-cut treatment plots and the control transects using geographic information system (GIS) software (ArcGIS).

Table 2: Details of the cutting and monitoring programme conducted from 2017-2019

Date	Activity	Purpose
2017		
25 July	Hydroacoustic survey	Pre-cut survey
27 July	Water plant cutting	Reduce growing plants height and volume
23 August	Hydroacoustic survey	First post-cut monitoring survey
26 September	Hydroacoustic survey	Second post-cut monitoring survey
17 October	Species ID survey	Species identification and abundance
24 October	Hydroacoustic survey	Final post-cut monitoring survey
2018		
14 May	Hydroacoustic survey	Survey to establish status of potential cutting
15 July	Species ID survey	Species identification and abundance
16 July	Hydroacoustic survey	Survey to establish status of potential cutting
20 August	Hydroacoustic survey	Monitoring survey
24 August	Species ID survey	Species identification and abundance
15 October	Hydroacoustic survey	Monitoring survey
2019		
1 May	Hydroacoustic survey	Monitoring survey
27 June	Species ID survey	Species identification and abundance
2 July	Hydroacoustic survey	Monitoring survey
22 August	Species ID survey	Species identification and abundance
11 October	Species ID survey	Species identification and abundance
14 October	Hydroacoustic survey	Monitoring survey

2.3.2 Species Identification Surveys

Two rake survey throws were undertaken within each cut plot to identify species present and quantify the relative abundance of each species. The methodology to generate the species abundance values, was as per the annual Broads water plant survey Broads Annual Water Plant Monitoring Report 2019.pdf (www.broads-authority.gov.uk). The dates of the species identification surveys are presented in Table 2.

Replicate species survey were carried out in the control areas in 2019. To provide the background and context to the water plant community across the wider broad, data on species present and their relative abundance was utilised from the routine annual water plant surveys.

2.4 Statistical Analysis

All statistical analysis of data across all three years of the trial was undertaken in R v. 4.2.2. The data did not follow a normal distribution and data transformation failed to produce a suitably normally distributed dataset. Consequently, Mann-Witney U tests were used to identify any statistically significant differences between the different plot types plots.

3. Results & Discussion

3.1 Consolidation of Treatment Plots

The cutting trial was originally undertaken based on a checkerboard design that allowed for 'non-cut', 'cut' and 'control' plots. On investigation of the data, it was found that there was little difference between the non-cut and cut plots over each trial month.

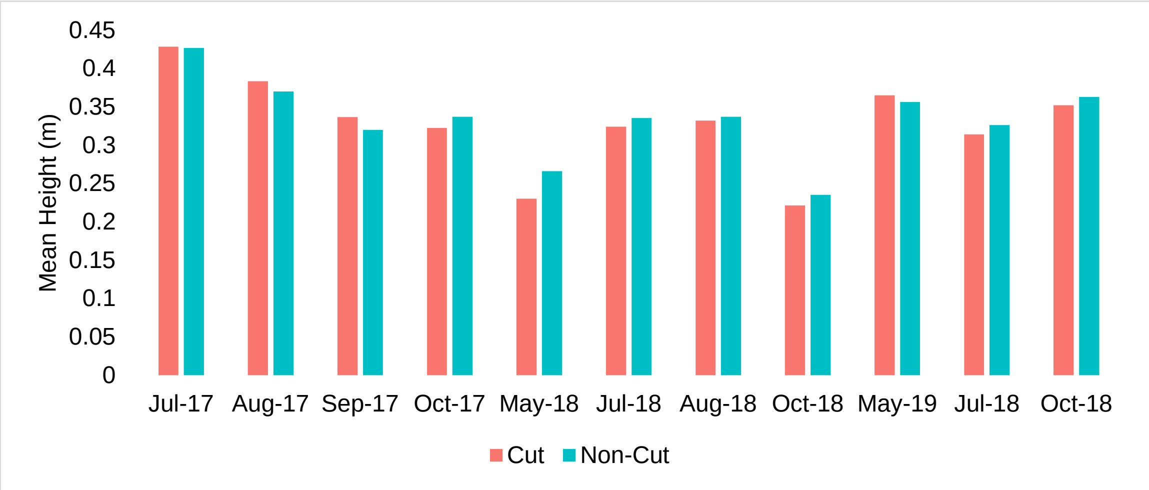

Figure 3: Average plant height between 'cut' and 'non-cut' treatment plots over the trial period.

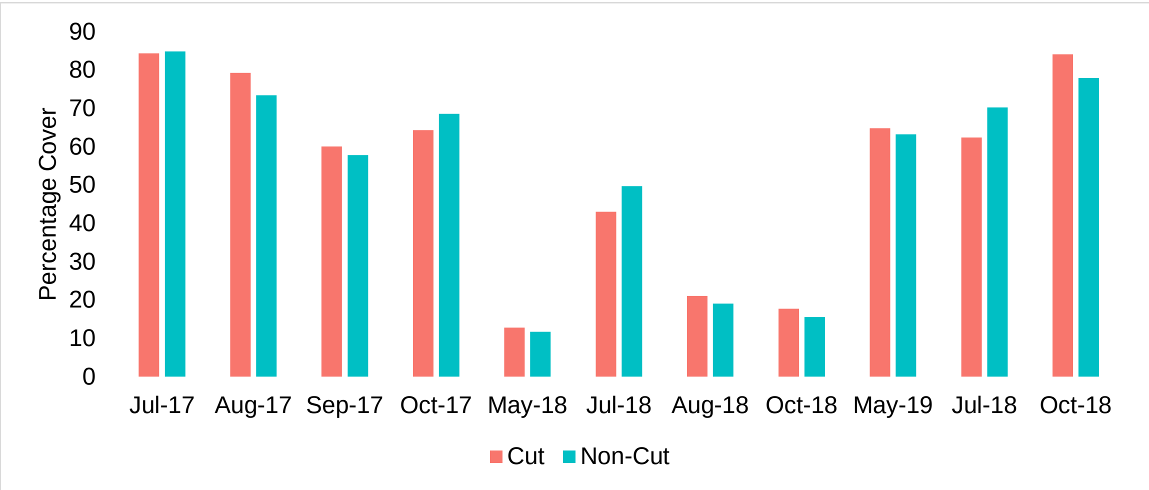

Figure 4: Average percentage cover between 'cut' and 'non-cut' treatment plots over the trial period.

Mann-Whitney U tests identified no statistically significant difference in mean plant height and percentage cover between cut and non-cut plots through 2017 and 2019. A statistically significant difference was identified in mean height between the cut and non-cut plots from August to October 2017 (Table 3). In 2018, no statistically significant differences were observed in percentage cover across the cut and non-cut plots. In July 2019 a statistically significant difference was observed between the cut and non-cut plots *(W = 68984, P <0.001).* However, this was not seen in any of the other trial months in 2019 (Table 3)

Table 3: Mann-Whitney U values (W) for mean plant height and percentage cover across the Non-Cut and Cut plots over each trial month.

	Mean Height (av.)		Percentage Cover (av.)	
Month	**W**	**Significance**	**W**	**Significance**
Jul-17	502318	0.5123	492110	0.8678
Aug-17	477076	0.7672	450072	<0.05*
Sep-17	296797	0.05432	296449	<0.05*
Oct-17	351968	0.08166	363686	<0.001*
May-18	5064.5	0.08926	4049.5	0.2891
Jul-18	47529	0.3154	49069	0.08319
Aug-18	9607	0.6579	8674.5	0.3321
Oct-18	4495	0.3215	4635	0.5199
May-19	68582	0.4349	36580	0.3904
Jul-19	63014	0.249	68984	<0.001*
Oct-19	34306	<0.05*	65019	0.534

Given the lack of statistically significant differences between the non-cut and cut plots outside of the summer and autumn months of 2017, it was decided to combine the two separate plots into one ‘treatment’ block. Non-cut and cut plots thereafter formed the combined treatment area to be compared against the control. This also had the advantage of equalising the number of treatment plots (20) to the number of control plots (20), which helped to meet the assumptions in the subsequent statistical testing.

