Insh Marshes National Nature Reserve
River Restoration Feasibility Study:
Technical Summary

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Insh Marshes National Nature Reserve River Restoration Feasibility Study: Technical Summary

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EXECUTIVE SUMMARY

The Insh Marshes is an internationally important wetland comprising approximately 1,000 hectares of the floodplain of the River Spey between Kingussie and Kincraig. RSPB Scotland has owned and managed most of the Insh Marshes as a nature reserve since the 1970's. Whilst Insh Marshes is often cited as one of the least modified floodplains in North West Europe, it is not a fully naturally functioning floodplain. Historic modifications from the late 18th and early 19th century include flood embankments, realignment of tributaries and an extensive internal drainage ditch system. The flow regimes of the Spey and Tromie are heavily modified by abstraction and transfer of water out of the upper Spey. Various management actions are required to sustain the favourable condition of the designated features of the floodplain wetlands, and the current management regime is considered by RSPB to be unsustainable in the long term.

A feasibility study was undertaken by RSPB in 2015/16 to identify options that could potentially restore a more naturally functioning river and floodplain system. Potential options aimed at restoring a more naturally functioning river and floodplain system were identified that included 'Doing Nothing', maintaining according the existing obligations, various embankment removal scenarios, options for morphological restoration of the tributaries and options to reduce the internal drainage of the floodplain. The option of repairing the existing breaches in the embankments was included for comparison purposes. An assessment of the implications of the options on channel and floodplain processes and the hydrological and flood regime was undertaken and used to inform the potential effects on the ecological features and properties, services or infrastructure.

Following a detailed assessment of the present functioning of the Insh Marshes system, an options assessment was undertaken and informed by a multi-criteria analysis. Feedback from the stakeholders consulted, indicated that they were supportive of creating a more naturally functioning floodplain system at Insh Marshes, and supportive of the principles of embankment removal.

Reduced floodplain connectivity and reduced channel dynamics are likely to have influenced the spatial distribution of flora and fauna with the reserve. The seasonality of flooding has a significant influence on the effects on the ecological features. The majority of high flow events in the gauged record (dating back to 1950's) occurred between October and March, and climate change projections indicate that the seasonality of precipitation is likely to become more pronounced, with winters becoming wetter on average and summers drier. The functioning parts of the drainage network can cause drawdown of the groundwater table during summer months. Embankment removal and/ or tributary restoration options will increase the channel-floodplain connectivity and allow a more natural sediment transport regime and depositional patterns to develop.

Increased channel-floodplain connectivity has the potential to increase the proportion of fen, marsh and swamp habitat and reduce the area of willow scrub. A more dynamic morphological regime provides new opportunities for the formation of floodplain water bodies and frequent flood zones, colonisation by pioneer species and successional processes, and may benefit in-channel habitat conditions for aquatic species. Options that involve removal of embankments are likely to provide the most benefit to bird species. Some wader species, rails, crakes and duck numbers may all increase over a period of time as the ground conditions flood more frequently, more small pools and boggy areas are created by remnant water, and habitat changes to a more fen-like composition. For embankment removal options, ground-nesting species may be affected should a flood occur during the breeding season. It is however noted that much of the site already experiences frequent flooding during existing conditions.

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1 OVERVIEW OF INSH MARSHES

The Insh Marshes is an internationally important wetland comprising approximately 1,000 ha of the floodplain of the River Spey between Kingussie and Kincraig. The importance of the site is reflected in its many conservation designations including Special Protection Area (SPA), Special Area of Conservation (SAC), Site of Special Scientific Interest (SSSI), Ramsar and National Nature Reserve (NNR). RSPB manages 781 ha of the floodplain as a nature reserve as shown in Figure 1 1.

Important features of the designated site include floodplain fen, quaking mire, mesotrophic lochs, alder woodlands, vascular plant and invertebrate assemblages, breeding bird assemblage, otter, osprey, spotted crake, wintering hen harrier and whooper swan. The River Spey flows through the marshes and is designated for sea lamprey, freshwater pearl mussel, char, salmon, otter and its trophic range.

Insh Marshes is often cited as one of the least modified floodplains in North West Europe. However, it is not a fully naturally functioning floodplain and reflects a system where historic management of the floodplain for agricultural production was attempted and is now largely abandoned. Historic modifications include flood embankments and bank protection works along the River Spey and its tributaries within the Insh Marshes, and an extensive internal drainage ditch system.

