Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Final Report

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EXECUTIVE SUMMARY

Aims

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 River Spey and River Tromie are also 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. The objective of this project was to assess the feasibility of options aimed at restoring a more naturally functioning river and floodplain system.

Approach

The project 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 of the project.

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.

Existing conditions

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 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 and a perched bed in the Raitts Burn. These modifications could affect the Water Framework Directive (WFD) classification of these watercourses.

The modelling results indicate that the existing breaches in the embankments and backing-up via the large arterial drains result in inundation of the reserve several times per year to depths ranging from less than 0.3 metre in the western part of the reserve up to 1 metre 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 metres. 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, and the direct connection between Loch Insh and the reserve via a large drain, also has a significant influence on flood mechanisms.

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.

The A9 crossing of the River 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 the reserve which has experienced flooding in the past and which could be affected by the options considered.

Options assessment

A long list of potential options aimed at restoring a more naturally functioning river and floodplain system were identified and agreed with RSPB and SEPA. These 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. The assessment considered changes up to 2028, for consistency with the River Basin Management Plan timeframe, although RSPB see restoring a more naturally functioning system as a 20 – 25 year aspiration.

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. Blockage of the direct connections between the large arterial drains and the River Spey or Loch Insh will increase the long term retention of a shallow depth of floodwater within the wetlands.

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.

Outline design and next stages

The findings of the options assessment were summarised using a multi-criteria analysis and discussed with RSPB. Outline designs for two pilot schemes have been developed, which include typical cross-section details, plan drawings, outline construction approach and indicative construction costs. Pilot 1 consists of embankment removal at Lynchat. Pilot 2 comprises embankment removal in proximity to the Tromie-Spey confluence, removal of short lengths of bank protection and placement of large woody material in the Tromie to encourage more dynamic channel processes. 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. These schemes provide discreet packages of work that can be 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 next stages for each of the pilot schemes are discussed.

The potential for an uncontrolled breach of the Raitts Burn is a key concern and could pose a risk to the stability of the railway and road bridges from upstream incision of the bed as the channel adjusts towards a new equilibrium slope. Active intervention to provide a long-term, sustainable solution for the restoration of Raitts Burn is recommended, which will need collaboration with the upstream land owners and relevant authorities responsible for the infrastructure. An indicative scope of works and costs for the detailed design of restoration works for the Raitts Burn has been provided.

Feedback from the stakeholders suggests that these organisations are supportive of creating a more naturally functioning floodplain system at Insh Marshes, and are generally supportive of the options selected for outline design. On-going consultation with the stakeholders will be a key element of defining the scope of the additional assessments that will be required to gain the necessary consents to implement the options on the ground.

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Acknowledgements

We would like to acknowledge SEPA's Water Environment Fund and Cairngorms National Park Authority (CNPA) for the funding for this project.

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1 INTRODUCTION

1.1 Context

The Insh Marshes is an internationally important wetland comprising approximately 1000 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. 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.

The River Spey between Spey Dam and Loch Insh is classified as a Heavily Modified Water Body (HMWB) for Water Framework Directive (WFD) 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.

1.2 Objectives

The objective of this project was to assess the feasibility of options aimed at restoring a more naturally functioning river and floodplain system.

The following tasks have been undertaken to achieve this objective:

- 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 a 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.

1.3 Project Location

RSPB's landholdings are shown in Figure 1-1. 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. The study area included assessment of the three main tributaries within the reserve boundary (Ruthven Burn, River Tromie and Raitts Burn) and the River Spey between Ruthven Bridge and the River Feshie confluence. The large drainage channel situated in the south-eastern part of the reserve that discharges to Loch Insh is referred to as the Main Drain within this report. Within this report all references to left and right river banks are made looking downstream.

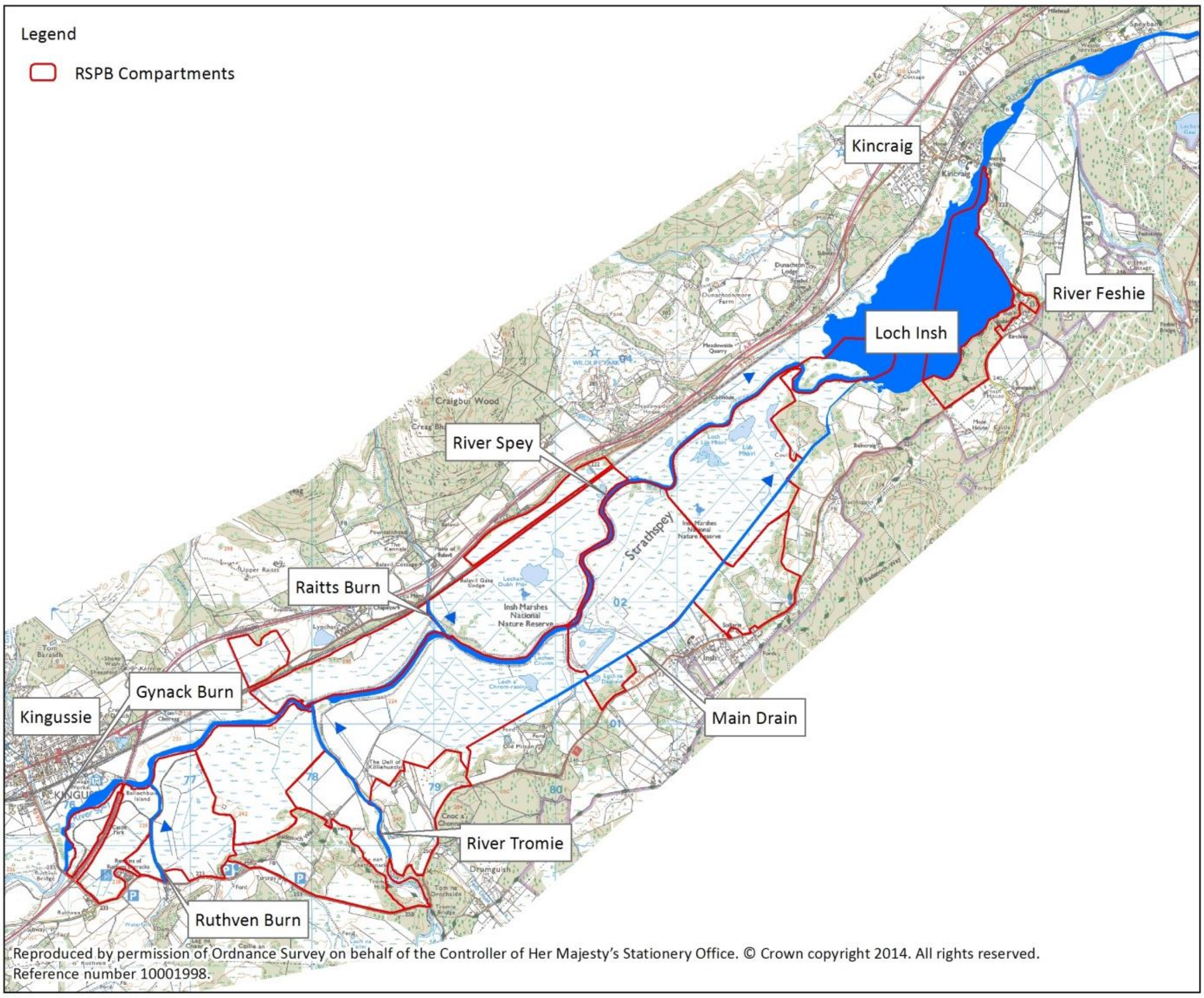


Figure 1-1: Project Location

2 METHODOLOGY

An overview of the project methods and approach is provided in this section, with more detailed descriptions of the technical assessments provided in the relevant appendices.

2.1 Desk-based review

A review of the large body of literature, reports and data that exist for the Insh Marshes reserve was undertaken. The existing data was used where possible in the assessments, including the ecological datasets provided by RPSB. Historic mapping and aerial photography were reviewed to assess changes in the channel and floodplain over time. Topographic survey data is available from the early 1990's, however this data was in hard copy with little spatial referencing information and was therefore not used in the current project.

2.2 Field surveys

Topographic survey

The topographic survey comprised of 52 channel cross-sections (River Spey, Ruthven Burn, River Tromie, Raitts Burn and the Main Drain), 11 structures and spot levels along the embankments to pick up low points and breach levels. A LiDAR digital elevation model (DEM) was used to provide high resolution elevation data in the floodplain (1m grid resolution, vertical accuracy ± 0.15m RMSE). Review of the data showed a good agreement between the topographic survey and LiDAR where these two sources overlapped and individual ditches and water bodies are clearly represented in the LiDAR data. LiDAR does not penetrate water and it is possible that the water surface may be represented rather than the ground surface in some parts of the site, however this is most likely to occur in the permanently waterlogged parts of the site where the water surface represents the surface level prior to a flood event occurring.

Walkover surveys

A fluvial audit was undertaken to map the key morphological features, evidence of morphological processes, man-made pressures and indicators of historic channel conditions. The fluvial audit extended along the Spey from Ruthven Bridge to Loch Insh and the modelled extents of the Ruthven, Tromie and Raitts Burns

A hydrological walkover provided information on flood mechanisms, floodplain flow paths, structures and location and nature of the existing breaches. This walkover also informed the specification of the topographic survey.

2.3 Hydrological Assessment and Hydrodynamic Modelling

Hydrological assessments and hydrodynamic modelling were carried out to provide an understanding of the flood regime of the River Spey and its tributaries, including the frequency, depth and duration of flooding through the various compartments within the reserve and the flood risk posed to local and downstream receptors. Existing literature and data provided information regarding the seasonal fluctuations of water levels within the marshes and the influence of the drainage ditches.

The modelling work 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.

Hydrological assessment

The hydrological assessment used Flood Estimation Handbook (FEH) methods to estimate inflows and design hydrographs for the hydrodynamic modelling for the River Spey at Kingussie, Gynack Burn, Ruthven Burn, River Tromie, Raitts Burn, Allt Baile Mhuilinn (tributary flowing into the Main Drain) and River Feshie.

Gauged data has been used where available in both the flow estimation and to extract real events to aid the model development. The use of gauged data was particularly important for the River Spey and River Tromie, where the hydrological regime is affected by large abstractions and transfers out of the upper catchments for hydro-power schemes. Gauges used in the assessment were the Spey at Invertruim (10km upstream of the study area), Tromie at Tromie Bridge, Feshie at Feshie Bridge, Spey at Kinrara (5.5km downstream of Kincraig) and the level record at Kincraig.

Frequent flood events are likely to have a greater impact on the ecological interests at the site than rare events, and the assessment therefore focuses on the following flow events:

- Flood event that occurs on average 5 times per year (referred to at the 5-POT flow in this report, see section B1, Appendix B for definitions);
- Flood event that occurs on average 3 times per year (referred to within this report as the 3-POT flow in this report, see section B1, Appendix B for definitions); and
- The annual average flood, which occurs on average once every 2 years (QMED).

Potential options which change the channel-floodplain connectivity could affect flood risk to local and downstream receptors at high magnitude, low frequency events. The assessment concentrates on the flood event used for planning purposes, which has a 0.5% chance of occurring in a given year (0.5% AEP, see section B1, Appendix B for definitions). An allowance for climate change has been included for the assessment by increasing this flow by 20%.

Hydrodynamic modelling

A coupled 1D-2D hydraulic model was developed using an industry standard software (Infoworks RS, v16). Recorded flow and level data was used in the model development, comparing the modelled levels with recorded levels at Kincraig Bridge and the model outflow to the recorded flow at Kinrara. Sensitivity testing was undertaken for downstream boundary conditions, floodplain roughness and spill coefficients.

The channels are represented in the 1D domain, whilst the majority of the floodplain is represented in the 2D domain to allow complex floodplain flow paths to be reproduced. The 1D domain includes:

- River Spey from just upstream of Ruthven Bridge to Dalnavert, downstream of confluence with River Feshie;
- Loch Insh, which is represented as a storage unit;
- River Spey floodplain out with the reserve boundaries;
- Ruthven Burn from the B970 to the confluence with Spey;
- River Tromie from downstream of Tromie Mill to the confluence with Spey;
- Raitts Burn from the railway to the confluence with Spey; and
- The Main Drain from the embankment between Dell of Killiehuntly Wetland and Insh Fen to Loch Insh.

The Gynack Burn and River Feshie are situated outside of the study area, but are included as inflows to the Spey in the model. The downstream boundary of the model is located downstream of the River Feshie confluence to ensure that the influence of this watercourse on upstream water levels in the reserve is taken into account.

Flow-path mechanisms represented in model include overtopping between the channels and floodplain, influence of embankments (along banks and within the floodplain), embankment breaches, interactions with Loch Insh and key open drain connections between the floodplain, River Spey and Loch Insh. The 2D domain extent includes land to the north of the railway in two key locations, at Cemetery Marsh and low-lying ground near Lynchat village. The internal drainage network is not represented in the model, other than the Main Drain and open drain connections in Invertromie Fen and Insh Fen.

The model was used to establish the baseline flood regime at the 5 flood events described above. The results were used to:

- Assess the extent of flooding through the reserve and identify the key flood mechanisms.
- Describe the frequency, depth and duration of flooding within the reserve. For this purpose, the reserve was split into a series of 'units' or compartments, representing areas with a similar flood regime (Figure 2-1). These units reflect RSPB's management compartments as far as possible. For each compartment the flood extent and frequency is described, and the depth/ duration data extracted from a representative point for each of the 3 high frequency flood events (5-POT, 3-POT, QMED).
- Identify potential local flood receptors using the 0.5% AEP results. Receptors to the north of the railway were identified by reviewing maximum flood levels in the adjacent part of the model. The identified receptors do not include those at risk of flooding from other sources of flooding which are not explicitly considered in this project (e.g. other tributaries, including the Gynack Burn, surface water flooding).

A number of option scenarios were incorporated into the model (options 3, 4a, 4b, 4c, 5 and 10b) to assess potential change in flooding regime within the reserve, and change in risk to the identified flood receptors for each option. Potential change in downstream flood risk has been assessed through comparison of the hydrograph at Kincraig for the baseline and option scenarios.

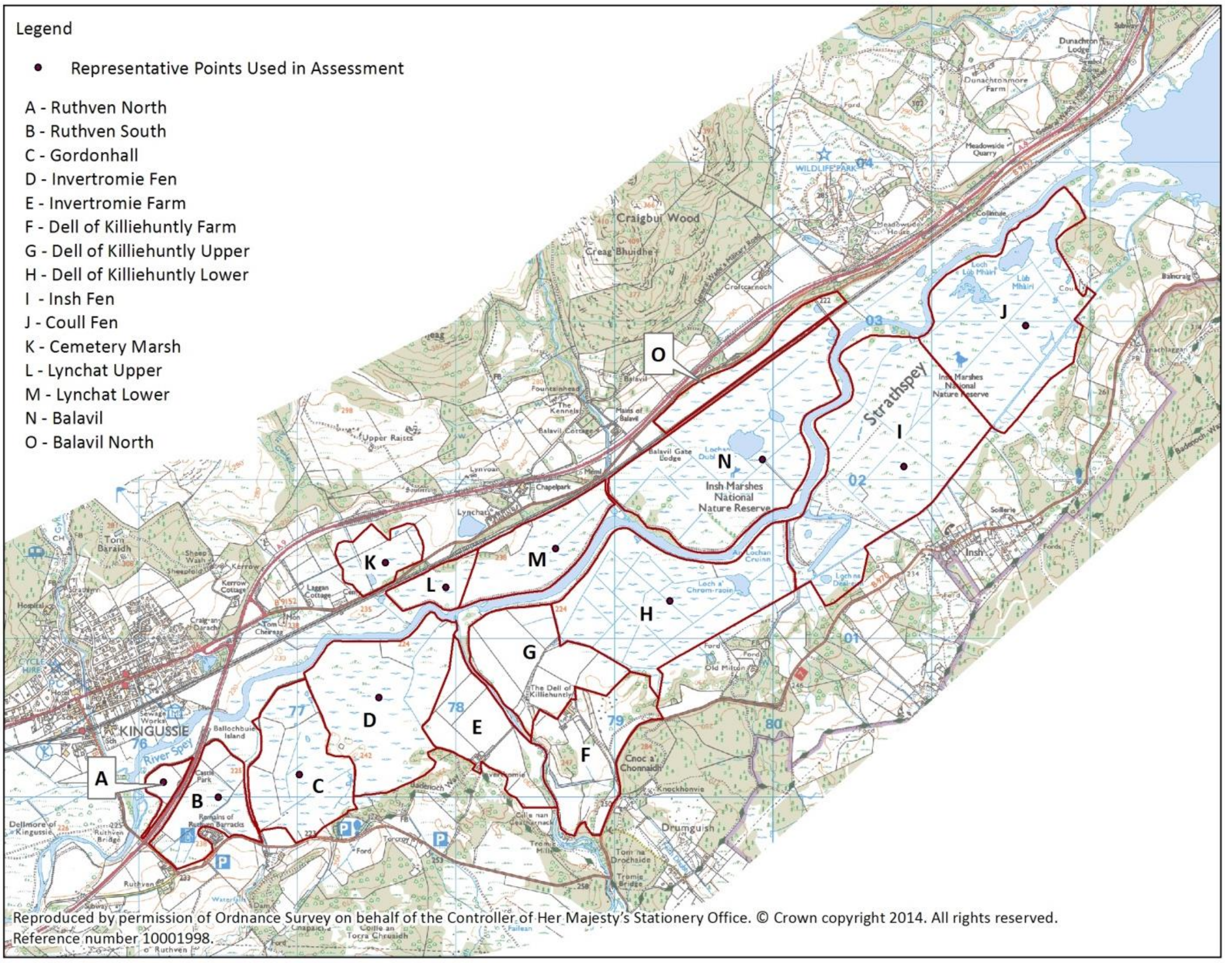


Figure 2-1: Hydrological Units

2.4 Morphological Assessment

The morphological assessment incorporated the River Spey between Ruthven Bridge and Loch Insh, and the modelled extents of Ruthven Burn, River Tromie and Raitts Burn. A high level assessment of the existing morphological forms and processes, particularly relating to the sediment transport regime, was undertaken through:

- Interpretation of the fluvial audit outputs and desk-based review;
- Extracting descriptors of channel form (e.g. width/ depth) and long profile from the topographic survey; and
- Calculations of stream power and the maximum size of sediment predicted to be transported at the QMED event, using outputs from the modelling results (e.g. water surface gradient, maximum water levels/ flows).

Potential change in the morphological forms and processes of each of the watercourses was assessed by using the modelled outputs and understanding of the existing conditions.

The impact of the man-made pressures on the channel morphology (e.g. embankments, channel straightening) was calculated using SEPA's assessment approach (MImAS) for the baseline and option scenarios.

2.5 Ecological Assessment

The ecological assessment relies on existing datasets, particularly NVC plant community data, composite habitat data and breeding bird datasets, and information available in existing reports. The data has been summarised for each of the hydrological units and reviewed in relation to the topography and baseline flood regime. The potential change for each option was assessed in relation to baseline conditions.

The scope of the feasibility study, encompassing a large number of potential options across all parts of the site, and the complexity of the ecological features necessitated that the ecological assessment was undertaken at a high level. The assessment refers to 'potential' or 'possible' changes due to both the high level nature of the assessment and uncertainties arising from a range of sources, including lack of data on the existing distribution of certain species across the site and their supporting conditions, complex interactions between different species, and a lack of a research evidence base of how certain species respond to changing hydrological conditions.

Table 2-1 summarises the approach and key assumptions used in the ecological assessment for each of the designated features, with further details of the current status of the designated features provided in Table 3-2. Potential impacts during the construction of options are not included in the options appraisal, however these are briefly considered in the outline design and construction approach in chapter 6.

The high level assessment of potential change in plant community composition within each hydrological unit for each option scenario focussed on whether each unit is likely to become wetter (through increased flood depth, duration and frequency) or drier. The predictions have been made using evidence from recent research to develop regulatory guidelines for wetlands (Sniffer, 2014), the NVC handbooks and additional literature referenced in Appendix A (e.g. in relation to *Carex chordorrhiza*). This evidence focuses on NVC communities, and as such the majority of predictions have been made for NVC communities, and then related back to the relevant designations. The composite habitat dataset was used where NVC data is absent, and to cross-check the predictions made where NVC data is available. The surveys undertaken for the composite habitat dataset (2002) indicated that there were no significant changes in vegetation since the NVC surveys (1988/1996). Reference has been made to SEPA's wetland typologies where appropriate (SNIFFER, 2009a).

Predictions have also been made for a number of specific species included in the SSSI vascular plant assemblage (*Carex chordorrhiza, Cicuta virosa, Carex aquatilis, Nuphar pumila* and *Ribes spicatum,* as agreed with RSPB), and for *Phragmites australis* (reed bed) and willow scrub which are considered as negative species indicators.

Taking cognisance of the potential changes to the flood frequency, duration and depth, and the predicted long-term changes in plant communities, broad vegetation types and habitat composition within each management unit, potential changes to individual bird species, and both the breeding and wintering bird assemblages within Insh Marshes have been extrapolated from the various modelled flood scenarios. Particular attention was paid to qualifying bird species of the various designations on the site and the RSPB Reserves Priority species.

The predictions of potential changes to the ornithological composition of each compartment are based on the overall change in flood conditions and vegetation responses. Prediction of the impacts of the options on different requirements of each species, for example nesting, roosting and foraging, was beyond the scope of the study. The majority of historic flood events have occurred in the winter period (Figure 3-1), and the predictions of potential changes to the ornithological features have been made on this basis. Late floods during this period may affect some early breeding species, although April to July has been used as the breeding season within this report.

Any future change to the management strategy for the site has not been incorporated into the option scenarios.

Table 2-1: Designated features and assessment method

Feature	Assessment Approach and Key Assumptions
Sea lamprey	• Options which improve the morphology of the River Spey or the tributaries assumed to have a potential positive influence on population.
Atlantic salmon	• Low densities of salmon have historically been recorded in the Tromie, Raitts and Ruthven Burns (Document 12, Appendix A). • Options which improve the morphology in these tributaries assumed to have a potential positive influence on population.
Otter	• Assumption that none of the options will negatively influence the presence of otter – all options will maintain natural otter holts and habitat for feeding and resting by maintaining the areas of floodplain habitat with a mosaic of wetness, open water and a mosaic of vegetation types.
Freshwater pearl mussel	• There is limited information regarding the freshwater pearl mussel in the study area, and it is assumed that they are only present in the River Spey. • Options which enhance natural river processes in the River Spey or the tributaries assumed to have a potential benefit for freshwater pearl mussel populations either directly (River Spey) or indirectly via potential benefits to the salmonid population (River Spey and tributaries).
Wigeon, breeding	• High level assessment of implications of the options for ducks undertaken based on predicted changes to flood characteristics and vegetation composition. Wigeon are included due to their requirements relating to open water and vegetation cover. • Predicting precise changes in plant species which may benefit Wigeon (e.g. specific submerged or floating plant species) is not possible within the scope of the project or from the resolution of the flood model.
Spotted crake, breeding	• High level assessment based on potential increase in water level and reedbed cover.
Wood sandpiper, breeding	• Not recorded breeding for many years within the main reserve. • It is considered that habitat enhancement for other species will not adversely affect Wood Sandpiper. • It is therefore assumed for the purposes of this study that none of the options will result in a change for breeding Wood Sandpiper.
Osprey, breeding	• It is assumed that Osprey breeding sites will not be affected by any of the options and there will be no detrimental impact on fish populations for any of the options. • It is therefore assumed for the purposes of this study that none of the options will result in a change for breeding Osprey.
Whooper swan, non-breeding	• Whooper swan will move to suitable compartments within the site as conditions change, and it is assumed that some suitable areas will be maintained within the site for all options. • High level assessment of implications for Whooper swan based on predicted increase in water level through the winter months.
Hen harrier, non-breeding	• It is assumed that the open ground of the reserve will continue to provide foraging resource for the species and water levels will not rise to a level that will provide no open ground within the reserve, or rise to levels that will affect roosting locations. • It is therefore assumed for the purposes of this study that none of the options will result in a change for breeding Hen harrier.
Breeding bird assemblage	• High level assessment undertaken for the overall breeding bird populations, focussing on the RSPB Reserves Priority wader and waterfowl species. • This has been assessed by reviewing changes in flooding, site wetness and potential vegetation changes across all compartments.

Feature	Assessment Approach and Key Assumptions
Invertebrate assemblage	• Includes invertebrates with a range of supporting conditions (wetland, riverine habitats including shingle, woodland). • Potential changes to hydrological and geomorphological conditions, and vegetation composition could influence invertebrate assemblage. Information on the locations within the reserve of most of the species is not available (RSPB, personal communication) and predictions for the species within the assemblage are not included in this feasibility study. Specialist input may be required to assess the potential implications of the options on the invertebrate assemblage to gain consent for the preferred options (see chapter 7 for more information about the next stages of the project).
Floodplain fen	• High level assessment of predicted changes to NVC communities listed under the fen, marsh and swamp feature, using evidence from recent research to develop regulatory guidelines for wetlands (Sniffer, 2014) and the NVC handbooks.
Mesotrophic loch	• It has been assumed that the options will not affect the nutrient status of the water bodies, and therefore that Loch Insh will not be affected by the options. • Options which could reduce terrestrialisation of the open water bodies (small lochans) within the marshes are assumed to have a potential benefit, and vice versa.
Arctic charr	• The Insh Marshes is the only site in Scotland where charr are known to spawn in streams and they also spawn along the main stem of the River Spey, although locations within the reserve are not detailed in the RSPB Management Plan. • Options which improve the morphology of the River Spey or the tributaries assumed to have a potential positive influence on population.
Vascular plant assemblage	• High level assessment of potential changes to the following species (list provided by RSPB): *Carex chordorrhiza, Cicuta virosa, Carex aquatilis, Nuphar pumila and Ribes spicatum*. • Other species in the assemblage are out with the NNR or are not associated with the wetland.
Trophic range – river/ stream	• A small number of specific hydrological and ecological features under this general feature have been assessed through other features in this table. • It has been assumed that the options will not affect the nutrient status of the water bodies.
Very wet mires often identified through unstable 'quaking surface'	• High level assessment of predicted changes to NVC communities listed under the fen, marsh and swamp feature, specifically S27, using evidence from recent research to develop regulatory guidelines for wetlands (Sniffer, 2014) and the NVC handbooks.
Alder woodlands on floodplains	• Designation refers to trees associated with dynamic gravel beds within the river rather than any alder tree growing on the floodplain. • Within the study area, alder woodland is only present at the River Tromie confluence. • It has been assumed that options which increase channel dynamics at the River Tromie confluence could benefit alder woodland.
Clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels	• It has been assumed that the options will not affect the nutrient status of the water bodies, and therefore that Loch Insh will not be affected by the options. • Options which could reduce terrestrialisation of the open water bodies (small lochans) within the marshes are assumed to have a potential benefit, and vice versa.

3 BASELINE ASSESSMENT

This chapter summarises the baseline conditions within the study area, with full details provided in the technical appendices. Contextual information regarding topography, geology and soils within the study area, detailed ecological information and geomorphological conditions at the Feshie fan are described fully in previous studies and is not repeated in this report (Document 34 and 46, Appendix A). The ecological information focuses on habitat within each unit and a summary of bird population trends.

3.1 Hydrological Regime

3.1.1 Hydrological Sources and Pathways

The complexity of the hydrological regime of the NNR has been well documented in previous studies (Appendix A). Hydrological inputs include overtopping from the River Spey, tributaries and from Loch Insh (directly onto floodplain or backing-up via Main Drain), plus direct precipitation, runoff from adjacent hillslopes and groundwater. Losses occur through evapotranspiration (mostly during summer months) and drainage via ditches and open connections to the River Spey, its tributaries and Loch Insh. Relative water levels of the River Spey, Loch Insh, Main Drain, internal drainage ditches and groundwater table, as well as local topography, embankments and structures, dictate flow pathways within and from the study area.

Groundwater levels within the low-lying areas of the reserve are close to the surface for the majority of the year, highlighted by the very flat stage-duration curves derived from the automated groundwater loggers installed in the Lynchat and Insh Fen compartments (Document 60, Appendix A). Longer term, manual records show that levels are highest in December/ January and lowest in May/ June (Document 37 and 46, Appendix A). During summer months, groundwater levels are influenced by localised drawdown towards drainage ditches and the River Spey, and upwelling of base-rich groundwater in units I, J and N (Document 29 and 35, Appendix A).

The hydrodynamic modelling focuses on interactions between the surface water bodies (Spey, tributaries, Loch Insh) and the floodplain and how changes to these interactions could affect flood depth, duration and frequency across the site. The QMED peak design flows (approximately equivalent to the 1 in 2 year flood event) used in the modelling are summarised in Table 3-1 to provide an indication of the relative size of flows in the watercourses within the study area. Further details of the hydrological assessment are included in Appendix B, and the hydrodynamic modelling is described in sections 3.1.2 and 4.2, and Appendix C.

Table 3-1: Peak Design Flow Estimates (QMED)

Location	Catchment Area (km^2)	QMED peak design flow (m^3/s)
A. River Spey at upstream model extent	537	140
B. Gynack Burn	22	16
C. Ruthven Burn	7	4
D. River Tromie	134	51
E. Raitts Burn	12	8
F. River Feshie	230	130
G. Allt Baile Mhuilinn (Main Drain)	14	6

Review of the flow record for the River Spey at Invertruim (1987-2014) shows that the majority of flows that exceed the 5-POT threshold occurred between October and March (Figure 3-1). The flood extent for the modelled 5-POT scenario is provided in Drawing C2, Appendix C. Thirteen events of this size occurred between April and July over the 27 years of record.

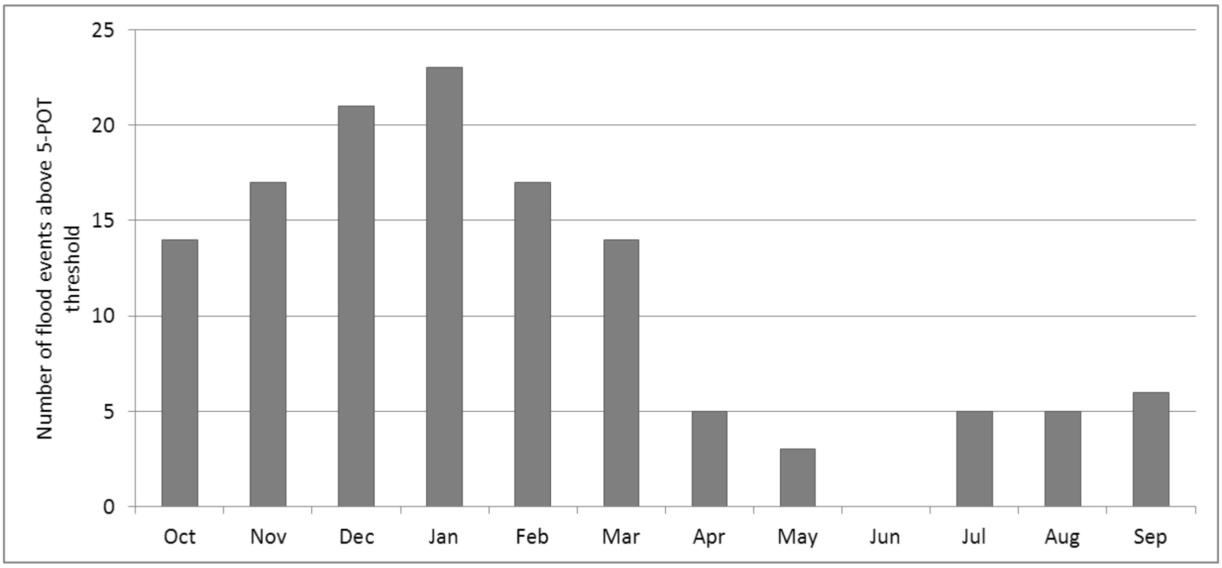


Figure 3-1: Monthly Distribution of Flows for River Spey at Invertruim Exceeding the 5-POT Threshold

Climate change projections produced by the UK Climate Programme (UKCP09) provide predictions of change in precipitation to 2020, 2050 and 2080 in terms of percentage change from the 1961-1990 baseline period. Predictions are available for 3 emission scenarios (low, medium and high) along with 10%, 50% and 90% probability levels. For the Northern Scotland region medium emissions scenario in the 2050's, annual mean precipitation is estimated to increase by -1% (50% probability level), and is very unlikely to be less than -7% and very unlikely to be more than 5% (10% and 90% probability levels). Winter mean precipitation is estimated to increase by 13%, and is very unlikely to be less than 3% (50% probability level) and very unlikely to be more than 24% (10% and 90% probability levels). Summer mean precipitation is estimated to increase by -11% (50% probability level), and is very unlikely to be less than -24% and very unlikely to be more than 2% (10% and 90% probability levels). The predicted change in the wettest day of each season is 0 – 10% in both winter and summer (50% probability level). These predictions suggest that the seasonality of precipitation is likely to become more pronounced in the future.

Surface water inputs to the marshes have been altered by historic alterations including embankments (many of which are now breached, as discussed further in section3.1.2), drainage and tributary diversions. There are two small tributaries that were diverted in the 1970's to reduce the water input to Dell of Killiehuntly Wetland (unit H). The Feith Dhubh previously flowed through Dell of Killiehuntly Farm and into the wetland in unit H, and was diverted into the River Tromie. The Allt Baile Mhuilinn also historically flowed directly into unit H and was diverted in the 1970's into the Main Drain in Insh Fen (unit I).

Hydraulic connectivity and flow direction in the drainage ditches is dependent on relative water levels and the maintenance regime. Direct connections between large arterial drains and the River Spey are located in units D and I (labelled in Figure 3-2). When the Spey rises, water backs up into the floodplain via these drainage connections resulting in more frequent inundation than under natural conditions. During drier conditions, these open connections allow more rapid drainage of the floodplain into the Spey and associated local drawdown of the groundwater table (Document 37, Appendix A). The arterial drain in unit B (Ruthven South) is also directly connected to the Ruthven Burn. Direct drainage of the study area also occurs via the Main Drain into Loch Insh. This large drain collects hillslope runoff from the southern valley side and acts as the main drainage route for the smaller ditches in units H, I and J.

Many of the smaller internal ditches within the reserve now act as 'wet fences' rather than as active drainage channels. For example, the drainage networks in units M (Lynchat Lower) and N (Balavil) are highly occluded and there is minimal connectivity between the drainage network and the River Spey. The breaches in these two units are scoured below the adjacent ground levels, allowing more floodwater to drain back into the Spey than under natural bank conditions. Previous research suggests the water levels in the River Spey affect groundwater levels adjacent to the river (Document 35, Appendix A), and as a result it is considered unlikely that these low-level breaches are having a drawdown influence on groundwater levels within units M and N that is significantly different than for other areas.

Historically the culvert at Coull causeway included a flap valve, which would allow the site to drain to Loch Insh but prevent Loch Insh backing-up into the site (Document 36, Appendix A). It is thought that this valve fell into disrepair or was removed at least 20 years ago, which may account for the average higher water levels recorded in Insh Fen in the period 2000-2009 (Document 46, Appendix A). The condition of the remaining flap valve on the culvert between units H and I could not be ascertained during the field surveys due to high water levels. It is understood that this flap value has limited functionality (RSPB, personal communication) and it has therefore not been incorporated in the baseline modelling. There is also a flapped culvert arrangement situated in unit A (Ruthven North) to allow water on the floodplain to drain back into the River Spey. The hydrodynamic model results suggest that the influence of this culvert is limited and the majority of water drains via the breach in the northern embankment.

3.1.2 Flood Depth, Duration and Frequency

The hydrodynamic modelling results for the baseline scenario are presented in Appendix C including flood extents (Drawings C2 – C5), maximum flood levels in the watercourses (Table C6 and long profiles in Figures C9 – C12) and the maximum flood depth at a representative point in each unit (Table C9).

Flooding occurs most frequently in the eastern part of the study area (units H, I, J, M and N) and adjacent to the open drain connection in unit D. During the modelled 5-POT event the majority of these areas are predicted to flood to a depth of <0.3m, other than in units M and J where depths up to 0.6m are predicted (Drawing C2, Appendix C). The majority of the low-lying parts of the study area are predicted to be inundated to depths ranging from <0.3m up to 1m for the modelled 3-POT event (Drawing C3, Appendix C).

At the QMED event, occurring approximately once every two years, the majority of the reserve is estimated to be inundated to a flood depth of 0.3 -1.0m, and up to 1.3m in low-lying areas in units D, M and J (Figure 3-2, and Drawing C4 Appendix C). During more extreme events, flood depths across the study area exceed 1m and are estimated to reach 2-2.5m across the majority of the site and 2.5 – 3.1m in units H, I and J for the 0.5% AEP flood event (Drawing C5, Appendix C).

The frequency, depth and duration of flooding varies across the site and is influenced by a range of flood mechanisms and complex interactions between relative flows and levels in the River Spey, the tributaries, Loch Insh and the individual floodplain units. Movement of water on the floodplain is controlled by the embankments, existing breaches, topography and the relative water levels in adjacent units or water bodies. The influence of the embankments and existing breaches on flow pathways is greatest at the frequent flood events (5-POT, 3-POT and QMED). In the baseline scenario, the majority of the embankments are overtopped at a flow approximately equivalent to the 2% AEP event. The embankments therefore have a reduced influence on water levels at flood events exceeding this, including the 0.5% AEP event where the maximum water levels are above the level of the embankments and inundate the full floodplain. It is noted that the embankments referred to here are those adjacent to the Spey, and that the modelled water levels in the marshes are lower than the level of the A9 and railway embankments.

3.1.3 Conceptual Understanding of Flood Mechanisms

A simplified conceptual understanding of flood mechanisms is described here to provide the baseline with which to compare to the option scenarios (described in section 4.2.1).

The modelled QMED event is used to describe the key mechanisms and the sequence of flooding, which is shown schematically in Figure 3-2. The dominant flow paths are shown by the direction arrows in Figure 3-2 and summarised in Table 3-3.

The key mechanisms are as follows:

- At the start of the flood event, increased flows in the River Spey are conveyed within the channel to Loch Insh where levels start to rise.
- Rising levels in Loch Insh cause water to back-up into the Main Drain, which results in overtopping of the Main Drain into low-lying parts of units I and J. The rate of flow into and out of unit J via the Main Drain is controlled by the Coull culvert.
- As the flow and levels rise further in the River Spey, Ruthven Burn and River Tromie, water enters the floodplain throughout the site via the existing breaches, open drainage connections and overtopping of banks where embankments are absent.
- There are no breaches in the embankments of the Raitts Burn within the site and the QMED flow is contained within the channel.
- As river levels continue to rise, much of the length of the Ruthven Burn within the study area is drowned out by the high water levels in the River Spey.
- Water levels in the River Spey start to drop in the upstream part of the site first and water starts to flow out of units A, B, D, K and M back into the Spey, while flood water in units C and L drain back to the Spey via overland flow into adjacent floodplain units.
- The water that flows out of the upstream units is conveyed downstream and contributes to rising water levels in the downstream part of the site and in Loch Insh. As a result, the flood hydrograph exiting the NNR is longer and has a lower peak flow than at Kingussie. This attenuation of flood flows in Insh Marshes is reflected in the gauged record at Kinrara.
- Water stored on the floodplain in units I and J cannot drain back into Loch Insh via the Main Drain until the loch levels fall below the level of water in the floodplain.

Water on the floodplain rises and falls in continuity with the hydrograph in the Spey where embankments are absent (e.g. unit D) and where the existing breaches and topography allow conveyance of water through the unit (e.g. units A, L and M). Water levels in units B, C, H, I, J and N are not in continuity with levels in the Spey and flood water is stored in these units for a longer duration due to the influence of the embankments (B, C, N) and by the high levels in Loch Insh or River Spey slowing the rate at which water can exit the units (H, I, J, N).

It is evident that the water levels in Loch Insh exert a strong control over the mechanisms, depth and duration of flooding in the eastern part of the study area (notably units H, I, J and N at the modelled QMED event). The Loch Insh levels are not only influenced by inflows from the study area but are also controlled by conditions downstream at the Spey-Feshie confluence. Episodic influxes of coarse sediment from the River Feshie influence bed levels at this location and the narrowing of the floodplain due to the fan deposits acts as a hydraulic control. Further hydraulic control occurs when flow from the Feshie exceeds that in the Spey, causing a backwater effect upstream. This backwater effect occurs in the modelled QMED and contributes to rising levels in Loch Insh early in the simulation.

At the 0.5% AEP flood event the key mechanisms are similar to the QMED event, other than that water also enters the floodplain from the River Spey and all tributaries, including the Raitts Burn, via overtopping of the embankments.