3.2 Plant Height

In the initial pre-cut survey, mean plant height in the treatment blocks was found to be 3 cm lower than in the control blocks prior to cutting in 2017. This height difference was statistically significant (*W = 2082409, P<0.001*, see Table 4). Following cutting, the treatment blocks were still significantly shorter than the control in August and September 2017, but the difference between the treatment and control increased to approximately 7-8 cm. By October this statistically significant difference in height was no longer observed (See Figure 5). No difference between the treatment and control plots was observed through the spring and summer of 2018. A small difference was found in October 2018 (*W = 28363, P <0.05).* In 2019, no statistically significant difference was observed between the control and treatment plots in May or October. A statistically significant difference between the plots was found in July 2019 (*W = 258626, P <0.001)*, however it was found that this occurred because of higher plant growth in the treatment plots compared to the control plots.

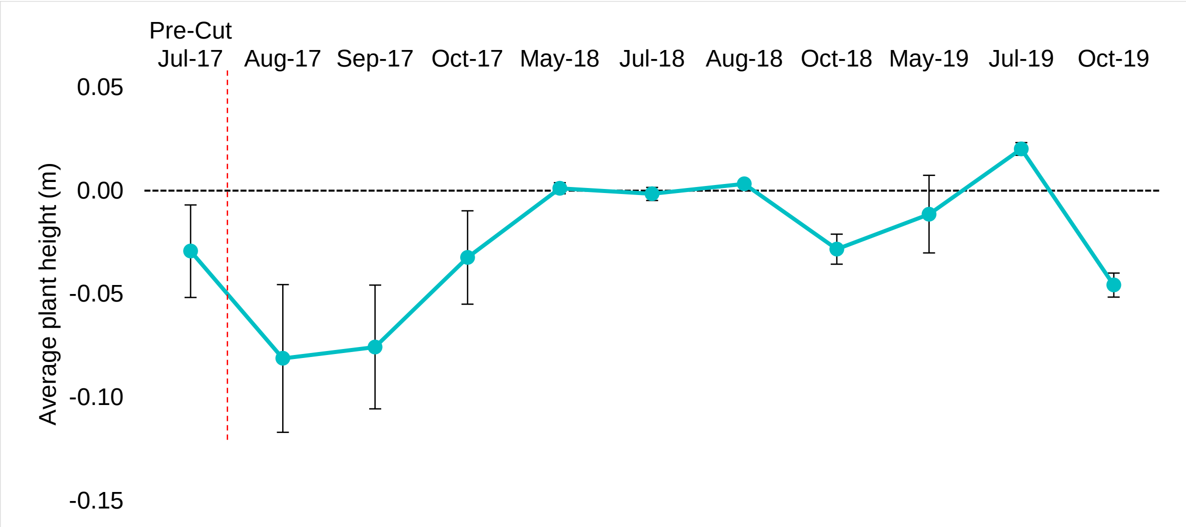

Figure 5: Line graph illustrating the variation in average plant height between treatment and control blocks across all trial months. Red dashed vertical line indicates the point of the cut. Error bars reflect the standard deviation of each point.

Table 4: Mann-Whitney U values (W) and associated significance levels for plant height. * indicates statistically significant results.

Year	Month	W	Significance
2017	July	2082409	< 0.001*
	August	1638887	< 0.001*
	September	1578917	< 0.001*
	October	1530538	2.79
2018	May	23672	0.08
	July	182170	0.85
	August	55576	0.43
	October	28363	< 0.05*
2019	May	288015	6.04
	July	258626	< 0.001*
	October	357286	4.93

With the height data bulked for each calendar year, average plant height was lower in the treatment plots in 2017 by around 14 cm compared to control. This equates to about a 12% difference in height. In 2018 and 2019 there was little observable difference in height between treatment and control (see Figure 6). 2019, the treatment plots were only 3% lower in height compared to control, but not to any statistically significant level.

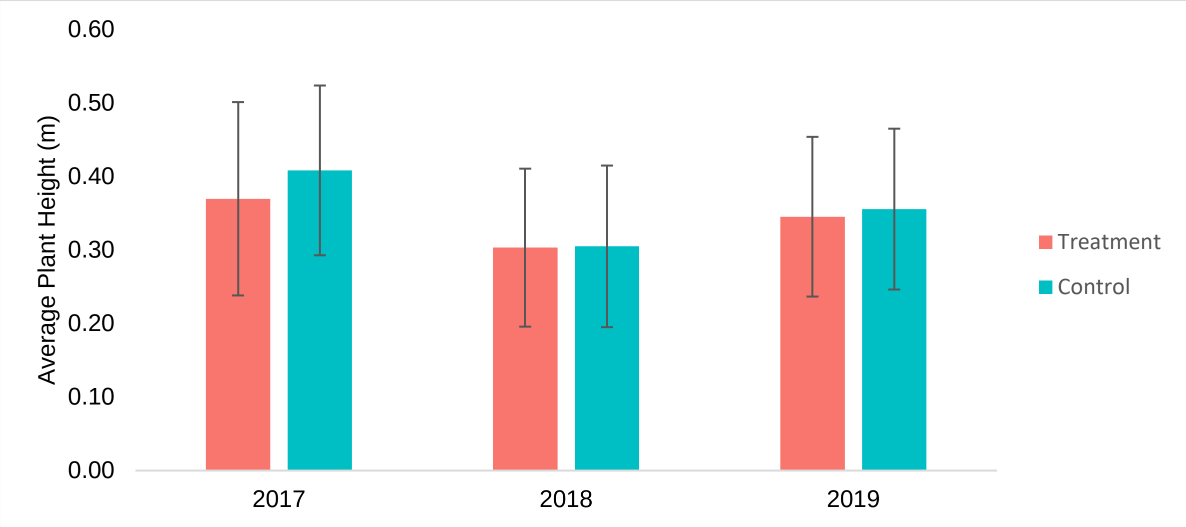

Figure 6: Bar graph illustrating average plant height between treatment and control blocks across the period of the cutting trial.

3.3 Plant Cover

From the individual surveys, significant differences in percentage cover between the control and treatment plots was observed throughout much of the study. For two years after the cutting, the treatment plots had significantly lower percentage cover of plants compared to control (see Figure 7 and Table 5). The reduced cover of plants was greatest in the late summer of 2017 and 2018. By May 2019, the continued pattern of reduced percentage cover of plants was no longer apparent in the treatment plots.

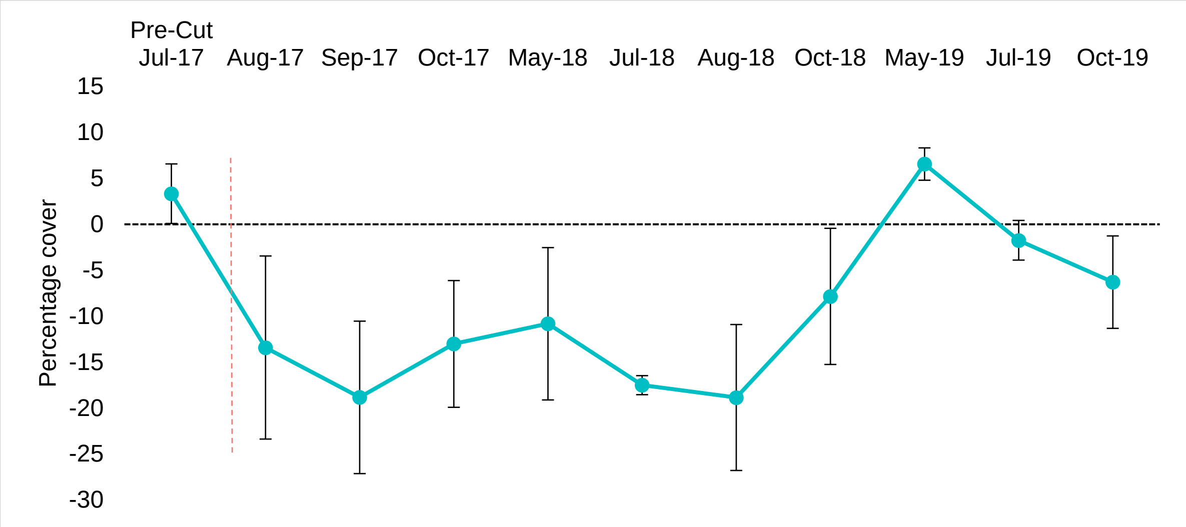

Figure 7: Line graph illustrating the difference in average percentage cover in the treatment plots (blue line) compared to control (black zero line). (red dashed line indicates when cutting occurred)

Table 5: Mann-Whitney U values (W) and associated significance levels for percentage cover. * indicates statistically significant results.