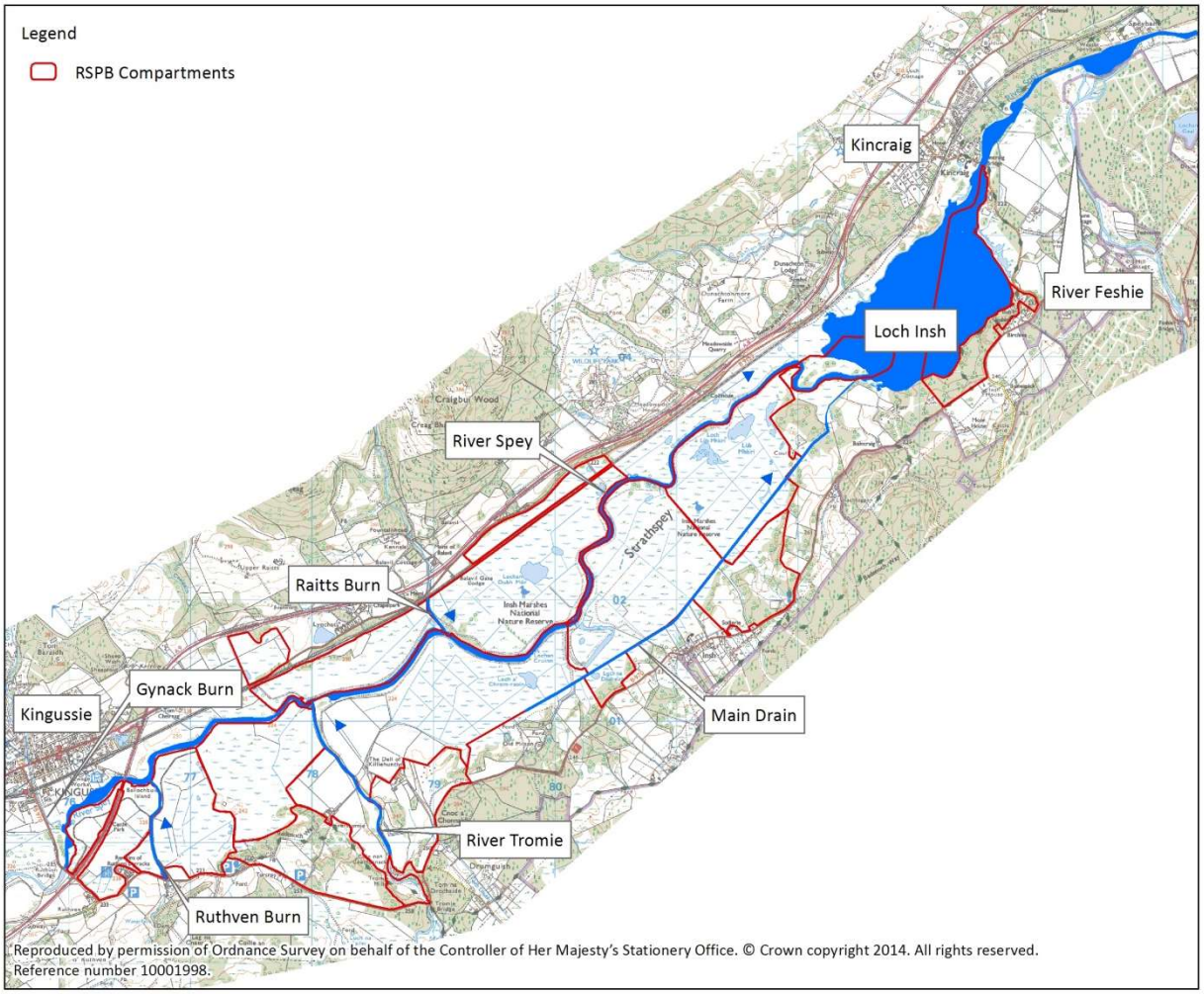


Figure 1.1: Overview of Insh Marshes showing RSPB land and main surface water features

The River Spey between Spey Dam and Loch Insh is classified as a Heavily Modified Water Body for Water Framework Directive River Basin Management Planning purposes due to upstream abstractions and transfers for hydropower generation. The water body was classified as having an overall status of Good Ecological Potential in 2014.

RSPB Scotland has owned and managed most of the Insh Marshes as a nature reserve since the 1970's. The key conservation objective for the reserve is to maintain and where appropriate enhance the wetlands of the River Spey floodplain for the benefit of its nationally and internationally important features. There are concerns that the impacts of the historic modifications, notably reduced channel-floodplain connectivity and a less dynamic floodplain system, may make it more difficult to maintain some of the designated conservation features and habitats in favourable condition in the future. There is already evidence of 'terrestrialisation' of open water habitat and vegetation succession towards increased scrub cover, which have prompted an increase in management operations. Restoring the natural functioning of the floodplain may create a more dynamic system which could require reduced human intervention to maintain the ecological interests of the site.

The RSPB land comprises of different hydrological management units as shown in Figure 1.2. Key infrastructure in the vicinity of the reserve includes the A9 crossing of the River Spey at Kingussie and the mainline railway that runs along the northern extent of the reserve.