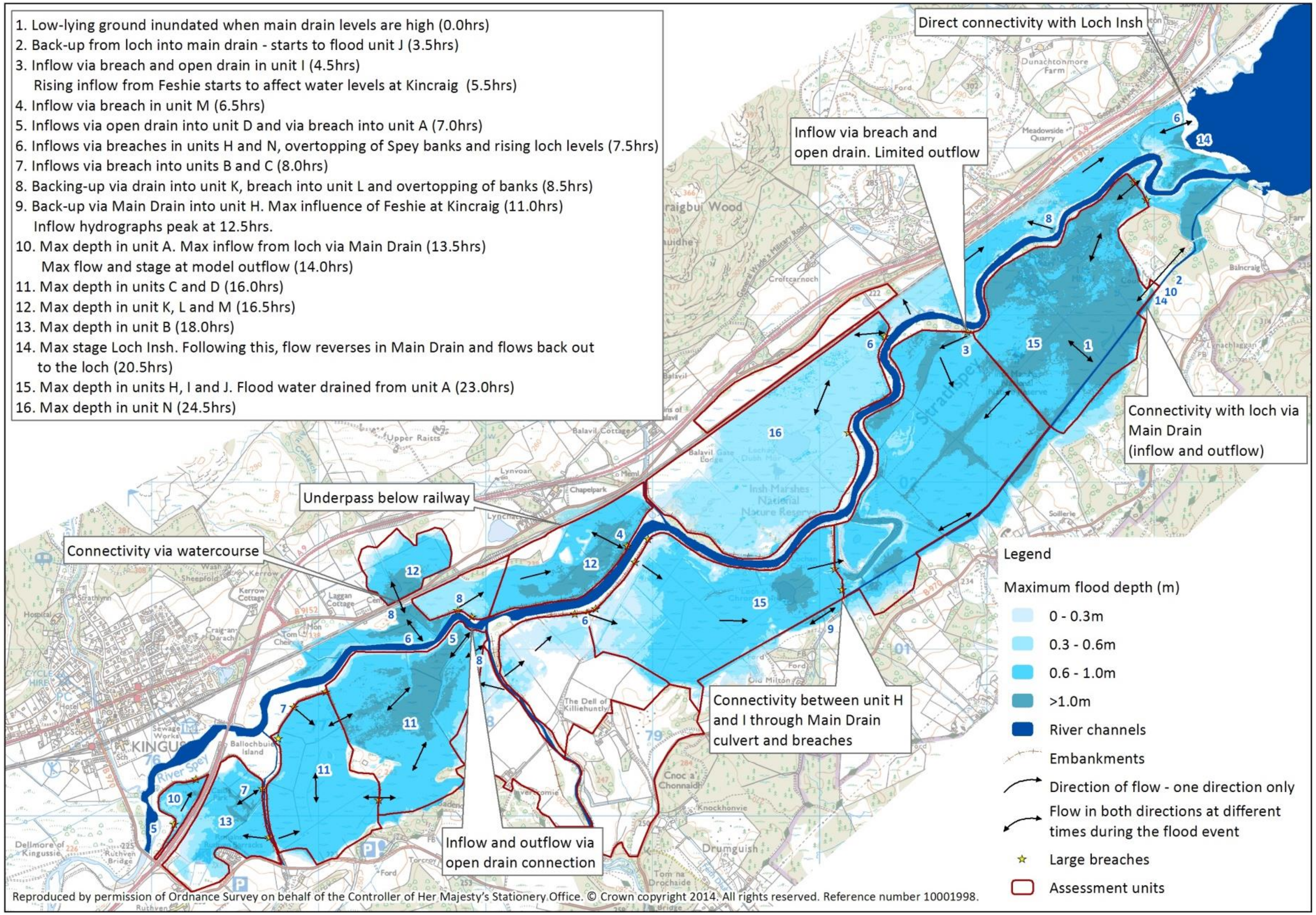


Figure 3-2: Sequence of Flooding (Baseline QMED Flood Event)

Notes – depths correspond to maximum at any point during the model simulation and are not representative of a particular point in time. Depths are shown for the 2D domain only.

3.1.4 Flood Risk

A full flood chronology is presented in the 1990 report 'Flooding in Badenoch and Strathspey' (Document 32, Appendix A) and is not repeated in this report. Flooding in Strathspey has been documented on numerous occasions in the chronology. In 1903 flood depths of 10 feet were noted on Loch Insh meadows, and flooding of 4-5 feet on the road at Balavil in 1906. Houses at Lynchat were recorded as flooding in December 1917 in a flood that lasted for 3 days and again in 1984. Roads around the study area are noted as being impassable on several entries. Damage to the railway at various locations through Strathspey was noted in 1914, 1915, 1943 and water levels high enough to threatened the line in 1913, 1915, 1920, 1947, 1988. Flooding in 2014 from the Raitts Burn breaching the flood embankment upstream of the site also resulted in damage to the railway embankment.

Two major flood events occurred in January 1989 and February 1990. In 1989 property flooded in Kingussie, Lynchat and Aviemore. The event in 1990 resulted in flooding of property in Newtonmore, Kingussie, Lynchat, near Balavil, at Loch Insh and Aviemore. Public infrastructure (roads/ utilities) were flooded and the lower parts of the Insh Marshes were under water for 8 – 15 weeks. SEPA's National Flood Risk Assessment highlights a 'potentially vulnerable area' (PVA) for flooding at Kingussie (05/12), which incorporates Kingussie, Ruthven and Lynchat. A second PVA (05/11) is located approximately 11km downstream of Loch Insh which includes Aviemore. These potential flood receptors were also identified as being at risk from the hydrodynamic model results (Appendix C).

3.2 Ecological Interests

The designated features are summarised in Table 3-2. The flood regime influences the spatial distribution of the flora and fauna within the site. A summary of the hydrological conditions and habitat in each unit is provided in Table 3-3, along with information from RSPB regarding the key species and current management plan actions. Flood depths, extents and durations described in Table 3-3 relate to the 3-POT event, with details for other flood events provided in Table C9, Appendix C. The habitat data is mapped in Appendix E.

Low densities of salmon have historically been recorded in the Raitts Burn and Ruthven Burn (Document 12, Appendix A), and the Spey District Salmon Fishery Board have confirmed that the lower reaches of these tributaries have some spawning and juvenile habitat (Brian Shaw, personal communication). The Tromie is an important salmon spawning tributary and timed electrofishing in at Invertromie in 2014 produced the highest salmon fry and parr counts from all the sites surveyed on the Tromie that year (Spey Foundation, 2014). Sea lamprey are located in an oxbow on Insh Fen (Document 46, Appendix A). The Insh Marshes is the only site in Scotland where Arctic charr are known to spawn in streams and they also spawn in the main stem of the River Spey (Document 46, Appendix A). There are no freshwater pearl mussel Site Condition Monitoring sites within the reserve, and although they are found upstream of the study area, freshwater pearl mussels are more abundant downstream of Grantown (Brian Shaw, personal communication). The lack of monitoring sites within the reserve may reflect the difficulties in surveying in deep water reaches rather than the absence of freshwater pearl mussels.

RSPB's Management Plan provides analysis of trends in key bird populations (Document 46, Appendix A). 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.

Table 3-2: Designated Features

Designation	Feature	Status	Date
Insh Marshes SAC	Alder woodland on floodplains	Unfavourable Recovering	2009
	Clear-water lakes or lochs with aquatic vegetation and poor to moderate nutrient levels	Favourable Maintained	2012
	Otter	Favourable Declining	2015
	Very wet mires often identified by an unstable 'quaking' surface	Favourable Maintained	2005
River Spey - Insh Marshes SPA	Hen harrier, non-breeding	Favourable Maintained	2010
	Osprey, breeding	Favourable Maintained	2009
	Spotted crake, breeding	Favourable Maintained	2005
	Whooper swan, non-breeding	Favourable Maintained	2005
	Wigeon, breeding	Unfavourable No change	2010
	Wood sandpiper, breeding	Unfavourable Declining	2005
River Spey - Insh Marshes RAMSAR	Breeding bird assemblage	Favourable Maintained	2005
	Floodplain fen	Favourable Maintained	2005
	Mesotrophic loch	Favourable Maintained	2012
	Trophic range river/stream	Favourable Maintained	2005
	Whooper swan, non-breeding	Favourable Maintained	2010
River Spey - Insh Marshes SSSI	Arctic charr	Favourable Maintained	2012
	Breeding bird assemblage	Favourable Maintained	2005
	Floodplain fen	Favourable Maintained	2016
	Invertebrate assemblage	Favourable Maintained	2014
	Mesotrophic loch	Favourable Maintained	2012
	Osprey, breeding	Favourable Maintained	2009
	Otter	Favourable Maintained	2007
	Vascular plant assemblage	Favourable Maintained	2011
	Whooper swan, non-breeding	Favourable Maintained	2010
River Spey – SAC	Atlantic salmon	Unfavourable Recovering	2011
	Freshwater pearl mussel	Unfavourable Declining	2014
	Otter	Favourable Maintained	2011
	Sea Lamprey	Favourable Maintained	2011

Table 3-3: Summary of Baseline Hydro-ecological Conditions

*Flood extent, depth and duration relates to a flood event that would occur on average 3 times per year. Flood depth and duration have been extracted from a representative point for each unit.

Unit	Hydrological Conditions*	Habitat Summary	Key Species	Current Management Plan Targets/Actions
A. Ruthven North	• Flood frequency: ~ 3 times per year • Flood extent: majority of unit • Flood depth: 0.41m • Flood duration: 10hrs • Bounded by A9 embankment to south and east and set-back embankment on Spey to north and west. • Shallow topographic gradient - flow of water from upstream breach to downstream breach, A9 embankment limits natural flow route into unit B. Flapped culvert through western embankment has limited influence on drainage (majority via northern breach). No ditches.	Majority is dry grassland, also a small amount of woodland/scrub at the southern end. No NVC data available. Some botanical interest including Greater butterfly orchid.	Breeding waders – Lapwing and redshank Breeding passerines – skylark Some botanical interest including Greater butterfly orchid.	Intensive grassland management on hay meadow: Cut for Hay/silage on an annual basis Sward <5cm over 70% of area on 1st April Grazing – cattle and ponies at a density of 0.4LSU/ha/yr Scrub cover target less than 2%
B. Ruthven South	• Flood frequency: ~ 3 times per year • Flood extent: unit partially flooded • Flood depth: 0.33m • Flood duration: >48hrs • Bounded by A9 embankment to west, embankments to north and east and high ground to south. • Flow enters unit from embankment breaches (Spey/ Ruthven) and drains via breaches to Spey and active open ditch connected to Ruthven Burn. Lowest ground in centre of unit.	Strip of dry grassland along river and in south, majority rush pasture/grassland, some woodland/scrub patches in south, mixed sedge swamp and *Carex rostrata*/*Glyceria fluitans* swamp and *C. aquatilis* swamp in east.NVC communities: Limited NVC data available, S9, S27, S11, MG9 in eastern corner	Breeding waders – lapwing, snipe, curlew and redshank Breeding and wintering wildfowl – wigeon, teal Breeding passerines – skylark, sedge warbler Some botanical interest including Greater butterfly orchid, branched bur reed and cowbane.	Intensive grassland management: Sward <5cm over 70% of area on 1st April 10% managed coarse vegetation - topping Grazing – cattle and ponies at a density of 0.4LSU/ha/yr Scrub cover target less than 2%
C. Gordonhall	• Flood frequency: ~ 3 times per year • Flood extent: majority of unit • Flood depth: 0.17m • Flood duration: >48hrs • Bounded by embankments to west, north and east, high ground to south. • Flow enters unit from breaches (Spey and Ruthven). Main drainage route is via breach in internal embankment into unit D. Ditches assumed to be abandoned/ not functioning.	Majority is *Carex rostrata*/*Equisetum fluviatile* swamp merging into *C. rostrata*/*Glyceria fluitans* swamp in the centre, small patches of mixed sedge swamp, reedbed, *C. aquatilis* and open water in central swamp, strip of *C. vesicaria* to west then rush pasture/grassland, *Sphagnum* flush to east and south with some open water, dry grassland in southern corner. *Carex chordorrhiza* present. NVC communities: Majority is S9, with S4, S27, S11, S10, M6, M25, M23, CG10.	Breeding waders – lapwing, snipe, curlew and redshank Breeding waterfowl – wigeon, spotted crake Breeding passerines – skylark, sedge warbler and grasshopper warbler Wintering wildfowl Wintering whooper swan Vascular plant Assemblage: *Carex chordorrhiza, Cicuta virosa,Carex aqualitis* Other important plant species; Branched bur reed, intermediate bladderwort, greater bladderwort, common skullcap Otter	Maintain the mosaic of semi natural wetland and grassland: Maintain a mosaic of sward heights by grazing with cattle and sheep at a density of 0.2LSU/ha/yr Maintain rush cover on grassland at <10% on grassland and 30% on wetland through topping and grazing. Water at or above ground surface with 10% standing water April to June with prolonged winter inundation Scrub less than 10% across the compartment Maintain area of phragmites at less than 1.84ha
D. Invertromie Fen	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.28m • Flood duration: 46hrs • No embankment along Spey (north). Embankment to west affects flow route from unit C. Higher ground to south and east. • Flow enters via overtopping of natural levees/ backing-up from large arterial open drain in north-east corner directly connected to Spey. Also receives inputs from unit C and E. Drains via the arterial drain. Lowest ground in centre of unit.	Large areas of *Carex rostrata*/*Equisetum fluviatile* and *C. rostrata*/*Glyceria fluitans* swamp. Around the swamp is reedbed in the south with *Sphagnum* lawn, mixed sedge swamp and *C. lasiocarpa*. In the east is *Molinia caerula* sedge mire, species poor tall sedge, mixed sedge swamp and rush pasture. Small areas of woodland/scrub in the centre. Northern and eastern edges are rush pasture/grassland with dry grassland in east. *Carex chordorrhiza* present. NVC communities: Majority is S9 with W23, W19, W18, W17, U4, S4, S4_S22, S27, S11, S10, MG9, M6, M5, M25_S9, M25, M25_M4, M23, CG10	Breeding waders – lapwing, snipe, curlew and redshank Breeding waterfowl – wigeon, spotted crake Breeding passerines – sedge warbler and grasshopper warbler Wintering wildfowl Wintering whooper swan Hen Harrier roost site Vascular plant Assemblage: *Carex chordorrhiza, Cicuta virosa,Carex aqualitis* Other important plant species; Branched bur reed, intermediate bladderwort, greater bladderwort Otter	Maintain the mosaic of semi natural wetland and grassland: Maintain a mosaic of sward heights by grazing with cattle and sheep at a density of 0.2LSU/ha/yr Maintain rush cover on grassland at <10% on grassland and 30% on wetland through topping and grazing. Water at or above ground surface with 10% standing water April to June with prolonged winter inundation Scrub less than 10% across the compartment Maintain area of phragmites at less than 6.14ha
E. Invertromie Farm	• Flood frequency: ~ 3 times per year • Flood extent: minor (overland flow) • Sloping ground – overtopping from Tromie (influenced by embankments) flows northwards via overland flow.	Permanent pasture with a small amount of unimproved species rich grasslands along the riparian corridor. Species include Burnet Saxifrage, fragrant orchid, shepherds cress, fragrant orchid and Downy Currant		Managed under a farm partnership dating back to the 1980's. Mix livestock farming includes silage production for winter keep.

Unit	Hydrological Conditions*	Habitat Summary	Key Species	Current Management Plan Targets/Actions
F. Dell of Killiehuntly Farm	• No overtopping from the Tromie or Spey even at extreme flood events.	A mix of permanent pasture, temporary grassland and unimproved species rich grasslands.		Managed under and agricultural tenancy to facilitate the grazing across the marshes.
G. Dell of Killiehuntly - Upper	• Flood frequency: ~ 5 times per year • Flood extent: unit partially flooded • Sloping ground – overtopping from Tromie and Spey (influenced by embankments) flows north/ east into unit H.	Alder woodland on the floodplain at the confluence of the Tromie and the Spey is a designated feature of the Insh Marshes SAC.	Breeding lapwing, redshank and feeding curlew Breeding passerines – skylark	Intensive grassland management: Cut for Hay/silage on an annual basis Sward <5cm over 70% of area on 1st April Grazing – cattle and ponies at a density of 0.4LSU/ha/yr
H. Dell of Killiehuntly Lower	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.41m • Flood duration: >48hrs • Bounded by high ground to west and south, embankments to north (Spey) and east (internal). Reduced water inputs due to tributary diversions. • Inputs from breaches (Spey / internal embankment between unit H and I), overtopping of Main Drain, overland flow from unit G. Shallow topographic gradient from west to east – flow of water through unit, drains via breach between unit H and I and internal drainage network (including Main Drain).	NVC communities: W3, W4, MG9, MG3, MG5, MG6, M5, M25, M27, S27, S19, S4, S8, S9, S10, S11, U4, G4	Breeding waders – lapwing, snipe, curlew and redshank Breeding and wintering waterfowl – wigeon, spotted crake Breeding passerines – sedge warbler and grasshopper warbler Hen Harrier roost site Otter Vascular Plant assemblage – *Carex chordorrriza, Cicuta virosa,and Carex aqualitis* Mature willow woodland and associated species assemblage	Maintain the mosaic of semi natural wetland and grassland Maintain a mosaic of sward heights by grazing with cattle and sheep at a density of 0.2LSU/ha/yr Maintain rush cover on grassland at <10% on grassland and 30% on wetland through topping and grazing. Water at or above ground surface with 10% standing water April to June with prolonged winter inundation Scrub reduced from 30% to less than 10% across the compartment Maintain area of mature willow woodland
I. Insh Fen	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.53m • Flood duration: >48hrs • Bounded by embankments to north (Spey) and west (internal), high ground to south. Flat topography, slopes slightly towards unit J to east. • Inputs from breaches (Spey and from unit H), via open drain connection with Spey and overtopping of Main Drain. Drains mostly via internal ditch network and via the Main Drain to Loch Insh.	Large areas of *Molinia caerula* sedge mire, mixed sedge swamp and rush pasture/grassland. Some reedbed, *Carex aquatilis* and dense areas of *Deschampsia cespitosa* in north, with smaller areas of open water and woodland/scrub. In south west corner and centre is species rich low sedge mire, in corner this is surrounded by *C. aquatilis*, an unmapped area, open water and deep water swamp. NVC communities: W4, W3, W23, S9, S4, S4_M6, S28, S27_S11, S27 (extensive), S22, S11, S10, MG9, M5, M25 (majority), M23, M10, CG10.	Breeding waders – lapwing, snipe, redshank and curlew, breeding wigeon. Breeding passerines – skylark sedge warbler and grasshopper warbler Wintering wildfowl Wintering whooper swan Hen Harrier roast site Vascular plant assemblage: *Ribes spicatum*, *Carex chordorrhiza, Cicuta virosa, Carex aqualitis, Nuphar pumila* Greater and intermediate bladderwort, Various leaved pondweed, mares tail Otter Mature willow woodland and associated species assemblage	Maintain the mosaic of semi natural wetland and grassland: Maintain a mosaic of sward heights by grazing with cattle and sheep at a density of 0.2LSU/ha/yr Maintain rush cover on grassland at <10% on grassland and 30% on wetland through topping and grazing. Water at or above ground surface with 10% standing water April to June with prolonged winter inundation Scrub less than 10% across the compartment Maintain area of phragmites at less than 2.73ha Maintain are of mature willow woodland
J. Coull Fen	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.72m • Flood duration: >48hrs • Bounded by embankment to north (Spey) and east (internal), high ground to south. • Inputs from breaches (Spey), overtopping of Main Drain, inflow from unit I. Drains mostly via internal ditch network and the Main Drain to Loch Insh.	Majority is reedbed with *Molinia caerula* sedge mire and mixed sedge swamp to south. To north is a complex of open water and woodland/scrub, interspersed with *Carex aquatilis*, *C. rostrata*/*Equisetum fluviatile* swamp, mixed sedge swamp, deep water swamp and dense *Deschampsia cespitosa*. Small areas of *Sphagnum* lawn. *Carex chordorrhiza* present. NVC communities: W4, W3 (extensive), W11, U5, S9, S8, S4 (extensive), S4_S27, S4_S22, S28, S27, S22, S19, S11 (extensive), S10, M9, M6, M5, M25, M25_S27, M10	Breeding waders – snipe, curlew Breeding waterfowl – wigeon, spotted crake Breeding passerines – sedge warbler and grasshopper warbler Wintering wildfowl Wintering whooper swan Hen harrier roast site Otter Vascular plant assemblage: *Ribes spicatum*, *Carex chordorrhiza, Cicuta virosa, Carex aqualitis, Calamagrostis stricta, Nuphar pumila* Greater and intermediate bladderwort, Mares tail Mature willow woodland	Maintain the mosaic of semi natural wetland Maintain a mosaic of sward heights by grazing with cattle and sheep at a density of 0.2LSU/ha/yr Water at or above ground surface with 10% standing water April to June with prolonged winter inundation Scrub reduced from 30% to less than 10% across the compartment Maintain area of phragmites at less than 30.07ha Maintain area of mature willow woodland

Unit	Hydrological Conditions*	Habitat Summary	Key Species	Current Management Plan Targets/Actions
K. Cemetery Marsh	• Flood frequency: ~ 3 times per year • Flood extent: majority of unit • Flood depth: 0.64m • Flood duration: >48hrs • Low ground dissected by railway embankment, connected to floodplain via open channel. Bounded by higher ground to north, west and east. • Inputs from hillslope tributary, and backing up from Spey via this open channel. Drains via the open channel.	*Carex rostrata*/*Equisetum fluviatile* swamp with *C. lasiocarpa*, reedbed and open water in west, *Molinia caerula*/*Myrica gale* mire in east and *Sphagnum* lawn in south. NVC communities: North and west unmapped. W3_M5, S9, S9_M5, S4, S27 (extensive), S10_S9, S10, M25, M25_M15.	Breeding waders - lapwing, redshank, snipe and curlew Breeding waterfowl	Low intensity wetland management across the rest of the fen - to achieve a mosaic of vegetation height through grazing at a stocking density of 0.1 LSU/ha/yr. Prolonged inundation through the winter period
L. Lynchat Upper	• Flood frequency: ~ 3 times per year • Flood extent: majority of unit • Flood depth: 0.03m • Flood duration: 5hrs • Bounded by embankments to north (railway), south (Spey) and west (internal). • Inputs from breaches (Spey). Shallow topographic gradient – flow of water from west to east into unit M. Drains via downstream breach in unit M. Ditches appear to be abandoned and assumed to no longer be functioning.	*Carex aquatilis* and woodland/scrub with *Molinia caerula* sedge mire in west and *Sphagnum* lawn in east. NVC communities: W3, U4, S11, MG9, M5, M27, M25, M23_S11 (majority), M23.	Mature willow woodland and associated species assemblage Wetland passerines including grasshopper warbler and sedge warbler.	Intensive grassland and wetland management on the old alluvial fan deposits of the Raitts burn. Target sward height of 0 to 15cm on the 1st April achieved by grazing at a target stocking density of 0.2LSU/ha/yr. Maintain rush cover at less than 10% on the grassland and 30% through topping and grazing. Maintain area of mature willow woodland
M. Lynchat Lower	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.57m • Flood duration: 13hrs • Bounded by embankments to north (railway), south (Spey) and east (Raitts Burn). Connection to Lynchat village via underpass in railway embankment. • Inputs from breaches (Spey – unit L and M). Shallow topographic gradient – receives overland flow from unit L. Drains via breach. Ditches appear to be abandoned and assumed to no longer be functioning.	Large areas of *Carex aquatilis*/mixed sedge swamp with rush pasture/grassland to south and east. Other areas of dry grassland, rush pasture/grassland and woodland/scrub to north and east. Reedbed, *Sphagnum* flush, fen meadow and *C. aquatilis* in west. Small area of *C. lasiocarpa* in centre. NVC communities: W3, U4, U4_MG9, U4_CG10, S27_S11, S27 (majority), S11, MG9, M27, M25_S27, M23_S27, M23_S11, M23.	Breeding waders – lapwing, redshank and snipe Breeding waterfowl – wigeon and spotted crakes Breeding passerines – skylark, sedge warbler and grasshopper warbler Wintering whooper swan Wetland passerines including grasshopper warbler and sedge warbler Mature willow woodland and associated species assemblage	Low intensity wetland management across the rest of the fen - to achieve a mosaic of vegetation height through grazing at a stocking density of 0.1 LSU/ha/yr. Prolonged inundation through the winter period. Maintain current area of mature willow woodland Maintain area of phragmites at less than 1.55ha
N. Balavil	• Flood frequency: ~ 5 times per year • Flood extent: majority of unit • Flood depth: 0.23m • Flood duration: >48hrs • Bounded by embankments to north (railway), south (Spey), west (Raitts) and east (internal). • Inputs from breaches (Spey). Drains via same breaches. Internal ditch network is highly occluded with minimal direct connectivity with the Spey. Unit drains via breach.	Dominated by mixed sedge swamp, with large areas of *Carex rostrata*/*Equisetum fluviatile* swamp, *Sphagnum* lawn and open water. Smaller areas of *C. aquatilis*, deep water swamp and *C. lasiocarpa*. Surrounded by rush pasture/grassland with small areas of woodland/scrub in north and pine plantation in south. Two stands of *Phalaris arundinacea* in east, close to a small area of ruderal. Dry grassland areas in west. *Carex chordorrhiza present.* NVC communities: W3, W23, U4, S9 (majority), S4, S28, S27, S22, S11 (extensive in centre and south), S10 (extensive in north and east), MG9, M5, M3, M23.	Clear freshwater Loch Breeding waders – lapwing, redshank, snipe and curlew Breeding waterfowl – wigeon and spotted crake Breeding passerines – skylark, sedge warbler and grasshopper warbler Wintering wildfowl Wintering whooper swan Vascular plant assemblage - *Ribes spicatum*, *Carex chordorrriza, Cicuta virosa, Carex aqualitis, Nuphar pumila* Other plant species – common skull cap, water purslane, mares tail, greater bladderwort, branched and unbranched bur reed, yellow loosestrife. Otter Mature willow woodland and associated species assemblage	Intensive grassland and wetland management on the old alluvial fan deposits of the Raitts burn. Target sward height of 0 to 15cm on the 1st April achieved by grazing at a target stocking density of 0.2LSU/ha/yr. Maintain rush cover at less than 10% on the grassland and 30% through topping and grazing. Low intensity wetland management across the rest of the fen - to achieve a mosaic of vegetation height through grazing at a stocking density of 0.1 LSU/ha/yr. Prolonged inundation through the winter period Maintain area of phragmites Remove mature pine shelter belts Maintain current area of mature willow woodland Scrub cover maintained at less than 10%
O. Balavil North	• Not included in flood modelling. May be connected to unit N via small drains/ culverts through railway embankment.	Mostly mixed sedge swamp and *Carex rostrata*/*Equisetum fluviatile* swamp, with smaller areas around the periphery of woodland/ scrub, fen meadow and reedbed. NVC communities: M27 and S27 (majority), S4, S9, S10, W3, W9, W11.		No active management

3.3 Morphology

3.3.1 Overview

Insh Marshes is often cited as one of the least modified floodplains in the UK. However, it is by no means an unmodified environment. The River Spey between Spey Dam and Loch Insh (water body ID 23141) and the River Tromie (water body ID 23138) are classified as Heavily Modified Water Bodies (HMWB) for Water Framework Directive (WFD) River Basin Management Planning purposes. Large scale abstraction and transfer of water out of the upper catchment for hydro-electric power occurs on both these water bodies. This loss of water is estimated to account for 19-49% of the natural mean annual flow at Kinrara (Document 61, Appendix A). 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 within these two water bodies. The most recent classification data for the water bodies within the study area dates from 2014 and is summarised in Table 3-4. It is noted that SEPA are currently updating the morphological classification of a large number of water bodies nationwide using field survey data, and as a result these classifications may change.

Table 3-4: RBMP Classification Results 2014

Water Body ID	Overall Status	Morphological Status
23142 River Spey – Spey Dam to Loch Insh	Good Ecological Potential	Good
23138 River Tromie – d/s Allt Bhran	Moderate Ecological Potential	Good
23136 Raitts Burn	Moderate Ecological Status	Good

Historic changes to the watercourses and floodplain within the study area are documented in Drawing D1 in Appendix D. 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 marshes. Leslie's 1863 map also highlights a former entry point of the Spey into Loch Insh (Document 32, Appendix A). In the Roy Map the Gynack and Ruthven Burns and the lower 800m of the River Tromie are represented 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 (see Drawing D1, Appendix D). 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 OS 1st Edition mapping surveyed in 1870 (NLS, n.d.). There are also records of attempts to dredge the outlet of Loch Insh in the 1790s to aid drainage of the marshes (Document 32, Appendix A). 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 (Document 32, Appendix A).

The River Spey within the study area has been split into two reaches to describe the morphological forms and processes. Reach 1 extends from Ruthven Bridge to the confluence with Ruthven Burn, and reach 2 from Ruthven Burn to Loch Insh. Quantitative descriptors of channel form and processes are provided in Appendix D.

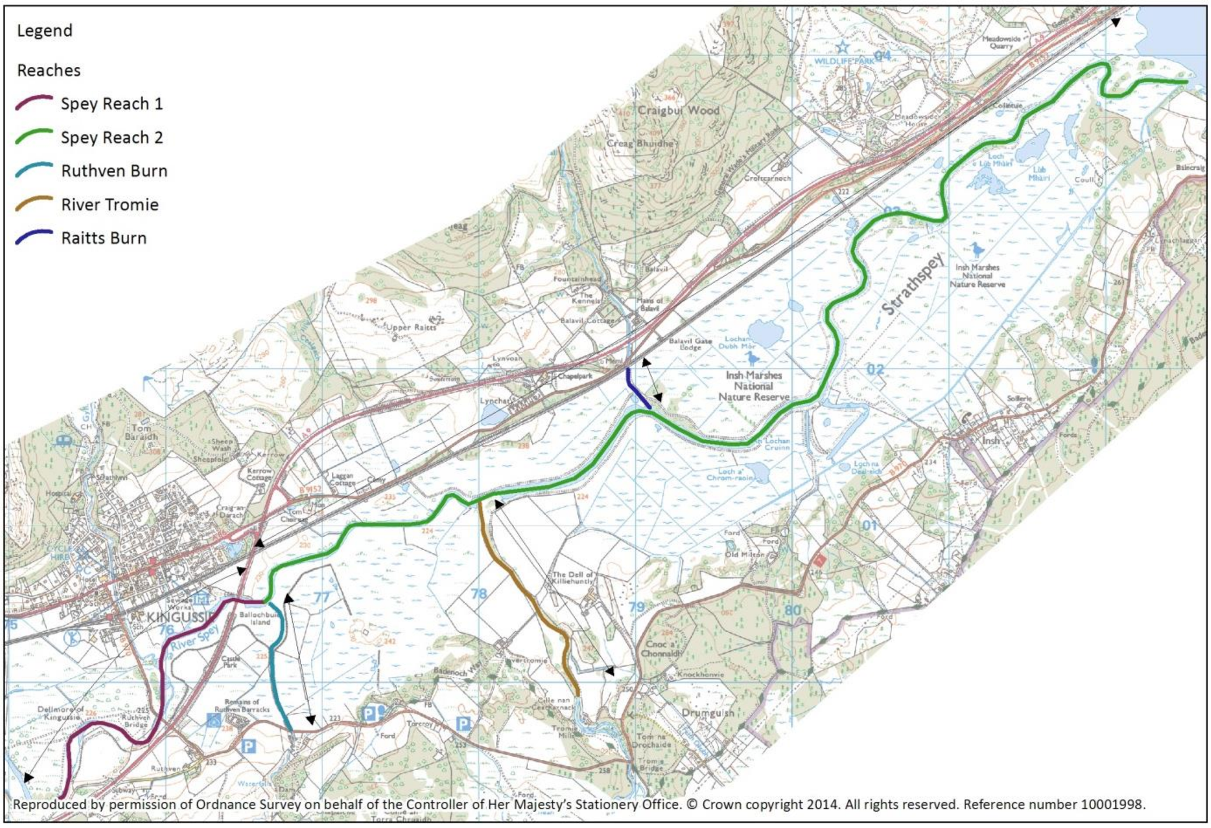


Figure 3-3: Morphological Reaches

3.3.2 River Spey – Reach 1

Throughout the study area the River Spey flows through a wide alluvial floodplain (generally 1.3km wide). Within reach 1 it is sinuous (sinuosity 1.4) with a relatively low gradient (~ 1 in 1100 at QMED). Drawing D1 (Appendix D) shows evidence of lateral migration and channel changes over the past 150 years within reach 1. The current morphology is characterised by variation in channel width, depth and flow types, presence of gravel bars and active bank erosion (Drawing D2, Appendix D and Figure 3-4 below). Dominant sediment sources within this reach are the significant input of coarse sediment from the Gynack Burn, and smaller inputs from bank erosion (fines and alluvial sands and gravels). The channel has a low-medium stream power (average 21 W/m^2, range 8 – 53 W/m^2, Drawing D3 Appendix D) and calculations in Appendix D indicate that the channel has the potential to transport of fine to coarse gravel at the QMED event. The significant input of sediment from the Gynack Burn is locally deposited and reworked within this reach, with limited transport of coarse material transported to reach 2 due to lower energy conditions downstream.

There is no evidence of physical modification of the channel, although morphological processes will be affected by the modified flow conditions. The main morphological pressures in reach 1 are the set-back embankment on the right bank, which limits channel-floodplain connectivity, and the embankment, bridge and hard bank protection at the A9 crossing (Drawing D4, Appendix D). The majority of the A9 embankment does not classify as a pressure using SEPA's MImAS approach (see Appendix D), however it prevents water following the natural floodplain flow route between Ruthven North and Ruthven South (units A and B), with all floodplain flow being directed parallel to the embankment and focussed through the bridge opening. The embankment also appears to have been constructed over a relict channel (Drawing D1, Appendix D), highlighting the potential impact of this structure on limiting future lateral channel migration. Active erosion of the right bank was recorded just upstream of the bridge, with the bank ~ 20m from the embankment toe under current conditions (Drawing D2,

Appendix D). Grazed banks may also affect the susceptibility of the banks to erosion. The MImAS capacity used in this reach is calculated at 1.0% (Appendix D).

Figure 3-4: River Spey – Reach 1
Left: looking downstream towards A9 embankment. Right: looking downstream at Gynack Burn confluence

3.3.3 River Spey – Reach 2

Reach 2 of the Spey is deeper and wider than reach 1, and is characterised by long, slow glides and pools (97%) interspersed with short, steeper riffle and run sections at the tributary confluences (River Tromie and Raitts Burn). The channel is less sinuous (1.2) and has a shallower gradient than reach 1 (~ 1 in 3,200 at QMED). Loch Insh acts as a downstream control on water levels in reach 2, and dominates the water surface profile downstream of the Raitts Burn confluence (Figure C9, Appendix C).

The River Tromie and Raitts Burn are the main sources of coarse sediment input to the Spey in reach 2 and depositional bars and active erosion are observed at the two confluences (Drawing D2, Appendix D). Active reworking of the coarse sediment is restricted to the locality of the confluences due to the very low energy of the Spey throughout the remainder of the reach (typically < 10 W/m^2). Depositional features in the form of gravel bars account for only 1% of the channel area under average flow conditions (Drawing D2, Appendix D). Calculations in Appendix D indicate that transport through the majority of the reach is limited to sands and fine gravel at QMED.

As noted in section 3.3.1, the meander cut-offs within this reach are believed to have occurred naturally. The key morphological pressures within the reach are therefore embankments and set-back embankments which are located on both banks throughout much of reach 2 (total length of 9.3km used in MImAS calculations). The main impact of these embankments is floodplain disconnection. The embankments and low-level revetments (exact length unknown as only visible during low water levels) 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. The MImAS capacity used in this reach is calculated at 7.7% (Appendix D).

Figure 3-5: River Spey – Reach 2
Left: typical low energy, embanked section. Right: Raitts Burn confluence

3.3.4 River Tromie

The River Tromie flows across a relict alluvial fan feature which extends onto the River Spey floodplain. It has a steeper gradient than the Spey (~ 1 in 150 at QMED) and is characterised by low-medium to medium-high stream power at a QMED event (average 124 W/m^2, range 49-256 W/m^2). Calculations indicate the channel has potential to transport coarse gravels and cobbles at QMED flows. The upper part of the surveyed reach is partially confined by higher ground on the right bank and exhibits characteristics of a naturally dynamic channel, with variation in channel width, depth and flow velocity, active reworking of coarse sediment bars and active bank erosion (Drawing D2, Appendix D). The lower 800m of the Tromie is unnaturally straight and is confined within embankments. The majority of this section lacks variability in form or flow velocity and there is a lack of depositional features. Transport and deposition of sediment are the dominant process through this section. Aggradation of the bed has occurred towards the lower end of this straightened reach, which is evident in the long profile in Figure D3, Appendix D. Channel change in the form of deposition of a large medial bar and subsequent channel widening has been observed in the past couple of years just upstream of the confluence with the Spey, which is believed to have arisen due to the release of sediment from in-channel works further upstream. Hard bank protection limits active erosion and lateral movement of the right bank at the confluence.

The relict alluvial fan feature, moderate energy conditions and Roy map suggest that the straightened reach would be significantly more dynamic and a zone of deposition under natural conditions, and it has therefore been classified as being subject to high impact realignment for the purposes of the MImAS calculations. The stream power assessment suggest that the Tromie has sufficient energy to recover a more natural morphology if the embankments are removed, although full recovery to its natural reference condition may be limited by the alteration of the natural flow and sediment regime caused by the upstream impoundment, including a lack of sediment reserves within the channel available for reworking. The embankments and channel realignment, and small lengths of hard bank protection, account for 17.6% morphological capacity used on the Tromie water body.

Figure 3-6: River Tromie
Left: looking upstream in realigned section. Right: looking upstream at recent channel change near confluence

3.3.5 Raitts Burn

The Raitts Burn within the study area has a moderate gradient (~ 1 in 140 at QMED) and energy conditions (average stream power 91 W/m^2, range 75-102 W/m^2). The channel has been significantly altered and there is evidence that the course has been realigned, straightened and the confluence location changed (Drawing D1, Appendix D). The main sediment input is from the upstream reach, and minor inputs from the embankments which are located on both banks. The Roy map and presence of alluvial fan deposits indicate that the channel would naturally be more dynamic and flow across a depositional zone as it moved from the steep, confined valley to the flat, unconfined conditions on the Spey floodplain. The embankments disconnect the channel from the floodplain and prevent lateral migration. Deposition remains the dominant process but is confined to the channel resulting in aggradation. The bed is now perched approximately 1m above surrounding ground levels (Figure 3-7). As a result, the embankments of the Raitts Burn are at risk of breaching and there is an increasing flood risk to the upstream infrastructure (railway and B9152) due to reduced capacity at the bridges. Repair work to the railway embankment has been required on a number of occasions as a result of scour from the Raitts Burn overtopping onto the floodplain upstream of the study area.

Small bars and associated bank erosion, a variety of in-channel flow types and moderate energy conditions (Drawing D2 and D3, Appendix D) suggest that natural recovery of the burn would be possible, however the large embankments, the aggraded bed and presence of infrastructure immediately upstream of the NNR pose risks to allowing the channel to recover naturally. The embankments and realignment account for 9.7% morphological capacity in just 340m channel length.

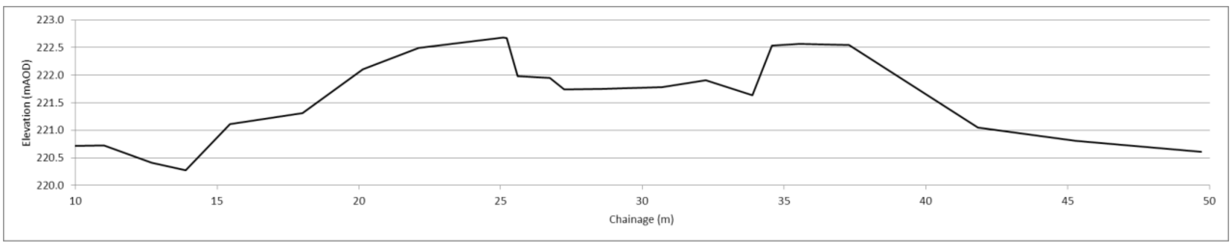


Figure 3-7: Raitts Burn Typical Cross-section (vertical exaggeration x 2)

Figure 3-8: Raitts Burn
Left: Railway crossing viewed from upstream of study area. Right: in the study area looking upstream.

3.3.6 Ruthven Burn

The Ruthven Burn has also been historically straightened and embanked, resulting in a relatively featureless channel with reduced connectivity to the floodplain and limited opportunity for lateral migration. The bed of the channel for ~ 200m downstream of the road bridge has aggraded and is perched approximately 0.5m above the adjacent floodplain levels. The bed gradient of the Ruthven Burn is lower than either the Tromie or Raitts and the sediment input from the upstream reach is lower, with little evidence of a relict alluvial fan. The upper section of the channel has a low-medium energy (35 W/m^2 stream power at QMED) and a coarse gravel bed. The section of the reach is dominated by levels in the River Spey and become drowned out at high flows. As a consequence there is a marked downstream fining of bed material and very low predicted stream power at the peak of the QMED event. In the lower section of the reach the Ruthven Burn flows into a relict meander of the Spey prior to the confluence with the current channel. The Ruthven Burn is not a classified water body.