Year	Month	W	Significance
2017	July	1588858	<0.05*
	August	1445819	<0.001*
	September	1824486	<0.001*
	October	1985436	<0.001*
2018	May	329739	1.93
	July	360876	<0.001*
	August	349376	<0.001*
	October	286523	<0.001*
2019	May	286572	6.55
	July	357329	0.05*
	October	388726	1.982

With the percentage cover data bulked for each calendar year, the 2017 treatment plots had approximately 17% less plant cover compared to control. This had increased to 36% less cover in 2018. Note the lower red bars in Figure 8 for 2017 and 2018. However, by 2019 the plant cover was very similar between treatment and control with very similar variance for each.

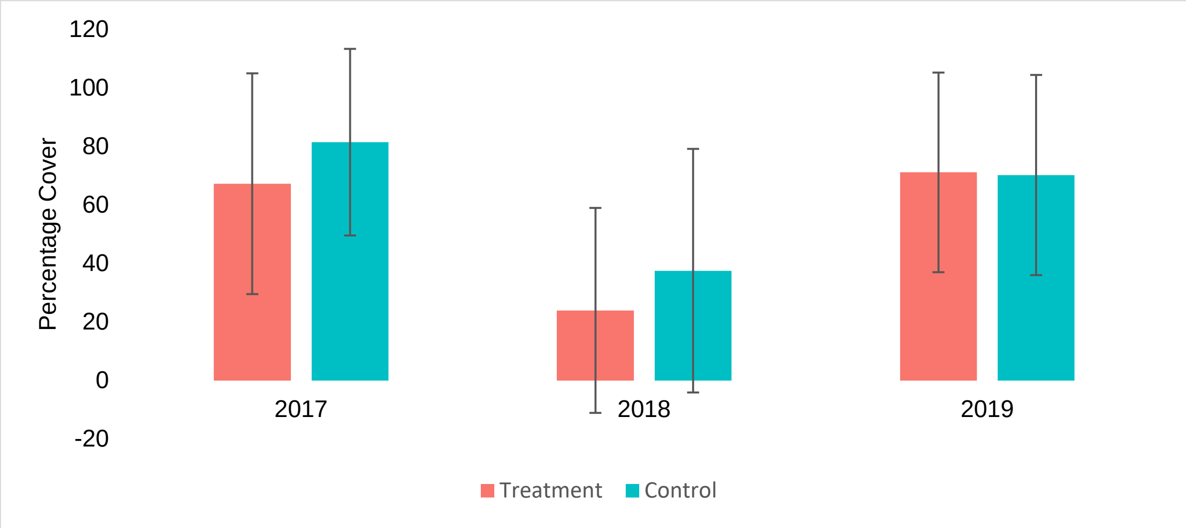

Figure 8: Bar graph showing annual average percentage cover of water plants between treatment and control

3.4 Species Composition

Species surveys supported the hydroacoustic monitoring of the treatment plots over the monitoring period. However, when it came to full analysis of the data, it became apparent that over the three years of monitoring, variations in how species data was gathered and quantified had occurred. As a result, a more limited data set is presented than set out in the methodology.

Figure 9 shows the variation over the monitoring period of intermediate stonewort, which has the scientific name *Chara intermedia*. *Chara intermedia* was initially the dominant stonewort species present in the experimental cutting area. The method used to quantify plant abundance was the same as used in the routine Broads annual water plant survey. In 2017 *Chara intermedia* had a greater abundance in the experimental cutting area compared to the whole of the broad. This is perhaps unsurprising, as the broad encompasses many different areas of mixed species, bare sediment areas and sample points within the marked channel. The experimental cutting was focussed within a large and contiguous stonewort bed.

However, by 2018 a significant drop in the abundance of *Chara intermedia* was observed in the treatment plots. This was mirrored by a similar trend across the broad a whole. Whilst the abundance of *Chara intermedia* increased again in 2019 in the treatment plots, it was still less abundant compared to 2017 (Figure 9). Given the similar patterns in the abundance of *Chara intermedia* over the three years, it would suggest that 2018 was generally a poorer year for *Chara intermedia* across the whole broad and not just in the treatment plots.

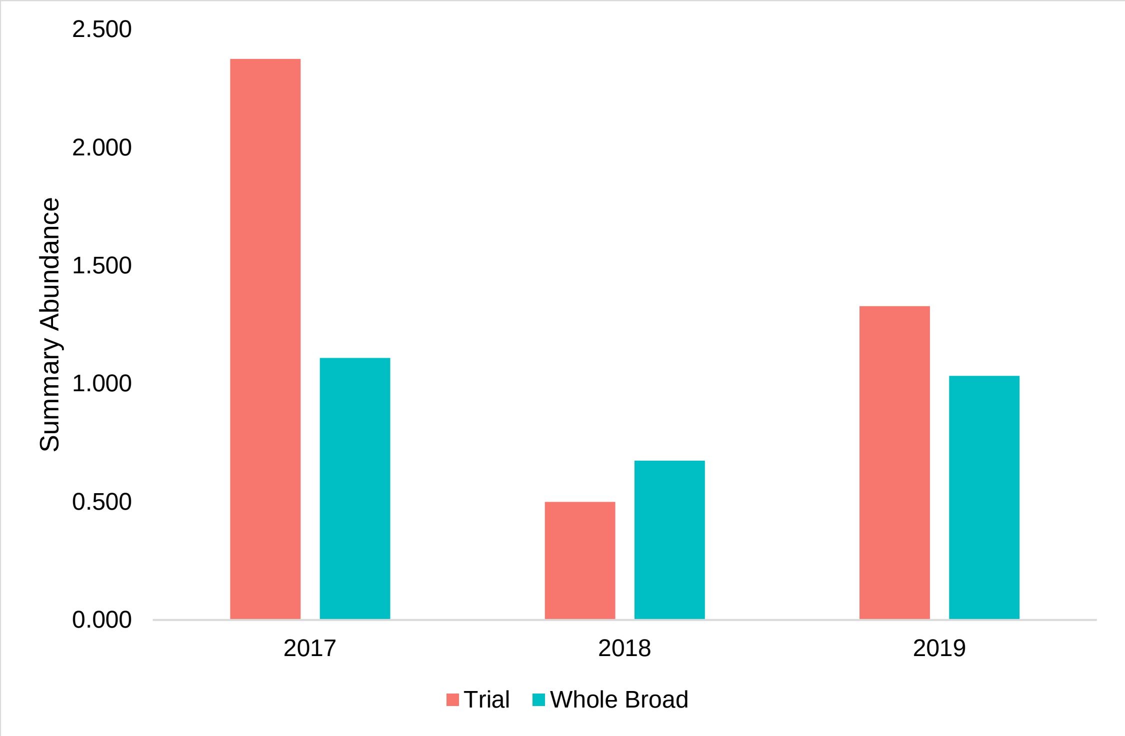

Figure 9: Abundance of intermediate stonewort in the treatment plots (red bars) and the whole broad survey (green bars)

The other consistently collected data was the relative abundance of the water plant species within the cut plots during 2017 and 2019 (Figures 10 and 11). Both years had 20 separate samples collected in the cut plots. Figure 10 shows the dominance of *Chara intermedia* in the cut plots during 2017, comprising 72% of the total abundance of all water plants. The second most abundant species was Baltic stonewort (*Chara baltica),* at 14%. In 2017 all stonewort species combined made up 93% of the total abundance of water plants species in the cut plots.