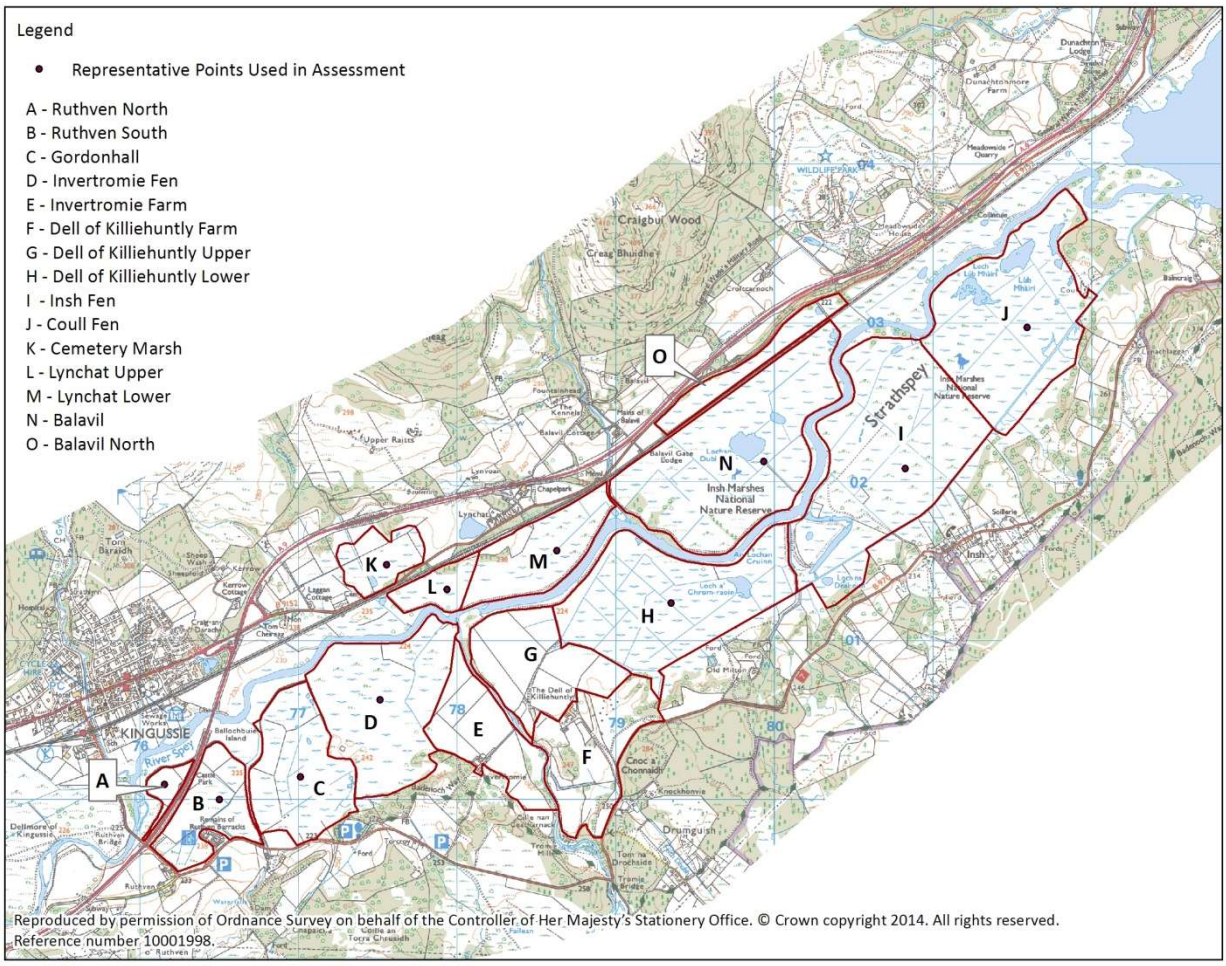


Figure 1.2: Hydrological management units across RSPB managed areas of Insh Marshes

2 RESTORATION OF NATURAL PROCESSES

In 2015-16, RSPB undertook a study to assess the feasibility of options aimed at restoring a more naturally functioning river and floodplain system. This involved:

- Assessments to further the understanding of the existing conditions and current functioning of the floodplain system;
- Identification of a wide range of potential options, informed by the understanding of the existing conditions;
- Predictions of the implications of the options on key factors, including the ecological interests, flood risk, and morphology of the River Spey and its tributaries, including consideration of the impacts of climate change; and
- Consultation with stakeholders covering a diverse range of interests in the reserve, including the Scottish Environment Protection Agency (SEPA), Scottish Natural Heritage (SNH), Cairngorms National Park Authority (CNPA), Spey Fishery Board, Spey Catchment Initiative, Network Rail, Transport Scotland and The Highland Council.

A review of the extensive body of literature for the Insh Marshes was undertaken along with field surveys to characterise the local topography, morphological processes and hydrological conditions.