Figure 3-9: Ruthven Burn
Left: looking downstream from B9152 road bridge. Right: looking downstream in mid-section of burn

3.3.7 Main Drain (Allt Baile Mhulinn)

The fluvial audit did not include the Main Drain, which is a straight, deep, artificial drainage channel. The drain receives inputs from hillslope tributaries including the Allt Baile Mhulinn. The catchment area of this watercourse is a similar size to the Raitts Burn and formerly flowed into the marshes at the Dell of Killiehuntly

Wetland (unit H). Prior to the Main Drain being dug, it is likely that the watercourse entered a small single thread or multi-thread sinuous channel well-connected to the marshes. It currently enters the Main Drain downstream of the embankment between units H and I having been diverted in the 1970's (Drawing D1, Appendix D).

3.4 Summary of Baseline Understanding

The key elements of the baseline understanding have been used to inform the options identification and appraisal:

- Natural channel-floodplain interactions and processes have been altered by the presence of embankments, channel realignments and drainage network that have been in place for over two hundred years.
- 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 the NNR via the Main Drain also have a significant influence on channel-floodplain interactions within the NNR.
- Downstream of the Ruthven Burn confluence (reach 2), the River Spey is a low energy watercourse. The main areas of dynamism and channel change are associated with coarse sediment inputs from the key tributaries (River Tromie and Raitts Burn), however there is insufficient energy for the channel to transport this coarse material downstream under QMED flow conditons. Upstream of the Ruthven Burn confluence (reach 1), the channel has more energy and there is increased evidence of current and historic channel dynamics. The Gynack Burn provides a significant input of coarse sediment which is locally transported and reworked within reach 1. The embankments along the Spey reduce connectivity with the floodplain and increase the channel conveyance compared to nature conditions.
- The River 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 River 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 the NRR 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 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 the NNR which could be affected by changes to the flood regime with the study area.

4 OPTIONS IDENTIFICATION AND ASSESSMENT

4.1 Approach

A wide range of potential restoration options were identified following the baseline assessments. The selection of options to be incorporated into the hydrodynamic model was agreed with RSPB and SEPA at a mid-project review meeting. It was necessary to define a series of assumptions to allow each option scenario to be assessed due to the large number of potential variations and combinations of options that are possible in such a large and complex study area. These assumptions are detailed in the following sections and should be considered when reviewing the outputs of the options assessment. The timeframe used in the options appraisal is to 2028 to coincide with river basin management planning cycles (13 years). It is however noted that RSPB view the aim of developing a more naturally functioning floodplain as a 20 – 25 year aspiration.

The options included in the assessment are as follows:

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. This feasibility study assesses three variations.
    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.

The options assessment has been undertaken using the methodology outlined in chapter 2 and Appendices C and D. As described in chapter 2, the options assessment does not include potential effects during the construction phase or the implications of changing land management. Units O and F are not included in the options assessment. Connections between unit O and the Spey floodplain have not been included in the model and therefore predictions of changes in flood depth, duration and frequency have not been made. Unit F covers the high ground comprising Dell of Killiehuntly Farm and is not impacted by the options.

The key findings from the options assessment, including the flood modelling, are discussed in section 4.2. This is followed by a summary of the potential impact of the proposed options on the hydrological regime, ecological interests at the site, morphological forms and processes and the risk to identified receptors in a factsheet for each option. The factsheets only include those factors or parts of the study area which are predicted to change as a result of the option, i.e. any factors or hydrological units where ‘no change’ is predicted are not included in the factsheet. Depth and duration of flooding refer to the 3-POT event unless stated otherwise.

4.2 Key Findings

4.2.1 Hydrological Regime and Flood Risk

Flood extent maps and changes in flood levels and depths for options 3, 4a, 4b, 4c, 5 and 10b are presented in Appendix C. Potential changes in hydrological regime for the options which have not been modelled have been assessed through extrapolation of the results from the modelled options and professional judgement. The assumptions used for the options modelling are outlined in sections 4.5, 4.6, 4.7 4.8, 4.9, 4.15 and section C6 of Appendix C.

The model outputs demonstrate that repairing the existing breaches in the embankments (Option 3) would have a significant impact on the flood regime within the NNR. A higher proportion of the flow is conveyed with the channel the frequency of flooding reduces for units A, B, C, H, L, M and N. In the units where the embankments overtop at the QMED event, the depth and extent of flooding is reduced compared to the baseline scenario but the duration of flooding increases as water can only drain back to the channels via the drainage network. The increased conveyance within the channel results in higher water levels within the River Spey, causing an increased backwater influence at the tributary confluences and increased overtopping into the areas where embankments are absent and increased flood depths at these locations (unit D and K). Backing-up from Loch Insh into unit J via the Main Drain occurs in a similar manner to the baseline scenario, with increased flood depths in units I and J due to higher water levels in the Spey and Loch Insh. At the QMED the key changes in the flood mechanisms compared to the baseline scenario are as follows:

- Increased conveyance within the channel, and reduced storage and reduced conveyance on the floodplain;
- As a result the hydrograph passes through the site more quickly, and the peak flow at Kincraig is higher and occurs earlier in the simulation;
- Higher water levels are experienced in the channel throughout the study area, while flood depths and extents on the floodplain are reduced.

At the 0.5% AEP flood event the increased conveyance in the channel results in slightly higher maximum predicted flood levels throughout the majority of the NNR for Option 3, potentially increasing flood risk to local receptors (Table C10, Appendix C). Modelled flood levels are however slightly lower than the baseline levels downstream of Balavil and at Kincraig. At the 0.5% AEP the key changes in the flood mechanisms compared to the baseline scenario are as follows:

- Whilst the water levels on the floodplain move up and down in continuity with the River Spey above the embankment level, once levels drop below the embankment height the remaining water becomes trapped within the floodplain unit.
- Repair of the embankments therefore means that the dominant mechanism for units A, L and M changes from floodplain conveyance to floodplain storage, and floodplain storage increases for units A, B, C, H, L, M and N.
- In the baseline scenario, floodwater in the upstream units A, B, C, L and M returns to the Spey and contributes to rising levels in Loch Insh and downstream flows. For option 3, the water retained in the upstream units prevents this mechanism occurring and as a result the peak flow and level at Kincraig are lower than in the baseline scenario.

In Option 4a (full removal of embankments) increased overtopping from the channel into the floodplain occurs as connectivity to the floodplain is no longer limited to the breaches. Flood depths and extents increase at the frequent events (5-POT, 3-POT) for the majority of floodplain units and frequency of flooding increases where new flow paths are opened up. Duration of flooding is predicted to decrease in units A and B. Elsewhere there is little change in flood duration because increased conveyance through the floodplain is offset by a flatter water surface long profile through the study area (Appendix C), and there is little or no change in the control point for water leaving the unit (for example, the existing low-level breach points remain or controlled by levels in Loch Insh).

The key changes in the flood mechanisms compared to the baseline scenario are as follows:

- A smaller proportion of the flow is conveyed within the channel compared to the baseline scenario and a higher proportion overtops into the floodplain.
- As a result peak water levels in the Spey are lower than the baseline scenario throughout the majority of the study area.
- Levels in Loch Insh do not rise as quickly at the start of the simulation due to the reduced conveyance in the channel, and backing-up into unit J is reduced.
- Floodplain conveyance becomes the dominant mechanism, rather than storage, and embankments no longer block floodplain flow pathways.
- In the majority of units water levels drop faster after the peak than in the baseline scenario due to increased connectivity with the channel. As for the baseline scenario, water that flows out of the upstream units is conveyed downstream and contributes to rising water levels in the downstream part of the site and in Loch Insh.
- Water levels in unit J rise in faster than the level in Loch Insh due to overtopping from the Spey. The dominant floodplain flow direction is towards Loch Insh, rather than backing-up from Loch Insh which occurs in the baseline scenario. Levels in Loch Insh and the Coull culvert still control the rate of drainage of flood water from unit J after the peak of the event.

At both the QMED and 0.5% AEP events the predicted flood levels are slightly reduced through the majority of the NNR in Option 4a (Table C10, Appendix C). Modelled flood levels are however slightly higher than the baseline levels downstream of Balavil and at Kincraig, potentially increasing flood risk for local receptors at these locations. The peak flow at Kincraig is slightly increased at both the QMED and 0.5% AEP events (2 – 5%) compared to the baseline scenario (Table C11, Appendix C). This change is explained by the change in the key mechanisms described above, whereby increased floodplain connectivity allows the larger floods to move through the marshes more quickly than in the baseline scenario. Similar conditions are observed for Options 4c and 5, but not for Option 4b where connectivity is restored only to a small part of the site.

The change in flood mechanisms described above for both Option 3 and Option 4a are independent of the timing and size of flood flows on the River Feshie. The options do however alter the ‘hydraulic dam’ effect of the River Feshie in the modelled scenarios, whereby the upstream backwater influence is reduced in Option 3a because the conveyance in the River Spey is increased, and vice versa for Option 4b.

The timing and size of flood flows on the River Feshie affects how the predicted changes at Kincraig influence downstream conditions. The options act to either slightly delay or slightly advance the peak flow on the River Spey at Kincraig (varies between scenarios and flows). For the modelled QMED event, this means that the peak flow downstream of the Feshie confluence is lower for Option 4a than the baseline scenario despite a higher peak flow being predicted at Kincraig, and for the 2% AEP the downstream peak flow is higher for Option 3 despite a lower peak flow being predicted at Kincraig (Table C12, Appendix C). The options appraisal therefore assesses potential change in downstream flood risk based on the change in conditions at Kincraig as this is considered to be a more robust and consistent approach.

The preceding discussion and the results in Table C10, Appendix C highlight that options which substantially alter the flood regime across the whole NNR, such as Options 3 and 4a, have the potential to reduce flood risk to some receptors and increase flood risk to other receptors. This occurs because the potential receptors are located adjacent to the NNR throughout its length, a distance of over 10km between Kingussie and Kincraig.

The assessment focuses on the *potential* for flood risk to change at these receptors in the order of magnitude of <0.1 – 0.3m for Option 3 and <0.1m for Option 4a.

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. Once a preferred option is agreed, it is recommended that any potential increase in flood risk is investigated further, for example through consideration of threshold levels for any properties at potential risk, and possible mitigation measures investigated. The model results indicate that embankment removal has the potential to cause a minor increase in peak flows at Kincraig. Investigation of the implications on downstream flood risk is out with the scope of this study but should be discussed with the relevant stakeholders and assessed prior to implementation of the options if required.

The options appraisal focuses on high flow events due to the nature of the majority of the proposed options and the modelling approach. Repairing the breaches (Option 3) could result in more surface water runoff being retained in the floodplain units and contributing to groundwater recharge, however it is considered unlikely that this would offset the reduced input from the adjacent watercourses.

Option 10a aims to reduce drainage of the site and maintain groundwater levels closer to the surface. This option has not been explicitly modelled, however modelled water level results have been used to assess the implications of blocking the direct connections between the Spey and the arterial drains in unit D and unit I. Ground levels in the centre of unit D are lower than the banks due to the presence of natural levees. If the artificial drainage connection to the Spey is removed and blocked to the same level as the adjacent banks, the frequency of flooding in unit D would reduce to an average of 3 times per year. When flooding occurs, water would be retained in unit D to a depth of up to 0.5m (at the representative point shown in Figure 2-1) until it infiltrated or evaporated. Blocking the direction connection at unit I would reduce the inflow from the River Spey into this unit under high flow conditions and drainage of the unit under low flow conditions. The influence on longer term retention of floodwater is minimal as the topography slopes towards Loch Insh.

Repairing the existing breaches to the same level as the adjacent banks is not included in Option 4a, 4b or 4c. It is considered unlikely that the existing breaches are currently having a significant drawdown influence on groundwater levels given the hydraulic connectivity between river levels and groundwater levels adjacent to the channel (Document 35, Appendix A). However, in some units the breaches are scoured below a natural bank level and therefore allow more floodwater to flow out of the unit. This is particularly the case in unit M and N. Repairing the breach up to a natural bank level would encourage longer term retention of a shallow depth of water on the floodplain in these two units. The ecological implications of this variation have not been assessed.

Blocking the Main Drain to adjacent ground levels (Option 10b) is expected to reduce drainage of the floodplain in units H, I and J and localised groundwater drawdown during drier conditions. During higher flow conditions the connectivity between Loch Insh and the floodplain remains via the overland flow path and the model results show minimal change in flood depths or levels.

4.2.2 Morphology

The majority of the options, other than Option 2 and 3, are expected to have a positive or neutral impact on morphological forms and processes. Embankment removal and/ or channel restoration works increase the channel-floodplain connectivity and dissipation of energy on the floodplain. The implications of this reconnection on the sediment transport regime and channel dynamics in the River Spey are limited due to the existing connections via the breaches and very low energy of the watercourse. Bank erosion and channel change in reach 2 of the River Spey is only likely to occur as a result of more extreme flows and is therefore not considered likely within the timescales used in the options assessment (13 years). Changing water levels on the River Spey would affect the backwater influence at the tributary confluences, which has the potential to alter channel dynamics at these locations.

The implications of embankment removal are more significant for the tributaries where reduced stream power may encourage formation of natural depositional features. Depositional features, combined with the removal of constraints such as embankments and bank protection, provide more opportunities for lateral movement and dynamics in the tributaries.

Increased channel dynamics and restoration of more natural channel processes and forms could be further encouraged by in-channel restoration measures (option 7) or channel realignment (option 8). Without active intervention in the short-term it is likely that an uncontrolled breach of the embankments along Raitts Burn will occur. This poses a risk to the stability of the railway and road bridges from upstream incision of the bed as the channel adjusts towards a new equilibrium slope. Active intervention for restoration of the Raitts Burn is therefore recommended, whilst measures to assist restoration (option 7) could be successful for the River Tromie and Ruthven Burn.

There is opportunity for significant release of capacity from the River Spey (8.5%), River Tromie (12.1%) and Raitts Burn (8.7%) within the study area (Appendix D). Full recovery of the River Tromie and Raitts Burn may be limited by conditions out with the NNR, specifically the modified flow and sediment regime of the Tromie and the upstream restrictions on lateral movement of the Raitts Burn.

4.2.3 Ecological Features

Flood frequency significantly reduces for units A, B, C, H, L, M and N for Option 3. Across these units changes to the habitat composition are predicted which are contrary to RSPB's management plan objectives. Willow scrub is likely to increase and the proportion of fen, marsh and swamp habitat decrease. There are potential implications for *Carex chordorrhiza,* arising both from generally drier conditions and from increased duration of inundation when flooding does occur. Units I and J are affected to a lesser extent due to the direct connectivity with Loch Insh and limited change in existing flood regime, and so there are no significant changes to habitat composition predicted.

Options which increase connectivity between the watercourses and the floodplain (Options 4a, 4b, 4c, 5) 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 I and J which are 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 (Options 4a, 4b, 4c, 7, 8), 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.

As noted in section 2.5, 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.

4.2.4 Wider Implications

Potential impacts of the options on the A9 embankment have not been explicitly discussed due to the on-going work regarding the A9 dualling. The model results do show that options which increase the floodplain connectivity and floodplain conveyance in unit A cause an increase in the maximum velocity of the floodplain flow.

The mainline railway runs along the northern edge of the River Spey floodplain. Significant flood depths can occur adjacent to the railway embankment within the NNR under existing conditions, but are not predicted to overtop the embankment at the modelled 0.5% AEP event from the southern floodplain (section 3.1.2 and Table C10, Appendix C). This remains unchanged under the modelled options. The railway is at risk of flooding from tributaries on the northern side under existing conditions, notably from the Raitts Burn (section 3.1.4). Options which incorporate restoration of the Raitts Burn so that the channel is no longer perched within the NNR have the potential to improve flood risk to the railway embankment from the northern side by lowering water levels. If there is an uncontrolled breach of the Raitts Burn embankments there is a risk that upstream bed incision could threaten the stability of the upstream railway and road bridge. Active intervention on the Raitts Burn is therefore recommended and is discussed further in section 6. In a similar manner to the A9, options which increase floodplain connectivity could cause a minor increase in maximum velocity of the floodplain flows. However, it is noted that the model grid is relatively coarse and the modelled floodplain velocities adjacent to the railway remain low in relation to river flows across all scenarios.

There are several discharges which could be affected by the options. The waste water treatment works at Insh currently discharge to the Main Drain. There are however proposals to move the outfall so that it discharges directly to the River Spey, which would remove one of the potential barriers to implementing Option 10. The distillery at Tromie Mills has a warm water discharge to the Feith Dhubh, and would need to be consulted prior to the progression of Option 9 to determine whether the discharge could be moved. There are no known services or utilities (locations provided by RPSB) at risk from the potential options.

Change in access is included in the following options assessment tables, with specific reference to existing access rights held by third parties. Mitigation, for example the provision of an alternative access route, could be incorporated into the design of the relevant options providing that this does not have a detrimental impact on the ecological interests of the site. Further potential legal constraints include the feasibility of removing embankments and flow control structures that were constructed under a Land Drainage Order Act, a matter which RSPB is currently investigating.

4.3 Option 1: Do nothing

Description: No maintenance of the embankments or of the internal drainage system.

- Limited change in breach extents up to 2028 across the majority of the site, based on there being little change observed by RSPB staff over the last 15 years. Conditions therefore similar to baseline.
- The breaches at unit A (Ruthven North) are expected to increase in size over time, based on the knowledge that these embankments have been repaired 3 times in the past 10 years. Conditions are assessed as being similar to but of a smaller magnitude as for option 5 (modelled).
- An additional breach on the right bank of the River Spey at unit H is included, assuming that there is the potential for this as a result of continuing bank erosion opposite the Raitts Burn confluence.
- An uncontrolled breach of the Raitts Burn is expected to occur within a short timeframe (months to a few years depending on size of flood flows) unless active intervention is undertaken, due to the aggrading bed, active channel erosion and moderate energy of the watercourse. For the purposes of the assessment it is assumed that the breach will occur on the right bank into unit M (Lynchat lower).
- It is assumed that there will be little or no change in morphological processes and forms within the other watercourses within the study area. As a result, there will continuing aggradation of the bed in the Ruthven Burn. Localised, minor changes in erosion and deposition patterns may occur at confluence locations.
- The appraisal timescales (13 years) fall within the current management regime of rotational ditch clearance every 10-15 years. The changes associated with a lack of maintenance of the internal drainage system (e.g. due to siltation/ vegetation succession) are therefore assumed to occur over longer timescales (> 13 years), and are not included in the Do nothing option.
- The location of Option 1 is shown in Figure 4-1. The factsheet in Table 2-1. only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

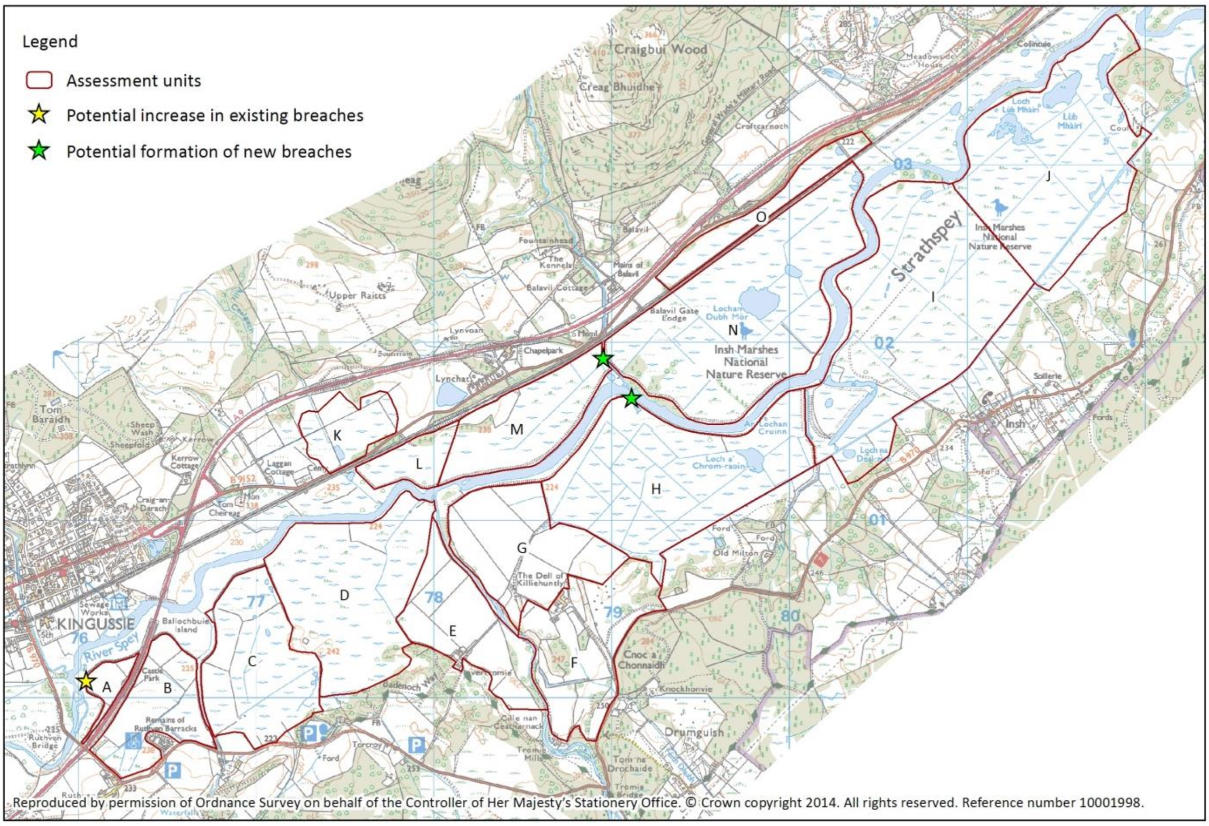


Figure 4-1: Option 1

Table 4-1: Option 1 Assessment Summary

Factor	Location	Description
Hydrology	A	Reduction in depth and duration of flooding (increase in extent of breaches).
	H	Increase in flood depth (potential for additional breach)
	M	Raitts Burn uncontrolled breach – very frequent inundation of adjacent ground initially until adjustment and formation of new channel. Once new channel formed, increased frequency and depth of flooding compared to baseline.
Ecology	A	Willow scrub may increase. Slight increase in passerines (Skylark on drier ground, Sedge Warbler and Reed Bunting should willow scrub increase).
	H	Increase in flooding may lead to slight increase in wader and duck numbers.
	M	Change in habitat due to Raitts Burn breach and deposition of sediment on floodplain. Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Marshy grassland community M25 may succeed to fen community M6 or to M23, which may increase in area. Increase in flooding may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	Water bodies	Uncontrolled breach could have a short term negative influence on fish habitat in the Raitts Burn and fish passage from the Spey into the Raitts Burn.
Morphology	Spey	Increased channel-floodplain connectivity at unit A – small increase in maximum velocity of floodplain flow adjacent to A9 embankment. New confluence between Spey and Raitts Burn (uncontrolled breach) – localised change in erosion/ deposition. No change in MImAS capacity.
	Raitts	Uncontrolled breach - deposition of gravels/ cobbles as water enters floodplain (crevasse splay formation) and distributed floodplain flow. Increased (high) channel-floodplain connectivity. Dynamic channel and natural adjustment over time towards development of new single or multi-thread channel and new confluence with Spey. Potential for upstream bed incision. MImAS capacity release - dependent on channel evolution.
Flooding	Adjacent to marshes	Not modelled. Negligible change expected.
	Kincraig	Not modelled. Any increased breaching of Spey embankments could have a similar impact as Option 5 – negligible change in peak flow and level at Kincraig expected.
Infrastructure	A9	Increase in maximum velocity of floodplain flow in unit A.
	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve). Potential risk to infrastructure stability from upstream incision following uncontrolled breach.
Access		Raitts Burn uncontrolled breach – access could be prevented/ reduced at Lynchat (or Balavil if left bank of Raitts Burn breaches).
Maintenance		Potential for increase in maintenance requirements as a result of vegetation succession (e.g. willow scrub).

4.4 Option 2: Maintain according to obligations

Description: Maintain the river embankments only in relation to RSPB's existing legal obligations; at unit A (Ruthven North, right bank of the River Spey), units L and M (Lynchat, left bank of River Spey), and the internal embankment between units H (Dell of Killiehuntly Wetland) and unit I (Insh Fen).

- Repairs undertaken to any existing breaches in the embankments listed in the description, and reinstatement of the flap valve on the Main Drain culvert between units H and I.
- At these locations (units A, L, M and H) the implications are assumed to be similar to option 3 (full repair, modelled).
- At all other locations, implications are as per option 1, or there are uncertainties in predictions e.g. regarding change in flood risk due to the complexity of the flood regime.
- The location of Option 2 is shown in Figure 4-2. The factsheet in Table 4-2 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

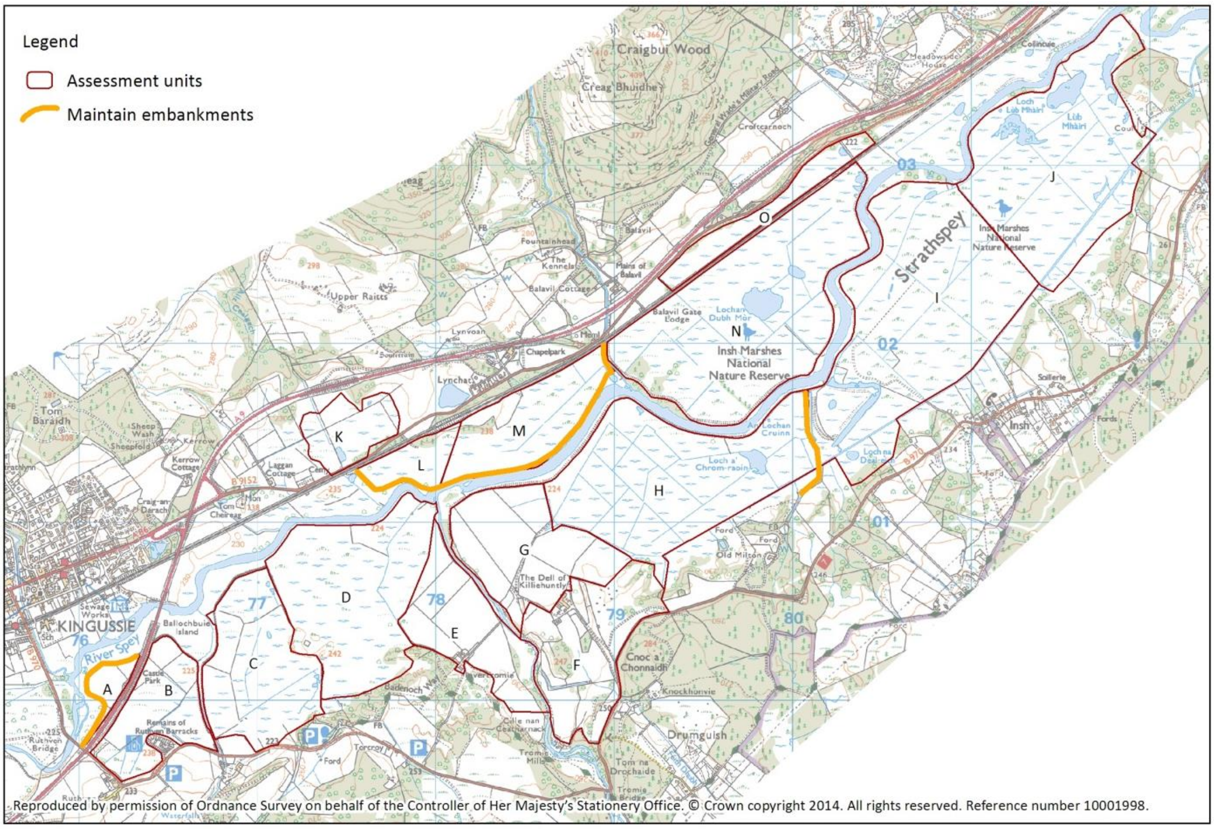


Figure 4-2: Option 2

Table 4-2: Option 2 Assessment Summary

Factor	Location	Description
Hydrology	A	Reduced flood frequency from ~ 3 times per year to less frequent than once every two years.
	H	Reduced extent and depth of flooding, but increase in duration of flooding.
	I & J	Increase in flood depth.
	L	Reduced flood frequency from ~ 3 times per year to less frequent than once every two years.
	M	Reduced flood frequency from ~ 5 times per year to less frequent than once every two years.
Ecology	A	Willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
	H	Willow scrub may increase due to reduced flood extent.
	I & J	Slight increase in flooding around the edge of the compartment may lead to slight increase in wader numbers.
	L	Fen community M5 may succeed to other fen communities such as M9, the area of M27 may increase, and swamp community S11 may succeed to fen community M5. The marshy grassland communities M23 and M25 may succeed to dry grassland. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may decrease and willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
	M	Fen communities M27 and S27 may succeed to rush pasture M23 and woodland W3 respectively. The area of M27 may increase, and swamp community S11 may succeed to fen community M5. The marshy grassland communities M23 and M25 may succeed to dry grassland. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may decrease and willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
Morphology	Spey	Reduced channel-floodplain connectivity at unit A. No significant change in processes predicted. No change to MImAS capacity.
	Raitts	Continuing bed aggradation/ risk of embankment breach.
Flooding	Adjacent to marshes	Not modelled. May results in a similar direction of change as option 3 but of a smaller magnitude (i.e. small increase in flood levels at 0.5% AEP through study reaches upstream of Balavil, slight reduction in flood levels downstream of Balavil).
	Kincraig	Not modelled. May results in a similar direction of change as option 3 but of a smaller magnitude (i.e small decrease in flood levels and peak flow at Kincraig at 0.5% AEP).
Infrastructure	A9	Reduced floodplain velocities in unit A.
	Railway at Raitts Burn	Continued or increasing flood risk from bed aggradation of Raitts Burn. Continued requirement for regular maintenance.
Access		Access maintained in unit A (Ruthven North), L and M (Lynchat) and N (Balavil).
Maintenance		Increased maintenance requirements in unit A, L, M and N, including on-going maintenance of Raitts Burn embankments (likely to involve erosion protection works). Vegetation succession in some areas will require an increased level of maintenance (e.g. willow scrub clearance).

4.5 Option 3: Full repair of embankments

Description: Reinstatement of embankments through repairing all existing breaches including along the tributaries (Ruthven, Tromie, Raitts) and internal embankments.

This option demonstrates the extent to which the existing breaches are having a natural flood management benefit.

- Modelled scenario. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- The scenario assumes breaches will be infilled rather than the full reinstatement of the embankments to a specified design flood level. The scenario is therefore modelled by raising the spill level at the breach to the same level as the adjacent embankment.
- All breaches in the embankments are assumed to be repaired including in lateral embankments (for example between unit J and Loch Insh, and between unit H and unit I) and at the drainage connection in unit I, effectively disconnecting this drainage pathway.
- The remnants of the embankment on the left bank of the River Spey downstream of Balavil are outside of RSPB ownership and it appears that maintenance of this embankment was abandoned earlier than the other embankments in the study area. Option 3 does not therefore include the repair of these remnant embankments.
- The scenario includes reinstatement of the flap valve on the culvert on the Main Drain between unit H and unit I. No other structures are reinstated in this scenario.
- The location of Option 3 is shown in Figure 4-3. The factsheet in Table 4-3 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

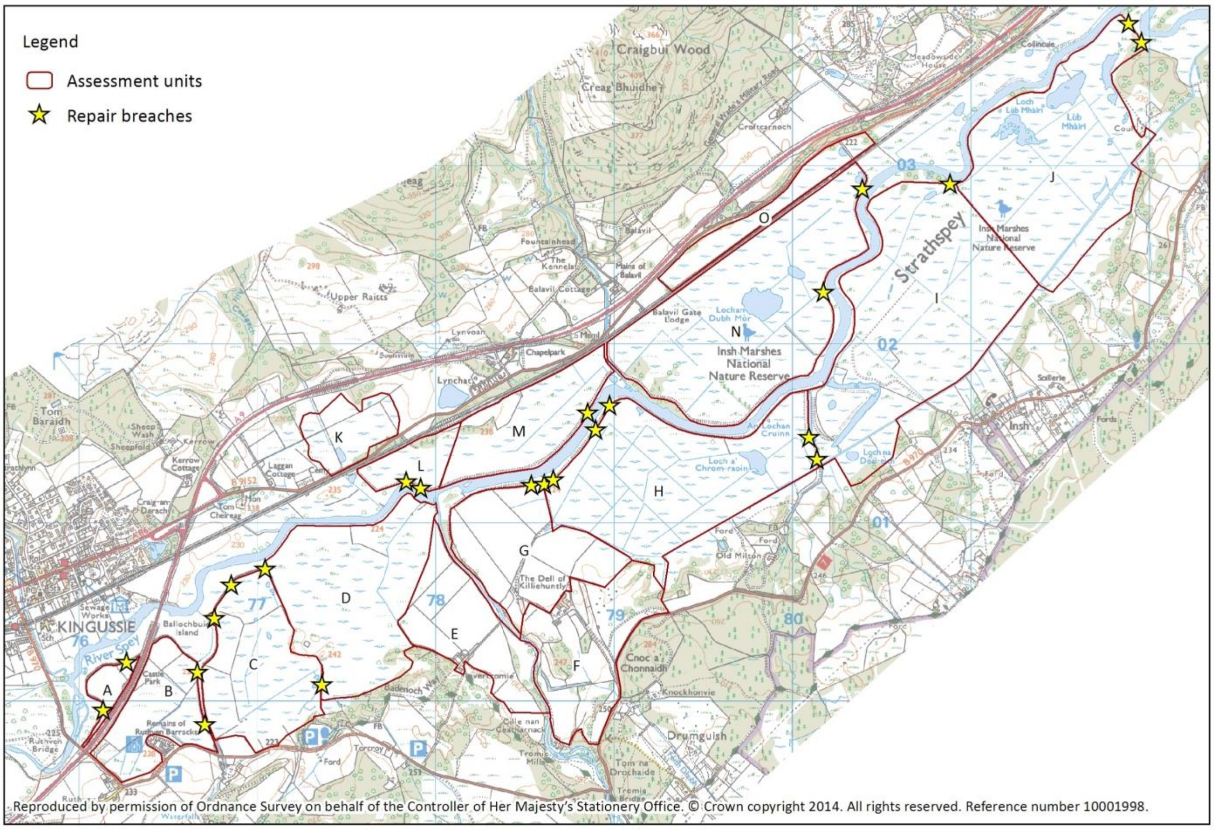


Figure 4-3: Option 3

Table 4-3: Option 3 Assessment Summary

Factor	Location	Description
Hydrology	A	Reduced flood frequency from ~ 3 times per year to less frequent than once every two years
	B	Reduced flood frequency from ~ 3 times per year to once every two years
	C	Reduced flood frequency from ~ 3 times per year to once every two years When does flood, longer duration
	D	Increased depth of flooding
	G	Reduced flood frequency from ~ 5 times per year to once every two years
	H	Reduced flood frequency from ~ 5 times per year to less frequent than once every two years
	I	Reduced depth of flooding
	J	Reduced depth of flooding
	K	Increased depth of flooding
	L	Reduced flood frequency from ~ 3 times per year to less frequent than once every two years
	M	Reduced flood frequency from ~ 5 times per year to less frequent than once every two years
	N	Reduced flood frequency from ~ 5 times per year to once every two years.
Ecology	A	Willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
	B	Rush pasture may succeed to dry grassland. Fen communities S9 and S27 and swamp community S11 may succeed to other fen communities M5 and M9. Willow scrub may increase. Slight decrease in wader species (Snipe, Redshank). Passerines may increase slightly.
	C	Fen communities S9, S10 and S27 and swamp community S11 may succeed to other fen communities M5 and M9. The spring, flush and seepage community M6 may succeed to a marshy grassland community, M23 or M25, and these, where they are already present, may succeed to dry grassland. S4 (*Phragmites australis* swamp and reedbed) may succeed to a different, drier, sub-community of S4, or to a fen community, and the proportion and extent of *Phragmites australis* may decrease. *Cicuta virosa* and *Carex aquatilis* may decrease. There may also be effects on *Carex chordorrhiza.* Reduced frequency of flooding may lead to slight increase in Lapwing and slight decrease in Snipe, although longer periods of inundation may result in no discernible change.
	D, G	Potential benefit to alder woodland at the Tromie confluence if channel dynamics and deposition increase at this location.
	H	Willow scrub may increase.
	L	Fen community M5 may succeed to other fen communities such as M9, the area of M27 may increase, and swamp community S11 may succeed to fen community M5. The marshy grassland communities M23 and M25 may succeed to dry grassland. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may decrease and willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).

Factor	Location	Description
	M	Fen communities M27 and S27 may succeed to rush pasture M23 and woodland W3 respectively. The area of M27 may increase, and swamp community S11 may succeed to fen community M5. The marshy grassland communities M23 and M25 may succeed to dry grassland. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may decrease and willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
	N	Fen communities S9 and S27 and swamp communities S10, S11, S22 and S28 may succeed to other fen communities M5 (which may increase in extent) and M9. The marshy grassland communities M23 and M25 may succeed to dry grassland. S4 (*Phragmites australis* swamp and reedbed) may succeed to a different, drier, sub-community of S4, or to a fen community, and the proportion and extent of *Phragmites australis* may decrease. *Cicuta virosa* and *Carex aquatilis* may decrease. There may also be effects on *Carex chordorrhiza*. Reduced frequency of flooding may lead to long-term increase in Lapwing, Redshank and Curlew.
Morphology	Spey	Reduced channel-floodplain connectivity. No significant change to existing morphological processes predicted. Increase in MImAS capacity used by 0.3%
	Ruthven	Reduced channel-floodplain connectivity. No significant change to existing morphological processes predicted.
	Tromie	No significant change to existing morphological processes predicted but option reduces the potential for natural recovery. At confluence decrease in energy predicted - higher maximum flood levels in Spey and therefore increased backwater influence at confluence. Increased deposition in Tromie at confluence could initiate localised channel change. No change in MImAS capacity
	Raitts	Significant reduction in energy in the 140m length of channel upstream of the confluence - higher maximum flood levels in Spey and therefore increased backwater influence. Increased deposition and increased bed aggradation likely. On-going risk of breach of Raitts Burn embankments. No change in MImAS capacity
Flooding	Adjacent to marshes	Increase in flood levels through study reaches at QMED – increased flood risk to adjacent land. At 0.5% AEP potential increased flood risk to receptors upstream of Balavil (flood levels increase 0.1 – 0.2m), slight reduction in flood risk to receptors downstream of Balavil (<0.1m).
	Kincraig	Slight decrease in 0.5% AEP flood levels at Kincraig (<0.1m) and slight reduction in peak flow.
Infrastructure	A9	Reduced floodplain flow velocities in unit A.
Access		Access maintained and improved.
Maintenance		Increased maintenance requirements for embankments – increase over time with predicted climate change. Level of maintenance required for vegetation management may increase (willow scrub clearance).

4.6 Option 4a: Full removal of all embankments

Description: Removal of all embankments within the study area, including along the River Spey, River Tromie, Ruthven Burn, Raitts Burn and internal embankments that cross the floodplain (Figure 4-4). The bed of the Ruthven and Raitts Burn is perched above the level of the adjacent floodplain and water would not be retained in the channel if the embankments were removed. This option therefore includes works within the Ruthven and Raitts Burn channels to lower and re-grade the bed to define a new channel that is connected to the floodplain. These works could occur either along the existing alignment or by creation of a new channel.