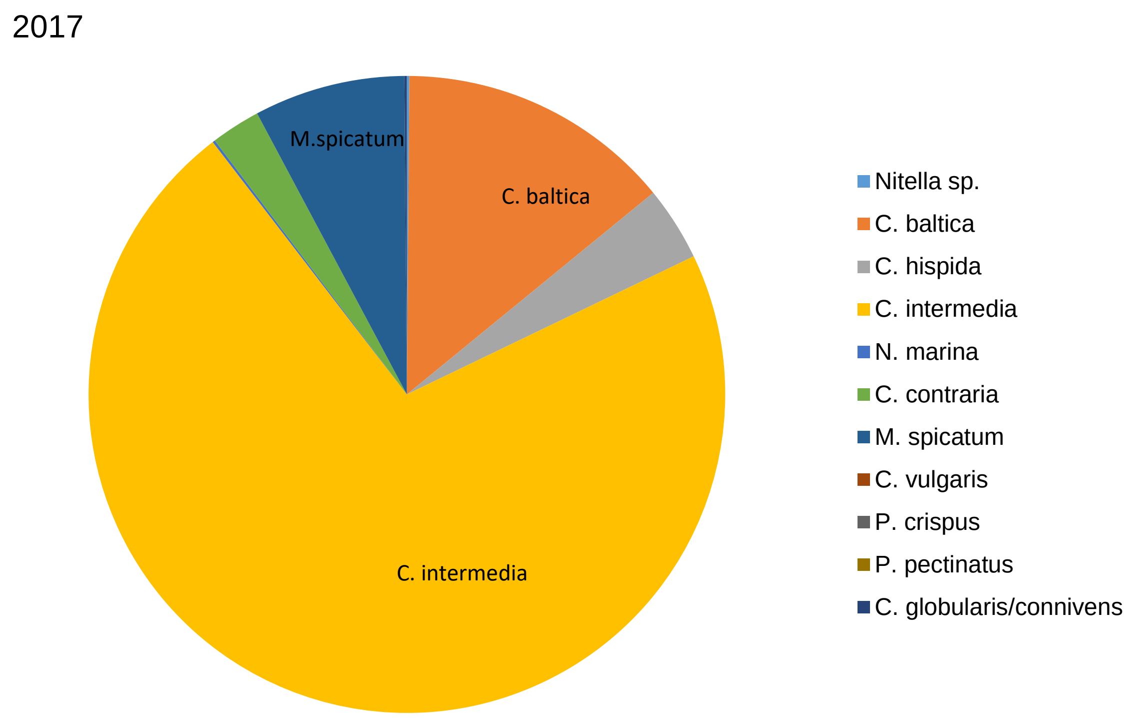

Figure 10: Relative abundance of plant species in “cut” plots during 2017

By 2019, the abundance of stonewort species in the cut plots had reduced to 46% of the whole water plant community. Presence of holly-leaved naiad (*Najas marina*) and spiked water milfoil (*Myriophyllum spicatum*) had increased, largely at the expense of *Chara intermedia.*

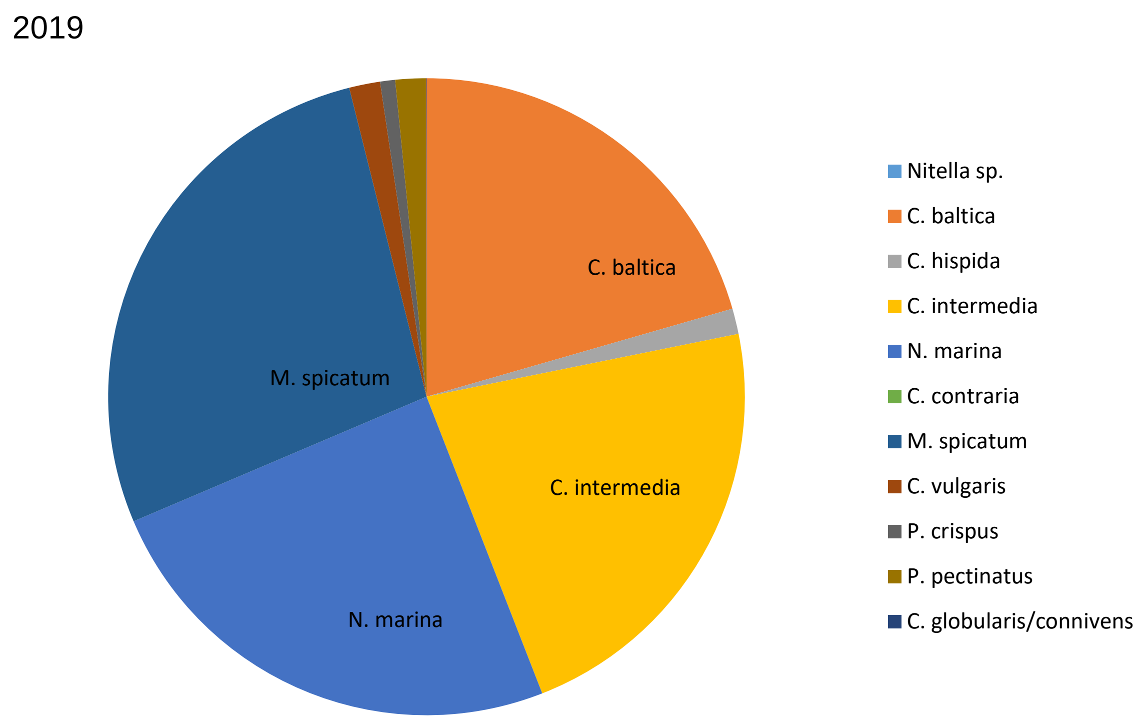

Figure 11: Relative abundance of plant species in “cut” plots during 2019

In comparison with the composition of the water plant community the whole broad (see Broads Annual Water Plant Monitoring Report 2019.pdf (www.broads-authority.gov.uk), graph 4 for Hickling), there was not a similar decline in stonewort species in the broad, as observed in the cut plots over the monitoring period. In 2017 stoneworts made up 41% of the total abundance across the broad. In 2019 this had increased slightly to 49%. This indicates that there was not a wider shift from stoneworts to other vascular plant species across the whole broad, and that the decrease in stoneworts observed within the cut plots was a local one. Whilst this observation is gained from data from just two years and cannot have the same kind of statistical treatment applied, due to the type of numerical data and the way in which it was collected, we can see that something happened within the cut plot areas to radically alter the plant community.

From the plant community composition data for 2017 and 2019, the Shannon-Weiner Diversity Index (H) was calculated. This index ranges from 0, which is low diversity, to 1, which is high species diversity.

Table 6. Shannon-Weiner diversity indices for plant community data in experimental plots

Plot type	2017	2019
Control	No Data	0.04
Cut	0.32	0.46

In the control plots in 2019 the Shannon-Weiner Index was very low (close to 0), suggesting dominance presence of a restricted range of species, as is typical in a stonewort bed. Compared to control, species diversity was significantly greater in the cut plots, *H = 0.46.* The greater species diversity in the cut plots is supported by the range and proportion of species shown graphically in Figure 11.

Between years in the cut plots, the Shannon-Weiner Index increased from, 0.32 in 2017 to 0.46 in 2019. Stonewort beds characteristically have relatively low species diversity (*H* closer to 0), so the increase in the Shannon-Weiner Index over time does not correspond with the conservation objectives for the site of stable, low diversity stonewort bed. The number of plant species present in the cut plots increased between 2017 and 2019. The increased Shannon-Weiner Index in 2019 was influenced by presence holly-leaved naiad (*Najas marina*), curled pondweed (*Potamogeton crispus*) and fennel-leaved pondweed (*Potamogeton pectinatus)*

The main conclusion from the experimental cutting area is that there was a large shift in the dominant species from *Chara intermedia* in 2017 to *Myriophyllum spicatum* in 2019.

In comparison to the trial cut area, there was no particular increase in the non-charophyte species recorded across the whole of Hickling Broad in the annual water plant survey from 2019.

4. Conclusion

Cutting had an immediate effect on plant height and cover. The checkerboard design of the initial "cut and "non-cut" plots as separate treatments, was shown to be a weakness in the experimental design and the data from these two plot types was successfully combined. The control plots were in close proximity to the treatments, but through robust statistical analysis of plant height and cover, the control was shown to be reliable. Planned repeat cuts of the water plants was not possible, as conditions in the wider broad changed. This took the experiment outside of the permitted criteria (see Appendix 1) in which repeat cutting could occur. However, hydroacoustic monitoring continued for three seasons after the cutting event, providing valuable data on the response of water plants to this impact.

The key findings of this trial are summarised, and whether each hypothesis could be supported.

4.1 Plant Height

The cutting did affect the mean height of water plants during the study period. In 2017 statistically significant differences were identified between treatment and control plots during the first season following cutting, but these were not observed in the following years.