The study extent covered the River Spey between Ruthven Bridge and the River Feshie confluence as well as the three main tributaries where they flow within the reserve boundary (Ruthven Burn, River Tromie and Raitts Burn) and the large drainage channel that drains the south-eastern part of the reserve to Loch Insh (referred to as the Main Drain).

The study included assessments to further the understanding of the existing conditions and current functioning of the floodplain system, identification and assessment of a wide range of potential options to restore a more naturally functioning river system, consultation with stakeholders, outline design of two potential pilot schemes, and summarising what may be required to progress to the next stage.

Baseline assessments included a literature review of previous research papers and data sources, hydrological assessment of river flows, topographic survey and fluvial audit of the River Spey and its tributaries within the reserve. A hydrodynamic model was developed of the River Spey between Kingussie and Kincraig to further the understanding of flood frequency, depth and duration throughout the reserve, and of the floodplain flow pathways and mechanisms.

A number of option scenarios were subsequently incorporated into the model to assess the potential changes in flood regime. The modelling focused on frequent flood events to inform the assessment of change in channel morphology and supporting conditions for ecological receptors. Extreme flood events have been assessed in terms of direction and magnitude of potential change in flood risk.

The use of pilot schemes provide the opportunity to monitor changes in hydrological regime, ecological receptors and morphological conditions prior to undertaking works across a larger part of the site, and provide design details that can be applicable to other areas.

The findings of the feasibility study are summarised in this present report.

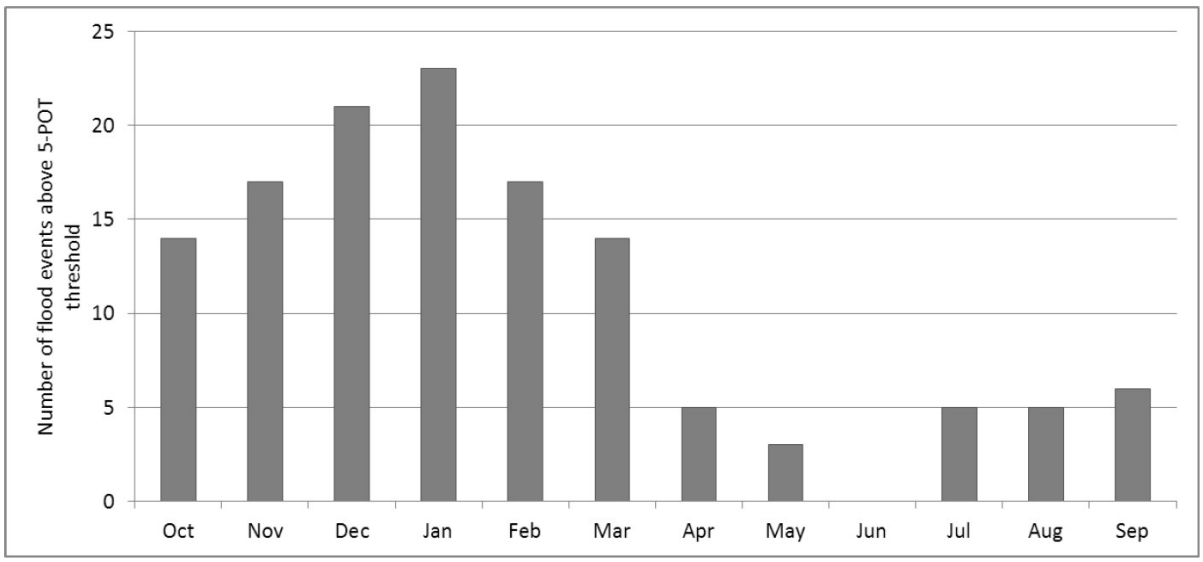
3 BASELINE CONDITIONS

3.1 Overview

The River Spey is characterised by a sinuous, low energy channel through the reserve, particularly downstream of the A9 crossing at Kingussie. Dynamic channel processes are associated with coarse sediment inputs from the key tributaries, including the Gynack Burn, River Tromie and Raitts Burn, and are generally confined to the locality of the confluences. The presence of flood embankments have reduced connectivity to the floodplain, and realignment of the tributaries and bank protection has limited lateral migration and altered sediment transport processes. This has resulted in aggradation (sediment deposition causing a raising of the river bed) leaving the bed of the Raitts Burn perched above the surrounding ground.

Hydraulic modelling indicates that the existing breaches in the embankments and backing-up via the large drains within Insh Marshes result in inundation of the reserve several times per year to depths ranging from less than 0.3 m in the western part of the reserve up to 1 m closer to Loch Insh. During extreme flood events the embankments are overtopped and the whole reserve is predicted to be inundated to depths of up to 3 m. The floodplain flow paths, depth and duration of flooding within different parts of the reserve are influenced by the embankments and drainage system. Water levels at Loch Insh and the River Feshie exert a downstream control on water levels.