- Modelled scenario. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- Within the model the embankments have been lowered to a similar level as the ground behind the embankment, simulating a natural levee (as evident in units where embankments are absent). Bank levels are therefore generally still slightly higher than floodplain levels.
- Reinstatement of deep scour holes at breaches to a similar level as a natural bank is possible but is likely to be costly and require more significant engineering works. It has therefore not been included in this modelled scenario and breaches are unchanged from the baseline scenario.
- The channel works in the Ruthven and Raitts Burns are represented in the model by lowering the bed levels of the existing cross-sections below the level of the adjacent floodplain whilst maintaining the same gradient and alignment. At some locations the cross-section shape has been widened to represent a more natural width-depth ratio (using regime equations) and to accommodate the QMED flow under free-flowing conditions. Detailed design of any channel works would be required before this option could be progressed to construction.
- The location of Option 4a is shown in Figure 4-4. The factsheet in Table 4-4 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

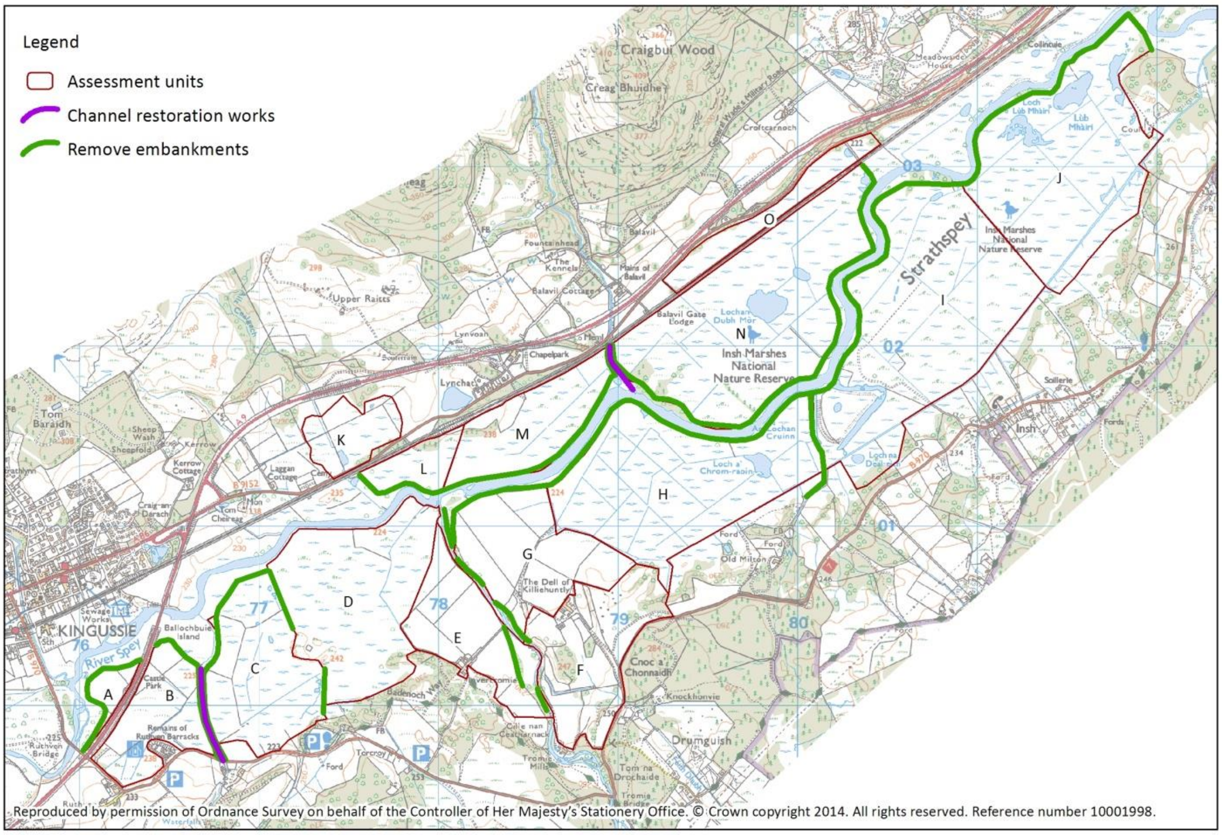


Figure 4-4: Option 4a

Table 4-4: Option 4a Assessment Summary

Factor	Location	Description
Hydrology	A	Reduced depth and duration of flooding
	B	Increased flood frequency from ~ 3 times per year to ~ 5 times per year Increased depth and extent, reduced duration of flooding.
	C	Increased depth and extent of flooding
	D	Increased depth and extent of flooding
	E	Increased flood extent - increased overland flow from Tromie to unit D
	G	Increased flood extent - increased overland flow from Tromie
	H	Increase in flood depth, slight increase in extent
	I	Increase in flood depth, slight increase in extent
	J	Increase in flood depth, slight increase in extent
	K	Reduced depth and extent of flooding
	L	Increased depth of flooding
	M	Reduced depth of flooding
	N	Small reduction in flood depth at frequent events but increase in extent, increase in flood depth and extent at QMED
Ecology	A	Willow scrub may increase. Slight increase in passerines (Skylark on drier ground, and Sedge Warbler and Reed Bunting should willow scrub increase).
	B	Dry grassland may succeed to rush pasture, which may increase in extent and/or succeed to fen, marsh and swamp communities. Swamp communities may increase in extent. *Cicuta virosa* and *Carex aquatilis* may increase. Willow scrub may decrease. Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Increase in flood frequency may benefit wader species.
	C	The spring, flush and seepage community M6, and the marshy grassland communities M25 and M23, may succeed to fen or swamp communities. *Cicuta virosa* and *Carex aquatilis* may increase. There may also be effects on *Carex chordorrhiza*. Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Increase in flooding may lead to slight increase in Snipe and duck numbers.
	D	The marshy grassland community M25 may succeed to fen community M6 or to M23, which may both increase in area. There may be effects on *Carex chordorrhiza.* Willow scrub may decrease. Potential benefit to alder woodland at the Tromie confluence if channel dynamics and deposition increase at this location. Increase in flooding may lead to slight increase in Snipe and duck numbers.
	E	Slight increase in flooding may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew.
	G	Potential benefit to alder woodland at the Tromie confluence if channel dynamics and deposition increase at this location. Slight increase in flooding may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew.
	H	Increase in flooding may lead to slight increase in wader and duck numbers.

Factor	Location	Description
	I	Slight increase in flooding around the edge of the compartment may lead to slight increase in wader numbers.
	J	Slight increase in flooding around the edge of the compartment may lead to slight increase in wader numbers.
	L	*Phragmites australis, Cicuta virosa* and *Carex aquatilis* may increase and willow scrub may decrease. Increase in flooding may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	M	Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. This may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	N	Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Potential for long-term increase in Lapwing, Redshank and Curlew over a wider area.
	Water bodies	Potential benefit for fish species and freshwater pearl mussel from improved morphological forms and processes. Potential benefit to existing floodplain lochans from increased connectivity with adjacent watercourses and floodplain conveyance.
Morphology	Spey	Increased channel-floodplain connectivity. Small reduction in channel energy between Tromie confluence and Loch Insh due to reduction in peak flow in channel. No significant change in processes or forms predicted - already a very low energy reach. Small increase in channel energy in reach 1 due to increased water surface gradient. 8.5% MImAS capacity release (embankment removal).
	Ruthven	Channel-floodplain connectivity restored, bed no longer perched. Reduced channel energy at upstream extent (increased backwater influence of Spey due to lowered bed levels) - potential deposition in upper part of reach and subsequent lateral movement.
	Tromie	Increased channel-floodplain connectivity, reduction in energy and potential for increased deposition and subsequent lateral movement. Potential for natural recovery of channel processes and forms in the longer term (timescales uncertain). At confluence, increased energy predicted due to reduced backwater influence of Spey and potential for localised change. 6.9% MImAS capacity release (embankment removal, further release may be possible through mitigation of realignment pressure).
	Raitts	Channel-floodplain connectivity restored, bed no longer perched. Small reduction in energy predicted, with larger reduction near confluence due to increased backwater influence of Spey due to lower bed levels. Channel has moderate energy and expected to be dynamic with lateral adjustment over time. Potential formation of shallow-grade alluvial fan. 8.7% MImAS capacity release (assumes that high impact realignment mitigated to low impact realignment and embankment removal).
Flooding	Adjacent to marshes	Reduced flood levels through study reaches at QMED – reduced flood risk to adjacent land. At 0.5% AEP potential reduced flood risk to local receptors from reduction in flood levels by 0.1 – 0.5m.

Factor	Location	Description
	Kincraig	Minor increase in 0.5% AEP flood level at Kincraig (<0.1m) and potential increase flood risk to local receptors. Small increase in peak flow.
Infrastructure	A9	Increased velocity of floodplain flow in unit A.
	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve).
Access		Access prevented/ reduced unless mitigation employed.
Maintenance		Reduced maintenance of embankments. Reduced requirement for willow scrub clearance, however access for grazers may be reduced.

4.7 Option 4b: Removal at Lynchat

Description: Options 4b and 4c assess the effects of removing selected embankments, representing a phased approach to embankment removal.

Option 4b represents the scenario where works focus on Lynchat (unit L and M), whereby embankments encompassing the west (internal), east (Raitts Burn right embankment) and south (left bank of River Spey) of the compartment are removed. The option incorporates channel works to the Raitts Burn as per option 4a. The compartment is bounded to the north by the railway. The Lynchat compartments could be used as a pilot scheme as RSPB have full ownership over the floodplain here, and it presents an opportunity to monitor the implications for an area of good habitat (unit M) and an area where more intensive management is currently required (unit L).

- Modelled scenario. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- Within the model the embankments have been lowered to a similar level as the ground behind the embankment, simulating a natural levee (as evident in units where embankments are absent). Bank levels are therefore generally still slightly higher than floodplain levels.
- Reinstatement of deep scour holes at breaches to a similar level as a natural bank is possible but is likely to be costly and require more significant engineering works. It has therefore not been included in this modelled scenario and breaches are unchanged from the baseline scenario.
- The channel works in the Raitts Burn are represented in the model by lowering the bed levels of the existing cross-sections below the level of the adjacent floodplain whilst maintaining the same gradient and alignment. At some locations the cross-section shape has been widened to represent a more natural width-depth ratio (using regime equations) and to accommodate the QMED flow under free-flowing conditions. Detailed design of any channel works would be required before this option could be progressed to construction.
- The location of Option 4b is shown in Figure 4-5. The factsheet in Table 4-5 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

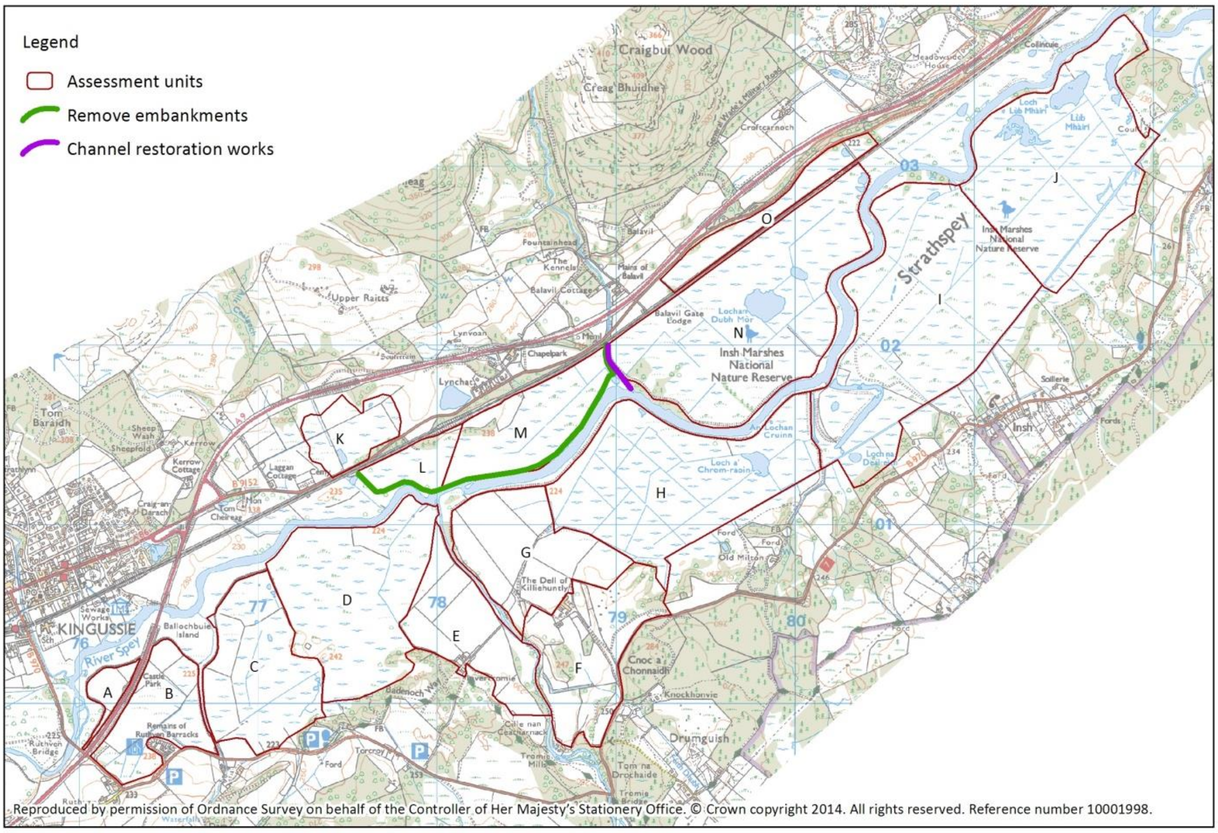


Figure 4-5: Option 4b

Table 4-5: Option 4b Assessment Summary

Factor	Location	Description
Hydrology	D	Reduced depth of flooding, slight reduction in flood extent
	K	Reduced depth and extent of flooding
	L	Increased depth of flooding - greater than full removal (due to no changes to embankments in other units). Slight increase in flood extent.
	M	Increased depth and extent of flooding.
Ecology	L	Fen communities M5 and M27 may succeed to swamp communities S9 and S27 or other fen and swamp communities. Marshy grassland community M25 may succeed to fen community M6 or to M23, which may increase in area. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may increase and willow scrub may decrease. Increase in flooding may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	M	Marshy grassland community M25 may succeed to fen community M6 or to M23, which may increase in area. Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Increase in flooding may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	Water bodies	Potential benefit for fish species and freshwater pearl mussel from improved morphological forms and processes. Potential benefit to existing floodplain lochans from increased connectivity with adjacent watercourses and floodplain conveyance.
Morphology	Spey	Increased channel-floodplain connectivity at unit L&M (Lynchat). Localised changes in energy predicted adjacent to Lynchat compartment - could affect localised erosion and deposition patterns. 1.2% MImAS capacity release (embankment removal)
	Tromie	Small increase in energy at confluence due to reduced backwater influence of Spey - potential for localised change. No change in MImAS capacity.
	Raitts	Channel-floodplain connectivity restored, bed no longer perched. Small reduction in energy predicted with larger reduction near confluence. Channel has moderate energy and expected to be dynamic with lateral adjustment over time (erosion risk to left embankment unless mitigated). Potential formation of shallow-grade alluvial fan. 6.4% MImAS capacity release (assumes that high impact realignment mitigated to low impact realignment and removal of right embankment).
Flooding	Adjacent to marshes	Reduced flood levels through study reaches at QMED – reduced flood risk to adjacent land. At 0.5% AEP potential reduced flood risk to local receptors from slight reduction in flood levels by 0.1 – 0.2m.
	Kincraig	Minor increase in 0.5% AEP flood level at Kincraig (<0.1m) and potential increase flood risk to local receptors. Negligible increase in peak flow.
Infrastructure	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve).
Access		Access prevented/ reduced along Lynchat bank unless mitigation employed. Access could be improved to Balavil if left embankment along Raitts Burn retained and erosion protection employed.
Maintenance		Reduced maintenance of embankments. Reduced requirement for willow scrub clearance, however access for grazers may be reduced.

4.8 Option 4c: Removal at Lynchat, Dell, Insh and Coull

Description: Option 4c represents a phased scenario whereby all measures in option 4b are incorporated plus removal of the embankment along the right bank of the River Spey in units G, H, I and J (Dell of Killiehuntly Wetland, Insh Fen and Coull Fen) and the internal embankments between units H and I and between unit J and Loch Insh.

- Modelled scenario. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- Within the model the embankments have been lowered to a similar level as the ground behind the embankment, simulating a natural levee (as evident in units where embankments are absent). Bank levels are therefore generally still slightly higher than floodplain levels.
- Reinstatement of deep scour holes at breaches to a similar level as a natural bank is possible but is likely to be costly and require more significant engineering works. It has therefore not been included in this modelled scenario and breaches are unchanged from the baseline scenario.
- The channel works in the Raitts Burn are represented in the model by lowering the bed levels of the existing cross-sections below the level of the adjacent floodplain whilst maintaining the same gradient and alignment to aid model stability and the interpretation of the results. At some locations the cross-section shape has been widened to represent a more natural width-depth ratio (using regime equations) and to accommodate the QMED flow under free-flowing conditions. Detailed design of any channel works would be required before this option could be progressed to construction.
- The location of Option 4c is shown in Figure 4-6. The factsheet in Table 4-6 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

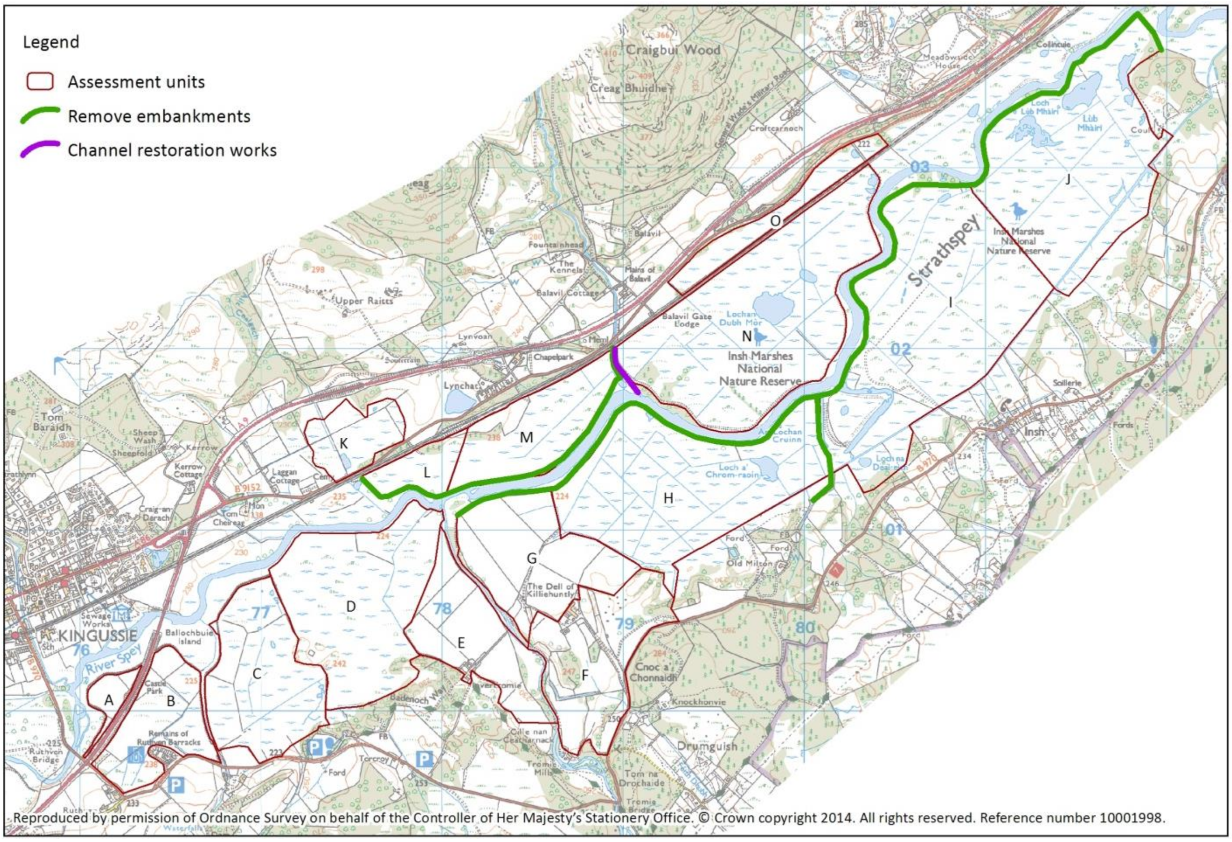


Figure 4-6: Option 4c

Table 4-6: Option 4c Assessment Summary

Factor	Location	Description
Hydrology	D	Reduced depth of flooding, slight reduction in flood extent
	G	Increased flood extent
	H	Increase in flood depth - to a greater extent than full removal (due to no changes in embankments in upper part of site). Slight increase in extent.
	I	Increase in flood depth - to a greater extent than full removal. Slight increase in extent.
	J	Increase in flood depth - to a greater extent than full removal. Slight increase in extent.
	K	Reduced depth and extent of flooding
	L	Increased depth of flooding - greater than full removal. Slight increase in flood extent.
	M	Slight reduction in flood depth and extent
	N	Reduced frequency of flooding from ~ 5 times per year to ~ 3 times per year. Reduced depth and extent of flooding
Ecology	G	Slight increase in flooding may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew.
	H	Increase in flooding may lead to slight increase in wader and duck numbers.
	I	Slight increase in flooding around the edge of the compartment may lead to slight increase in wader numbers, and long-term decline in willow scrub may lead to slight decrease in passerines.
	J	Slight increase in flooding around the edge of the compartment may lead to slight increase in wader numbers, and long-term decline in willow scrub may lead to slight decrease in passerines.
	L	Fen communities M5 and M27 may succeed to swamp communities S9 and S27 or other fen and swamp communities. Marshy grassland community M25 may succeed to fen community M6 or to M23, which may increase in area. *Phragmites australis, Cicuta virosa* and *Carex aquatilis* may increase and willow scrub may decrease. Increase in flooding may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	M	Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. This may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	Water bodies	Potential benefit for fish species and freshwater pearl mussel from improved morphological forms and processes. Potential benefit to existing floodplain lochans from increased connectivity with adjacent watercourses and floodplain conveyance.
Morphology	Spey	Increased channel-floodplain connectivity where embankments removed. Very small changes in energy predicted adjacent to Lynchat compartment - could affect localised erosion patterns. Very small reduction in energy predicted adjacent to units H, I and J. No significant change in processes or forms expected as already a low energy reach. 5.5% MImAS capacity release (embankment removal).
	Tromie	Small increase in energy at confluence due to reduced backwater influence of Spey - potential for localised change. No change in MImAS capacity.

Factor	Location	Description
	Raitts	Channel-floodplain connectivity restored, bed no longer perched. Small reduction in energy predicted with larger reduction near confluence. Channel has moderate energy and expected to be dynamic with lateral adjustment over time (erosion risk to left embankment unless mitigated). Potential formation of shallow-grade alluvial fan. 6.4% MImAS capacity release (assumes that high impact realignment mitigated to low impact realignment and removal of right embankment).
Flooding	Adjacent to marshes	Reduced flood levels through study reaches at QMED – reduced flood risk to adjacent land. At 0.5% AEP potential reduced flood risk to local receptors from reduction in flood levels by 0.1 – 0.5m.
	Kincraig	Minor increase in 0.5% AEP flood level at Kincraig (<0.1m) and potential increase flood risk to local receptors. Negligible increase in peak flow.
Infrastructure	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve).
Access		Access prevented/ reduced along Lynchat bank unless mitigation employed. Access could be improved to Balavil if left embankment along Raitts Burn retained and erosion protection employed.
Maintenance		Reduced maintenance of embankments. Reduced requirement for willow scrub clearance, however access for grazers may be reduced.

4.9 Option 5: Increased breaching of embankments

Description: Extending the length of existing breaches or creating new breaches could provide increased connectivity with the floodplain at a lower cost and reduced construction impact compared to option 4. There are numerous variations of this option in terms of size, location and combination of breaches. For the purposes of the feasibility study, option 5 increases the size of the existing breaches in units H and I (Dell of Killiehuntly Wetland and Insh Fen) and includes an additional breach in unit J (Coull Fen).

- Modelled scenario, where the existing breaches were extended to a minimum 50m length. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- The location of the increased / additional breaches are purely indicative to assess how this scenario compares with Option 4c hydrologically. If increased breaching of embankments is selected in preference to removal of embankments then the location and size of the breaches would need to be determined for each individual unit in which the measure was implemented.
- The location of Option 5 is shown in Figure 4-7. The factsheet in Table 4-7 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

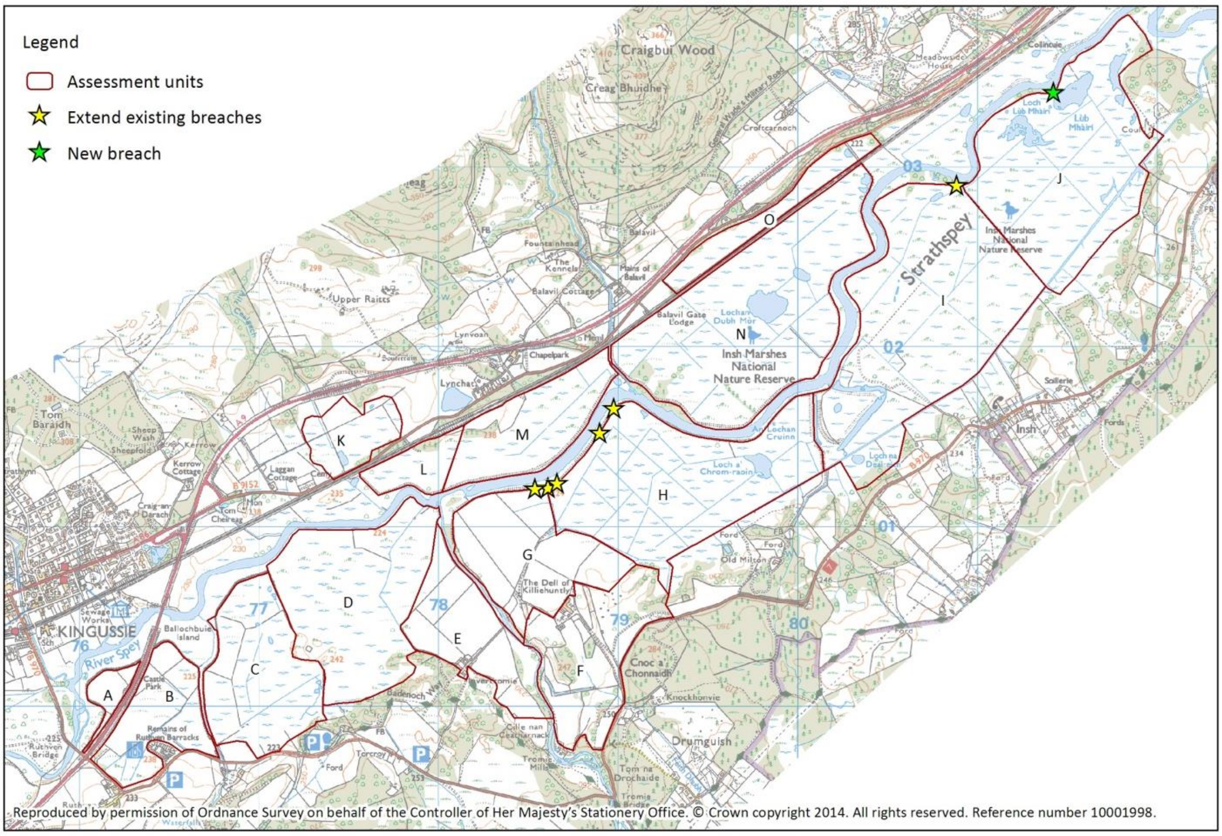


Figure 4-7: Option 5

Table 4-7: Option 5 Assessment Summary

Factor	Location	Description
Hydrology	G	Increased flood depth and extent
	H	Increase in flood depth and extent - to a greater extent than full removal
	I	Increase in flood depth - to a greater extent than full removal. Slight increase in flood extent.
	J	Increase in flood depth - to a greater extent than full removal. Slight increase in flood extent.
	L	Reduced flood depth
	M	Reduced flood depth
	N	Reduced frequency of flooding from ~ 5 times per year to ~ 3 times per year. Reduced depth and extent of flooding
Ecology	D, G	Potential benefit to alder woodland at the Tromie confluence if channel dynamics and deposition increase at this location. Slight increase in flooding may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew.
	Water bodies	Potential benefit to existing floodplain lochans from increased connectivity with adjacent watercourses and floodplain conveyance.
Morphology	Spey	Localised increase in channel energy near Tromie confluence due to increased water surface gradient. Potential for localised change. Very small reduction in energy predicted adjacent to units H, I and J. No significant change in processes or forms expected as already a low energy reach. 0.3% MImAS capacity release
	Tromie	Increase in energy at confluence due to reduced backwater influence of Spey. Potential for localised change. No change in MImAS capacity
	Raitts	Increase in energy at confluence due to reduced backwater influence of Spey - potential for increased transport of sediment to Spey confluence. On-going bed aggradation and risk of embankment breach. No change in MImAS capacity.
Flooding	Adjacent to marshes	Reduced flood levels through study reaches at QMED – reduced flood risk to adjacent land. At 0.5% AEP potential reduced flood risk to local receptors from slight reduction in flood levels by <0.1m.
	Kincraig	Minor increase in 0.5% AEP flood level at Kincraig (<0.1m) and potential increase flood risk to local receptors. No change in peak flow.
Access		Reduced access depending upon breach locations.
Maintenance		Similar level of maintenance as for the existing conditions.

4.10 Option 6: Remove bank protection

Description: This option consists of removing the bank protection at the confluence between the River Tromie and River Spey, and removing the low-level revetments on the River Spey. These low-level revetments are below the average water level and could not be observed during the field surveys. Their extent is therefore uncertain, however they are known to be present adjacent to Insh Fen. Removal of the bank protection at the A9 embankment is not included in this option.

- Qualitative assessment of potential implications on morphology and channel dynamics.
- Assessment assumes that low-level revetments could be present along both banks of the River Spey in the lower part of reach 2, affecting units I, J and N.
- The location of Option 6 is shown in Figure 4-8. The factsheet in Table 4-8 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

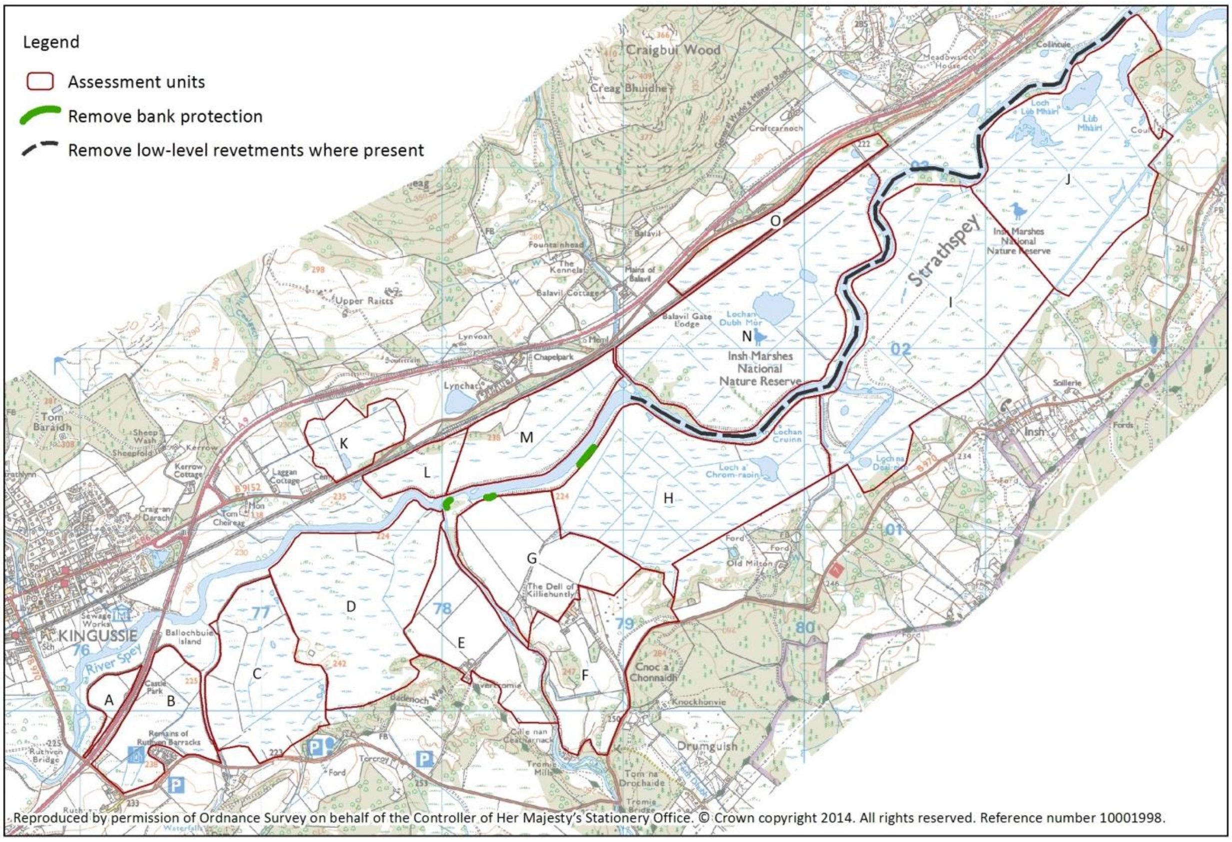


Figure 4-8: Option 6

Table 4-8: Option 6 Assessment Summary

Factor	Location	Description
Ecology	D, G	Increased channel dynamics at the confluence between the River Tromie and River Spey provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species (including alder woodland) and successional processes.
Morphology	Spey	Very low energy reach and the potential for increased channel dynamics and change within the options appraisal timescales is low. MImAS capacity not calculated - extent of revetments unknown.
	Tromie	Increased bank erosion and channel adjustment at the confluence. 0.7% MImAS capacity release.
Flooding	Adjacent to marshes	Not modelled. Change only expected if additional breaches develop – similar to option 5 whereby minor reduction in maximum flood levels could occur.
	Kincraig	Not modelled. Change only expected if additional breaches develop – similar to option 5 whereby negligible change in peak flow expected.
Access		Reduced access if embankments breach (does not affect embankments which RSPB has a right to maintain).

4.11 Option 7: In-channel restoration measures (tributaries)

Description: This option focuses on small-scale in-channel restoration measures for the three main tributaries within the study area (Ruthven Burn, River Tromie, Raitts Burn), which could assist recovery of natural morphological processes in these straightened watercourses. The measures could include placement of woody material or boulder flow deflectors.

- Qualitative assessment of potential implications on morphology and channel dynamics, and how changes in morphology could affect the adjacent hydrological units.
- The option assumes that this is a standalone option with no other changes to the channel or embankments, however it could be combined with option 4.
- The location of Option 7 is shown in Figure 4-9. The factsheet in Table 4-9 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

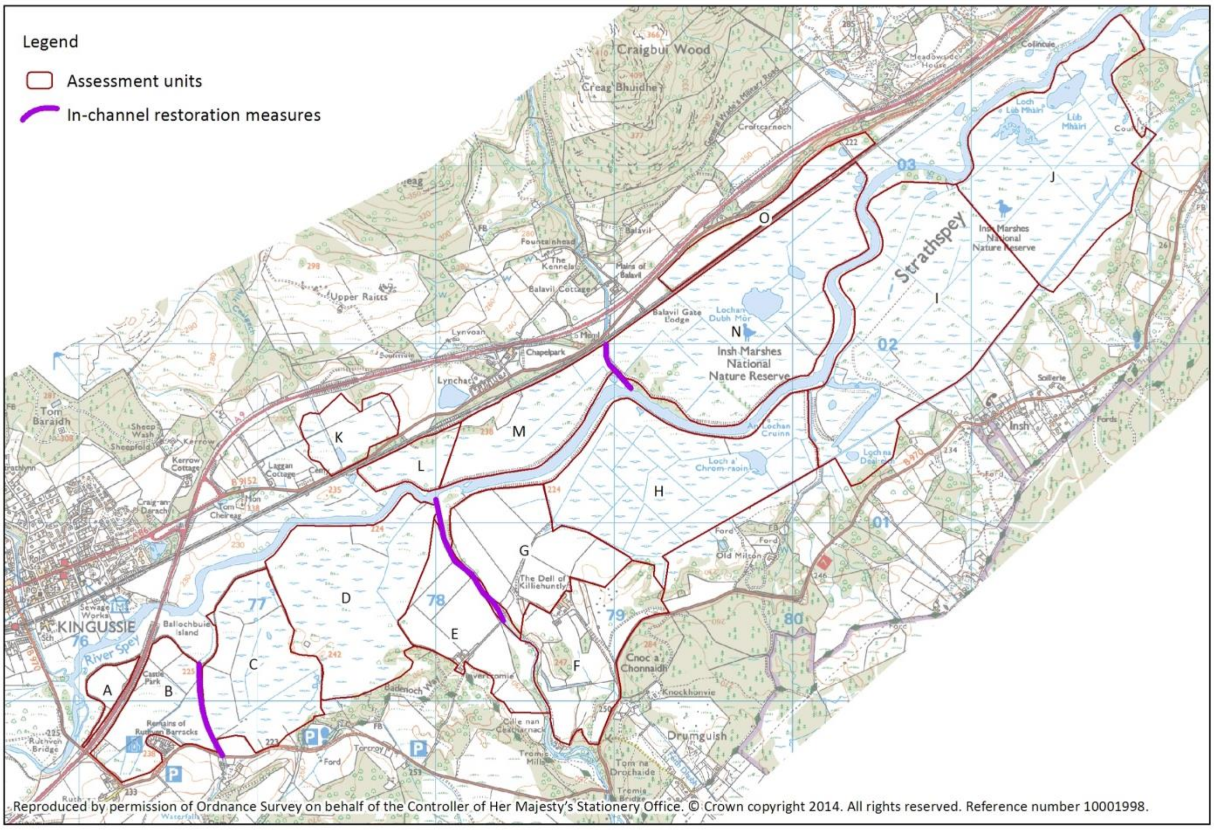


Figure 4-9: Option 7

Table 4-9: Option 7 Assessment Summary

Factor	Location	Description
Hydrology	B, C, D, E, G, H, M, N	Increased likelihood of new breaches in the tributary embankments forming – potential increase in flood frequency, depth and extent (to a lesser extent than full removal).
Ecology	B, C, D, E, G, H, M, N	Changes depend on if and where new breaches form. Uncontrolled breach of Raitts Burn likely – change in habitat in unit M or N due to sediment deposition. Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. Potential benefit to alder woodland at the Tromie confluence if channel dynamics and deposition increase at this location. There may be effects on *Carex chordorrhiza*. Potential increase in flooding frequency and flood levels in certain areas may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	Water bodies	Potential benefit for fish species and freshwater pearl mussel from improved morphological forms and processes.
Morphology	Ruthven	Localised channel change possible at upstream extent of study reach - increased risk of erosion and embankment breaches. In mid and lower sections of channel, backwater influence of Spey will limit the effectiveness of the in-channel measures.
	Tromie	Localised channel change possible and could kick-start natural recovery towards low impact realignment. Full recovery could be limited by altered flow and sediment regime by upstream dam. Increased risk of erosion and breach of embankments. 8.1% MImAS capacity release (assumes low impact realignment achieved however timescales are uncertain).
	Raitts	Likely to initiate uncontrolled breach - deposition of gravels/ cobbles as water enters floodplain (crevasse splay formation) and distributed floodplain flow. Increased (high) channel-floodplain connectivity. Dynamic channel and natural adjustment over time towards development of new single or multi-thread channel and new confluence with Spey. Potential for upstream bed incision. MImAS capacity release - dependent on channel evolution.
Flooding	Adjacent to marshes	Not modelled. Potential reduced flood risk to railway if Raitts Burn embankment breaches. Embankment breaches on tributaries unlikely to affect flood risk to the same extent as embankment breaches on Spey (e.g. option 5).
	Kincraig	Not modelled. No signficant change in peak flow expected.
Infrastructure	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve). Potential risk to infrastructure stability from upstream incision following uncontrolled breach.
Access		Raitts Burn uncontrolled breach – access could be prevented/ reduced at Lynchat (or Balavil if left bank of Raitts Burn breaches).
Maintenance		Similar level of maintenance as for the existing conditions.

4.12 Option 8: Channel realignment / re-meandering (tributaries)

Description: Option 8 assesses the scenario where channel restoration measures are undertaken without any works to the River Spey embankments. The aim of option 8 is to improve the morphological form and re-establish natural processes within the tributaries which have been historically straightened and degraded by the presence of the embankments (Ruthven Burn, River Tromie and Raitts Burn).