The hypothesis that cutting would result in a reduction in overall plant height is supported by statistically significant differences in plant height, when compared to the control area, but only for a time-limited duration of one growth season.

4.2 Plant Cover

Percentage cover of plants was significantly lower in the treatment plots for two seasons following cutting. By the third season (2019) differences in cover were not apparent.

The hypothesis that cutting would result in a reduction in overall plant cover is supported by statistically significant differences in plant height, when compared to the control area, but only for a time-limited duration of two growth seasons.

4.3 Species composition

In the treatment plots, dominance by stonewort species, particularly *Chara intermedia*, had changed two years after cutting, to a more even mix of stoneworts and other vascular plants, mainly holly-leaved-naiad and spiked water milfoil. From the limited, but comparable species data in the cut plots, Shannon-Weiner Diversity Index indicates an overall increase in water plant diversity between 2017 and 2019. Increased species diversity the context of stonewort dominated plant beds is a negative trend in conservation terms, as it indicated other vascular and perhaps more common species have established in what was once dense stonewort growth.

The hypothesis that cutting would result in a decrease in charophyte prevalence within the plant community is not supported statistically, but the data gathered shows that the plant community in cut plots was more diverse, and contained less stonewort, than in control areas.

Appendix 1: Charophyte Cutting Decision Process

Table showing the decision process for the experimental chara cut.

Year 1		Years 2 & 3	
Are water plants causing a problem for water users within the priority area?		Is there clear evidence that the previous year's trial cut impacted on the cover and growth of charophytes in the study area?	
Yes	No	Yes	No
Have Favourable Condition targets for Chara community been met?			Are water plants causing a problem for water users within the priority area?
Yes	No	No	Yes
Is there a 2.3 ha contiguous Chara bed with plants within 60 cm of the water surface?			Have Favourable Condition targets been met?
Yes	No	No	Yes
Start experimental charophyte cutting & monitoring programme	No charophyte cutting		Is there a 2.3 ha bed with plants 60 cm in height?
		No	Yes
		No cutting required. Continue with monitoring programme	Recommence cutting and monitoring programme

Appendix 2: Species List

Species list for species ID surveys undertaken across all three years of the trial

Scientific Name	Common Name
Chara baltica	Baltic stonewort
Chara globularis/connivens	Fragile/convergent stonewort
Chara hispida	Bristly stonewort
Chara intermedia	Intermediate stonewort
Chara sp.	Chara species
Chara vulgaris	Common stonewort
Myriophyllum spicatum	Spiked water milfoil
Najas marina	Holly-leaved naiad
Potamogeton crispus	Curled pondweed
Potamogeton pectinatus	Fennel-leaved pondweed
Chara contraria	Opposite stonewort

Method Statement

Task:	Water Plant Harvesting – Upper Bure	
Job Code:	**Site Location:**	**Grid Reference & What 3 Words:**
NAV BUR	River Bure	From: TG 26746 19452 (train.loss.invoices) To: TG 29552 17213 (townhouse.remodel.dairy)
Proposed Start Date:	**Proposed Duration:**	**Completion Date**
May/June	4 months	September
Main contact for task:	Erica Murray 07789954147	

Description of Works (Methodology & Sequence of work):

Specification

- Cutting Height

Cutting height for the **River Bure** is specified as **no lower than 30cm above the bed** to preserve the aquatic macrophytes. The maximum cutting depth of the water plant harvester is 150 cm; good practice to periodically check water depth as channel depth could be deeper or shallower than specified.

- Margin

Between Horstead and Wroxham the river is between 13m and 27m wide – **leave 3m uncut margin from either bank**

Please note: Operator judgment is needed when channel depth or width become lower/smaller.

See Additional Maps section for further information regarding cutting at specific locations

Working method

Cutting:

- Only cut aquatic plants if they are causing a navigation issue
- Only cut aquatic plants to specified depth - check gauge boards for water depth prior to cutting and adjust cutting height as necessary to ensure plants are cut no lower than 30cm above the river bed
- Propellers to be raised to the surface when navigating at river margins, particularly when collecting fragments of cut plants that are floating on the surface
- All cut material must be removed from the river and placed on the river bank

Disposal:

- Cut material can be disposed of at the designated disposal sites only (see maps).
- It is not best practise to pile the material too high. Piles to be no higher than 1m after final disposal.
- Where space allows, disposal area should be split so only half of the bank stretch is used each year.
- Dispose of one load then move along to the adjacent section of bank to limit disturbance to the reeded edge.
- Cut material should be placed on the top of the bank to the furthest extent that the conveyor belt can reach; this is c.2.5 to 3m for the Harris & Megan harvesters. This distance ensures that the material remains on the bank whilst allowing mobile invertebrates to escape back into the river.

  Be aware of any nesting birds in the marginal vegetation. Coots and Great Crested Grebes commonly nest in floating vegetation on the water, and warblers and Reed Buntings commonly nest in the taller marginal vegetation. **If any birds are seen nesting within 10m of the works area, an Ecologist should be called.**

PLEASE SEE DOCUMENTATION FOR OPERATION TO MONITOR WATER TEMP & DISSOLVED OXYGEN TO ASSESS SUITABLE CUTTING CONDIDITONS.

Method Statement

Aquatic Plant Harvester Route - Coltishall to Belaugh

Scale: 1:10,000

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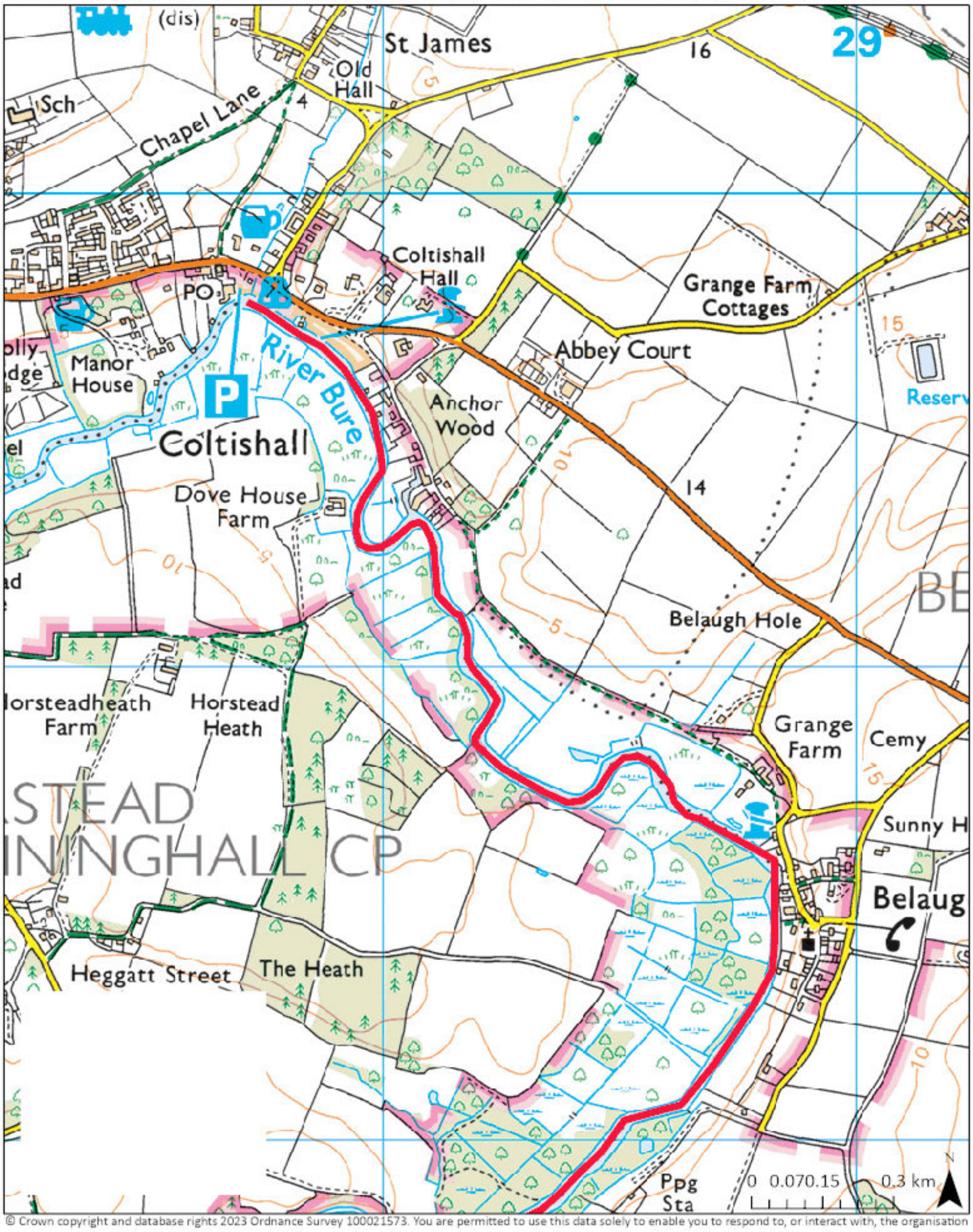