Reduced floodplain connectivity and reduced channel dynamics are likely to have influenced the spatial distribution of flora and fauna with the reserve. The seasonality of flooding has a significant influence on the effects on the ecological features. The majority of high flow events in the gauged record (dating back to 1950's) occurred between October and March, as shown in Figure 3.1, and climate change projections indicate that the seasonality of precipitation is likely to become more pronounced, with winters becoming wetter on average and summers drier. The functioning parts of the drainage network can cause drawdown of the groundwater table during summer months.



Note: 5-POT refers to the magnitude of flood that will be exceeded typically 5 times per year on average

Figure 3.1: Monthly distribution of high flow events on the River Spey recorded at Invertruim

The baseline conditions at Insh Marshes were assessed in 2015/16 in terms of hydrology, morphology and ecology. The key elements of the baseline understanding identified were:

- Natural channel-floodplain interactions and processes have been altered for over 200 years by the presence of embankments, channel realignments and constructed drainage network.
- The flow regime of the Spey and Tromie are also heavily modified by impoundment, abstraction and transfer of water out of the upper catchments.
- Groundwater levels in the low-lying parts of the floodplain are close to the surface for the majority of the year. The extensive network of ditches can cause localised drawdown of the water table during summer months. Direct connections between the drainage network and the Spey and Loch Insh result in more frequent inundation during higher flows than under natural conditions, and increased drainage and drawdown during drier conditions.
- The embankments increase conveyance in the Spey and reduce floodplain connectivity. Existing breaches in the embankments allow water into the floodplain during frequent flood events, however the embankments affect floodplain flow paths and conveyance, affecting the depth and duration of water retained on the floodplain.
- The downstream control on water levels (River Feshie/ Loch Insh) and direct connectivity between Loch Insh and Insh Marshes via the Main Drain also have a significant influence on channel-floodplain interactions within Insh Marshes.
- Downstream of the Ruthven Burn confluence, the Spey is a low energy watercourse. The main areas of dynamism and channel change are associated with coarse sediment inputs from the key tributaries (Tromie and Raitts Burn), however there is generally insufficient energy for the channel to transport this coarse material downstream. The embankments along the Spey reduce connectivity with the floodplain and increase the channel conveyance compared to natural conditions.
- The Tromie and Raitts Burn are of moderate energy, whilst the Ruthven Burn is a lower energy watercourse and is more readily influenced by water levels in the Spey. Realignment and embanking of the tributaries has reduced in-channel diversity, lateral migration and connectivity with the floodplain. In the case of Raitts Burn, the modifications have resulted in the development of a highly altered channel form and a perched bed.
- The spatial distribution of the flora and fauna across Insh Marshes are affected by these altered hydrological and morphological regimes. Various management actions are required to sustain the favourable condition of the designated features of the wetland and the current management regime is considered to be unsustainable in the long term.
- The A9 crossing of the Spey and the railway crossing at Raitts Burn are two key locations where infrastructure both affects and is affected by channel morphology, and where a potential conflict of interest exists between the desire to restore more natural processes and the need to protect these transport routes.
- There are also a number of properties, roads, sewage treatment works and land outside of Insh Marshes which could be affected by changes to the flood regime with the study area.

3.2 Hydrological Regime

The complexity of the hydrological regime of Insh Marshes has been well documented in previous studies. Hydrological inputs include overtopping from the Spey and tributaries such as the Tromie and Raitts Burn, plus direct precipitation, runoff from adjacent hillslopes and groundwater. Losses occur through evapotranspiration and drainage via ditches and spills to the Spey and its tributaries.

Previous studies have identified that groundwater levels within the low-lying areas of Insh Marshes are close to the surface for the majority of the year, highlighted by the very flat stage-duration curves derived from automated groundwater loggers. Longer term, manual records held by RSPB show that groundwater levels are highest in December/ January and lowest in May/ June.

Many of the smaller internal ditches within the reserve now act as 'wet fences' rather than as active drainage channels, being are highly occluded with vegetation and having minimal connectivity between the drainage network and the Spey. Some of the breaches in the flood embankments are scoured below the adjacent ground levels, allowing more floodwater to drain back into the Spey than under natural conditions. Previous research suggests the water levels in the Spey affect groundwater levels adjacent to the river, and as a result it is considered unlikely that these low-level breaches are having a drawdown influence on groundwater levels that is significantly different than for other areas.

3.3 Ecological Interests

The nature designations at Insh Marshes include the Insh Marshes Special Area of Conservation (SAC), River Spey SAC, Insh Marches Special Protection Area (SPA), Insh Marshes RAMSAR and Insh Marshes Site of Special Scientific Interest (SSSI). The hydrological, and in particular, the flood regime influences the spatial distribution of the flora and fauna within the site.

The baseline hydro-ecological conditions were established for each of the RSPB hydrological management units. These were characterised by identifying the habitats and key species present. The hydrological conditions were characterised by the sources of inflow and flood frequency, extent, depth and duration for a flood event that would occur approximately three times per year on average. The RSPB management plans and actions for each of the hydrological units were confirmed.