- Qualitative assessment of potential implications on morphology and channel dynamics, and how changes in morphology could affect the adjacent hydrological units.
- It is assumed that the restoration works would require the tributary embankments to be removed.
- Appropriate reference conditions would need to be established at the design stage, however these have been considered at a high level during the options appraisal.
- The location of Option 8 is shown in Figure 4-10. The factsheet in Table 4-10 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

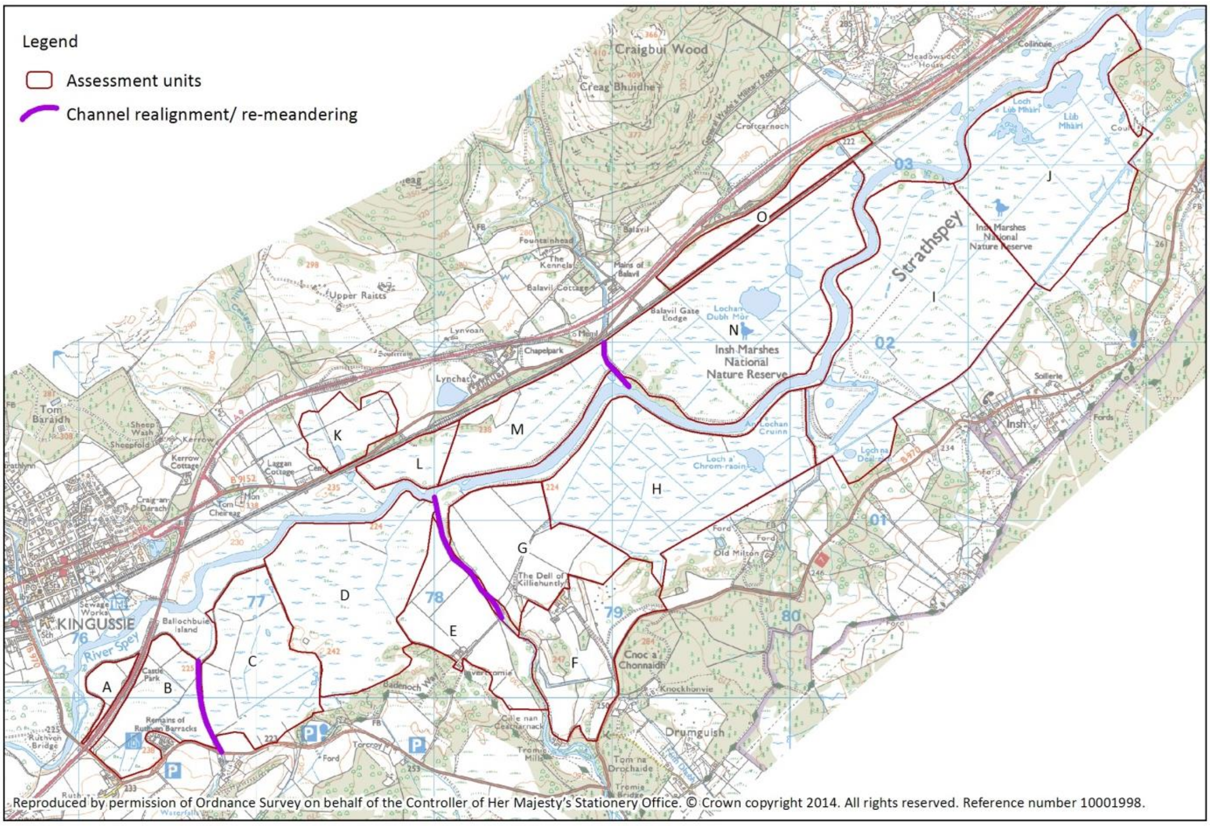


Figure 4-10: Option 8

Table 4-10: Option 8 Assessment Summary

Factor	Location	Description
Hydrology	B, C	Increase channel-floodplain connectivity and flood frequency from restoration works to Ruthven Burn.
	D, E, G, H	Increase channel-floodplain connectivity and flood frequency from restoration works to River Tromie (dependent on new alignment).
	M, N	Increase channel-floodplain connectivity and flood frequency from restoration works to Raitts Burn (dependent on new alignment).
Ecology	B, C	Small input of water to units compared to River Spey, therefore effect on habitat across whole unit may be limited. Localised change - increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. There may be effects on *Carex chordorrhiza*. Increase in flood frequency may benefit wader species.
	D, E, G, H	Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species (including alder woodland at the Tromie confluence) and successional processes. Increased flooding in unit E may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew. Increased flooding in units G and H may lead to slight increase in wader numbers (Snipe, Redshank, Lapwing) and Curlew in unit G, and slight increase in wader and duck numbers in unit H.
	M, N	Increased channel dynamics provides increased opportunity for formation of new floodplain water bodies/ frequently flooded zones, pioneer species and successional processes. There may be effects on *Carex chordorrhiza*. Increase in flooding in unit M may lead to slight increase in wader, duck (and possibly rail and crake) numbers.
	Water bodies	Potential benefit for fish species and freshwater pearl mussel from improved morphological forms and processes.
Morphology	Spey	Confluence location with Raitts Burn may change, resulting in localised channel adjustments at existing and new locations.
	Ruthven	Channel-floodplain reconnection restored. Bed no longer perched. Low-energy sinuous channel, natural processes of deposition, erosion and channel adjustment over time.
	Tromie	Channel-floodplain reconnection restored. Potential to improve morphological processes towards a more natural condition (processes of erosion/ deposition/ channel migration). Full recovery may be limited by modified flow and sediment regimes. 12.1% MImAS capacity release (embankment pressure removed, assumes low impact realignment achieved).
	Raitts	Channel-floodplain connectivity restored, bed no longer perched. Small reduction in energy predicted. Channel has moderate energy and expected to be dynamic with lateral adjustment over time (erosion risk to left embankment unless mitigated). Potential formation of shallow-grade alluvial fan. 8.7% MImAS capacity release (embankment pressure removed and assumes that high impact realignment fully mitigated).

Factor	Location	Description
Flooding	Adjacent to marshes	Not modelled. Embankment removal on tributaries unlikely to affect flood risk to the same extent as embankment removal on Spey (option 4). Potential change in flood risk for receptors local to the tributaries e.g. potential decrease in risk to railway at Raitts Burn, potential increase at Invertromie.
	Kincraig	Not modelled. No signficant change in peak flow expected.
Infrastructure	Railway at Raitts Burn	Flood and erosion risk to embankment may be reduced at moderate flood events by increased gradient/ bed lowering of Raitts Burn (extreme events flood risk controlled by floodplain levels in reserve).
Access		Access could be prevented/ reduced at Lynchat or Balavil by realignment of Raitts Burn unless mitigation incorporated.
Maintenance		May require reduced vegetation management. Access for grazers could be maintained by leaving existing embankments in place.

4.13 Option 9: Reinstatement of stream diversions

Description: Two diversions of hillslope tributaries were undertaken in the 1970's and have reduced the inflows to the Dell of Killiehuntly Wetland (unit H). Option 9 would reinstate these tributaries to their historic alignments.

- The two diversions are:
  - the Feith Dhubh, currently flows into the River Tromie and would be reinstated along the pre-1970's alignment to the north past Dell of Killiehuntly Farm; and
  - Allt Baile Mhuilinn at Old Milton which currently flows into the Main Drain in unit I (Insh Fen), and would be reinstated along the pre-1970's alignment to the north-west into the Main Drain in unit H (Dell of Killiehuntly Wetland).
- Qualitative assessment of potential implications on morphology and the changing inputs to the relevant hydrological units.
- The location of Option 9 is shown in Figure 4-11. The factsheet in Table 4-11 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

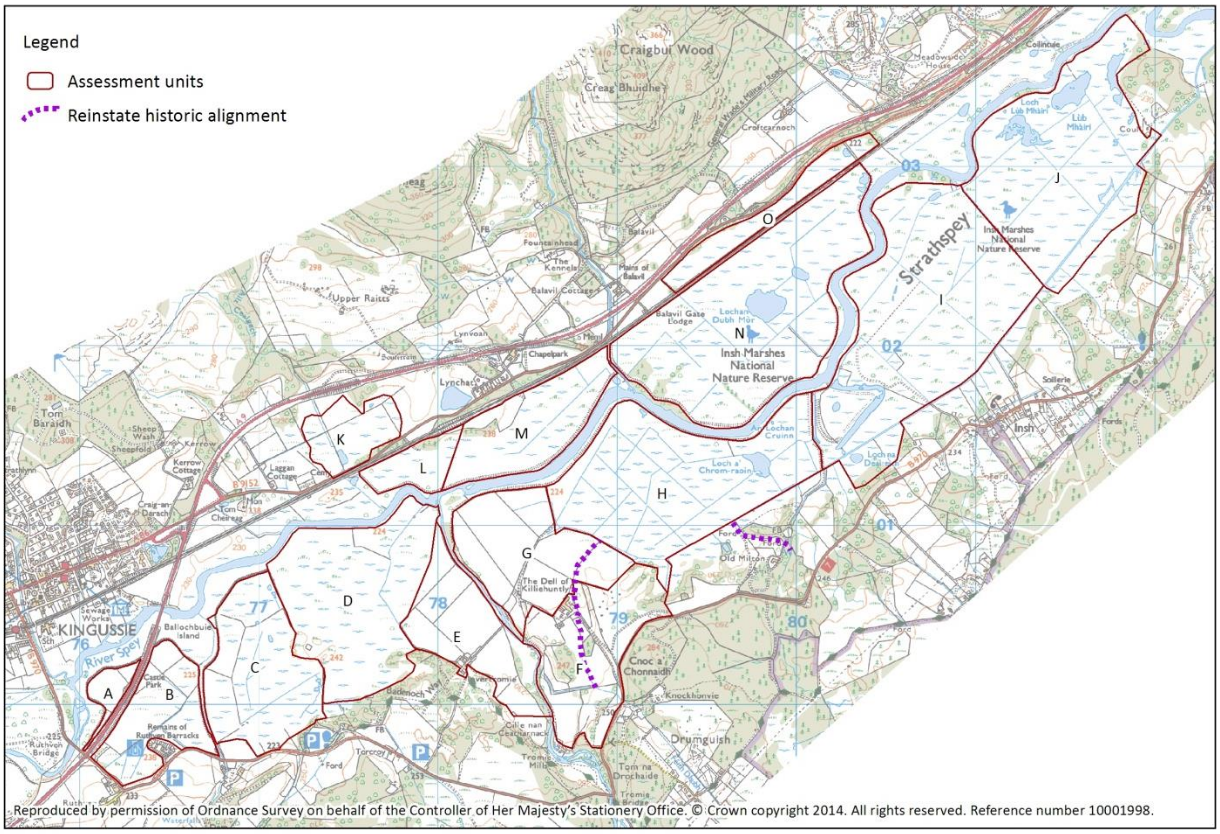


Figure 4-11: Option 9

Table 4-11: Option 9 Assessment Summary

Factor	Location	Description
Hydrology	H	Increased inflow from Feith Dhubh could increase the flood extent, depth and frequency in south-west part of unit (small catchment). Increased inflow from Allt Baile Mhuilinn into main drain – connectivity with unit I may limit influence of this change.
	I	Reduced inflow from Allt Baile Mhuilinn into main drain – connectivity with unit H may limit influence of this change.
Ecology	H	The extent of fen communities may increase due to the increased inflow from Feith Dhubh. Increase in flooding may lead to slight increase in wader and duck numbers.
	I	No change expected.
Morphology	Tromie	Small reduction in inflow, however this is not considered to be significant due to small catchment of Feith Dhubh and therefore little or no impact on morphological processes and forms.
	Feith Dhubh	Reinstatement of natural alignment. Potential to improve morphological processes and in-stream habitat in new alignment (currently straightened). Increased channel length by ~ 500m. No longer directly connected to the Tromie or Spey – not accessible for fish migration.
	Allt Baile Mhuilinn	Reinstatement of natural alignment. Potential to improve morphological processes and in-stream habitat in new alignment (currently straightened). Reduced channel length by ~120m.
Infrastructure	Distillery discharge	Mitigation may be required e.g. relocation of discharge point.
Flooding	Adjacent to marshes	Not modelled. No significant change expected. Formalised flow route for Feith Dhubh may improve flood risk for Dell of Killiehuntly Farm.
	Kincraig	Not modelled. No significant change in peak flow expected.
Maintenance		May require reduced vegetation management in unit H.

4.14 Option 10a: Block internal drainage ditches and reduce direct connectivity with the River Spey

Description: Option 10a includes measures to block the internal drainage ditches throughout the study area. The option also includes measures to reduce the direct connectivity between the drainage network and the River Spey by blocking the open connections at unit D (Invertromie Fen) and unit I (Insh Fen), and the direct connection between unit B and the Ruthven Burn. The aim of the option is to reduce the drainage of the floodplain and to raise water levels within the ditch system to reduce groundwater draw-down from the adjacent ground.

- It is assumed that ditches will be blocked in units B, D, H, I, J and N.
- The units not included have a drainage network which has been abandoned and is believed to no longer be functioning, based on information provided in the reserve management plan.
- There are no changes to the Main Drain in this option.
- The implications for adjacent habitats have been assessed qualitatively using the trajectory diagrams from the SNIFFER wetland regulatory guidance (Sniffer, 2014). The model results have informed the assessment of changes to the drainage of the units following a flood event (for units D and I).
- The location of Option 10a is shown in Figure 4-12. The factsheet in Table 4-12 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

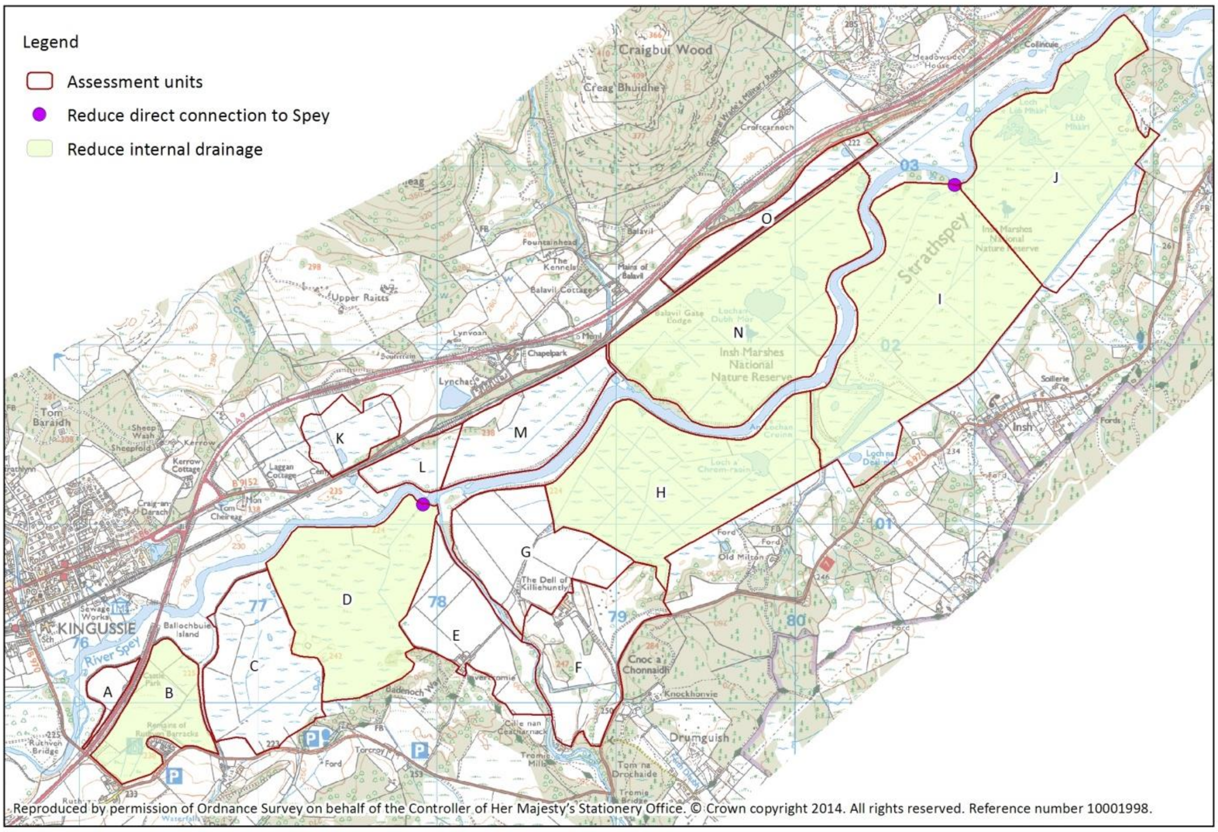


Figure 4-12: Option 10a

Table 4-12: Option 10a Assessment Summary

Factor	Location	Description
Hydrology	B	Increase duration of flooding. Potential to maintain higher groundwater levels adjacent to ditches during drier months.
	C	Reduced inflow from unit D during QMED event. Increased duration of inundation - main drainage mechanism is into unit D and to Spey via open drain.
	D	Reduced frequency of flooding from ~ 5 times per year to ~ 3 times per year. Reduced depth of flooding at 3-POT event due to reduced inflow. Increase in duration of inundation - natural levees along banks of Spey limit the drainage of floodwater back to the channel.
	H	Potential to maintain higher groundwater levels adjacent to ditches during drier months.
	I	Reduced depth of flooding due to reduced inflow of water. Potential to maintain higher groundwater levels adjacent to ditches and restrict outflow to Spey during drier months.
	J	Potential to maintain higher groundwater levels adjacent to ditches during drier months.
	N	Potential to maintain higher groundwater levels adjacent to ditches during drier months.
Ecology	B	Rush pasture, fen, marsh and swamp communities may increase in extent. *Cicuta virosa* and *Carex aquatilis* may increase. Willow scrub may decrease. Potential benefit for wader species.
	C	The extent of spring, flush and seepage community, and the marshy grassland communities may reduce, and fen and swamp communities increase. *Cicuta virosa* and *Carex aquatilis* may increase. There may be effects on *Carex chordorrhiza*. May lead to slight increase in Snipe and duck numbers
	D	The extent of marshy grassland communities may reduce and extent of fen communities increase. There may be effects on *Carex chordorrhiza*. May lead to slight increase in Snipe and duck numbers
	H	The extent of fen and swamp communities may increase. Willow scrub may decrease. *Cicuta virosa* and *Carex aquatilis* may increase. May lead to slight increase in wader (and potentially duck) numbers
	I	The extent of fen and swamp communities may increase. Willow scrub may decrease. *Cicuta virosa* and *Carex aquatilis* may increase. There may be effects on *Ribes spicatum*. May lead to slight increase in wader (and potentially duck) numbers
	J	The extent of fen and swamp communities may increase. Willow scrub may decrease. *Cicuta virosa* and *Carex aquatilis* may increase. There may be effects on *Ribes spicatum* and *Carex chordorrhiza*. May lead to slight increase in wader numbers
	N	The extent of fen and swamp communities may increase. Willow scrub may decrease. *Cicuta virosa* and *Carex aquatilis* may increase. There may be effects on *Ribes spicatum* and *Carex chordorrhiza*.

Factor	Location	Description
	Water bodies	Potential benefit to existing floodplain lochans from increased retention of water on the floodplain and reduced drainage during drier conditions.
Flooding	Adjacent to marshes	Not modelled. No significant change expected – influence of ditches and open connections with Spey at start and end of hydrograph only.
	Kincraig	
Infrastructure	Insh WWTW discharge	Dilution for WWTW discharge may be reduced.
Maintenance		Potential reduced requirement for willow scrub clearance, however access for grazers may be reduced.

4.15 Option 10b: Reduce connectivity between the Main Drain and Loch Insh

Description: Option 10b focuses on blocking the Main Drain to reduce the connectivity to Loch Insh, and the rate that the floodplain drains to the loch.

- Option 10b has been modelled as the connectivity between the Main Drain and Loch Insh is a key flood mechanism. Model outputs are provided in Appendix C and morphological calculations in Appendix D.
- The Main Drain is blocked towards the downstream extent of RSPB's ownership, near Coull. The drain is assumed to be blocked to the same height as the adjacent ground level. The option assumes no changes are made to the Coull culvert, which is outside of RSPB's ownership.
- The location of Option 10b is shown in Figure 4-13. The factsheet in Table 4-13 only includes features and units which are predicted to change as a result of the option, i.e. any features or hydrological units where 'no change' is predicted are not included in the factsheet.

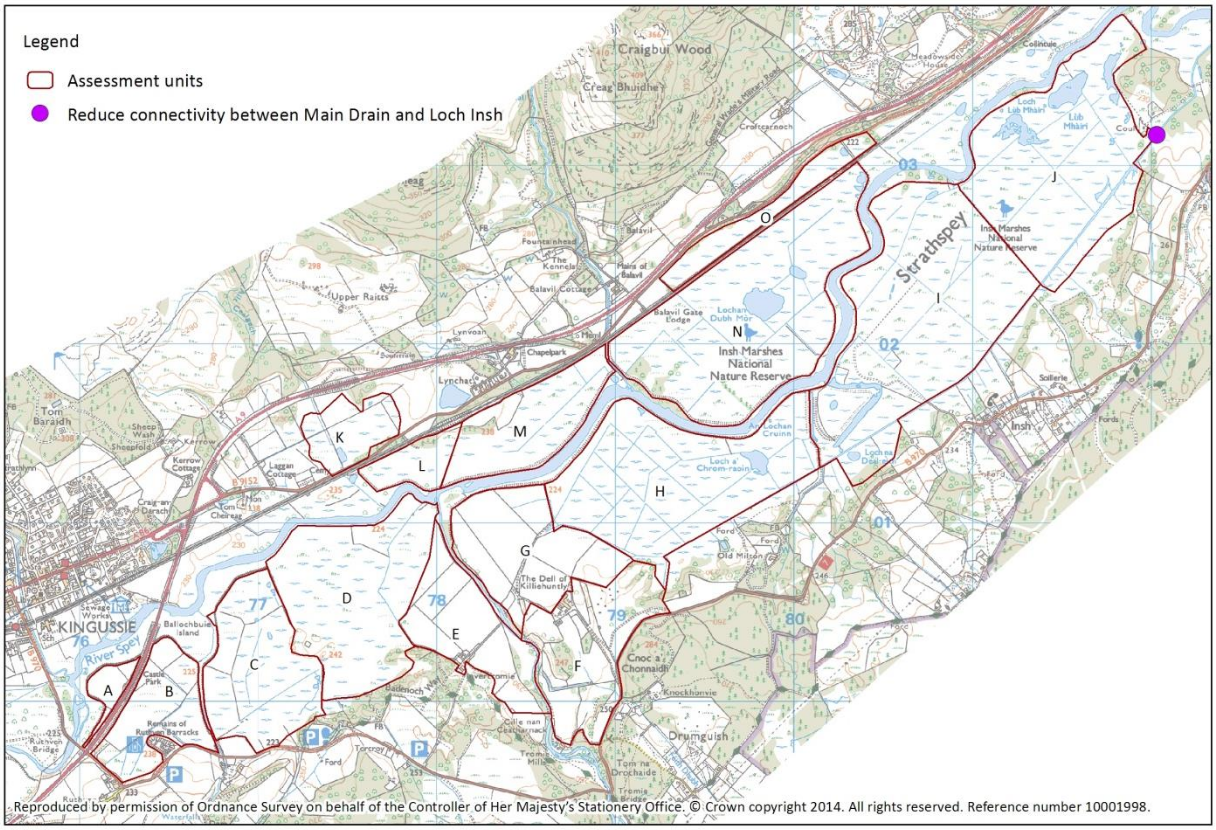


Figure 4-13: Option 10b

Table 4-13: Option 10b Assessment Summary

Factor	Location	Description
Hydrology	H	No significant change at flood events. Drainage of unit outside of flood events likely to reduce, potential to maintain higher groundwater levels.
	I, J	Slight reduction in flood depth at frequent events. No significant change in flood depth at QMED - when loch levels are high, connectivity between marshes and loch will remain. Potential to maintain higher groundwater levels.
Ecology	H, I, J	The extent of fen and swamp communities may increase. Willow scrub may decrease. *Cicuta virosa* and *Carex aquatilis* may increase. There may be effects on *Ribes spicatum* and *Carex chordorrhiza*. May lead to slight increase in wader and duck numbers.
Flooding	Adjacent to marshes	No significant change in flood risk.
	Kincraig	No significant change in flood risk.
Infrastructure	Insh WWTW discharge	Mitigation required to for discharge if Main Drain no longer outfalls to Loch Insh.
Maintenance		Potential reduced requirement for willow scrub clearance, however access for grazers may be reduced.

5 OPTION APPRAISAL

5.1 Multi-criteria Analysis

A multi-criteria analysis (MCA) has been undertaken for the proposed options based on the information presented in section 4. The approach adopted uses a simple matrix of positive, negative or neutral to provide an overview of potential benefits and risks of each of the options 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: MCA 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 MCA demonstrates that Options 4 – 10 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 is provided in section 7.

Table 5-2: MCA

Factor	Location	1	2	3	4a	4b	4c	5	6	7	8	9	10a	10b
Hydrological regime	A	+	-	-	+	N	N	N	N	N	N	N	N	N
	B	N	N	-	+	N	N	N	N	+	+	N	+	N
	C	N	N	-	+	N	N	N	N	+	+	N	+	N
	D	N	N	-	+	+	+	N	N	+	+	N	+	N
	E	N	N	N	+	N	N	N	N	+	+	N	N	N
	G	N	N	-	+	N	+	+	N	+	+	N	N	N
	H	+	-	-	+	N	+	+	N	+	+	+	+	+
	I	N	+	-	+	N	+	+	N	N	N	-	+	+
	J	N	+	-	+	N	+	+	N	N	N	N	+	+
	K	N	N	+	+	+	+	N	N	N	N	N	N	N
	L	N	-	-	+	+	+	-	N	N	N	N	N	N
	M	+	-	-	+	+	+	-	N	+	+	N	N	N
	N	N	N	-	+	N	-	-	N	+	+	N	+	N
Ecological interests – habitat features	A	-	-	-	-	N	N	N	N	N	N	N	N	N
	B	N	N	-	+	N	N	N	N	+/-	+	N	+	N
	C	N	N	-	+/-	N	N	N	N	+/-	+/-	N	+/-	N
	D	N	N	+	+/-	N	N	+	+	+/-	+	N	+/-	N
	E	N	N	N	N	N	N	N	N	+/-	+	N	N	N
	G	N	N	+	+	N	N	+	+	+/-	+	N	N	N
	H	N	-	-	N	N	N	N	N	+/-	+	+	+	+
	I	N	N	N	N	N	+	N	N	N	N	N	+/-	+/-
	J	N	N	N	N	N	+	N	N	N	N	N	+/-	+/-
	K	N	N	N	N	N	N	N	N	N	N	N	N	N
	L	N	-	-	+/-	+/-	+/-	N	N	N	N	N	N	N
	M	+	-	-	+	+	+	N	N	+/-	+	N	N	N
	N	N	N	-	+	N	N	N	N	+/-	+/-	N	+/-	N
Ecological interests – bird features	A	+	+	+	+	N	N	N	N	N	N	N	N	N
	B	N	N	+/-	+	N	N	N	N	+/-	+	N	+	N
	C	N	N	-	+	N	N	N	N	+/-	+	N	+	N
	D	N	N	N	+	N	N	N	N	N	N	N	+	N
	E	N	N	N	+	N	N	N	N	+/-	+	N	N	N
	G	N	N	N	+	N	+	+	N	+/-	+	N	N	N
	H	+	N	N	+	N	+	N	N	+/-	+	+	+	+
	I	N	+	N	+	N	+/-	N	N	N	N	N	+	+
	J	N	+	N	+	N	+/-	N	N	N	N	N	+	+
	K	N	N	N	N	N	N	N	N	N	N	N	N	N
	L	N	+	+	+	+	+	N	N	N	N	N	N	N
	M	+	+	+	+	+	+	N	N	+/-	+	N	N	N
	N	N	N	+	+	N	N	N	N	+/-	N	N	N	N
	Fish/ FWPM	-	N	N	+	+	+	N	N	+	+	N	N	N
Morphology	Spey	+	-	-	+	+	+	+	+	N	+	N	N	N
	Ruthven	N	N	-	+	N	N	N	N	+	+	N	N	N
	Tromie	N	N	-	+	N	N	N	+	+	+	N	N	N
	Raitts	+/-	N	-	+	+	+	N	N	+/-	+	N	N	N
Wider benefits and risks	Flood – adjacent to marshes	+/-	+/-	-	+	+	+	+	N	+	+/-	N	N	N
	Flood – Kincraig/ downstream	+/-	+/-	+	+/-	+/-	+/-	+/-	N	N	N	N	N	N
	Railway at Raitts Burn	+/-	N	N	+	+	+	N	N	+/-	+	N	N	N
	Discharges (WWTW/ distillery)	N	N	N	N	N	N	N	N	N	N	-	-	-
	Access rights	N	+	+	-	-	-	N	N	-	+	N	N	N
	Recreation	N	N	+/-	+/-	+/-	+/-	N	N	+	+	N	+/-	+/-

Where:

+	Potential positive change
-	Potential negative change
+/-	Change is uncertain due to circumstances of the option or location
N	No significant change to existing conditions/ processes

5.2 Selection of Options for Outline Design

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 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. Design of restoration works for the Raitts Burn are therefore outside the scope of the current commission, however it is the key area of concern and an information package will be put together scoping the detailed design requirements.

6 OUTLINE DESIGN

6.1 Overview

Outline design details for the proposed pilot schemes at Lynchat (Pilot 1) and Dell of Killiehuntly Wetland (Pilot 2) are provided in the following sections, with plan and typical cross-section details included in Appendix F. Section 6.2.1 (Pilot 1) and 6.3.1 (Pilot 2) provide the outline design details upon which the design drawings and costings are based. Section 6.2.2 (Pilot 1) and 6.3.2 (Pilot 2) provide a discussion regarding the proposed design, alternative approaches and the next stages.

A proposed construction approach is included for each pilot scheme. Detailed works method statements should be provided by the successful contractor upon tender award. These should include appropriate pollution prevention measures and incident response procedures to minimise the risk of pollution. The time of year at which the works are undertaken should be agreed with RSPB and would preferably occur during summer months. The works should be supervised by a suitably qualified professional.

Indicative construction costs have been developed based on the outline design details and anticipated work items, using the Institution of Civil Engineers Civil Engineering Standard Method of Measurement (CESMM4) and supplemented by experience on typical costs on other recent similar projects managed by EnviroCentre. A contingency allowance of 20% has been incorporated into the costing. It should be noted that the actual costs received during a tendering process will vary due to factors including the experience of the contractor to undertake these type of works, workload of contractor and timing of the contract. The indicative costs do not include an allowance for any further assessment or design that may be required to obtain the relevant permissions and licencing for the works.

The restoration works will comply with the CDM Regulations, ensuring that health and safety considerations are an integral part of the entire project from design through to construction. The design phase of the works has been undertaken to comply with the CDM Regulations and the main health and safety implications of the construction works relate to working adjacent to the River Spey and within its floodplain.

The CDM Regulations 2015 state that should the construction phase of the works last more than 30 working days and have more than 20 workers working at the same time at any point on the project or involve more than 500 person days of construction work, then it will be a notifiable project under the CDM Regulations and require to be notified to the Health and Safety Executive prior to works commencing on site. The Client has the duty to notify a construction project but may ask someone else to do it on their behalf.

There are a number of residual risks identified through the design, which are listed below:

- Working near to watercourses of significant water depth;
- Working near potentially unstable river banks;
- Areas of undulating or soft and wet ground conditions in potential corridors for accessing works;
- Working in an environment where water levels may rise quickly;
- Absence of services from works area to be confirmed by RPSB; and
- Access via railway crossing (Pilot 1).

These risks can be adequately managed with reference to best practice guidance, appropriate communication and monitoring. The construction works will be undertaken within the River Spey floodplain. The contractor's method statement and health and safety plans must include their approach to monitoring river levels and procedures to evacuate the site prior to inundation of the floodplain.

6.2 Pilot 1 at Lynchat – Outline Design

6.2.1 Outline Design Summary

A pilot scheme at Lynchat aims to increase the floodplain connectivity between the River Spey and the Lynchat compartment (unit L and M) in order to reinstate more natural river-floodplain dynamics. Undertaking a pilot scheme at Lynchat provides the opportunity for the hydrological and ecological effects of embankment removal on a single compartment to be monitored, and the results of this monitoring could subsequently be used to inform future works.

The works included in Pilot 1 at Lynchat are summarised in Table 6-1.

Table 6-1: Pilot 1 at Lynchat - Outline Design Summary

Description	• Removal of 1.7km of embankment. • Includes the embankment that runs perpendicular between the railway and the River Spey at the western extent of unit L, and the embankment along the left bank of the River Spey at units L and M. • Excludes any works to the Raitts Burn (channel and embankments) • Excludes works to the internal drainage network or to repair the existing breaches to bank level. • Excludes measures to prevent floodwater passing under the railway embankment at Lynchat village.
Design Drawings	• Plan drawing provided as Drawing F2, Appendix F. • Typical cross-section detail of embankment removal provided as Drawing F1, Appendix F.
MImAS Capacity Release	1.2% (water body ID 23142) *(1389m of embankment removal contributes to MImAS capacity release. Remainder is >50m from channel bank).*
Indicative works duration	8 weeks
Indicative Construction Cost	£220k (excluding VAT)

The proposed construction approach is as follows:

- All works will be undertaken from the reserve i.e. no machinery will enter the watercourse.
- The works will leave the existing river bank intact.
- Vegetated turves and topsoil from the embankment and reinstatement area (typically 15 – 25m width from the existing embankment toe) will be stripped and stored within close proximity to the works, retaining its integrity as far as possible.
- The remaining material forming the embankment will be excavated to a similar level as the adjacent river bank.
- This excavated material will be placed behind the current embankment footprint and graded into the ground levels within the compartment with a very shallow slope (typically shallower than 1 in 30). The width over which this re-grading occurs varies depending upon the size of the embankment but will typically be 15 – 25m.
- The graded slope will be reinstatement using the retained topsoil and vegetated turves.

There are a number of reasons for this approach. The ground levels behind the embankments are generally lower than the river bank. Where embankments are absent (for example at Invertromie Fen, unit D) natural levees have formed which are typically 0.5 – 0.7m higher than the floodplain ground levels and 25 – 70m wide. It is therefore assumed that the natural levees at Lynchat would also have been wider than under existing conditions prior to the construction of embankments. The proposed design approach mimics these natural features using the excavated material. It is also believed that the material forming the embankments would have been sourced locally from the floodplain, for example from the excavation of the drainage network or from the natural levees that would have been present prior to the modifications. Finally, the proposed approach significantly reduces the tracking of vehicles across the reserve, reducing disturbance to existing soil and vegetation, and the carbon footprint of the scheme compared to transporting the material off-site.

There are two vehicular access points into the Lynchat compartment, as shown in Drawing F2, Appendix F. Low-lying, and potentially wet, soft ground is situated between the access points and the embankments. The contractor should agree the proposed access routes and approach (e.g. use of low ground pressure vehicles/ temporary bog mats) with RSPB.

6.2.2 Discussion and Next Stages

The next stages of work are as follows:

- Consultation with stakeholders.
- Determine the legal implications of the proposed scheme with respect to access rights and consult with the holders of the access rights.
- Undertake further assessment if deemed to be required to secure the relevant permissions to proceed (informed by stakeholder engagement).
- Confirmation of the proposed scheme and update design details if required.
- Secure the necessary permissions, including CAR licence and planning permission if required. Recent experience suggests that planning permission is likely to be needed.
- Undertake any necessary pre-construction ecological surveys or monitoring.
- Preparation of contract documents and tendering the construction works.
- Construction works, including contract management and site supervision.
- Post-construction monitoring.

The hydrological and ecological implications of Pilot 1 will be similar to those predicted for Option 4b (described in Table 4-5). However Option 4b also included restoration of the Raitts Burn which is not proposed in Pilot 1. There will therefore be no benefits to the Raitts Burn (morphological, aquatic ecology, railway infrastructure).

The potential change in flood risk for Pilot 1 will be similar to Option 4b (see section 5) as the Spey is the dominant influence on flood levels. It is therefore considered that this feasibility study should provide sufficient flood risk information to inform a planning application. However, confirmation of this should be sought from THC and SEPA.

The model results for Option 4b suggest that Pilot 1 could reduce flood risk to Lynchat village from the River Spey. There may be a public perception however that removing the embankments will increase flood risk. Further investigation into providing a set-back embankment to prevent water from the Spey floodplain passing northwards under the railway at Lynchat village may therefore still be beneficial. This investigation will need to consider drainage on the northern side of the railway, the permeability of a set-back embankment, a suitable location and level for the set-back embankment (including a freeboard allowance) and implications for access.

When preparing the outline design details alternative arrangements were considered, including use of extended breaches and repair of the existing breaches. The width of the graded slope between the bank and the reserve can be varied to suit local conditions, for example it could be made narrower to reduce the footprint of the works on the existing vegetation. This would result in a flatter area and a slighter steeper gradient towards the reserve. The proposal to use the embankment material to mimic natural levee features could encroach onto fen habitat, and consultation with SNH will be needed at an early stage to discuss this approach. It is noted that levees are expected to form naturally over the longer term once embankments are removed due to deposition of fine material by overbank flows, and the timescales over which vegetation changes are assessed for a HRA are therefore important. If the proposed approach to mimic natural levees is not acceptable to SNH, further consultation will be required regarding how the material will be removed from site and where it will be removed to.

Removal of the embankments was selected for the outline design as it provides maximum channel-floodplain connectivity and would provide maximum benefits in terms of SEPA's MImAS scoring. However, extended breaches could improve channel-floodplain connectivity while reducing the volume of material that needs to be dealt with and reducing construction costs. Any extended breaches should be as long as possible to reduce the potential for scouring of the bank, and it is suggested that a minimum length of 100m would be reasonable. Based on the understanding of dominant flowpaths, it is recommended that extended breaching would include as a minimum a breach in the perpendicular embankment at the western extent of the unit, removal of the embankment opposite the Tromie confluence (~ 250m to the west of the confluence and ~ 300m to the east of the confluence) and an extension of the eastern-most breach in unit M. It is noted that modelling of extended breaches at Lynchat has not been undertaken.

Repairing the existing breaches up to a natural bank level would result in a slight reduction in the frequency of overtopping of the River Spey into the Lynchat compartment, although flooding is still expected to occur at the 3-POT design flow event (approximately 3 times per year). Repair of the breach in unit M would encourage longer term retention of a shallow depth of water (0.1 – 0.5m) across the majority of unit M. The ecological implications of this variation have not been assessed.

Undertaking a pilot scheme offers an opportunity to monitor and assess the changes to the hydrological regime and ecological receptors arising from embankment removal within a small part of the reserve. It is recommended that a monitoring plan is developed prior to construction commencing. Baseline information on groundwater levels is available from two SNIFFER loggers located with the Lynchat compartment, and it may be beneficial to supplement these datasets with a non-vented logger to capture above-surface water levels.

6.3 Pilot 2 at Dell of Killiehuntly Wetland – Outline Design

6.3.1 Outline Design Summary

A pilot scheme at Dell of Killiehuntly Wetland will increase connectivity between the floodplain and the River Spey and River Tromie in proximity to the confluence between these two watercourses, with the aim of increasing water inputs to the Dell of Killiehuntly Wetland and encouraging increased morphological dynamics at the confluence.

The works included in Pilot 2 at Dell of Killiehuntly Wetland are summarised in Table 6-2.

The embankment removal will be undertaken in the same manner as Pilot 1, replicating a natural levee feature along the bank. The extent of embankment removal has been informed by the aims of the pilot scheme and the extent of bed aggradation with the River Tromie. A single extended breach on the River Tromie is proposed, which is situated just upstream of the aggraded reach.

In the lower 275m of the Tromie there are two distinct embankments. The channel bank itself is raised above the ground behind and is typically 0.3m higher than the modelled QMED water level, although there are low points in the bank allowing connection with the ground behind. A continuous coverage of trees is present along this right bank for much of the reach of interest, and it has been assumed that removing large numbers of trees as part of the restoration works is not desirable. It is therefore proposed that a small section of the channel bank is lowered by 0.3m, which would allow overtopping into the lower ground behind the bank at the modelled QMED event. The larger and more significant embankment in terms of floodplain disconnection is set-back from the channel bank by 20 - 45m. This embankment is typically over 1m higher than the modelled QMED water level in the area of interest. The proposed embankment removal focuses on this set-back embankment to avoid felling as far as possible.