Method Statement

Aquatic Plant Harvester Route - Belaugh to Bridge Broad

Scale: 1:10,000

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Method Statement

Operational Details (Access, Egress, Materials, Plant, Equipment & Storage)**:**
2. Directions to site; see maps 3. Directions to work areas; see maps 4. Work area specific hazards listed; Nesting Birds & boat traffic 5. Temporary works identified; none 6. Explicit instructions if fires are planned; none 7. Way out; see maps

Site Emergency Plan:	..\..\..\..\Management\Operational Safety Files\Site Emergency Plans & Hazard Maps\UpperBure_Site_Emergency_Plan.doc
Risk Assessment:	Senior OpTech to complete
COSHH Assessments:	
Consents Obtained:	Cutting area and disposal sites are not within a designated site so permission from NE is not required.
Contractors Details:	n/a
Plant/Materials Required:	Aquatic plant harvester, associated PPE
Biosecurity or Waste requirements:	To reduce the risk of the invasive Killer Shrimp, *Dikerogammarus villosus*, being spread to other aquatic sites in the Broads, the machine should be steamed cleaned once it has finished work on the River Bure.
Site Welfare Requirements: (Portaloo if >5 working days)	*(NB: Tarps can be collected from Dockyard for shelter)*
Arrangements for the Public:	n/a
Other Site Contact Details or Information:	• ESOP 1 – Cutting Aquatic Water Plants • ESOP 2 – Biosecurity • ESOP 13 – Breeding bird mitigation • Sediment Management Strategy – a standard 3m margin is left to either bank where the river width can accommodate this. **Op Techs** – please record on map which parts actually required cutting, and how many loads were deposited at each disposal point.

	Signature	Date
Ecologist	**Erica Murray**	17/02/2023
Supervisors	Sue Stephenson	03/04/2023

Additional Maps & Drawings:
Locations where aquatic plant cutting can take place at the harvester operators' discretion: • between Bridge Broad & Caen Meadow • the bends upstream of Caen Meadow towards Belaugh