RSPB's Management Plan provides analysis of trends in key bird populations. Wader populations appear to have peaked in the late 1990's and early 2000. Since then wader numbers have fallen but seemed to stabilise in the late 2000's. Breeding wildfowl and wetland passerine numbers appear to have been stable, as were Goldeneye numbers 2000-2009. It is noted that movement of birds within the site had occurred, reflecting changing ground and vegetation conditions. Wood sandpiper has not been recorded as breeding within the reserve for many years.

3.4 Morphology

The River Spey between Spey Dam and Loch Insh, and the River Tromie are classified as Heavily Modified Water Bodies for River Basin Management Planning purposes due to large scale abstraction and transfer of water out of the upper catchment for hydro-electric power. This loss of water is estimated to account for 19-49% of the natural mean annual flow at Kinrara. The impoundments will have a lower impact on high flow events, however the physical barrier caused by the impoundment and the altered flow regime are likely to affect sediment transport processes and channel dynamics.

Historic changes to the watercourses and floodplain within the study area are documented in historic maps. The Roy Military Map (c1750) depicts the Spey as a sinuous channel with no meander cut-offs and indicates that Loch Insh may have been at a higher level than current conditions, extending further west into the marsh. Leslie's 1863 map also highlights a former entry point of the Spey into Loch Insh. The Roy Map shows the Gynack and Ruthven Burns and the lower 800 m of the River Tromie as highly sinuous channels. The Raitts Burn is shown to continue on a south-easterly alignment downstream of Balavil cottage and to confluence with the Spey downstream of the current location in the Roy Map. It too is depicted with a sinuous channel within the marshes. The Roy map was a rapid reconnaissance exercise rather than a carefully measured topographic survey, and this has to be taken into consideration when interpreting the map data, particularly with respect to the relative spacing and size of meanders. However, it does provide useful evidence of pre-modified conditions of the tributaries.

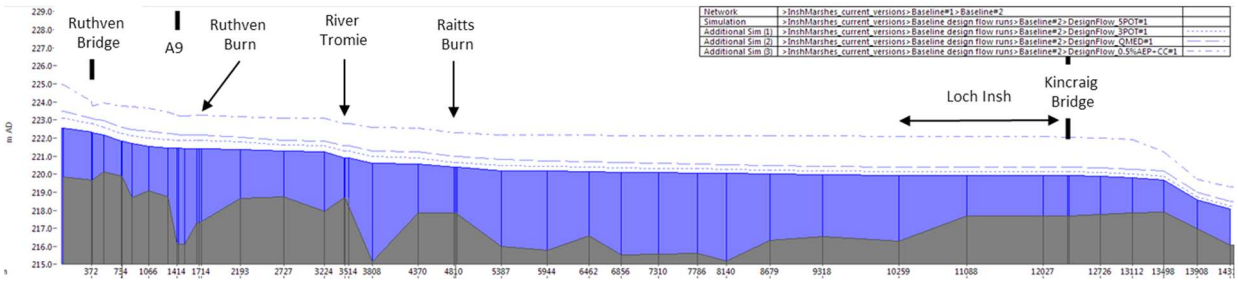
It is believed that the extensive modifications to the tributaries and floodplain occurred in the late 18th century and early 19th century (prior to 1814). Embankments, channel straightening and realignment, and an extensive drainage system were constructed in an attempt to improve the land for agriculture and are clearly shown on the Ordnance Survey 1st Edition mapping surveyed in 1870. There are also records of attempts to dredge the outlet of Loch Insh in the 1790s to aid drainage of the marshes. The two meander cut-offs in the study area, at Ballochbuie Island and at Insh Fen, took place prior to 1863 and appear to have occurred naturally. It has been speculated that changes to the control level, as would occur if the outlet at Loch Insh was dredged, could have contributed to these cut-offs.

As the Spey flows from the confluence with the Tromie downstream to Loch Insh (Figure 3.2), it is deeper and wider than upstream of the Tromie confluence, and is characterised by long, slow glides and pools interspersed with short, steeper riffle and run sections at the tributary confluences (Tromie and Raitts Burn). A long profile down through the bed of the River Spey from the river model developed is shown in Figure 3.3. This shows controlling effect of the bed levels around Kincraig Bridge and towards the confluence with the River Feshie at the downstream end of the model.

The key morphological pressures within the reach are embankments and set-back embankments located on both banks, resulting in floodplain disconnection. The embankments and low-level revetments may also restrict lateral migration, although natural rates of migration are expected to be low due to the very low energy of watercourse through this reach.

a) b)

Figure 3.2: River Spey – a) typical low energy, embanked section; b) Raitts Burn confluence



Note: The river bed level is shown in grey. The bed levels are all from the 2015 survey apart from through Loch Insh, where bed levels were not surveyed and the levels shown are appropriate for modelling purposes, but not representative of actual loch bed levels (levels shown are higher than actual).