Table 6-2: Pilot 2 at Dell of Killiehuntly Wetland - Outline Design Summary

Description	• Removal of 665m of embankment consisting of: o An extended breach in the right embankment of the River Tromie (50m); o Removal of the lower 140m of the right embankment of the River Tromie; and o Removal of 475m of embankment on the right bank of the River Spey downstream of the confluence. • Lowering of a short section of the right bank of the River Tromie (10-20m length). • Removal of 2 lengths of rip-rap hard bank protection (~43m on River Spey and 59m on River Tromie). • Installation of large woody material in the River Tromie.
Design Drawings	• Plan drawing provided as Drawing F3, Appendix F. • Typical cross-section detail of embankment removal provided as Drawing F1, Appendix F. • Typical cross-section detail of rip-rap removal provided as Drawing F4, Appendix F. • Typical detail of large woody material installation provided as Drawing F5, Appendix F.
MImAS Capacity Release	0.3% on Spey (water body ID 23142) 3.8% on Tromie (water body ID 23138) *On Spey, 374m of embankment removal contributes to MImAS capacity release. Remainder is >50m from channel bank.* *On the lower Tromie, 70m of embankment removal contributes to MImAS capacity release. The baseline MImAS calculations incorporated only the closest embankment in the locations where there are two parallel embankment. The pilot scheme focuses on removal of the set-back embankment which has less impact on the MImAS capacity release but more impact in terms of floodplain reconnection.*
Indicative works duration	6 weeks
Indicative Construction Cost	£80k (excluding VAT)

The proposed construction approach is as follows:

- Embankment removal, including breaching:
    - All works will be undertaken from the reserve i.e. no machinery will enter the watercourse.
    - The works will leave the existing river bank intact.
    - Vegetated turves and topsoil from the embankment and reinstatement area (typically 15 – 25m width from the existing embankment toe) will be stripped and stored within close proximity to the works, retaining its integrity as far as possible.
    - The remaining material forming the embankment will be excavated to a similar level as the adjacent river bank.
    - This excavated material will be placed behind the current embankment footprint and graded into the ground levels within the compartment with a very shallow slope (typically shallower

    - than 1 in 30). The width over which this re-grading occurs varies depending upon the size of the embankment but will typically be 15 – 25m.
    - The graded slope will be reinstatement using the retained topsoil and vegetated turves.
- Bank lowering:
    - One short length of bank lowering (10-20m length) is proposed. This will be conducted in a similar manner to embankment removal other than:
        - Excavated material will be removed and replaced where the slopes are being re-graded at embankment removal locations (i.e. not at location of the bank lowering).
        - The location and location of bank lowering will be micro-sited to avoid felling of mature riparian trees.
- Removal of short lengths of rip-rap bank protection:
    - All works will be undertaken from the banks i.e. no machinery will enter the watercourse.
    - The turf and topsoil along the bank top behind the rip-rap will be stripped or rolled back, retaining the integrity as far as possible.
    - The rip-rap stone will be removed using an excavator whilst minimising disturbance to the channel bed and transported to an agreed location.
    - The sub-soil behind the rip-rap will be re-graded to approximately a 1 in 2 slope. Selected cobbles or gravel may be retained at the bank toe if conditions are deemed appropriate by the supervising engineer. If sub-soil is excavated to form the 1 in 2 slope, this will be used to form the levee feature at the embankment removal locations.
    - The turf and topsoil will be replaced at the top of the re-profiled slope and additional measures to encourage re-establishment of vegetation will be taken where necessary.
- Installation of large woody material (LWM):
    - Works will be undertaken from the banks if possible, however it may be necessary for machinery to enter the Tromie.
    - The LWM will consist of whole trunks with root ball and branches still attached where possible, sourced from the limited felling which will be required for the bank lowering and extended breach.
    - The LWM will be oriented with the root wad facing upstream and will be placed close to the bank, with a shallow angle into the channel (typically less than 30 degrees between bank and trunk).
    - The LWM will be secured by:
        - At least one third of the length of the trunk will be trenched into the channel bed with the gravels replaced over the trunk;
        - Use of timber or steel rebar stakes on either side of the trunk driven into the bed and secured to log using cross-braced wire; and
        - Cabling to secure the trunk to trees on the adjacent bank if deemed to be necessary by the supervising engineer.

The designated location for the excavated rip-rap stone will need to be identified by RSPB prior to submission of planning or CAR licence applications. It may be possible for this material to be set-back from the current bank, or there may be a use for it elsewhere on the reserve.

In-channel measures are incorporated into this pilot scheme in the form of introducing LWM to the channel. LWM was observed in proximity to the confluence during the walkover surveys, sourced from bank erosion and collapse of riparian trees into the channel, and the proposed approach (including orientation and angle) aims to replicate the presence of natural LWM in the channel. The existing channel is straight and erosion of the banks is limited. The aim of using LWM is to provide a localised narrowing of the channel and deflection of flow, encouraging local scour of the bed and banks and 'kick-start' more dynamic channel processes. The location of the LWM and final positioning (in terms of angle and orientation) will be determined on site by a suitably qualified person based on the morphological conditions at the time of installation. It is anticipated that LWM will be installed at three locations within the defined reach, spaced approximately 5 – 7 times the channel width (100 – 140m).

Vehicular access to the proposed works area will be from the B970 and the existing track to Dell of Killiehuntly Farm. There may be wet, soft ground adjacent to the embankments. The contractor should agree the proposed access routes and approach (e.g. use of low ground pressure vehicles/ temporary bog mats) with RSPB.

6.3.2 Discussion and Next Stages

The next stages of work are as follows:

- Consultation with stakeholders, graziers and tenant.
- Consult with the owner(s) of the low-lying land to the south of the Main Drain in unit H which could be affected by the proposals.
- Undertake further assessment if deemed to be required to secure the relevant permissions to proceed (informed by stakeholder engagement).
- Confirmation of the proposed scheme and update design details if required.
- Secure the necessary permissions, including CAR licence and planning permission if required. Recent experience suggests that planning permission is likely to be needed.
- Undertake any necessary pre-construction ecological surveys or monitoring.
- Preparation of contract documents and tendering the construction works.
- Construction works, including contract management and site supervision.
- Post-construction monitoring.

As for Pilot 1, the outline design proposes removal of a complete section of the River Spey embankment and set-back River Tromie embankment, rather than using extended breaches, to allow maximum channel-floodplain connectivity at this location and provide the maximum MImAS benefit. A single extended breach further upstream on the River Tromie is proposed, which is situated just upstream of the aggraded reach of the Tromie. Embankment removal or further breaches immediately downstream of this extended breach has been avoided as the bed of the burn here is at a similar elevation to ground levels behind the right embankment. If further breaching along the right bank of the River Tromie is considered desirable for increasing water flow into unit G, the implications on the flow conditions and habitat within the River Tromie channel will need to be considered.

Modelling of the implications of this pilot scheme has not been undertaken, however a conceptual overview of the potential hydrological changes is provided in Figure 6-1. The frequency of overtopping into unit G will be increased. Based on the modelled results, lowering the right embankment of the River Tromie at the extended breach to a typical bank level of 223mAOD would permit minor overtopping at the 5-POT event. Water would flow in a north-easterly direction through unit G and onto unit H. The embankment removal along the Spey would permit overtopping at the modelled 3-POT event. Pilot 2 is also likely to increase the depth and extent of flooding in units G and H. Based on current topography, floodwater in unit G is unlikely to flow back into the Spey through the existing breaches unless an intervention is installed to actively manage this flow pathway.

Lowering of the bank at the lower part of the Tromie and removing the set-back embankment will permit greater overtopping from the lower Tromie into unit G. It is anticipated that introducing LWM will assist the channel in naturally recovering a more sinuous thalweg, encouraging bank erosion and channel change. Removal of the bank protection at the confluence has been proposed as this will further assist in increasing channel dynamics at this location. In the longer term, the channel may bypass this rip-rap, however it would be beneficial to speed this process. If the rip-rap is not removed, it may continue to affect patterns of erosion and deposition even if there are changes to the channel planform at this location. Bank erosion is likely to occur in the short-term in the locations where the rip-rap is removed. If this is of concern, soft bank protection measures could be incorporated into the design. As the channel becomes more dynamic, channel avulsion could occur. However, it is considered unlikely that a braided channel will develop to the extent that fish passage will be prevented, as the upstream flow regulation also affects the sediment supply to the restoration reach.

Buoyancy calculations confirm that the LWM is unlikely to be large enough to remain in situ at the QMED event and the proposed approach therefore includes a method to secure the wood whilst minimising disruption to the existing banks. Alternatively, the LWM could be trenched into the bank, however this approach would require further works to stabilise the weakened bank. Although the proposed approach includes securing the wood in place, the method does not guarantee that the wood will not move during flood events. Increased channel dynamics may also introduce further wood to the channel through bank erosion and collapse. The introduction of wood to the River Tromie is beneficial for morphological and ecological processes, and it is likely that much of the wood will remain locally in the Tromie. There is however a chance that some wood could be transported downstream into the River Spey.

Undertaking a pilot scheme offers an opportunity to monitor and assess the changes to the hydrological regime and ecological receptors arising from embankment removal within a small part of the reserve. It is recommended that a monitoring plan is developed prior to construction commencing, which should include monitoring of the morphology of the River Tromie. This should also be undertaken to address the concerns of the Spey Fishery Board regarding the potential for impeded fish passage if a highly braided channel develops (section 7.2.6). As a minimum, an annual walkover survey and fixed point photography can be used to document changes to the morphology. Repetition of the monitoring work undertaken by Ruth Maier in 2002 looking at indicator habitats and species would be beneficial.

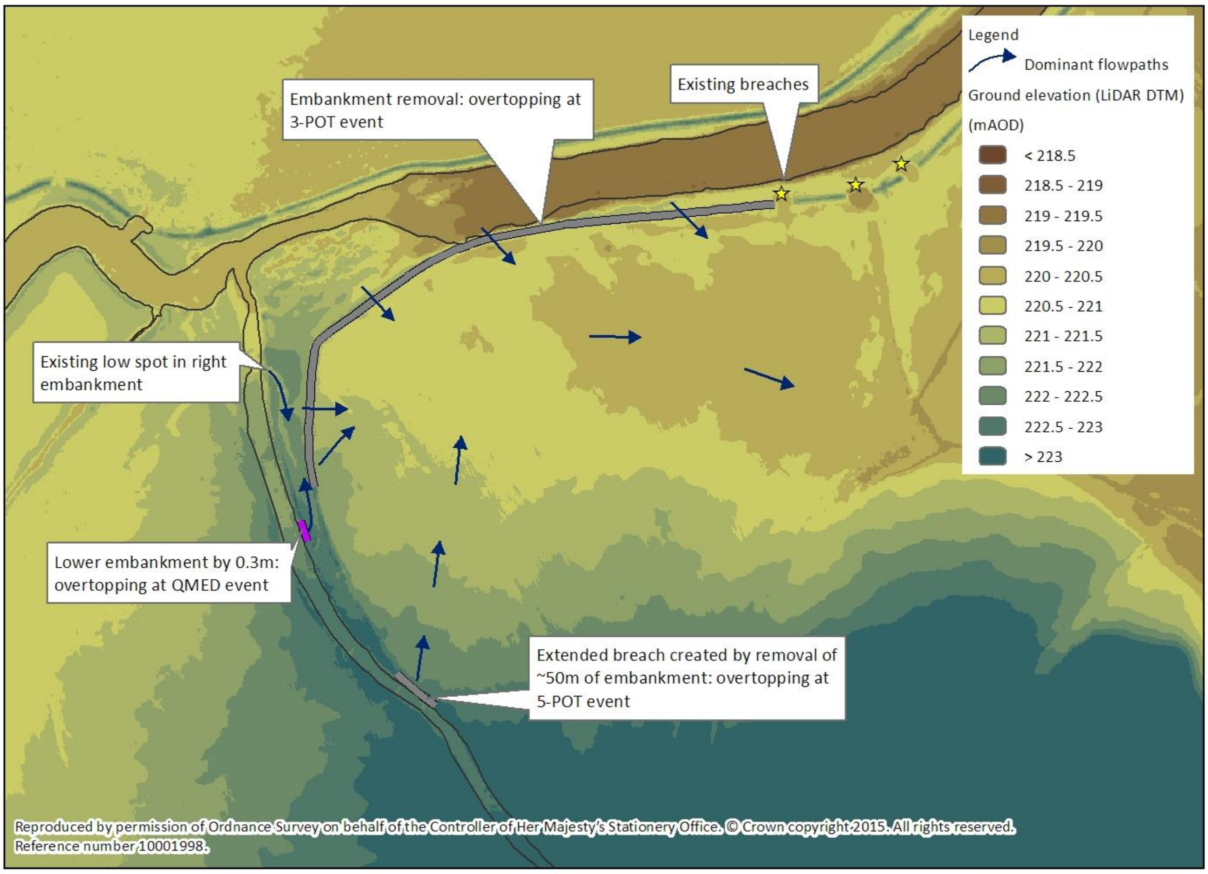


Figure 6-1: Conceptual Summary of Pilot 2 – Dominant Flowpaths

6.4 Raitts Burn Restoration – Next Stages

The Raitts Burn has been severely impacted by historic realignment and embankments, resulting in a disconnected floodplain, fixed planform and perched bed. The mainline railway and B9152 cross the burn immediately upstream of the reserve, and the burn passes under the A9 approximately 160m upstream of the reserve. There is also a CAR licenced discharge from the Lynchat sewage treatment works into the burn between the A9 and the B9152.

Under current conditions, there is a requirement for on-going maintenance of the embankments to reduce the risk of an uncontrolled breach, which could pose a risk to the stability of the upstream infrastructure. The level of risk to the upstream infrastructure has not been assessed as part of this project. Deposition within the embankments restricts the conveyance capacity at the road and railway crossings, increasing flood risk to this infrastructure and the adjacent properties.

Restoration of the Raitts Burn should aim to provide a more sustainable solution to river management at this location by reinstating natural river processes and forms as far as is possible within the constraints of the key infrastructure. Such an approach will contribute to WFD objectives and should reduce the future maintenance requirements. Reconnection to the floodplain within the reserve and establishing more natural processes should also provide benefits for in-channel habitat and the adjacent wetland.

Historically it is likely that the Raitts Burn followed a more direct course from the Mains of Balavil to the River Spey (Figure 6-2) and under natural conditions would form a shallow alluvial fan at the transition between the steeper, more confined valley and the flat, unconfined floodplain of the River Spey. It is assumed that realignment of the burn outside of the reserve and replacing the existing road and railway crossings is not feasible. However, for restoration works within the reserve to be successful, the reach upstream of the reserve will need to be included in the assessment, and it is likely that works will be also be required within this reach. Consultation with the relevant stakeholders and landowners will be needed so that the final design is acceptable to all parties.

Within the reserve, restoration works should focus on removing the confining influence of the embankments, restoring a natural bed level (i.e. not perched) and increasing the sinuosity of the planform. These approaches should reconnect the channel to the floodplain and allow it more space to deposit sediment and migrate laterally. There are two broad approaches that could be taken:

A. The works could be undertaken along the existing channel alignment; or
B. A new channel alignment could be created either to the right or the left of the existing channel.

Indicative restoration corridors are shown in Figure 6-2. Approach B has the advantage that the majority of the construction works could occur offline, whilst Approach A would reduce the disturbance to the adjacent wetland during construction. The corridors in Figure 6-2 are purely indicative and are provided to illustrate the possible variation in channel length and existing levels rather than the exact location or sinuosity of the new channel. No historic channel routes have been identified within the LiDAR data. The discrepancy between the existing bed levels and the floodplain levels at the start of the two corridors shown in Figure 6-2 is approximately 1m on the left and 1.2m on the right.

It is recommended that the design of the restoration works is undertaken as a phased approach to ensure that the final design is acceptable to all parties. A phased approach would consist of the following stages:

1. Consultation to confirm scope of works;
2. Options assessment and conceptual/ outline design;
3. Consultation to confirm preferred scheme; and
4. Detailed design.

During Stage 1, consultation with SEPA, SNH, THC, Network Rail, Transport Scotland, SCI, upstream landowner(s) and those with access rights would be undertaken to confirm the scope of assessment and design, and identify key concerns and opportunities that need to be considered in the restoration design. It is anticipated that this would be led by RSPB and undertaken prior to issuing a tender specification for Stage 2. There are potential benefits of the project for THC, Network Rail and Transport Scotland through providing a better understanding of the risks to the infrastructure, and potential for reduced maintenance requirements after the restoration works, and there may be opportunities for collaborative funding.

It is recommended that a conceptual design and assessment stage is carried out initially (Stage 2). This will build upon the work undertaken for this feasibility study and appraise a range of realignment and on-line options to determine the most appropriate scheme. The anticipated scope of Stage 2 is provided in Table 6-3, which would have an indicative budget in the region of £15k - £20k (excluding VAT). The actual cost for Stage 2 may be higher or lower than this depending upon the final scope of works, which would be informed by consultation with the stakeholders and regulatory bodies in Stage 1, and the number of variations to be assessed or modelled.

Table 6-3: Stage 2 Anticipated Requirements – Restoration Options Assessment and Conceptual Design

Task	Indicative Scope
Topographic survey	Supplement existing survey – likely to include channel cross-sections and embankment details upstream of the reserve, structure details of the road and railway crossings, detailed bed profile, additional cross-sections within the reserve if required, and surveyed floodplain levels in the likely corridors for channel realignment.
Hydrodynamic modelling	Update the existing model to extend the modelled reach of the Raitts Burn upstream of the reserve, including 2D representation of the floodplain between the A9 and the railway. Run the updated model for a range of return periods to establish the existing flood regime upstream of the reserve.
Sediment transport assessment	Establish existing sediment transport regime of the Raitts Burn upstream of the reserve by extending the fluvial audit of Raitts Burn upstream of the reserve, recording of bed and bank sediment character, sampling of bed sediment size distribution, and sediment transport calculations as appropriate.
Conceptual understanding & options identification	Conceptual summary of existing river dynamics, and the aims, opportunities, constraints and risks of the restoration works. The constraints and risks should be informed by the consultation undertaken in stage 1 and may require a utilities search to be undertaken. Conceptual design of several indicative restoration schemes based on approach A and B detailed above. The 'Do Nothing' scenario may also be considered at this stage. The conceptual design should consider the proposed long profile, cross-section and planform within the reserve and how these would tie into existing floodplain levels and upstream conditions, constraints imposed by the existing infrastructure, requirements for excavation/ fill and the source/ reuse of materials.
Assessment of options	Assessment of benefits, constraints and risks of each of the alternative schemes. It may be beneficial to incorporate the key options into the hydrodynamic model to inform the assessment of potential change in flood risk, channel processes and hydrological regime on the adjacent floodplains. Consideration should be given to increasing the resolution of the floodplain representation in units H and N if required for more detailed assessment of potential ecological impacts.
Reporting	Reporting of conceptual/ outline design and provision of non-technical plans and drawings to illustrate the conceptual/ outline design options assessed.

Stage 3 would involve consultation with the relevant parties to agree upon the preferred option, and any mitigation or amendments that might be required at the detailed design stage. Stage 4 will include detailed design work, assessment of the implication of the final scheme on the designated features, flood risk and hydromorphology (if different to the options assessed in Stage 2), preparation of engineering drawings suitable for use by a contractor, outline construction method statement, Bill of Quantities and budget cost estimate. A targeted ground investigation along the route of any proposed excavations would be beneficial to inform the design. Support in preparing the construction contract and tender documents could also be provided by the designer in stage 4 if required.

Stages 2 and 4 should also provide all the necessary supporting information for planning and CAR licence applications. It is recommended that a screening opinion is submitted as soon as possible in the design process to determine whether an EIA will be needed. The scope and budget for Stage 4 will be highly dependent on the specifics of the preferred option, including whether any ancillary works will be required in relation to the existing structures, service diversions or new crossings, and the requirements of the funding body and other stakeholders. Indicative costs for Stage 4 have therefore not been included. Similarly, construction costs for restoration works on the Raitts Burn are dependent on the final design, but could be in the region of £100k - £150k.

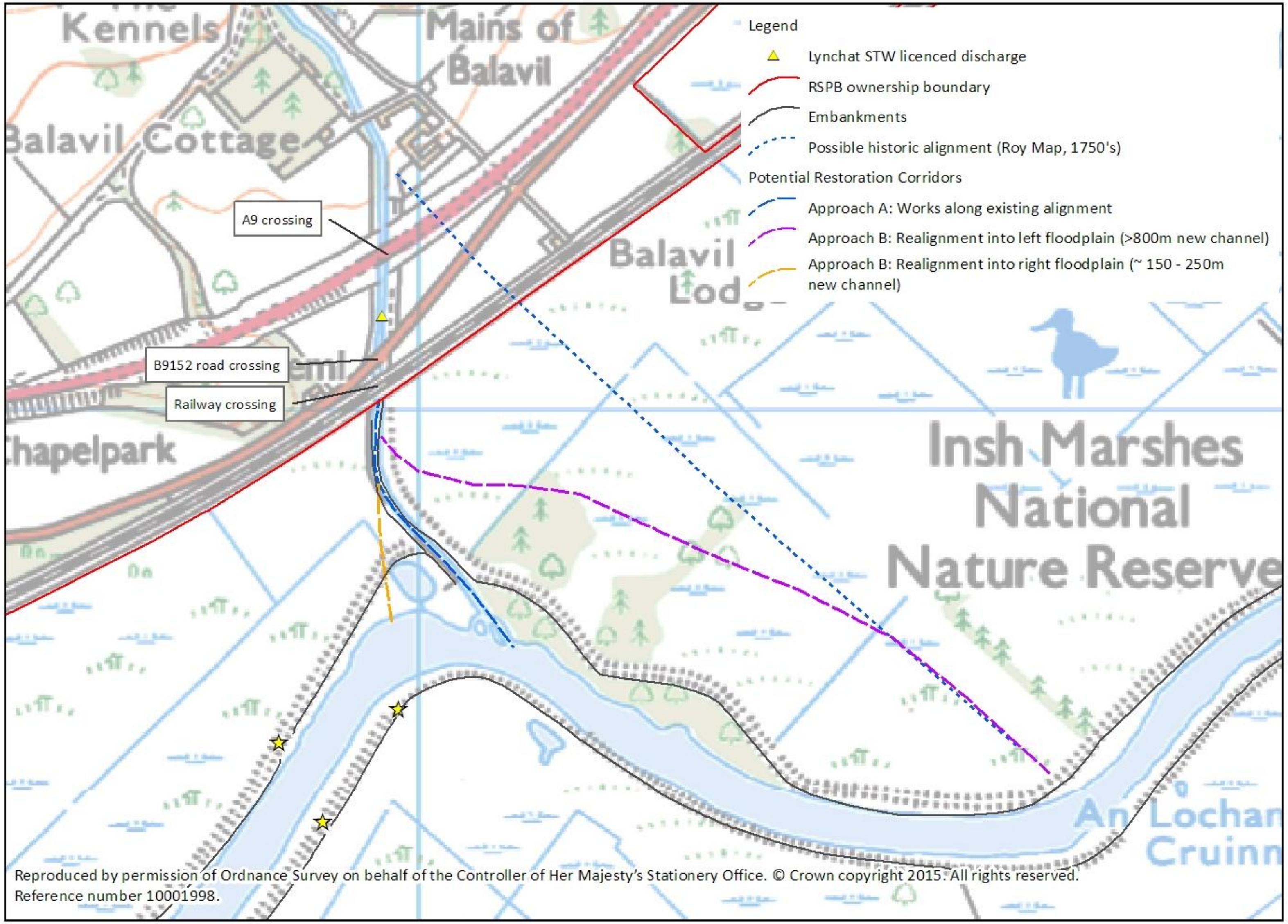


Figure 6-2: Raitts Burn Restoration Considerations

7 NEXT STAGES

7.1 Flood Events December 2015

Prolonged heavy rainfall resulted in widespread and severe flooding across northern England and Scotland in December 2015, which was the wettest month on record for much of Scotland (CEH, 2016). River levels at SEPA's gauging stations were the highest recorded for the River Spey at Invertruim on 5th December 2015 and for the River Tromie and River Feshie on 30th December 2015. High river levels were also recorded on the Spey at Kincraig Bridge and Kinrara, though these were not as high as during the flood events in 1990/ 1993. Whilst the Spey catchment did not experience flooding to the same extent as that on the River Dee, river levels were high enough to cause evacuation and flooding of a number of properties in the Kincraig to Aviemore area.

The assessments described in this feasibility report were undertaken prior to December 2015. The recorded flows were therefore not incorporated into the hydrological analysis. It is also noted in Table C5 in Appendix C that the bed level of the River Spey at the Feshie confluence can change over time as a result of episodic inputs of coarse bedload from the River Feshie, and that the bed level at the confluence influences upstream water levels through Loch Insh and the River Spey within the lower section of the reserve. The December 2015 flood event was large enough to mobilise coarse sediment in the Feshie and conditions at the confluence may therefore have changed as a result. However, the modelling undertaken for the feasibility study represented a single baseline scenario with which to compare various options and assess the magnitude of potential change. The information presented therefore remains valid for the purpose of this feasibility study.

The December 2015 flood events may also have affected the channel morphology of the River Spey and its tributaries within the reserve, particularly the patterns of erosion and deposition. A repeat morphological survey has not been undertaken, however RSPB have provided information on changes to the River Tromie, the main location at which change was observed. A secondary channel has formed on the left bank as shown in Figure 7-1 and Figure 7-2, which conveys water during average flow events as well as during flood events. The lower part of the secondary channel follows the course of a historic channel in the floodplain. This suggests that the Tromie has the ability to adjust its form under certain conditions and supports the use of measures to assist recovery (section 6.3) rather than full-scale realignment.


Figure 7-1: River Tromie Secondary Channel formed December 2015 Upper (left) and Lower (right) extents

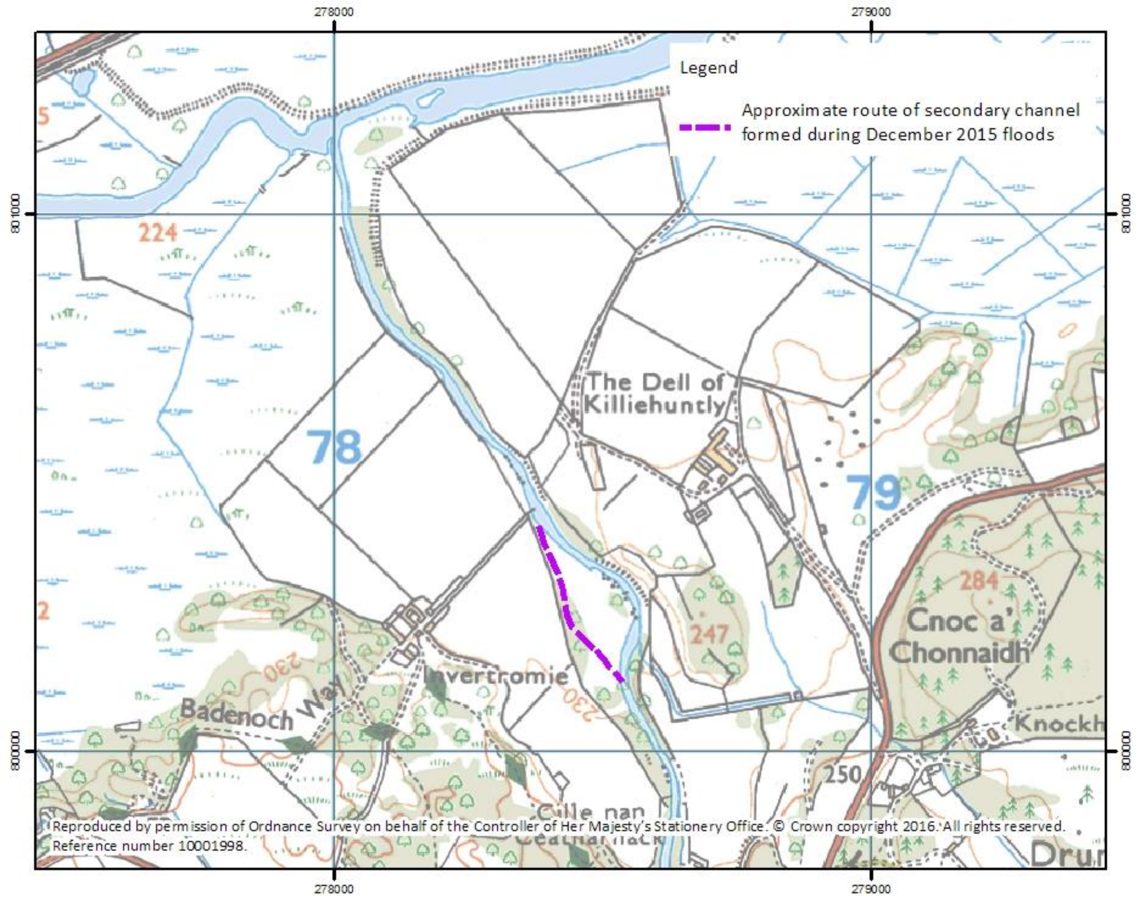


Figure 7-2: River Tromie Changes December 2015

7.2 Stakeholder Feedback

Feedback on the feasibility study was sought from the project stakeholders, specifically relating to:

- Whether the organisation is supportive of RSPB's long term aspiration to restore Insh Marshes to a more naturally functioning floodplain system and remove (or reduce) the influence of the embankments;
- Comments on the ten restoration options assessed in the feasibility study;
- Whether there are any options that could be considered if more funding becomes available;
- Whether the organisation agrees with the options selected for outline design (section 5.2);
- Whether there are other preferred options that the organisation feels that RSPB should be exploring in preference to those selected for outline design;
- Details on what further information the organisation would require to consent to the options selected in section 5.2;
- Details on what further information the organisation would require to consent to Option 4a; and
- Whether the organisation holds any existing studies or modelling data that could allow further investigation on the potential implications on downstream flood risk.

Stakeholders were provided with a copy of the draft feasibility report prior to providing feedback, however it is noted that the report did not include chapters 6 (outline design) or 7 (next stages) at that stage.

The following sections summarise the feedback from the various organisations. A section is also included on views from internal specialists within RSPB as to what further information may be required for the project to progress to the next stages. Feedback was not received from SNH regarding non-wetland designated features, The Highland Council or Network Rail within the project timescales.

7.2.1 RSPB

RSPB have provided feedback and comments throughout all stages of the project, and this section discusses only those items which are out with the scope of this study and could be addressed at the next stages of the project.

In a similar manner to SNH, RSPB consider that more detailed information on the effects on each of the qualifying/ notified features will be required in order to inform a Habitats Regulation Appraisal (HRA). They have also suggested that assigning a level of confidence to the predicted effects and justification for why effects have been predicted would be useful. For predicting changes in bird populations, a more detailed assessment should make reference to what is driving the change and address different stages, for example nesting, feeding, wintering. It was noted that it would be useful to have the changes in NVC communities mapped and quantified. For hydrological changes, it would be useful to gain an understanding of the relative importance of groundwater and surface water in maintaining groundwater levels within various parts of the site, and which internal ditches are the most important ones to block.

It is noted that RSPB's invertebrate specialist confirmed that for most of the species within the invertebrate assemblage notified feature, the supporting conditions of these species and the locations they are found within the reserve are unknown.

RSPB's archaeologist confirmed that the significance of the manmade features in the floodplain will need to be determined at the next stage of the project, to inform an Environmental Impact Assessment if required. They also note that Historic Environment Scotland should be consulted about the proposals to determine whether they have any concerns from a setting perspective regarding Ruthven Barracks (Scheduled Monument).

7.2.2 CNPA

The CNPA is supportive of RSPB's long term aspiration for Insh Marshes, citing potential benefits for wildlife (including Cairngorms Nature Action Species), flood reduction, water provision, recreation and livelihoods. They consider that on-going maintenance of flood banks is not a long term solution or good use of resources. The CNPA is supportive of Option 4 in theory as long as flood risk is carefully assessed so that there is no increase at Kincraig, and note that Options 4b and 4c may offer a cautionary approach and opportunities for more detailed assessment and monitoring. The CNPA is also supportive of Options 5, 6 (as long as this is limited to low energy reaches), 7, 8, 9 and 10a. If Option 10b was progressed, they would want confirmation of the effect on the dilution of the discharge from Insh WWTW, noting that there have been new FWPM populations in the upper reaches of the Spey catchment which are sensitive to elevated nutrient levels.

The CNPA are supportive of the options selected for outline design, particularly as these are pilot-scale schemes that can subsequently be monitored. They suggest that Option 8 should also be considered for the Raitts Burn and River Tromie (note that the stakeholders had not seen chapter 6 of the report when providing feedback). For the project to progress to the next stages CNPA would want to see a full flood risk assessment for the option(s) to be taken forward that concludes that there will be no increase in flood risk to properties upstream, downstream or adjacent to Insh Marshes. They would also want to see details on archaeological impacts and suggest that a watching brief could be used when works undertaken.

7.2.3 SEPA

SEPA is supportive of the options selected for outline design, and note that the study has highlighted how the various roles that SEPA has can affect the preferred options:

- The morphological team prefers options for embankment removal/ breaching (Option 4 and 5) and those that provide morphological improvement to the tributaries (Option 8);
- The flood risk team note that their least preferred options are the ones with the greater negative effect on flooding (Options 3 and 4a).
- The WEF team prefers options that improve the WFD classification class on downgraded water bodies (e.g. Option 4).

When considering all these viewpoints, SEPA's overall preferred options are 4b or 4c. SEPA note in their feedback that any application for SEPA funding for next stages would have to demonstrate that RBMP2 objectives are being addressed and that the project fits within rural morphology policy. It is suggested that this is discussed with a WEF case officer.

The flood risk team accept that appropriate methods and approaches have been used and consider the baseline modelling to be adequate for the purpose of comparing the effects of different options on flood risk. They noted that while none of the options are entirely negative or entirely positive with regards to flood risk, most of the changes (whether positive or negative) are of a small magnitude. The flood risk team suggest that changes to the flood regime of the area throughout the last 100 – 200 years have been more significant than those predicted for the options outlined. It is their feeling that the predicted change of to flood risk for the 'middle ground' options (i.e. not option 3 or 4a) is on a par with the current natural cycle of processes in the marshes area and similar magnitude of effects could be possible under a 'do nothing' scenario. The flood risk team therefore do not have concerns about the options selected for outline design.

7.2.4 SNH

SNH's comments relate to the designated wetland features only. Comments on the other designated features at the site were not received within the timescales of the project.

SNH note that restoration of a more naturally functioning flood regime has the potential to be beneficial for the wetland habitat features. However it is also noted that, given the complexity of the site and the number of different designated features, it is possible that some options may benefit some features and disadvantage others. SNH state that it will be necessary to consider the potential effect of the proposals on each of the qualifying features and that it is likely that all options will require a HRA. The assessment would need to cover both the construction phase and the operational phase (i.e. conditions once the option is in place), and how the works will be phased.

SNH's feedback provides some information on what would be required to inform the HRA. A more detailed assessment of the effects on the qualifying features, and their component communities, will be required. However, it is noted in the feedback that during the work undertaken to establish eco-hydrological thresholds for maintaining good ecological condition for Scottish wetlands, it was considered that there is not yet sufficient data to set separate guidelines/ thresholds for a number of the wetland typologies. It is also suggested through the feedback that the detailed assessment will need to provide a justification for all of the predicted effects and consideration of flood duration (note that comments are made on duration in section 4.2.1). Cumulative effects of combinations of options (if proposed) should be considered and plans for hydrological and ecological monitoring will be needed.

Comments were provided on individual options, and several queries were raised. For option 3 it is queried whether there would be negative effects on swamp communities in unit D (*it is noted that there are no* *embankments on the River Spey in unit D and the flood depths are actually slightly increased in this compartment for option 3, which is why no negative effects on swamp communities are predicted*). SNH also highlight that for a number of options the report states that there may be effects on *Carex chordorrhiza* but the assessment does not stipulate whether these will be positive or negative.

7.2.5 Spey Catchment Initiative

It is noted that this feedback represents the views of the Spey Catchment Initiative project officer and does not necessarily reflect the specific views of individual partner organisations.

The Spey Catchment Initiative supports RSPBs long term aspiration for Insh Marshes as it will create a more naturally functioning watercourse, contributing to NFM and resilience building for future predicted climate change. Options 1, 2 and 3 are highlighted as being unrealistic in light of current Scottish Government policies, best practice and climate change predictions. It is considered that Option 4a, 6, 8, 9 and 10 together would fully restore the floodplain within RSPB holdings, but may require unfeasible groundworks that may not give sufficient value for money.

The project officer suggests that a high proportion of the benefits could be realised from a combination of Options 5, parts of 6, mix of 7/ 8 and elements of Option 10. Their preferred approach for tributary restoration would be to implement Option 8 as much as possible, working up from the confluence with the Spey, and reverting to Option 7 where Option 8 is not feasible. They note that Option 9 has limited benefit as a standalone option but could enhance a large funding package by addressing related issues and bringing in other parties (e.g. Scottish Water).

It is suggested that options to restore more natural floodplain conditions in proximity to the A9 embankments could be investigated, although it is acknowledged that this would need to be incorporated into the A9 dualling project. For example, the potential to install culverts through the A9 embankment to connect Ruthven North (unit A) and Ruthven South (unit B) during flood events could be assessed. It is also suggested that comparing the impact of the options to baseline conditions for a known flood event (e.g. December 2015 events) or by linking the results to water levels at key infrastructure would aid public engagement. Quantification of the actual level or flow at which flooding occurs for receptors between Kingussie and Aviemore is also highlighted as being useful for public engagement.

They are supportive of the options selected for outline design to an extent but suggest that it may be easier to plan 'big' and downscale later if needed. They agree that the focus should be in the mid and lower sections of the reserve while the A9 dualling project is on-going in the upper part of the reserve. It is suggested that the focus should be on restoration of a whole section of the floodplain taking into account both banks, drainage and tributaries, and on this basis they would like to see the following scheme:

- Investigate Option 8 for the lower end of the Tromie and reconnections with Invertromie Fen;
- A modified version of Option 4c by undertaking enhanced breaching through units L, M and H;
- Carrying out Option 6 where appropriate;
- Undertaking Option 8 for Raitts Burn; and
- Undertaking Option 10a for units H (and potentially L and M).

7.2.6 Spey Fishery Board/ Spey Foundation

The Spey Fishery Board/ Spey Foundation is supportive of RSPB's long term aspiration for Insh Marshes, and regards floodplain restoration as one of the highest priority actions that could help mitigate against increasing frequency of high flow events in the Spey catchment. They note that the project provides an opportunity to ameliorate, to some extent, the detrimental impacts of catchment drainage. The key concern of the Spey

Fishery Board/ Spey Foundation is the impact of the options on downstream flows, and they provided information on a study that the Spey Foundation published on the impact of spate flows on the Spey (Shaw, 2015). They also note that they would be interested in working with RSPB to progress the delivery of Option 4a.

The Spey Fishery Board/ Spey Foundation could not support Option 3 on the basis that it maintains historic detrimental management practices with the direct impact of increasing peak flows downstream for most flood events. They comment that Option 4a appears to provide the best retention of water and reduction in peak flows across the most frequently occurring flood events. Whilst a small increase in peak flow is predicted for the most extreme events analysed, 0.5% AEP flood event, these events are likely to have significant impacts on the river regardless of which options are implemented. Whilst the Spey Fishery Board/ Spey Foundation acknowledge the merits of Option 4b as a pilot scheme, they note that it would be missed opportunity if this was the only restoration work carried out at Insh Marshes. In that respect they consider Option 4c as a worthy aspiration for the project.

The Spey Fishery Board/ Spey Foundation is also supportive of restoration of the Raitts Burn, which it is noted can only be achieved through removal of the embankments, but question whether Option 5 could deliver the changes needed for the WFD.

With regards to the options selected for outline design, the Spey Fishery Board/ Spey Foundation note that any proposals to alter the lower reaches of the River Tromie would need to consider the requirement to maintain fish passage. This is a concern arises due to the regulated flow regime of the River Tromie, and how this could affect water depths in a multi-thread channel. Comments regarding this concern have been included in section 6.3.2.

7.2.7 Transport Scotland

Transport Scotland note two aspects of the potential options which could affect the existing operation of the A9 and the dualling of the A9, which are:

- Treatment of the embankment at Ruthven North (unit A); and
- Potential impact on the A9 from measures on the Raitts Burn.

Transport Scotland states that if the embankments in unit A are restored, the existing drainage mechanism (i.e. the culvert through the flood embankment) should be maintained to avoid prolonged duration of water impounding against the A9 embankment. If the embankments are removed or allowed to fail then the implications on the A9 need to be considered to ensure that the risk to the A9 embankment would not change. They note that a number of the options could increase flood depths or durations in units A and/ or B, and that increased floodplain velocities are predicted for Options 1 and 4a which could increase erosion potential to the A9 embankment. Transport Scotland highlight that the potential impact of restoration works on the A9 embankment will depend upon the design of the dualling at this location, and that these works may provide opportunities to support RSPBs objectives.

Transport Scotland highlight that any works to restore Raitts Burn will need to consider the implications for the A9, for example arising from upstream incision. They note that if a potential impact on the A9 is predicted, replacement of the existing A9 crossing over the Raitts Burn might allow for any mitigation to be incorporated into the design.

7.3 Next Stages of Project

This section provides more general comments about taking the project forward in light of the stakeholder feedback, and mainly relates to further consultation to define the scope of work required to allow the project to progress. The next stage for each of the two pilot schemes are described in sections 6.2.2 and 6.3.2, and the next stages to progress works at Raitts Burn are described in section 6.4. Funding opportunities for the next stages of the project are already being considered by RPSB, and it is recommended that early discussions are held with WEF case officer.

The feedback received suggests that the majority of organisations are supportive of creating a more naturally functioning floodplain system at Insh Marshes. The feedback also suggests that they are supportive of the options selected for outline design and of the approach to use these as pilot schemes to further understand the potential effects through more detailed assessment and monitoring. However, a number of organisations note that on their own these pilot schemes will not achieve RSPB's ambition of restoring a more naturally functioning floodplain system across Insh Marshes. The 'middle ground' options seem to gain the most support due to lower magnitude of change, and therefore risk. Consultation with the organisations that were unable to respond within the project timescales, and Historic Environment Scotland, is recommended.

Feedback from the stakeholders, and from RSPB, highlights that the next stage of the project will need to provide more detail on predicted effects to flood risk receptors and for each of the qualifying features that make up the various statutory designations.