Aquatic Plant Harvester route -Bridge Broad to Caen Meadow

Scale: 1:10,000

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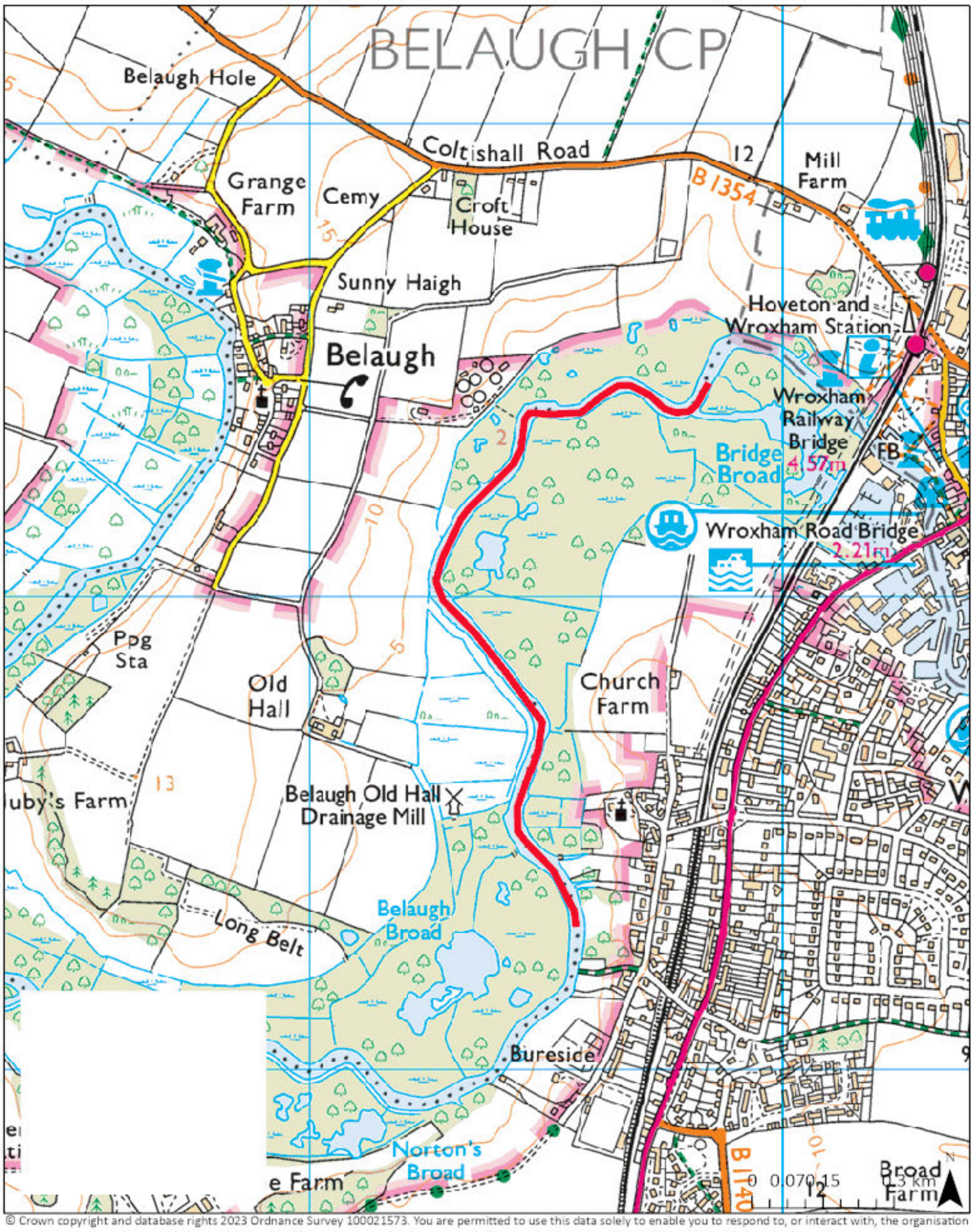
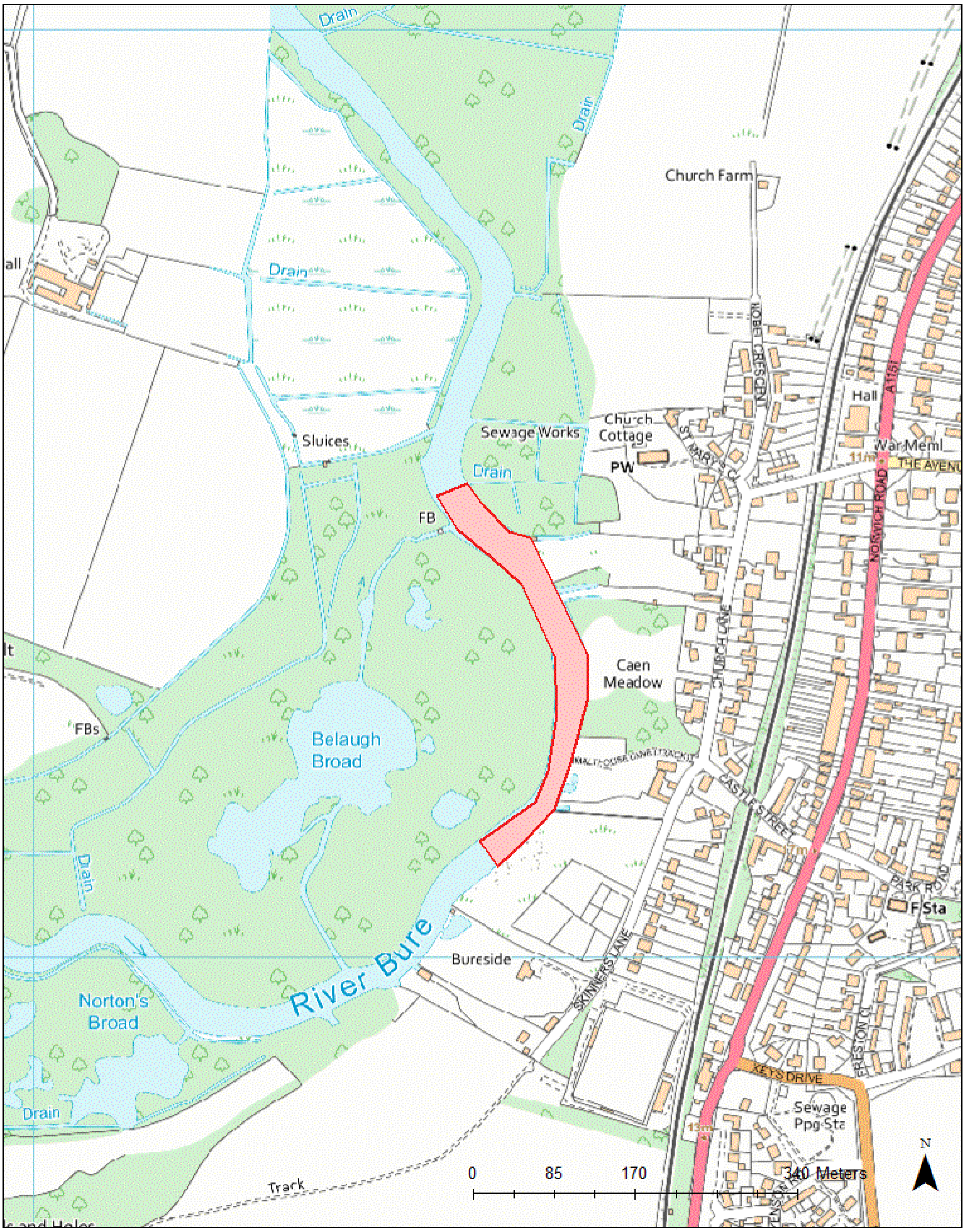
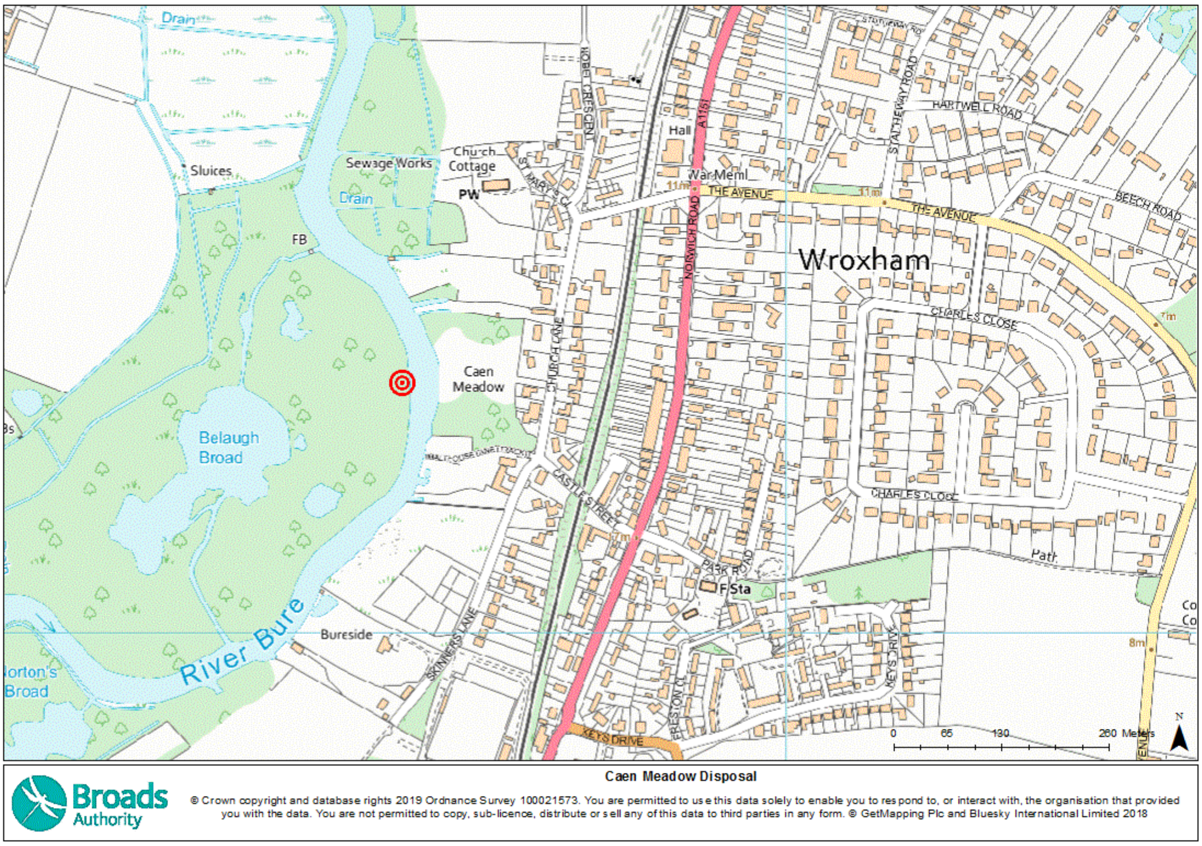


- <u>Cutting area near Caen Meadow:</u> Cutting section mainly on bends either side of Caen Meadow.