Figure 3.3: River bed levels and typical water levels through the centre of the River Spey

4 FLOODPLAIN RECONNECTION

4.1 Options Identified to Restore Floodplain Connectivity

A wide range of potential restoration options were identified following the baseline assessments. From this a targeted range of potential options aimed at restoring a more naturally functioning river and floodplain system were identified and agreed with RSPB and SEPA. These are listed in Table 4.1 and included 'Doing Nothing', maintaining according the existing obligations, various embankment removal scenarios, options for morphological restoration of the tributaries and options to reduce the internal drainage of the floodplain. The option of repairing the existing breaches in the embankments was included for comparison purposes. An assessment of the implications of the options on channel and floodplain processes and the hydrological and flood regime was undertaken and used to inform the potential effects on the ecological features and properties, services or infrastructure.

Table 4.1: Potential restoration options identified for assessment

Potential restoration option
1. Do nothing
2. Maintain according to obligations
3. Full repair of embankments
4. Remove embankments. There are many potential variations of embankment removal due to the large number of embankments across the study area, three location were considered: a. Full removal of all embankments b. Removal at Lynchat c. Removal at Lynchat, Dell, Insh and Coull
5. Increased breaching of embankments
6. Remove bank protection
7. In-channel restoration measures (tributaries)
8. Channel realignment/ re-meandering (tributaries)
9. Reinstatement of stream diversions
10. Reduce internal drainage of the floodplain. Measures to reduce the effectiveness of the internal drainage of the floodplain could be employed across the full site, or for individual units or individual ditches. For the purposes of the options appraisal two variations of this option have been assessed. a. Block internal drainage ditches and remove the direct connectivity with the River Spey b. Reduce the direct connectivity between the Main Drain and Loch Insh

Setting-back of embankments has not been considered as a standalone option as it is not considered a desirable option given the character of the site and the aspirations of the project. If measures are required to mitigate increased flood risk to adjacent land or property these would be considered further at the design stage.

Each of the options were assessed in terms of the potential impact on the hydrological regime, ecological interests at the site, morphological forms and processes, and the risk to identified receptors. These were informed by the river model and summarised in a factsheet format for each option for ease of comparison.

4.2 Benefits of Floodplain Reconnection

Retaining the embankments in exactly the same condition they are currently in is not a viable option due to the on-going maintenance burden for the RSPB.

Embankment removal and/ or tributary restoration options will increase the channel-floodplain connectivity and allow a more natural sediment transport regime and depositional patterns to develop. It is expected that these options will encourage a more dynamic morphological regime. Full recovery of natural morphological conditions in the River Tromie and Raitts Burn may be limited by the modified flow and sediment regime of the River Tromie and the upstream restrictions on lateral movement of the Raitts Burn caused by key infrastructure.

Increased channel-floodplain connectivity has the potential to increase the proportion of fen, marsh and swamp habitat and reduce the area of willow scrub. Changes in habitat composition are less likely in the areas of the reserve where flood conditions are strongly influenced by Loch Insh, including Insh Fen and Coull Fen. A more dynamic morphological regime provides new opportunities for the formation of floodplain water bodies and frequent flood zones, colonisation by pioneer species and successional processes, and may benefit in-channel habitat conditions for aquatic species.

Options that involve removal of embankments are likely to provide the most benefit to bird species. Some wader species, rails, crakes and duck numbers may all increase over a period of time as the ground conditions flood more frequently, more small pools and boggy areas are created by remnant water, and habitat changes to a more fen-like composition. For embankment removal options, ground-nesting species may be affected should a flood occur during the breeding season. It is however noted that much of the site already experiences frequent flooding during existing conditions.

The modelling results for embankment repair and embankment removal demonstrate the influence that the embankments have on the flood mechanisms and levels throughout the reserve, and on downstream flows. The embankments increase conveyance in the channel and reduce inundation, storage and conveyance in the floodplain during frequent flood events, allowing flood flows to pass through the reserve more quickly. However, at extreme flood events a proportion of the flood flow is trapped in the floodplain by the embankments.

When the embankments are removed, conveyance in the channel is reduced and more of the flood flow enters the floodplain. Within the floodplain, conveyance is increased and storage reduced. As a result, the model results suggest that removal of the embankments could result in a minor decrease in peak flow at Kincraig for frequent flood events, and a reduction in flood levels adjacent to the reserve in the range of 0.1 – 0.5m. At extreme events, a minor increase in peak flow at Kincraig and a minor increase in levels of <0.1m could occur. A change of this magnitude is considered to be of the same scale as those caused by natural variations in river and floodplain conditions through the study reach.

4.3 Ecological Features

Options which increase connectivity between the watercourses and the floodplain have the potential to increase in the proportion of fen, marsh and swamp habitat, and reduce the area of willow scrub. Changes are less likely for units predicted to experience less change in hydrological conditions, such as those more strongly influenced by Loch Insh.