The Spey Catchment Initiative provided useful suggestions of how to assess flood risk change in a way that could be meaningful for the public and it is worth considering this approach in the next stage of the project. None of the organisations provided information on whether they hold topographic survey or river model data between Kincraig and Aviemore, and it is recommended that Transport Scotland and THC are approached again with this request. To assess risk to individual properties in more detail, topographic data at the property location would be required and the model may need adjusting or extending to allow this assessment to be undertaken. Given SEPA's flood risk response, it would be worthwhile having a meeting with representatives of the flood risk teams from SEPA, THC and CNPA to discuss the magnitude of the predicted change in flood risk further and develop a consensus as to whether further modelling and assessment of flood risk is needed. If it is deemed to be necessary, agreement should be sought on the scope of the assessment and what level of change would be considered to be negligible compared to the natural variability of the river system through Insh Marshes.

There are a number of potential obstacles to providing a detailed assessment of predicted effects for each qualifying feature to inform a HRA. There is currently a lack of detailed information about the spatial distribution and frequency of certain species in the reserve, for example invertebrates. The NVC mapping has not been renewed in recent years, though undertaking such a survey would form an important baseline for monitoring of the proposed works. There are also gaps in the current research and understanding of the supporting conditions of some of the qualifying species. This is acknowledged both by RSPB's invertebrate specialist and through SNH's comments on the eco-hydrological thresholds. The complexity of the hydrological system at Insh Marshes also contributes to uncertainty in predictions in effects on wetland habitats. It is therefore questionable whether the change in NVC communities could be quantified with any certainty. Finally, the modelling undertaken for this feasibility study was appropriate for assessing potential change across a large area, for a range of variables (flooding, morphology, ecology) and a range of options. The model may require refining in the area of interest to provide a higher level of detail for a more detailed ecological assessment, for example by using a smaller grid and consideration of including drainage ditches. This would need to be complemented by existing data, where available, on groundwater levels and regime.

SNH note in their feedback that it is likely that many of the proposed options may have positive effects for some qualifying features and negative effects on others. It is our opinion that this is likely to be the case, and may be unavoidable. It is recommended that further consultation is carried out with SNH prior to the next stages of work commencing to try to come to a consensus regarding what may be an acceptable level of change in the qualifying features and an acceptable level of uncertainty. Documenting the existing information on distribution and supporting conditions for each qualifying species will highlight the knowledge gaps and inform the level of assessment that would be possible, and would be useful to inform the discussions with SNH.

REFERENCES

CEH (2008). *Flood estimation handbook (five volumes)*. Wallingford: Centre for Ecology & Hydrology.

CEH (2009). FEH CD-ROM 3 (Software). Wallingford: Centre for Ecology & Hydrology.

CEH (2016, January). Briefing Note: Severity of the December 2015 floods - preliminary analysis.

Cuthbertson, R. H., & Partners (1990). *Flooding in Badenoch and Strathspey Final Report Volume I*. Edinburgh: Cuthbertson and Partners Consulting Engineers.

Environment Agency (n.d.). The Fluvial Design Guide. Retrieved from http://evidence.environment-agency.gov.uk/FCERM/en/FluvialDesignGuide.aspx

Kjeldsen, T. R., Jones, D. A. & Bayliss, A. C. (2008). *Improving the FEH statistical procedures for flood frequency estimation* (No. SC050050). Bristol: Environment Agency.

MWH Soft (2011). InfoWorks RS.

NLS (n.d.). Map images. Edinburgh: National Library of Scotland. Retrieved from http://maps.nls.uk/

RCAHMS (n.d.). National Collection of Aerial Photography. RCAHMS. Retrieved from http://ncap.org.uk/home

Shaw, B. (2015). *River Spey flows, spates and impacts on rod catch*. Spey Foundation. Retrieved from http://www.speyfisheryboard.com/wp-content/uploads/2016/01/Spey-flows-and-spates.pdf

SNIFFER (2009a). *WFD95: A Functional Wetland Typology for Scotland; Project Report*. Edinburgh: SNIFFER.

SNIFFER (2009b). *Environmental Supporting Conditions for Scottish Wetlands - Phase 1* (No. WFD35). Edinburgh.

Sniffer (2014). *Regulatory standards for Scottish and UK upland wetlands (in publication)* (No. ER37). Glasgow: Sniffer.

Spey Foundation (2014). *Electrofishing Survey of the Rirver Spey Summer 2014*.

WHS (2009). WINFAP-FEH 3 (Software). Wallingford: Wallingford HydroSolutions Limited.

APPENDICES

A DATA REVIEW

A large volume of data and literature for the Insh Marshes NNR exists and has been provided by RSPB. This data has been reviewed and is summarised in Table A1. Data provided by SEPA is also noted in Table A1. The relevance of the various reports and dataset to the current feasibility study is discussed below.

The existing hydrological understanding of the site is based on several key studies (e.g. items 14, 29, 37, 42) which have investigated groundwater levels, fluctuations and water sources to describe a conceptual water budget for the site, and the influence of conditions at the Spey-Feshie confluence on water levels of the River Spey through the NNR. Earlier reports (e.g. items 28, 36) are less relevant due to the availability of more up-to-date data and revised methods of undertaking hydrological assessments.

Reports relating to the flood alleviation scheme proposed in 1990 in response to the flooding in 1989 and 1990 provide a wealth of information with respect to the history of flooding and channel change/ modifications. These reports also provide useful information regarding the predicted influence of the downstream control at the Feshie confluence.

The previous topographic surveys are in paper format and are therefore of limited use to the current study. The LiDAR data provides high resolution coverage of the whole of the floodplain area which until now has been difficult to achieve due to the size and accessibility of the marshes.

There is a large body of ecological data for the NNR. The NVC vegetation data is not particularly recent and there is a lack of recent data on rare plants, or of algae, mosses, liverworts or fungi. There is limited data available for mammals, amphibians, reptiles and recent invertebrate data for the lochs, river and soil. However, this is not of particular concern for this study.

Table A1: Data Review Summary

Item no	Name	Author	Date	Format	Summary
1&2	combined_habitats simplehabitatmap2	-	-	ArcGIS	Vegetation mapping for most compartments. Excludes much of Lynchlaggan, Dell of Killiehuntly wetland, Invertromie Farm, Dell of Killiehuntly Farm, Invertromie Woodland and part of Invertromie Fen compartments.
3	Reedbed re-mapping at Insh Marshes RSPB reserve 2012	Claire Rickerby	2012	PDF report, plus transect data as excel file	Reedbed mapping done in 2012 - extent of Phragmites. Reed has increased on the reserve in the areas surveyed by 5.43ha, the few areas where it has decreased are more than outweighed by the increase elsewhere resulting in an overall percentage increase of 15%. The increases are greatest on Coull fen and Lynchat fen. There are differences in expansion and in community change between the compartments. Areas of reedbed decline associated with increased grazing. Aerials and detailed transect data provided.
4	Site Condition Monitoring of Fen, Marsh and Swamp Feature at River Spey - Insh Marshes SSSI	Alistair Headley (SNH commissioned report)	2012	Word report	Survey carried out in summer 2011. Raw data provided (includes measurement of water table for each feature; % open water and % bare ground also recorded for some samples). The flood-plain fen feature passed eight of the 12 targets for the fen habitat. Common reed too high and positive indicators either too few or cover too low in some communities. Most of these missed targets can be regarded as technical failings as they are within the limits of error of the methods used. Apart from these technical issues there are no signs that there are any threats to the flood-plain fen habitat at this site where management is favourable for maintaining the interests of this feature. Much of the fen vegetation is dominated by swamp communities, in particular S9 and S27. S27 and M27 plant communities fail on not having the requisite number of appropriate positive indicator species at a sufficiently high frequency in their respective communities.
5	Report on the Plant Communities of Part of the Insh Marshes SSSI for Scottish Natural Heritage	Dr Theo Loizou (for SNH)	1997	PDF, scanned document, appendices not included.	Survey carried out in summer 1996. 12 areas not surveyed by Fojt in 1988. >50 NVC types recorded in swamps, poor-fens, mires, scrub, woodland and grassland. Most widespread types were S9b, S10b, S11b, S11c and S27a. Some vegetation not easily attributable and may be unique. Much intergradation. Locally abundant populations of the rare Carex chordorrhiza (S27a variant i). The rare Calamagrostis purpurea recorded locally on Dunachton Fen (mapped). Includes a section on swamp habitat where water levels and water flow are discussed. Apart from S8 all the swamp types were grazed. Other NVC types also have sections on habitat. Descriptions of the 12 sites also provided.

Item no	Name	Author	Date	Format	Summary
6	A vegetation survey of the Insh Marshes SSSI	Dr Wanda Fojt	1989	PDF, scanned document	Survey carried out in summer 1988. Seven areas surveyed. Sketch maps provided. NVC used but this would have been in its early days, before the books were published. There was true community differentiation between the peripheral areas and the floodplain mire expanse but only a limited degree of community differentiation within the floodplain mire expanse. The peripheral areas are higher and experience less prolonged flooding. Drainage, burning and grazing were preventing development of a bryophyte layer. Floodwaters retained on the marsh by the embankments. Sphagnum islands discussed. Guiding principles for management provided with respect to hydrological conditions. Changes in these (alterations to drains and drainage) were regarded as the biggest threat to the continued development of the marshes after past management practices. Area descriptions provided in Appendices.
7	NVC data	David Wood	1998	ArcGIS	NVC vegetation mapping, excludes Ruthven North, Ruthven South, Dell of Killiehuntly Farm, Dell of Killiehuntly Wetland, and part of Lynchlaggan compartments.
8	Ditch invertebrate survey of Insh Marshes RSPB reserve	Andy Godfrey (for RSPB)	2006	PDF, scanned document (p2 methods missing).	40 sample points on Insh Fen and Balavil Fen prior to ditch management (and dredging elsewhere). Survey carried out in 2005. Rich in aquatic invertebrates, some may have entered ditches from flood water. Some notable species. Detailed environmental variables recorded. Management recommendations for invertebrates on the fen and in the ditches are presented. No measurement of ditch water levels but provides average ditch widths in Insh fen (1.9m) and Balavil (1.3m).
9	Eel Fishing in the River Spey and Loch Insh	Philip D. Bloor	1988	PDF, scanned document	Eel fishing in Loch Insh, River Spey and some drains in 1988 (6th year fished and 2nd year monitored). Wildfowl disturbance monitored. Eel catches recorded ('yellow' and 'silver' presumably referring to different stages of the life cycle as all are Anguilla anguilla (silver are smaller, yellow are prey for birds)). No silver eel run in 1988. Air temperature and water level data for fishing dates presented. Concern about overfishing as weights of eels decreasing. Concerns over pesticide Dieldron.

Item no	Name	Author	Date	Format	Summary
10	The Effects of Management Regimes on Plant Species Richness within Drainage Channels of the Insh Marshes	Alice Sedgwick	2002	PDF, scanned document. BSc thesis	Fieldwork done in 2001. 84 sample sites on a wide variety of drainage channels. Number of years since most recent management is the dominant variable affecting plant community composition (greatest diversity soon after dredging, although this result is not statistically significant). Depth and width also important. 25yr rotational management cycle recommended to prevent succession and maintain diversity. 20m stretches on alternate banks. Drainage channels important as wet fences for grazing animals that maintain suitable sward structure for birds; also habitats in their own right. Includes literature review - notes that smaller ditches contain species similar to the adjacent fen and larger ditches contain a floating aquatic plant community, including nationally rare Nuphar pumila. However, some differences between fens on the site. Plant data and environmental data collected. Useful timelines of past management presented. Raw data provided.
11	Experimental investigation of the response of the String Sedge *Carex chordorrhiza* to changes in water depth in summer	Colin J Legg, Neil R Cowie & Alistair Hamilton (SNH report)	1995	PDF, scanned document	Controlled experiment July to October 1994. Concluded that Carex chordorrhiza does not withstand prolonged inundation. Growth is retarded in drier areas. It is postulated that the plant would not survive significant alterations in the water levels on the site. Needs investigations in spring and early summer though. Main threat likely to be from drainage or lowering of the water table rather than from flooding. Raw data provided.
12	Fisheries Research Services Report No 14/91 River Spey Juvenile Survey 1990	R Laughton (for The Scottish Office Agriculture and Fisheries Department)	1991	PDF, scanned document	Distribution and population densities of salmon and trout in the upper Spey catchment in 1990 (further work on the lower catchment to be undertaken in 1991). 64 sites electrofished (38 done three times to calculate population density). Sites on tributaries of the Spey in the area of the Insh Marshes and into Loch Insh. Low densities of salmon recorded on lower Tromie, notes that this location of the Tromie had been recently bulldozed.

Item no	Name	Author	Date	Format	Summary
13	GIS Analysis of the relationships between wader distributions, vegetation structural characteristics and stocking densities, Insh Marshes	Robert McMorran	2003 or 2004	PDF, scanned document. MSc thesis	Focus on snipe, redshank, lapwing and curlew. Fieldwork undertaken in July 2003 only so a snapshot - five years or more would have been better to tie in with other datasets. Includes literature review. Variables of particular importance to breeding wader success include water table depth, soil surface wetness (penetrability) and amount of flooding/surface water in early spring. Flooding can lower prey densities and can kill the sward, with knock-on effects on prey. However, the effects are complex and different for different species. Spatial and temporal hydrology are of fundamental importance for wader management. Grazing important and complex relationships with waders in connection with flooding, vegetation preferences, trampling damage etc. GIS used to analyse these relationships. No field data or other datasets collected on water levels or hydrology in general. Notes that compartment corners and edges wetter than the middle in late spring and summer as evapotranspiration rates were higher in the middle and ditches kept edges wet.
14	Hydrological and hydrochemical conditions characterising *Carex chordorrhiza* L. fil. (String Sedge) habitat in a Scottish riverine floodplain wetland	Michael P. Kennedy, Kevin J. Murphy	2003	Journal article, scanned document	Requirements are moderately reducing hydrosoil conditions and near constant shallow inundation. Vegetation (NVC) and groundwater (water level gauges) data collected in the field over 2 seasons (1998 and 1999). Data on Carex chordorrhiza plants also collected. Generally associated with S9b community. Is experiencing intermediate levels of environmental stress. Has rapid shoot elongation after winter flooding. Concludes that species has a narrow ecological niche.
15	Hydrological-ecological interactions: the Insh Marshes	Professor Geoffrey E. Petts, Dr Andrew R.G. Large and Dr Robert Wilby (Loughborough University)	1991	PDF, scanned document	Considers the hydrology and ecology of the marshes and defines the 'normal' flow regime considered necessary to maintain the important ecological characteristics. Desktop analysis of flow data from 4 gauging stations and a synthesis of the data to estimate the flow regime through the marshes (FDC). Also field survey of surface water levels (winter) in relation to vegetation communities and synthesis of ornithological and other ecological records. Groundwater levels also collected later in summer. All fieldwork done in 1991. Use of 'describer' species. Autecological requirements presented graphically. The marsh is flooded for about 150 days a year on average due to inundation from the Spey and relatively slow drainage. Further research could include a linear model for the marsh-loch system.

Item no	Name	Author	Date	Format	Summary
16	Economic appraisal of the social, economic and environmental benefits of the Insh Marshes floodplain	Ian Dickie (RSPB)	2001	PDF	Calculates economic value of the marshes, considering tourist spending, outdoor recreation, quality of life, education, agriculture, fishing, flood defence benefits and water quality/ resource benefits.
17	Insh Marshes - Its hydrology, Multiple Uses and Economic Value	RSPB Scotland	2002	PDF	High level overview of the site, including ecological characteristics and conceptual understanding of hydrological regime based on previous research (described elsewhere in this list).
18	Insh Marshes Whooper swan survey 1995/6	Damon Bridge	1996	PDF, scanned document	Winter visitors - forage on wetland vegetation. Fieldwork done in 1995/96. Focus on Balavil swans. Significant relationship between distribution and vegetation type. Mostly in S9 and S10. Centres of compartments favoured as less disturbance.
19	Investigating the impacts of grazing on the distribution of breeding waders at RSPB Insh Marshes Reserve, Strathspey	Chris Robinson & Claire McKeever	2003 est.	PDF, scanned document	Grazing and topping vegetation is the main management for waders. Cut vegetation not removed unless taken away by floodwaters. Grazing data from 1997-2003. Contains NVC maps of whole reserve. Grazing intensity significantly determined the numbers of all breeding waders apart from curlew but habitat type was the strongest predictor of distribution. Grazing monitoring recommended, along with measuring the productivity rates of breeding waders. Topping management to be looked at as a separate project.
20	Monitoring of Soil Invertebrates of Lowland Wetland RSPB Reserves - a brief interim report for reserve staff	Unknown	Unknown	PDF, scanned document	Low numbers of earthworms in samples but only wet areas possible to sample and these generally have lower numbers. Tussocks seen as important refugia for invertebrates. Further survey recommended.
21	Monitoring of the eel fishery within the River Spey-Insh Marshes SSSI	David Pullan	1986	PDF, scanned document. Maps not legible	October to November 1986. Autumn of 1985 7 tonnes of yellow eels caught (all nets in Loch Insh). In 1986 nets were deployed upstream of the loch and at the downstream bridge at Kincraig. Numbers in 1986 well down on previous year. No silver eel run. Arctic charr also caught as bycatch.
22	NCC - The National Importance of The Insh Marshes, Scotland	W.Fojt, K. Kirby, I. McLean, M. Palmer, M. Pienkowski	1987	PDF, scanned document	Definitive description of the site in response to threat to drain the fen at Balavil

Item no	Name	Author	Date	Format	Summary
23	NCC Spey Valley Loch Survey	Elizabeth Charter	1987	PDF, scanned document	Standard freshwater botanical loch surveys of a number of waterbodies along the Spey and on the marshes, including Loch Insh. Fieldwork done summer 1987. Additional echo-sounder survey. Sections on geology, land use, water chemistry and pathways, fauna. Plant species lists provided for each waterbody but no vegetation maps.
24	Scrub Encroachment at Insh Marshes	Jonathan G.W. Hodge	1993	PDF, scanned document	Spread of willow scrub since 1946 from aerial photographs. 1946 - 1964 little increase in scrub on the marshes. 1964 - 1975 large increase in extent and density of scrub on the marshes. 1975 - 1989 scrub continued to expand at a lower rate. Main Insh area of marsh the worst affected. Balavil and Gordonhall not so bad. No conclusions reached as to whether the increase in scrub is due to changes in hydrology or management.
25	Survey of the Aquatic Invertebrates and Fish communities in the Insh Marshes lochans	John J. Breslin (for SNH)	1993	PDF, scanned document	Electrofishing, angling and gill netting in the marsh lochans in August 1992. Map provided. Timed hand net sweeps of invertebrates. Pike, eels, trout and lamprey caught. Lochan invertebrate communities typical of fens and marshes. Raw data provided.
26	Flood alleviation in Upper Stathspey Modelling and Environment Study	Various (IoH, for NCC)	1991	PDF, scanned documents. Main report plus key supporting studies (terrestrial plant communities, geomorphology, aquatic fauna	IoH commissioned to assess the potential impact of two proposed flood alleviation schemes at Feshie-Spey confluence on hydrology, geomorphology and ecology of the Insh Marshes and Feshie SSSI's. Main report outlines the flooding concerns and proposed scheme (see item no 32). Hydrological analysis undertaken and hydraulic model set-up using SALMON-F, based on topographic survey sections. Separate hydrological model developed to assess how water moves through the marshes based on water level records in the marshes, in the river and topographic data of the marshes. Both models calibrated. Predicted 0.2m reduction in water levels within marshes at high flow and 0.03-0.04m at low flows with realignment of Feshie at confluence. Predicted 1.55m reduction in water levels at high flows in marshes and 0.50-0.64m reduction at low flows if Spey re-graded according to the proposals. Recommendations made for possible adjustments to schemes. Supporting reports assess potential implications of schemes on ecological receptors. Scheme did not progress as described in this and item no 32, but a smaller scale scheme was implemented in 1992 (see item no. 34).
27	Flood images	RSPB	Various	Photographs	Photographs of various flood events, particularly Jan/Feb 2008. The most recent photographs have locational data embedded into the file.
28	An analysis of the hydrology of Insh Marshes, River Spey, Scotland 1951-1989	Unknown	1989 or 1990	PDF, scanned document	Review of hydrological trends, including consideration of seasonality. Estimates of flows entering Insh Marshes using flow duration percentiles. Relationship derived between inputs to marshes and water levels. Used data from Tromie, Invertruim, Ruthven and Kinrara gauges.

Item no	Name	Author	Date	Format	Summary
29	An investigation into the hydrology of Insh Fen, Coull and Lynachlaggan, Insh Marshes RSPB Reserve in relation to the distribution of *Carex chordorrhiza* and water level management options	Matt Self (RSPB)	2005	PDF	Builds upon work by Gilvear (see item no. 37). Investigates links between important species/ habitats and hydrological regime, especially ditch and groundwater levels in compartment 18 supporting String Sedge. Water levels from gauge boards and 3 x transects of dipwells and piezometers to measure groundwater depth and pressure. Automated stage recorder at breach location destroyed in flood event. Compartment 16, adjacent to Spey, groundwater levels recorded up to 0.6m below surface. In more central parts of fen, groundwater levels consistently close to surface. More marked drop in water levels closer to ditches. Piezometer results suggest some groundwater upwelling in compartment 25 in summer.
30	Completion of the topographic survey of the Insh Marshes	J T Law and R C Johnson	1991	PDF, scanned document	Topographic survey of several areas of site for which none available from the 1950's surveys. Relates to item no. 58
31	Dell of Killiehuntly, Insh Marshes RSPB Reserve. Results of topographical survey and concept for potential wet grassland enhancement	Matt Self and Heather McCallum	2013	PDF	Provides overview of topographic survey undertaken at Dell of Killiehuntly compartment in 2013 (limited in extent). Well-drained improved fields adjacent to Tromie grading into rush-pasture and swamp as enter Spey floodplain. State that current drainage network appears similar to that from 1872. Some recent ditch maintenance. Embankment unlikely to have been maintained in past 40 years. Provides options for water level control/ to make the improved fields wetter.
32	Flooding in Badenoch and Strathspey Final Report Volume I	Robert H Cuthbertson and Partners Consulting Engineers	1990	PDF, scanned document	Commissioned by Highland Council following severe flooding in 1989 and 1990 to propose flood alleviation measures. Provides useful background information regarding flood history and geomorphological change. Describes the 1989 and 1990 events and their consequences in terms of properties flooded etc. Recorded wrack marks for these events provided. Looked at potential for storing more water in upstream reservoirs but dismissed as too costly. Presented a number of non-structural (e.g. development control/ flood warning) and structural flood alleviation measures. Main recommendations focused on Spey-Feshie confluence: regrading of Spey, realigning Feshie to change confluence location. Also recommended repairing breaches. No modelling to assess effectiveness of proposals undertaken and no detailed assessment on potential impacts on SSSI's.
33	Flooding in Badenoch and Strathspey Final Report Volume II	Robert H Cuthbertson and Partners Consulting Engineers	1990	PDF, scanned document	Useful supporting information to item no 32 including photographs of flooding in 1989/ 1990 and various mapped outputs.

Item no	Name	Author	Date	Format	Summary
34	Geomorphological and hydrological changes at the River Feshie/ Spey confluence and Insh Marshes SSSIs	Alan Werritty, Trevor Hoey and Andrew Black (for SNH)	1999	PDF, scanned document	Describes the revised flood alleviation scheme that was implemented in 1992 - excavation of flood alleviation channel to north of islands in Spey at Feshie confluence and repairing flood banks on western side of Feshie which had failed in 1990. Report investigates impact of these works on both SSSI's. Provides an overview of the geomorphology of the Feshie alluvial fan. Topographic survey of the Spey between Kincraig bridge downstream of confluence - provided in the report. Bed steepening starts ~ 1.6km downstream of bridge. Compared hydrological data (flows and levels) pre and post-1992. Found that changes were within the natural variability arising from the changing bed control at the confluence and no significant effect of the works detected in terms of influence on the marshes. May have been mitigated through aggradation since 1992.
35	Hydrochemical and water source variations across a floodplain mire, Insh Marshes, Scotland	Ian C Grieve, David J Gilvear and Robert G. Bryant	1993	PDF, scanned document	Linked to research described in item no. 37. Testing of samples taken from a transect through Insh fen suggested hillslope water sources important at edge of fen (shallow groundwater high acidity and enriched with DOC). A zone of base-rich shallow groundwater identified, suggesting upwelling of groundwater. Closer to Spey, base poor shallow groundwater - suggests inflow from Spey. Useful conceptual diagram in Figure 7.
36	Hydrological restraints on the management of the Loch Insh Marshes	I R Smith and A A Lyle	Unknown	PDF, scanned document	Focus on large-scale hydrological aspects of site ie. not ditch level. Water level data from Kincraig, Ruthven and Tromie gauges reviewed, plus data from two gauge boards. Flood frequency analysis using Gumbel extreme value distribution. Conclusions made regarding flood frequency, rate of decline of water levels and low flows - these will be superseded by more recent data and methods. Comparison between water levels in Loch Insh and Main Drain - loch levels generally representative of levels in lower marsh, but at low flows levels in main drain can be higher than those in the loch. Some recommendations for water level control made. Notes that gravel deposits at Feshie confluence have control on water levels upstream - estimates that removal of gravel at confluence could reduce low water level in loch by ~1 foot. Note that used to be a flap valve at bridge at lower end of main drain, no longer there.
37	Hydrological survey of the Insh Marshes	David J Gilvear (for RSPB)	1994	PDF, scanned document	Key report on hydrological regime of marshes, often quoted in other reports. Provides overview of inputs and outputs from marshes. Monthly water levels presented for 1975-89 with precipitation, PE and effective precipitation. Summarises ATM research (item no. 45) and hydrological transect in 1993 in Insh fen. Water table dips towards Spey - suggests groundwater outflow to Spey in summer, and that hillslope inputs must be an important input. Plotted ditch flow directions - note that this is a snapshot in time and flow directions will depend on relative water levels in different parts of site/ Spey/ main

Item no	Name	Author	Date	Format	Summary
					drain etc. Hydrochemistry described - see item no. 35. Groundwater upwelling seems to be occurring at some locations. Makes some recommendations with regards to control structures.
38	Implications of a flood alleviation scheme for the conservation and management of the Insh Marshes, Invernesshire	Claire Forrest	1991	PDF, scanned document. MSc thesis	Two aims - relationship between hydrology and flora/fauna, and likely effects of the proposals for a flood alleviation scheme on the Feshie/Spey confluence (downstream of Loch Insh) - as presented in Cuthbertson report (item no.32). Flooding data from 1991 presented. Groundwater monitoring carried out (raw data provided). Predicted effects of the proposed scheme would be to dry out the marshes, especially in summer, due to a reduction in the frequency and duration of flooding and an increase in drainage (the gradient would increase). The whole of the Spey from the Feshie confluence to 10km upstream treated as one hydrological unit. Vegetation communities would be affected - analogous examples from the literature are provided. Effects on fauna described in more general terms. Cuthbertson report did not address any effects further downstream. 'Wise use' of the wetland is promoted - this pre-dates sustainability and making space for water, natural flood management etc.
39	Insh Weather Records 2000 - 2012	-	-	Excel	Rainfall, water level and temperature data 2000 - 2013. Already processed into monthly average, minimum and maximum values
40	Levels 1991 memo	Zul Bhatia	1991	PDF, scanned document	Memo regarding transparencies with contours for site. Not useful in current study.
41	Rainfall, temp & water level 1973 - 1999	-	-	Excel	Rainfall, water level and temperature data 1973-1999. Already processed into monthly average, minimum and maximum values
42	Water level variations along the River Spey between Loch Insh and the Feshie confluence	Professor G. E. Petts, Dr D.J. Gilvear and Dr A.R.G. Large (for NCC)	1990	PDF, scanned document	Topographic and field survey in 1990 when water levels of Spey above bankfull. Topographic survey included profiles across the alluvial fan, and also of the water slope of the Spey. On day of survey (4th March 1990) negligible gradient for 550m downstream of Kincraig bridge with main break in slope ~230m upstream of confluence. Morphological control will be upstream of this break. Data provided. Reviewed hydrological data with respect to the recent flood events. Suggest that these are more likely a result of hydrological variability than due to changes in Feshie confluence. Feshie controls levels in Spey for ~10km upstream due to gravel deposits maintaining a high bed level, alluvial fan acting as a significant constriction on the floodplain, and floodwaters of Feshie restricting flows on Spey during flood events.

Item no	Name	Author	Date	Format	Summary
43	Levelling Survey River Spey and Insh Marshes	Halcrow (for SNH)	1993	PDF, scanned document	Describes the long sections as detailed in item no. 57
44	Supplementary Report to Report on Flooding in Badenoch and Strathspey	Robert H Cuthbertson and Partners Consulting Engineers	1991	PDF, scanned document	Follows on from item 32 and 33. Report details outcomes of stakeholder meeting Jan 1991 about proposals to re-grade Spey at Feshie confluence and realignment of Feshie across lower fan. States NCC accepted in principle a scheme to realign the Feshie but not re-grading of the Spey. No agreement on the solution reached therefore modelling and environmental impact assessment to be undertaken (see item no. 26).
45	The use of remotely sensed imagery for mapping wetland water table depths; Insh Marshes, Scotland	Dr David Gilvear and Dr Alistair Watson	1995	PDF, scanned document	ATM imagery from 1992. Representative transect of piezometers. 60 open augur holes. Aim to determine spatial variability in water tables. Will aid the setting up of a hydrological monitoring scheme. Elevation of the floodplain does not account for differences in water table depth - areas close to waterbodies were wetter, as if they are a water source. Surface dips towards the River Spey, with dips and rises associated within internal drainage ditches. Adjacent hill slopes considered to be important water sources. A reasonable relationship between ATM reflectance and ground-truthing was obtained. Raw data, maps and technical information provided.
46	Insh Marshes management plan 2009 - present	Karen Sutcliffe (RSPB report)	2009	PDF, plus associated maps in PDF/ jpeg format	Overview of all aspects of the NNR, including geology and soils, hydrology, ecology etc. Provides useful map overview of the existing conditions. Current issues and constraints detailed, including the focus of the current study. Notes issues for A9 road embankment from scour on north side and erosion of Balavil flood banks which may prevent access along a wayleave in future. Current condition of features described and main factors affecting them detailed. Long term vision provided, and objectives for future management.
47	Insh Marshes Management Work 2005 to 2014	-	-	Word document with maps	Maps of various management practices carried out across the reserve between 2005 and 2014.
48	Insh Marshes Case Study The First Twenty Five Years	Fiona Rout, Dave Beaumont, Paula Fraser, Les Street, Tom Prescott	1998 or 1999	PDF	Describes early approach to management by RSPB (excluding grazing, tree planting, digging of pools) and change to current management where focus is on maintaining a diverse sward structure through grazing and topping. Scrub clearance being undertaken. Useful information to provide overview of site and how it has been/ is being managed.
49	NNR compartments	RSPB	-	GIS	

Item no	Name	Author	Date	Format	Summary
50	Breach points	RSPB	-	GIS	
51	Deep water region	RSPB	-	GIS	
52	Ditches	RSPB	-	GIS	
53	Marsh region	RSPB	-	GIS	
54	Roads	RSPB	-	GIS	
55	Watercourses	RSPB	-	GIS	
56	Railway crossings	RSPB	-	GIS	
57	Topographic survey - longitudinal sections	SNH	1993	Paper	Longitudinal sections along embankments and adjacent floodplain
58	Institute of Hydrology survey 1991	Institute of Hydrology	1991	Paper	Spot heights in marsh areas
59	Topographic survey - cross-sections	SNH	1995	Paper	No master plan of where cross-sections are located, and no grid references with the cross-sections
60	Regulatory standards for Scottish and UK upland wetlands: Hydrological monitoring data analysis	EnviroCentre (for Sniffer)	2013	Word	Hydrological data interpretation for Sniffer project developing regulatory thresholds for wetland typologies. A number of automated groundwater and surface water loggers installed, some of which are outside RSPBs boundary. Location IM18 in Lynchat compartment shows that groundwater levels are close to the surface for the majority of the monitoring period (Jan 2009 - Jan 2013) with a very flat stage-duration curve. Spikes in the data up to 0.5m above ground level likely to be associated with high rainfall and flood events. IM22 in the Insh Fen compartment shows a very flat stage-duration curve with water levels close to the surface for the majority of the time. There are a number of high peaks in the data series (>1m above ground level) relating to flood occurrences.
61	River Spey Abstractions	EnviroCentre (for Spey Fishery Board)	2008	Word	Review of water abstractions from the River Spey catchment, and assessment of the potential impact of these abstractions on managing fish populations. There are major abstractions from the Spey for hydro-power schemes, with water transferred from the catchment. Estimated that 19-49% of the mean annual flow at Kinrara is transferred. Results in reduced flow regime downstream.
62	LiDAR DTM	Provided by SEPA	-	GIS	High resolution topographic data across the floodplain, representing key features such as the embankments. Date flown should be checked to determine if standing water was present on floodplain as this will reduce the accuracy of the data (LiDAR does not penetrate water).

Item no	Name	Author	Date	Format	Summary
63	Hydrometry data - POT (Feshie Bridge, Invertrium, Kinrara	Provided by SEPA	2015	Text file	Provision of relevant hydrological data for the stated gauges. Confirmation from Andy Lowe that this is most up-to-date data
64	Hydrometry data - DMF (Feshie Bridge, Invertrium, Kinrara, Tromie Bridge)	Provided by SEPA	2015	Text file	
65	Hydrometry data - 15 minute stage (Kincraig)	Provided by SEPA	2015	Text file	
66	Hydrometry data - 15 minute flow (Feshie Bridge, Invertrium, Kinrara, Tromie Bridge)	Provided by SEPA	2015	Text file	
67	Flood history	Provided by SEPA	2015	Excel	Flood records, plus description in email of damage associated with flood in August 2014
68	CAR licence data	Provided by SEPA	2015	PDF	CAR licences in proximity to the site.

B HYDROLOGICAL ASSESSMENT

This section provides a summary of the hydrological analysis undertaken, using the Flood Estimation Handbook (FEH) methods to establish design inflows for the hydrodynamic modelling.

B.1. Flood Frequency

The annual exceedance probability (AEP) of particular flood conditions is the chance these conditions (or more severe) occur in any given year.

The return period of a flood is the long-term average period between flood conditions of such magnitude (or greater).

Within this report, the AEP is used to reference the flood frequency. The relationship between the AEP and return periods is shown in Table B1.

Two frequent flood events have also been defined for this study using the Peaks Over Threshold (POT) approach, where the threshold has been set to include an average of 5 flood events per year (referred to a '5-POT' flow in this report) and an average of 3 flood events per year (referred to a '3-POT' flow in this report).

Table B1: Relationship between annual exceedance probability and return periods

Annual exceedance probability, AEP (%)	Return period, T (year)	Comment
50	2	Median annual flood, in the long-term this occurs every other year, on average.
20	5	
10	10	
5	20	
3.3	30	Typical design standard for urban drainage systems.
2	50	
1	100	
0.5	200	Typical design conditions standard for river or coastal flooding for most developments. Defines "functional floodplain" under Scottish Planning Policy.
0.2	500	
0.1	1,000	Typical design conditions standard for sensitive or vulnerable developments/contexts.

B.2. Catchment Characteristics

Catchment characteristics were extracted from the FEH CD ROM (CEH, 2009) for the following seven flow estimation points on the River Spey and its tributaries. Figure B1 shows the location of each of the flood estimation points and gauging stations operated by SEPA. Gauge station details are provided in Table B2.

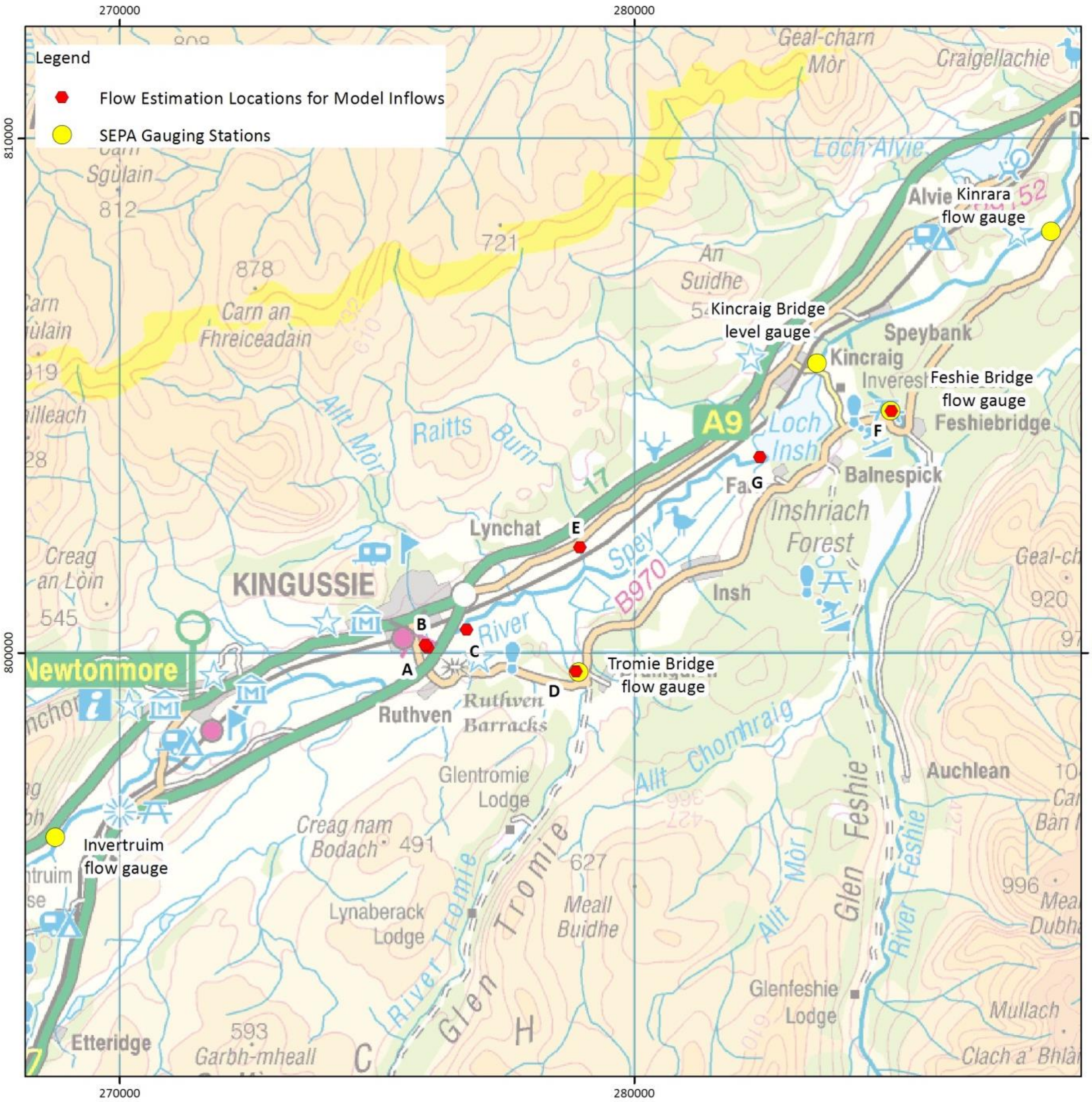


Figure B1: Flow Estimation Locations

Table B2: Flow Gauge Details

Station	Grid Reference	Period of Record	Use in Assessment
Spey @ Invertruim (8007)	NN 68759 96400	1952-2014	Flow estimates at Invertruim scaled to provide estimates at location A
Spey @ Kinrara (8002)	NH 88052 08161	1951-2014	Flow estimates derived as comparison only
Tromie @ Tromie Bridge (8008)	NH 78050 01100	1952-2009	Flow estimates used directly for location D
Feshie @ Feshie Bridge (8013)	NH 85000 04700	1992-2014	Flow estimates used directly for location F. For calibration runs only, flow estimates also scaled to provide inflows for locations B, C , E and G.

A. River Spey Upstream of the Study Area

The catchment of the River Spey is located in the central highlands of Scotland and, to the upstream boundary of Insh Marshes, drains an area of approximately 540km^2 of land between Fort Augustus and Kingussie. The River Spey originates as a series of small tributaries which drain into Loch Spey approximately 34km to the west of Kingussie. The River Spey flows north eastwards through the Cairngorms and then northwards discharging into the North Sea at Spey Bay. The key catchment characteristics for the River Spey at the upstream boundary of Insh Marshes are summarised in Table B3.

Significant abstractions occur in the upper catchment of the Spey for hydro-power schemes (Spey Dam, Mashie, Truim, Cuaich) and the water is transferred out of the catchment. These abstractions have affected the natural hydrological regime of the River Spey, and as such the flow estimates for the River Spey at the upstream extent of the study area (location A, Kingussie) use gauged data from the station at Invertruim.

B. Gynack Burn

The Gynack Burn originates approximately 6km to the north-west of Kingussie, draining the hills on the northern side of the Spey valley before flowing through the town of Kingussie. The Gynack Burn has a catchment area of approximately 22km^2 to the confluence with the River Spey. The key catchment characteristics for the Gynack Burn are summarised in Table B3.