Caen Meadow Weedharvester cutting zone

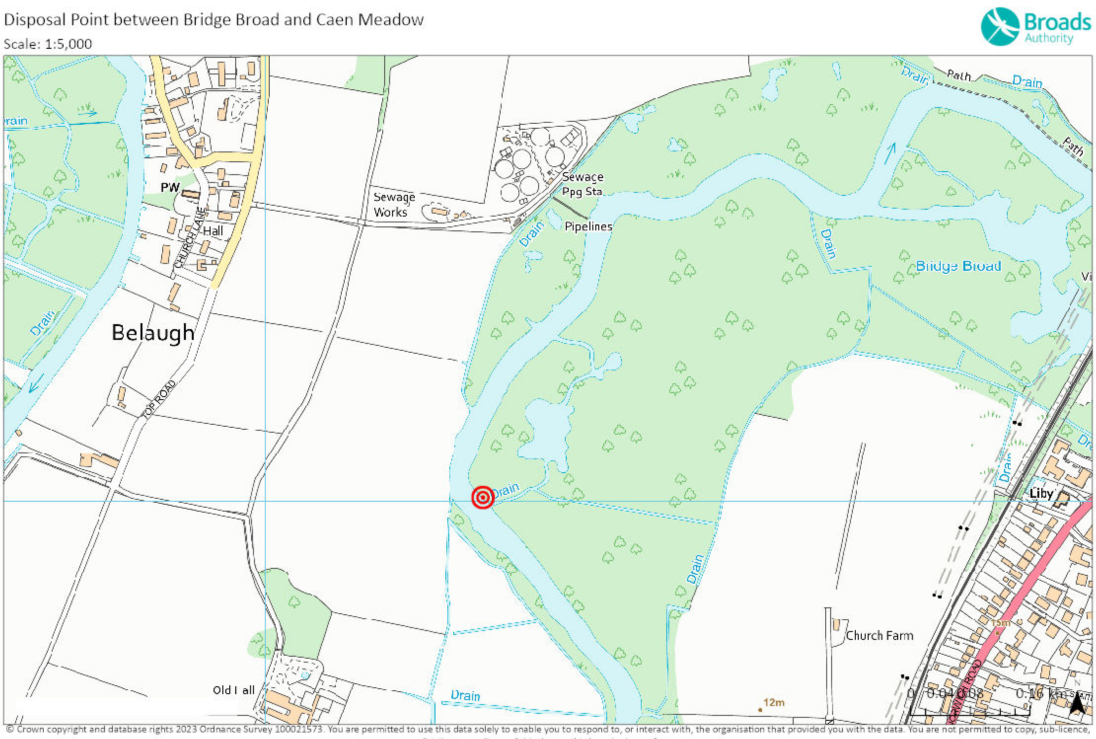
Caen Meadow Disposal Site



New - Disposal point between Bridge Broad & Caen Meadow

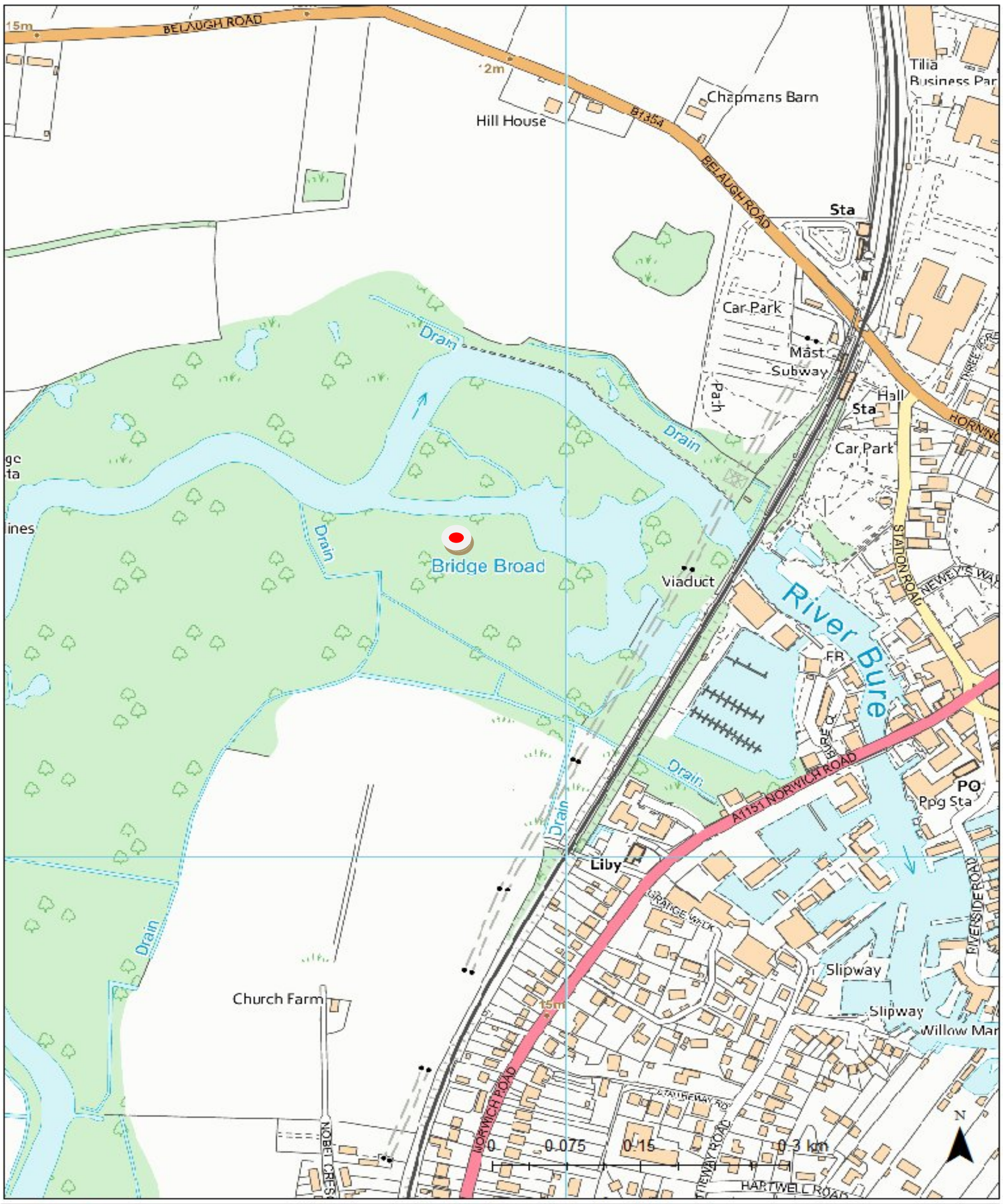
Disposal Point between Bridge Broad and Caen Meadow

Scale: 1:5,000



Method Statement

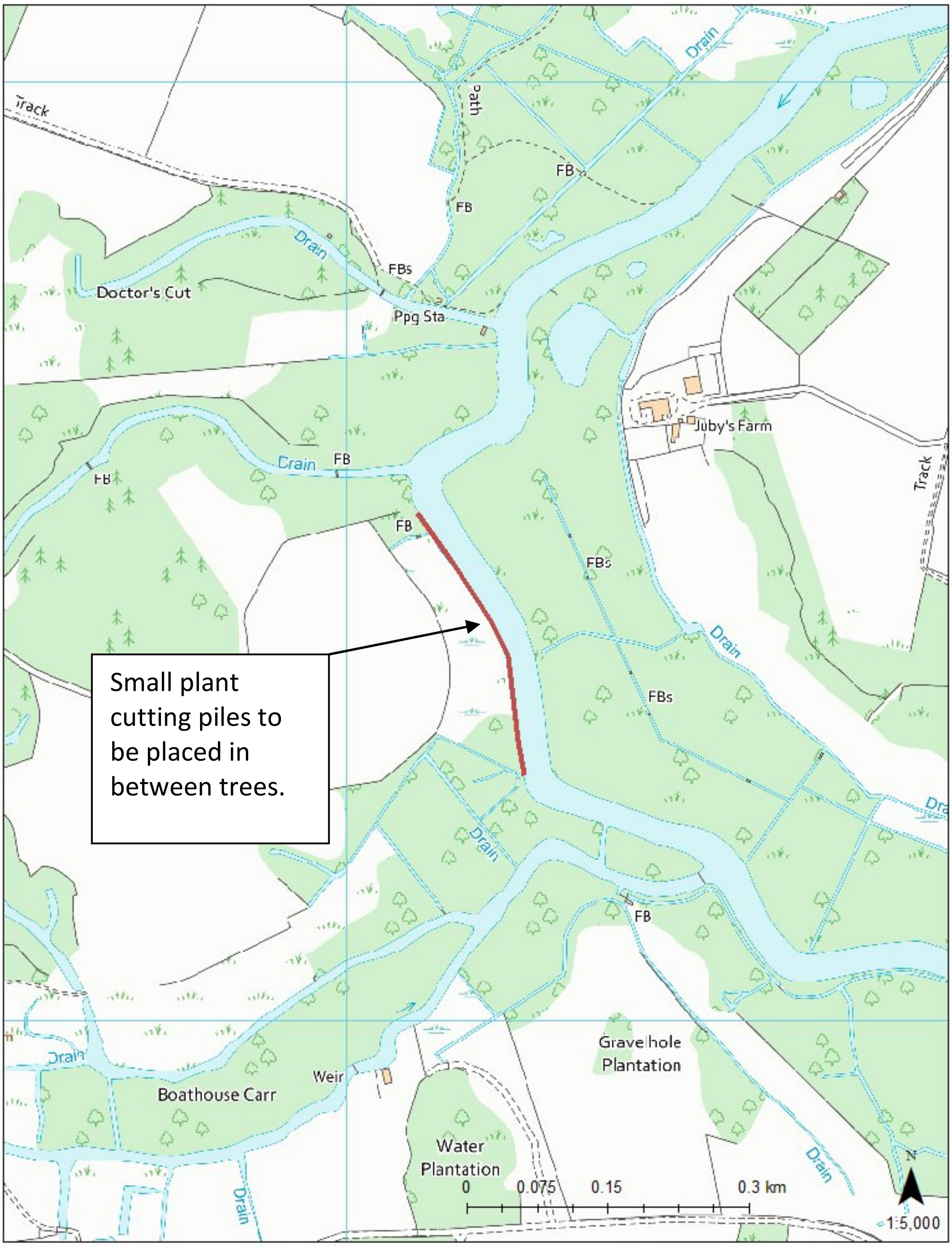
Bridge Broad Disposal Site



Bridge Broad disposal site (marked with red circle).

Method Statement

Disposal site between Belaugh & Caen Meadow



Disposal point between Belaugh & Caen Meadow