A more dynamic morphological regime provides new opportunities for the formation of floodplain water bodies and frequently flood zones, colonisation by pioneer species and successional processes. These changes are particularly associated with options which increase natural processes in the

tributaries, which also have the potential to improve in-channel habitat conditions for aquatic species. Increased floodplain connectivity and conveyance of water on the floodplain may benefit floodplain water bodies.

Options that involve removal of embankments are likely to provide the most benefit to bird species due to a more extensive area of land being inundated during flooding. Some wader species (Snipe and Redshank), rails, crakes and duck numbers may all increase over a period of time as the ground conditions flood more frequently, more small pools and boggy areas are created by remnant water, and habitat changes to a more fen-like composition. Changes in duration of flooding could occur, however with most flood events occurring during the winter period (October to March), this only effects the overwintering duck and Whooper Swan population, and has less bearing on breeding bird populations.

The options assessment has been undertaken on the basis that the majority of flood events occur during the winter period. During the breeding season, an embankment-free area may increase the area of inundation, and should a flood event occur during the spring or early summer period, ground-nesting species within many of the compartments may be affected. It is however noted that many of these compartments already experience frequent flooding during existing conditions. Reduced duration of flooding in some compartments may provide greater opportunity for recovery than under existing conditions. Waders that prefer drier breeding habitat (Lapwing and Curlew) are likely to move in line with the change in vegetation and ground saturation levels, and no significant decline in breeding numbers is expected.

5 OPTIONS APPRAISAL

5.1 Appraisal of Options Considered

A multi-criteria analysis has been undertaken for the selected options based on the assessment information derived for each option. The approach adopted uses a simple matrix of positive, negative or neutral to provide an overview of potential benefits and risks as described in Table 5.1. Scoring of the options has been avoided due to the complexity of the study area. Access rights relate to the existing legal access rights at the reserve. Recreation encompasses visitor access to the site, visitor interest in the site and fishing opportunity and as such this item could result in positive or negative change for most options.

Table 5.1: Multi-criteria analysis description

Factor	Positive (+)	Negative (-)	Variable/ Uncertain (+/-)
Hydrological regime	Option results in a more natural flood regime (or an increase in flood frequency/ extent if no change to the floodplain connectivity)	Option results in a less natural flood regime (or a decrease in flood frequency/ extent if no change to the floodplain connectivity)	-
Ecological interests	Positive change predicted for designated features (e.g. increase in fen, marsh and swamp, reduced willow scrub)	Negative change predicted for designated (e.g. decrease in fen, marsh and swamp, increased willow scrub)	Positive change predicted for some features and negative for others.
Morphology*	Option benefits/ restores natural forms and processes	Option has a negative impact on natural forms and processes	Uncertainty is noted for the Raitts Burn in the scenario of an uncontrolled breach
Wider benefits and risks	Reduce risk at 0.5% AEP or perceived benefits	Increased risk at 0.5% AEP or perceived dis-benefits	Option could give rise to reduced risk for some receptors and increased risk for others, or risk is uncertain

* Note that 'No change' for morphology implies no significant change of processes, not that morphological form will remain static over the assessment timescales.

The findings of the multi-criteria analysis demonstrates that Options 4 – 10 (Table 4.1) provide most benefits to the natural conditions within the study area (i.e. all active restoration options). Feedback from the stakeholders and recommendations for further assessment required prior to implementing any of these options.

5.2 Identification of Pilot Schemes

It is anticipated that consultation will be required with a wide number of stakeholders and landowners prior to the progression of any of the options on the ground, and that there may be further assessment and design work required following this consultation. In light of this, the potential options have been discussed by the project team and two pilot schemes have been selected for outline design at this stage of the project.

These schemes provide examples of the kind of discreet packages of work that can be taken forward and delivered on the ground, if and when, the relevant agreements and permissions have been obtained, and provide indicative design details that could be applicable to other parts of the study area.

The two schemes are:

- Pilot at Lynchat (embankment removal or breaching only) where the land is fully owned by RSPB and works to a discreet unit could be monitored before implementation of measures across the wider study area.

- Pilot at Dell of Killiehuntly Wetland (embankment removal or breaching, and consideration of in-channel measures for the River Tromie). These works would increase flows to an area of wetland which currently suffers from reduced water inputs and provides the opportunity to test the response of the River Tromie to in-channel measures in a location where there are no adjacent receptors.

The potential for an uncontrolled breach of the Raitts Burn is a key concern for RSPB, however providing a long-term, sustainable solution for the restoration of the Raitts Burn will need to incorporate the reach upstream of the reserve and will need collaboration with the upstream land owners and relevant authorities responsible for the upstream infrastructure. Due to the potential risk to the upstream infrastructure, a detailed design will be needed and the impacts on morphological processes and flood risk assessed in detail.