C. Ruthven Burn

The Ruthven Burn originates as a series of small tributaries draining Corry Ruthven approximately 3km to the south of the confluence with the River Spey. The catchment area of the Ruthven Burn is approximately 7km^2. The key catchment characteristics for the Ruthven Burn are summarised in Table B3.

D. River Tromie

The River Tromie originates at the outflow of Loch an t-Seilich located in the Gaick Forest 14km to the South of Kingussie. The dam at the outflow of Loch an t-Seilich abstracts water from the upper reaches of the River Tromie catchment, conveying it approximately 9km westwards to the Cuaich Power Station which forms part of the Tummel Hydro-Electric Power Scheme. This abstraction of water results in significant attenuation of flows through the River Tromie downstream, and therefore the gauged record has been used in the flow estimation. The River Tromie has a catchment area of approximately 130km^2 at the gauging station.

E. Raitts Burn

The catchment of the Raitts Burn is located on the northern slopes of the River Spey valley. The Raitts Burn originates as a series of small tributaries draining Beinn Bhreac and Meall a' Chòcaire approximately 7km to the north of the Raitts Burn confluence with the River Spey to the east of Lynchat. The Raitts Burn drains an area of approximately 12km^2 at the B9152 road.

F. River Feshie

The River Feshie originates as a series of tributaries, approximately 21km to the south out the confluence with the River Spey, which drain the hills at the southern boundary of the Cairngorms National Park. The River Feshie has a catchment area of approximately 230km^2 at the gauging station which is located approximately 400m downstream of Feshie Bridge.

G. Allt Baile Mhuilinn

The Allt Baile Mhuilinn drains the hillslopes of the southern valley side between the River Tromie and River Feshie catchments. The catchment area of 13.7km^2 incorporates all the hillslope inflows between the Tromie and Loch Insh. The Allt Baile Mhuilinn has historically been diverted into the Main Drain, and this inflow is referred to as the Main Drain inflow throughout the rest of this report.

A summary of the key hydrological characteristics for each catchment is presented in Table B3.

Table B3: Catchment Characteristics

Flow Estimation Point	Description	Grid Reference	Key catchment descriptors				
			AREA (km^2)	BFIHOST	FARL	SAAR (mm)	SPRHOST
-	Invertruim gauging station (8007), approx. 10km upstream of location A	NN 68759 96400	402	0.41	0.95	1431	51.2
A. River Spey Upstream	Immediately upstream of the River Spey/Gynack Burn confluence	NH 76000 00100	537	0.43	0.95	1370	50.3
B. Gynack Burn	Immediately upstream of the outflow into the River Spey	NH 75950 00150	22	0.41	0.96	1230	56.9
C. Ruthven Burn	Immediately upstream of the outflow into the River Spey	NH 76750 00450	7.1	0.43	1.00	870	45.2
D. River Tromie	At the gauging station (8008)	NH 78050 01100	134	0.45	0.90	1430	53.1
E. Raitts Burn	At the B9152 road culvert	NH 78950 02050	12	0.36	1.00	1090	55.6
F. River Feshie	At the gauging station (8013)	NH 85000 04700	230	0.48	0.99	1286	49.1
G. Allt Baile Mhuilinn	Tributary that flows into the Main Drain – to Loch Insh	NH 82450 03800	13.7	0.51	0.97	824	40.7
-	At the Kinrara gauging station (8002), approx. 5.5km downstream of Kincraig	NH 88050 08150	1009	0.45	0.93	1320	49.7

B.3. Flood Frequency Analysis

A number of Flood Frequency Analysis (FFA) methods were used to obtain flow estimates for a range of flood event magnitudes. The methods at each flow estimation location are outlined below. The final flow estimates are summarised in Table B25.

Mean Annual Flow (MAF)

For Location A, the MAF was extracted from gauged record at Invertruim, and then scaled by catchment area to provide the estimate at the upstream extent of study area.

For Locations D and F (Tromie Bridge and Feshie Bridge) and at Kinrara the MAF was extracted from the relevant gauging stations with no further scaling.

The MAF for the River Feshie was scaled by catchment area to provide a MAF estimate for the ungauged tributaries at locations B, C, E and G. The River Feshie was used in preference to the River Tromie due to the impact of the abstractions of the natural flow regime of the Tromie and absence of similar abstractions on the River Feshie and the ungauged tributaries.

Frequent Flood Events (POT)

The Peaks over Threshold (POT) method (CEH, 2008) was used to derive flows for flood events which occur approximately 5 times per year (5-POT) and 3 times per year (3-POT) in the long term at each of the available gauging stations, and used directly for locations D and F and at Kinrara. The values derived for Invertruim gauge station were scaled by catchment area to provide the 5-POT and 3-POT flow estimates at location A.

As for the MAF, the 5-POT and 3-POT values for the River Feshie were scaled by catchment area to derive estimated POT values for the ungauged tributaries (locations B, C, E and G).

QMED

At locations D, F and Kinrara the QMED (median annual maximum flood, equivalent to the 50% AEP) was derived from the Annual Maximum flow records (AMAX) for each of the relevant gauging stations (see Tables B2 and B3). At these locations, the QMED was also estimated based on the FEH regression model (Kjeldsen, Jones & Bayliss, 2008) using catchment descriptors alone (CEH, 2009) to evaluate the potential degree of the catchment being affected by upstream reservoirs and abstractions.

The QMED at location A was calculated from catchment descriptors using the FEH regression model (CEH, 2009; Kjeldsen et al., 2008) and adjusted using a donor transfer from the Invertruim gauge station. The ratio between the QMED derived from the AMAX series at Invertruim ($QMED_{obs}$) and the QMED derived from catchment descriptors at Invertruim ($QMED_{desc}$) was applied directly at location A i.e. a weighting of 1 is assumed between Invertruim and the subject site (Table B4). This will ensure that the flow records at Invertruim – which are affected by upstream reservoirs and abstractions – are fully taken into account at the flow estimation location.

Table B4: Donor Transfer at Location A

Location	Parameter	Value
Invertruim gauge station	$QMED_{descr}$	180
	$QMED_{obs}$	114
	Ratio	0.63
A. River Spey Upstream	$QMED_{descr}$	217
	QMED	137

The FEH Rainfall-Runoff Method (CEH, 2008) was used to determine the 50% AEP flow for ungauged locations (B, C, E and G).

High Flows Analysis

The following sections describe the methods used to estimate peak flows at each location for high flow events. At the gauging stations, Enhanced Single Site Analysis was used to determine the rating curve, which is appropriate given the length of the gauging station records. A Single Site Analysis was also undertaken for the gauging stations which gave higher estimates of the 0.5% AEP flow at Invertruim (430 m^3/s) and at Feshie Bridge (320 m^3/s), and a similar estimate at Tromie Bridge (160 m^3/s) For the modelling, design hydrographs were derived using the FEH rainfall-runoff approach and scaled to fit the peak flow estimate.

A. River Spey Upstream of the Study Area

Flood flow rates at the River Spey Upstream flow estimation point were estimated by undertaking the primary analysis at the nearby (upstream) gauging station at Invertruim using the FEH Statistical Method, Enhanced Single Site approach (Kjeldsen et al., 2008) as implemented in WINFAP (WHS, 2009). The estimates are then transferred to the flow estimate location assuming a correlation of 1 is between model errors at Invertruim and the subject site to ensure that the impact of the upstream abstractions are fully taken into account.

Table B5: Enhanced Single Site Analysis at Invertruim Gauge - Pooling Group Catchments

Station	Similarity distance	Years of data	L-CV	L-SKEW	Discordancy
8007 (Spey @ Invertruim)	0.000	62	0.285	0.232	2.144
27043 (Wharfe @ Addingham)	0.306	39	0.166	0.060	1.080
79006 (Nith @ Drumlanrig)	0.393	39	0.133	0.132	0.507
21007 (Ettrick Water @ Lindean)	0.412	45	0.195	0.036	1.685
7001 (Findhorn @ Shenachie)	0.424	47	0.198	0.162	0.458
202001 (Roe @ Ardnargle)	0.424	36	0.081	0.024	0.972
45002 (Exe @ Stoodleigh)	0.436	52	0.152	0.141	1.602
81002 (Cree @ Newton Stewart)	0.456	43	0.148	0.038	0.508
27034 (Ure @ Kilgram Bridge)	0.469	45	0.131	0.078	0.533
77002 (Esk @ Canonbie)	0.476	44	0.130	0.160	0.899
25008 (Tees @ Barnard Castle)	0.481	48	0.176	0.144	0.614
Total/weighted average		500	0.258	0.145	

Table B6: Enhanced Single Site Analysis at Invertruim Gauge - Pooling group evaluation

Parameter	Value	Comment
H2	2.02	Heterogeneous
H1	11.56	Strongly Heterogeneous

Table B7: Enhanced Single Site Analysis at Invertruim Gauge - Growth curve fitting

Distribution Function	Z-value	|Z|< 1.645	Comment
Generalised Logistic (GL)	5.3	No	Poor Fit
Generalised Extreme Value (GEV)	2.1	No	Poor Fit, Adopted because of lowest |Z|

Table B8: Enhanced Single Site Analysis at Invertruim Gauge - Pooling group results

AEP (%)	Growth factor (-)	Peak flow rate (m^3/s)	
		Invertruim gauging station	Location A
50	1.00	110	140
20	1.45	170	200
10	1.74	200	240
4	2.09	240	290
2	2.34	270	320
1	2.59	300	360
0.5	2.82	320	390
0.2	3.13	360	430

B. Gynack Burn

The Gynack Burn is ungauged and has a catchment area <25km^2. For this reason the FEH Rainfall-Runoff method (implemented in Infoworks RS (MWH Soft, 2011)) was used to estimate the 0.5% AEP flood flow through the Gynack Burn.

Table B9: Gynack Burn Rainfall-Runoff Output

```
IW RS Network, FILE=CHD.dat,   ISIS VER= 11.5.0.21007
************************************************************
ISIS
************************************************************

HYDROLOGICAL DATA

Catchment: Gynack Burn
************************************************************
Catchment Characteristics
************************************************************
Easting         :         0 Northing       :         0
Area            :    21.880 km2
DPLBAR          :     6.670 km
DPSBAR          :   180.500 m/km
PROPWET         :     0.680
SAAR            :  1230.000 mm
Urban Extent    :     0.000
c               :    -0.023
d1              :     0.391
d2              :     0.510
d3              :     0.429
e               :     0.267
f               :     2.281
SPR             :    56.910 %
************************************************************
Summary of estimate using Flood Estimation Handbook rainfall-runoff method
************************************************************
Estimation of T-year flood
==========================
Unit hydrograph time to peak    :     2.753 hours
Instantaneous UH time to peak   :     2.628 hours
Data interval                   :     0.250 hours
Design storm duration           :     6.250 hours
Critical storm duration         :     6.140 hours
Return period for design flood  :   200.000 years
requires rain return period     :   246.667 years
ARF                             :     0.943
Design storm depth              :    65.138 mm
CWI                             :   124.500
Standard Percentage Runoff      :    56.910 %
Percentage runoff               :    61.085 %
Snowmelt rate                   :     0.000 mm/day
Unit hydrograph peak            :    79.903 (m3/s/cm/100km2)
Quick response hydrograph peak  :    50.426 m3/s
Baseflow                        :     0.805 m3/s
Baseflow adjustment             :     0.000 m3/s
Hydrograph peak                 :    51.231 m3/s
Hydrograph adjustment factor    :     1.000

Flags
=====
Unit hydrograph flag            : FSRUH
Tp flag                         : FEHTP
Event rainfall flag             : FEHER
Rainfall profile flag           : WINRP
Percentage Runoff flag          : FEHPR
Baseflow flag                   : F16BF
CWI flag                        : FSRCW
************************************************************
```

C. Ruthven Burn

The Ruthven Burn is ungauged and has a catchment area <25km^2. For this reason the FEH Rainfall-Runoff method was used to estimate the 0.5% AEP flood flow through the Ruthven Burn.

Table B10: Ruthven Burn Rainfall-Runoff Output

```
IW RS Network, FILE=CHD.dat,    ISIS VER= 11.5.0.21007
************************************************************
ISIS
************************************************************

HYDROLOGICAL DATA

Catchment: Ruthven Burn
************************************************************
Catchment Characteristics
************************************************************
Easting         :          0 Northing       :          0
Area            :      7.140 km2
DPLBAR          :      3.230 km
DPSBAR          :     93.400 m/km
PROPWET         :      0.710
SAAR            :    872.000 mm
Urban Extent    :      0.000
c               :     -0.023
d1              :      0.379
d2              :      0.480
d3              :      0.418
e               :      0.266
f               :      2.218
SPR             :     45.200 %
************************************************************
Summary of estimate using Flood Estimation Handbook rainfall-runoff method
************************************************************
Estimation of T-year flood
==========================
Unit hydrograph time to peak   :      2.287 hours
Instantaneous UH time to peak  :      2.162 hours
Data interval                  :      0.250 hours
Design storm duration          :      4.250 hours
Critical storm duration        :      4.280 hours
Return period for design flood :    200.000 years
requires rain return period    :    246.667 years
ARF                            :      0.954
Design storm depth             :     54.656 mm
CWI                            :    121.880
Standard Percentage Runoff     :     45.200 %
Percentage runoff              :     47.367 %
Snowmelt rate                  :      0.000 mm/day
Unit hydrograph peak           :     96.214 (m3/s/cm/100km2)
Quick response hydrograph peak :     13.757 m3/s
Baseflow                       :      0.180 m3/s
Baseflow adjustment            :      0.000 m3/s
Hydrograph peak                :     13.937 m3/s
Hydrograph adjustment factor   :      1.000

Flags
=====
Unit hydrograph flag           : FSRUH
Tp flag                        : FEHTP
Event rainfall flag            : FEHER
Rainfall profile flag          : WINRP
Percentage Runoff flag         : FEHPR
Baseflow flag                  : F16BF
CWI flag                       : FSRCW
************************************************************
```

D. River Tromie

Flood flow rates at the River Tromie flow estimation location were analysed using the FEH Statistical Method, enhanced single site approach.

Table B11: Enhanced Single Site Analysis at Tromie Bridge Gauge - Pooling Group Catchments

Station	Similarity Distance	Years of data	L-CV	L-SKEW	Discordancy
8008 (Tromie @ Tromie Bridge)	0.000	57	0.240	0.167	0.516
48011 (Fowey @ Restormel)	0.366	24	0.188	0.001	0.867
12005 (Muick @ Invermuick)	0.378	29	0.216	0.069	1.037
45009 (Exe @ Pixton)	0.409	14	0.273	0.361	1.324
27088 (Calder @ Mytholmroyd)	0.487	23	0.223	0.270	1.377
6008 (Enrick @ Mill of Tore)	0.550	27	0.214	0.142	0.227
21020 (Yarrow Water @ Gordon Arms)	0.563	39	0.220	0.288	0.326
76004 (Lowther @ Eamont Bridge)	0.586	50	0.242	0.171	0.918
4003 (Alness @ Alness)	0.617	32	0.220	0.351	0.695
47004 (Lynher @ Pillaton Mill)	0.622	51	0.202	0.260	0.244
69017 (Goyt @ Marple Bridge)	0.645	42	0.175	0.053	1.369
203033 (Upper Bann @ Bannfield)	0.649	37	0.126	0.001	1.972
79003 (Nith @ Hall Bridge)	0.668	47	0.193	0.427	1.908
60006 (Gwili @ Glangwili)	0.672	44	0.168	0.171	1.220
Total/weighted average		516	0.232	0.186	

Table B12: Enhanced Single Site Analysis at Tromie Bridge Gauge - Pooling group evaluation

Parameter	Value	Comment
H2	2.76	Heterogeneous
H1	1.49	Strongly Heterogeneous

Table B13: Enhanced Single Site Analysis at Tromie Bridge Gauge - Growth curve fitting

Distribution Function	Z-value	|Z| < 1.645	Comment
Generalised Logistic (GL)	1.04	Yes	Acceptable Fit
Generalised Extreme Value (GEV)	-0.87	Yes	Acceptable Fit, Adopted because of lowest |Z|

Table B14: Enhanced Single Site Analysis at Tromie Bridge Gauge - Pooling group results

AEP (%)	Growth factor (-)	Peak flow rate (m^3/s)
50	1.00	51
20	1.41	72
10	1.69	86
4	2.05	100
2	2.32	120
1	2.59	130
0.5	2.87	150
0.2	3.24	170

E. Raitts Burn

The Raitts Burn is ungauged and has a catchment area <25km^2 For this reason the FEH Rainfall-Runoff method was used to estimate the 0.5% AEP flood flow through the Raitts Burn.

Table B15: Raitts Burn Rainfall-Runoff Output

```
IW RS Network, FILE=CHD.dat,   ISIS VER= 11.5.0.21007
************************************************************
ISIS
************************************************************

HYDROLOGICAL DATA

Catchment: Raitts Burn
************************************************************
Catchment Characteristics
************************************************************
Easting          :          0 Northing       :         0
Area             :     12.410 km2
DPLBAR           :      5.610 km
DPSBAR           :    134.200 m/km
PROPWET          :      0.680
SAAR             :   1091.000 mm
Urban Extent     :      0.000
c                :     -0.023
d1               :      0.388
d2               :      0.510
d3               :      0.416
e                :      0.269
f                :      2.253
SPR              :     55.580 %
************************************************************
Summary of estimate using Flood Estimation Handbook rainfall-runoff method
************************************************************
Estimation of T-year flood
==========================
Unit hydrograph time to peak   :      2.781 hours
Instantaneous UH time to peak  :      2.656 hours
Data interval                  :      0.250 hours
Design storm duration          :      5.750 hours
Critical storm duration        :      5.814 hours
Return period for design flood :    200.000 years
requires rain return period    :    246.667 years
ARF                            :      0.951
Design storm depth             :     62.867 mm
CWI                            :    124.198
Standard Percentage Runoff     :     55.580 %
Percentage runoff              :     59.403 %
Snowmelt rate                  :      0.000 mm/day
Unit hydrograph peak           :     79.122 (m3/s/cm/100km2)
Quick response hydrograph peak :     27.448 m3/s
Baseflow                       :      0.404 m3/s
Baseflow adjustment            :      0.000 m3/s
Hydrograph peak                :     27.851 m3/s
Hydrograph adjustment factor   :      1.000

Flags
=====
Unit hydrograph flag           : FSRUH
Tp flag                        : FEHTP
Event rainfall flag            : FEHER
Rainfall profile flag          : WINRP
Percentage Runoff flag         : FEHPR
Baseflow flag                  : F16BF
CWI flag                       : FSRCW
************************************************************
```

F. River Feshie

Flood flow rates at the River Feshie flow estimation point were estimated using the FEH Statistical Method, enhanced single site approach.

Table B16: Enhanced Single Site Analysis at Feshie Bridge Gauge - Pooling Group Catchments

Station	Distance	Years of data	L-CV	L-SKEW	Discordancy
8013 (Feshie)	0.000	23	0.183	0.207	0.141
54038 (Tanat @ Llanyblodwel)	0.078	40	0.151	0.133	0.334
76806 (Eden @ Great Musgrave Bridge)	0.089	12	0.148	0.069	1.802
47006 (Lyd @ Lifton Park)	0.125	43	0.275	0.293	1.839
49001 (Camel @ Denby)	0.170	48	0.220	0.240	0.847
83004 (Lugar Water @ Langholm)	0.234	34	0.217	0.188	0.816
12008 (Feugh @ Heugh Head)	0.252	21	0.201	0.110	0.592
202002 (Faughan @ Drumahoe)	0.266	36	0.162	0.213	0.663
84014 (Avon Water @ Fairholm)	0.267	42	0.178	0.212	0.469
79005 (Cluden Water @ Fiddlers Ford)	0.314	43	0.122	0.249	2.738
66006 (Elwy @ Pont-y-gwyddel)	0.326	38	0.187	0.133	0.134
12007 (Dee @ Mar Lodge)	0.354	25	0.148	0.133	0.478
23005 (North Tyne @ Tarset)	0.356	19	0.154	0.060	0.892
60013 (Cothi @ Pont Ynys Brechfa)	0.361	10	0.207	0.256	0.376
82001 (Girvan @ Robstone)	0.386	23	0.100	-0.107	3.012
15013 (Almond @ Almondbank)	0.437	33	0.187	0.144	0.151
78005 (Kinnel Water @ Bridgemuir)	0.441	27	0.091	-0.083	1.715
Total/weighted average		517	0.179	0.159	

Table B17: Enhanced Single Site Analysis at Feshie Bridge Gauge - Pooling group evaluation

Parameter	Value	Comment
H2	1.22	Possibly Heterogeneous
H1	6.10	Strongly Heterogeneous

Table B18: Enhanced Single Site Analysis at Feshie Bridge Gauge - Growth curve fitting

Distribution Function	Z-value	|Z| < 1.645	Comment
Generalised Logistic (GL)	2.45	No	Poor Fit
Generalised Extreme Value (GEV)	-0.06	Yes	Acceptable Fit, Adopted because of lowest |Z|

Table B19: Enhanced Single Site Analysis at Feshie Bridge Gauge - Pooling group results

AEP (%)	Growth factor (-)	Peak flow rate (m^3/s)
50	1.00	130
20	1.31	160
10	1.51	190
4	1.76	220
2	1.94	240
1	2.12	270
0.5	2.30	290
0.2	2.53	320

G. Allt Baile Mhuilinn

The Allt Baile Mhuilinn is ungauged and has a catchment area <25km^2 For this reason the FEH Rainfall-Runoff method was used to estimate the 0.5% AEP flood flow.

Table B20: Allt Baile Mhuilinn Rainfall-Runoff Output

```
                                              FILE=AB9B.dat          ISIS VER=
************************************************************
ISIS
************************************************************

HYDROLOGICAL DATA

Catchment: Main_drain
************************************************************
Catchment Characteristics
************************************************************
Easting          :     282450 Northing        :     803800
Area             :     13.730 km2
DPLBAR           :      4.790 km
DPSBAR           :     69.400 m/km
PROPWET          :      0.680
SAAR             :    824.000 mm
Urban Extent     :      0.001
c                :     -0.023
d1               :      0.379
d2               :      0.480
d3               :      0.402
e                :      0.268
f                :      2.217
SPR              :     40.700 %
************************************************************
Summary of estimate using Flood Estimation Handbook rainfall-runoff method
************************************************************
Estimation of T-year flood
==========================
Unit hydrograph time to peak    :      3.177 hours
Instantaneous UH time to peak   :      3.052 hours
Data interval                   :      0.250 hours
Design storm duration           :      5.750 hours
Critical storm duration         :      5.795 hours
Return period for design flood  :    200.000 years
requires rain return period     :    246.667 years
ARF                             :      0.949
Design storm depth              :     59.115 mm
CWI                             :    118.400
Standard Percentage Runoff      :     40.700 %
Percentage runoff               :     42.618 %
Snowmelt rate                   :      0.000 mm/day
Unit hydrograph peak            :      0.951 (m3/s/mm)
Quick response hydrograph peak  :     18.720 m3/s
Baseflow                        :      0.310 m3/s
Baseflow adjustment             :      0.500 m3/s
Hydrograph peak                 :     19.031 m3/s
Hydrograph adjustment factor    :      1.000

Flags
=====
Unit hydrograph flag            : FSRUH
Tp flag                         : FEHTP
Event rainfall flag             : FEHER
Rainfall profile flag           : WINRP
Percentage Runoff flag          : FEHPR
Baseflow flag                   : F16BF
CWI flag                        : FSRCW
************************************************************
```

Kinrara Gauge

Flood flow rates at Kinrara gauging station (~5.5km downstream of the study area) were estimated using the FEH Statistical Method, enhanced single site approach.

Table B21: Enhanced Single Site Analysis at Kinrara Gauge - Pooling Group Catchments

Station	Distance	Years of data	L-CV	L-SKEW	Discordancy
8002 (Spey @ Kinrara)	0.000	64	0.204	0.192	0.321
67015 (Dee @ Manley Hall)	0.148	38	0.171	0.228	0.235
84018 (Clyde @ Tulliford Mill)	0.321	38	0.170	0.222	0.682
8005 (Spey @ Boat of Garten)	0.324	55	0.233	0.232	1.618
16004 (Earn @ Forteviot Bridge)	0.384	33	0.135	0.088	1.435
84003 (Clyde @ Hazelbank)	0.386	51	0.144	0.250	1.698
56001 (Usk @ Chainbridge)	0.394	55	0.182	0.203	0.250
25001 (Tees @ Broken Scar)	0.409	56	0.185	0.112	0.385
27089 (Wharfe @ Tadcaster)	0.417	21	0.184	0.016	1.874
55007 (Wye @ Erwood)	0.442	73	0.190	0.220	0.247
54028 (Vyrnwy @ Llanymynech)	0.453	43	0.168	0.186	2.255
Total/weighted average		527	0.198	0.186	

Table B22: Enhanced Single Site Analysis at Kinrara Gauge - Pooling group evaluation

Parameter	Value	Comment
H2	-0.57	Acceptably Homogenous
H1	1.85	Possibly Homogenous

Table B23: Enhanced Single Site Analysis at Kinrara Gauge - Growth curve fitting

Distribution Function	Z-value	|Z| < 1.645	Comment
Generalised Logistic (GL)	2.52	No	Poor Fit
Generalised Extreme Value (GEV)	0.35	Yes	Acceptable Fit, Adopted because of lowest |Z|

Table B24: Enhanced Single Site Analysis at Kinrara Gauge - Pooling group results

AEP (%)	Growth factor (-)	Peak flow rate (m^3/s)
50	1.00	160
20	1.35	210
10	1.58	250
4	1.89	300
2	2.12	330
1	2.35	370
0.5	2.58	400
0.2	2.90	450

B.4. Flood Frequency Analysis Summary

Table B25: Flood Frequency Analysis Summary

	Location								
	Invertruim Gauge	**A. River Spey US**	**B. Gynack Burn**	**C. Ruthven Burn**	**D. River Tromie**	**E. Raitts Burn**	**F. River Feshie**	**G. Allt Baile Mhuilinn (Main Drain)**	**Kinrara Gauge**
Catchment Area (km^2)	402	537	22	7.1	134	12	230	13.7	1010
Mean annual flow (m^3/s)	6.4	8.5	0.7	0.2	2.5	0.4	7.9	0.5	25
5-POT (5 peaks per year) (m^3/s)	34	45.4	5.1	1.7	19	2.9	53	3.2	85
3-POT (3 peaks per year) (m^3/s)	62	82.8	7.4	2.4	27	4.2	78	4.7	113
QMED – 50% AEP flood (m^3/s)	110	140	16	4.1	51	8.3	130	5.7	160
2% AEP flood (m^3/s)	270	320	39	10	120	21	240	14	330
0.5% AEP flood (m^3/s)	320	390	51	14	150	28	290	19	400
0.5% AEP flood plus climate change* (m^3/s)	-	468	61	16.8	180	33.6	348	22.8	-

*Increase of flow by 20%

C HYDRODYNAMIC MODELLING

C.1. Objectives

Hydrodynamic modelling was undertaken to provide an understanding of the existing flood regime (baseline scenario) and to predict how this could change with the implementation of the potential options. The modelling work focused on frequent flood events to inform the assessment of change in channel morphology and supporting conditions for ecological receptors. Extreme flood events have also been modelled, however it should be noted that these events are used to assess direction and magnitude of potential change in flood risk. The resulting flood levels should not be used as a definitive assessment of flood risk to individual properties or infrastructure as critical conditions (storm duration/ relative timings of peak flows/ influence of un-modelled tributaries) for each location have not been determined.

For the baseline and the option scenarios the following information was extracted from the model results:

- The frequency, depth, sequence and duration of flooding of the Insh Marshes reserve;
- Potential flood risk to local and downstream receptors; and
- Input data for the hydromorphological assessment to aid the understanding of sediment transport processes.

C.2. Data Sources

The data sources used for the hydrodynamic modelling are described in Table C1. The topographic survey is summarised in section 2.2 and is provided separately to this report. The gauged flow data and hydrological assessment are described in Appendix B. There are a number of automated water level loggers within the Insh Marshes reserve which were installed in 2009. The data obtained from the loggers was used in the SNIFFER wetland regulatory guidance project (Sniffer, 2014), which has informed the ecological assessment in this feasibility project. The logger data has not been used in the flood model calibration as the accuracy of the readings is affected if the loggers are submerged for extended periods of time (SNIFFER, 2009b), as would occur during a large flood event.

Table C1: Data Sources

Data	Description	Use in modelling
Site walkover	• Walkovers undertaken by EnviroCentre for the project (geomorphological survey, flood risk walkover).	• Informed topographic survey specification and identification of likely flood mechanisms. • Informed model roughness.
Topographic survey	• Channel cross-sections • Spot levels along embankment crests including breach levels. • Structure details • Commissioned for the feasibility study and surveyed December 2014 and February 2015.	• Topographic input for 1D cross-sections and structures. • Informs the 1D-2D boundary levels and levels for internal embankments.
LiDAR DTM	• 1m grid resolution (typical vertical resolution ±0.15m RMSE). • Provided by SEPA for the area of the Insh Marshes Reserve.	• Provides floodplain levels for 1D and 2D domain.

Data	Description	Use in modelling
OS 1:25k map OS Opensource Vectormap Data	• Background mapping.	• Defining 2D domain feature locations e.g. drain locations/ railway footprint
Gauged flow records	• Provided by SEPA for Spey @ Invertruim, Tromie @ Tromie Bridge and Feshie @ Feshie Bridge.	• Model inflows (see Appendix B) • Extraction of calibration events used in model development.
	• Provided by SEPA for Spey @ Kinrara	• Extraction of calibration events used in model development – compared with model outflow.
Gauged level data	• 15min stage record for Spey @ Kincraig Bridge, provided by SEPA	• Comparison of modelled stage with recorded stage for the calibration events.
Stage board readings	• Daily readings for stage board located on Main Drain at NH 80746 01687. • Provided by RSPB	• Comparison of modelled stage with recorded stage for the calibration events, taking into account uncertainty as to the time of day of the reading.
SEPA flood map	• As shown on SEPA website.	• Indication of likely flood extents to inform 2D domain extent and 2D boundaries.
Previous reports	• Various reports detailing flood history, mechanisms and previous topographic survey downstream of Loch Insh (see Appendix A).	• Model schematisation. • Sense checking results. • Bed levels downstream of Loch Insh.

C.3. Overview of Modelled Scenarios

The option and flow scenarios modelled are summarised in Table C2. Design hydrographs were developed using the FEH rainfall-runoff method in ISIS and adjusted to the fit the peak flows shown in Table B25. The design hydrographs were adjusted so that the peak flows at the inflows are coincident. Comparison of the flow records at Invertruim and Feshie Bridge suggests that this is not an unreasonable assumption. Full investigation of further duration/ timings of inflows was beyond the scope of the study. However sensitivity testing (not presented in this report) of the influence of the River Feshie has been undertaken during the model development whereby the timing of the River Feshie inflow in comparison to the River Spey was varied (coincident, 4-hours ahead, no peak on Feshie). The change in peak flood levels and downstream flows varied between the baseline scenario and Option 4a, however there was a consistent change in flood mechanisms for these inflow scenarios. .

Table C2: Overview of Modelled Scenarios

Option	Flow scenario				
	5-POT	3-POT	QMED	2% AEP	0.5% AEP+CC
Baseline	Y	Y	Y	Y	Y
3. Full repair of embankments	Y	Y	Y	Y	Y
4a. Full removal of embankments	Y	Y	Y	Y	Y
4b. Removal at Lynchat	Y	Y	Y	-	Y
4c. Removal at Lynchat, Dell, Insh and Coull	Y	Y	Y	-	Y
5. Increased breaching of embankments	Y	Y	Y	-	Y
10b. Reduce connectivity between Main Drain and Loch Insh	Y	Y	Y	-	Y

C.4. Baseline Model Schematisation

A 1D-2D coupled model has been developed using the Infoworks RS software version 16.0. The 1D domain represents the in-channel hydraulics and the 2D domain represents the floodplain hydraulics due to the complex floodplain flow paths within the reserve. The model extents have been informed by the objectives of the modelling and the likely flood extents, as shown in SEPA's Flood Map outputs and informed by the topographic data. The model schematisation is shown in Drawing C1, and described in Table C3 and Table C4. This section details the final schematisation used. Calibration and sensitivity testing have informed the model development, and are described in section C5.

The following flood mechanisms have been included in the model:

- Overtopping of embankments, or bank tops where embankments are absent, of the reaches of the River Spey, Ruthven Burn, River Tromie and Raitts Burn that are explicitly included in the 1D model (see Table C3 and Drawing C1);
- Overtopping of the banks of the reach of the Main Drain that is explicitly included in the 1D model (see Table C3 and Drawing C1);
- Flooding from Loch Insh via direct overtopping into the left floodplain of the River Spey;
- Backing-up of Loch Insh into the Main Drain;
- Inflow to unit D (Invertromie Fen) and unit I (Insh Fen) from the River Spey via open drain connections;
- Floodplain flow into unit K (Cemetery Marsh) via a culvert through the railway;
- Floodplain flow to the north of the railway at Lynchat village via an underpass; and
- Influence of high flows in River Feshie on upstream water levels in Loch Insh and the reserve.

Flood mechanisms excluded from the model are:

- The internal drainage network is not represented in the model, other than the elements listed above, due to the large area of floodplain modelled and the focus on flood events.
- The Gynack Burn and River Feshie channels are not explicitly modelled as these watercourses are outside of the study area and project scope. The model includes inflows for both these watercourses using the flow estimates presented in Appendix B.
- Detailed floodplain flow mechanisms in floodplain areas outside of the study area are not included e.g. flood relief culverts under B970 between Kingussie and Ruthven Bridge.
- There are a number of other minor tributaries that enter the reserve which have not been included in the model, due to being outside of the study area or are considered to be too small to have a significant influence on the flood regime.

The 1D domain uses the surveyed channel cross-sections and includes a number of interpolated sections to increase numeric stability. Where junctions are used at confluences the link length (i.e. length between cross-sections) has been adjusted manually to ensure that the full channel length is taken into account in the model.

The floodplain within the reserve is modelled in 2D, and the floodplain outside of the reserve is generally modelled in 1D. The 1D-2D boundary has been placed along embankments where possible to aid stability, including set-back embankments. Where the 1D-2D boundary is located on a set-back embankment, the area between the channel bank and the embankment is included in the 1D channel cross-section. There are a number of breaches which have been scoured out to below the level of the adjacent floodplain and/or channel bank (Figure C1). At these locations the breach levels in the spill units have been raised manually to a similar level as the ground levels behind the breach to prevent unrealistic spilling into the floodplain and to aid model stability.

Figure C1: Breach scoured below level of adjacent channel bank.

The extent of the 2D domain has been defined based on topographic features and focuses on the parts of the floodplain within the Insh Marshes NNR. The 2D domain uses a triangulated mesh of variable size, with a smaller sized mesh used at features in the floodplain and the southern valley side, and a larger mesh in the flatter parts of the floodplain. The mesh size is a compromise between detailed representation of the topography and computational run times due to the large size of the model, and as such the 2D domain generally excludes higher ground at the valley sides due to the need to represent steeper sloping ground using a smaller mesh. The slight underestimate of floodplain storage capacity arising from this approach will be small in comparison to total floodplain capacity within the modelled domain. The railway on the northern extent of the NNR provides a discreet boundary for the 2D domain. The floodplain to the north of the railway is included in the 2D domain at two locations where there are large openings through the railway (Cemetery Marsh and Lynchat). Inclusion of other connections through the railway was beyond the scope of the project, however potential connections have been considered when identifying potential flood risk receptors.

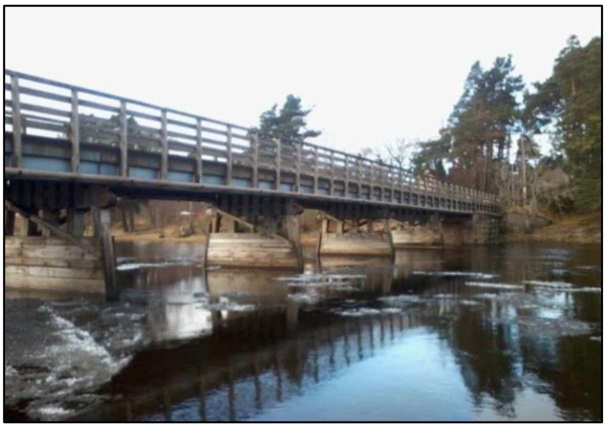
Smaller meshes are used to define features in the floodplain, notably:

- Used in combination with ‘porous walls’ (porosity set to 0, impermeable) to represent the internal floodplain embankments; and
- Used to lower the mesh at the open drain connections in Invertromie Fen (unit D) and Insh Fen (unit I), based on LiDAR levels at the drain locations.

There are a number of floodplain structures incorporated into the 2D domain which are informed by topographic survey. The culvert through the embankment between Dell of Killiehuntly Wetland (unit H) and Insh Fen (unit I) was submerged during the walkover and no flap structures were observed or recorded during the topographic survey. Subsequent information suggests that there was a flap valve at this location installed at the time of the flood bank which could still be operational. The culvert is modelled without a flap valve for all scenarios except option 3 (full repair) where a flap valve is included. A sensitivity test was undertaken to determine the influence of the flap valve on the baseline results, as described in section C5.

Table C3: Baseline schematisation – 1D

Parameter		Description
1D Extent	River Spey	Length of 13.82km from NH 75679, 99719 (upstream of Ruthven Bridge) to NH 85038, 06668 (Speybank).
	Ruthven Burn	Length of 0.77km from NH 76752, 99793 (downstream of the B970) to NH 76705, 00470 (confluence with the River Spey).
	River Tromie	Length of 1.42km from NH 78640 99941 (downstream of Tromie Mills) to NH 78019 01127 (confluence with the River Spey).
	Raitts Burn	Length of 0.33km from NH 78956 02010 (Balavil railway crossing) to NH 79103 01740 (confluence with the River Spey).
	Main Drain	Length of 3.45km from NH 80160 01323 (internal embankment between Dell of Killiehuntly and Insh Fen) to NH 82473 03814 (Loch Insh).
Floodplain representation	Extended cross-sections	Right floodplain of Spey upstream of Ruthven Bridge. Left floodplain of Spey from Ruthven Bridge to A9, and for ~ 700m downstream of A9. Floodplain of Main Drain at Coull between MD00851 and MD00431. Left and right floodplain of Spey downstream of Loch Insh.
	1D storage unit	Left floodplain of Spey upstream of Ruthven Bridge.
	2D	All other areas – see Table C4.
Roughness	Channel – Spey, Ruthven, Tromie, Raitts	0.035 –gravel bed channels, little or no in-channel vegetation.
	Channel – Main Drain	0.05 – silt bed channel, bankside and in-channel vegetation.
	Floodplain (where represented in 1D)	0.05 – height-varying grass/ light scrub. Sensitivity testing described in section C5.
Boundaries	Upstream boundaries of each watercourse	Stage-time boundary with design hydrographs fitted to peak flows as estimated in Appendix B.
	Additional point inflows	Gynack Burn and River Feshie - stage-time boundary with design hydrographs fitted to peak flows as estimated in Appendix B.
	Downstream – Spey only	Normal depth boundary using surveyed gradient of 0.000265m/m based on 3.78m bed level fall over River Spey reach.
	1D-2D boundary	Lateral spill units used at the boundary taking levels from topographic survey, or LiDAR data where survey is not available. Lateral spill also located between Loch Insh storage area and 2D domain (simulation polygon C4). Spill coefficient of 0.5 used due to high roughness (height varying grass/scrub). Sensitivity testing described in section C5.
Other Features	Loch Insh	Modelled as a 1D storage area. No bathymetry data however it is the storage above normal water levels that is of interest for flood modelling. The level-area curve was extracted from the LiDAR data.

Parameter		Description
Structures	Ruthven Bridge – River Spey NH 75973 99765 US node SP14908us DS node SP14908	USBPR bridge unit comprising 2 piers. Dimensions taken from topographic survey. Soffit and springing height 225.25mAOD. Deck spill not required. Minimum deck height 227.18 mAOD – spill not required.  *Looking upstream towards Ruthven Bridge*
	A9 Road Bridge – River Spey NH 76458 00524 US node SP13882 DS node SP13863	USBPR bridge unit. 6 piers, total pier width 5.1m. Dimensions taken from topographic survey. Soffit height 228.02mAOD, springing height 227.13mAOD. Minimum deck height 228.66 mAOD – spill not required.  *Looking upstream towards A9 road bridge*
	Kincraig Bridge – River Spey NH 83506 05595 US node SP03041 DS node SP03026	USBPR bridge unit. 4 piers, total pier with 7.5m. Dimensions taken from topographic survey. Soffit height 221.94mAOD, springing height 221.66mAOD. Minimum deck height 222.66 mAOD – spill not required.  *Looking upstream from left bank towards Kincraig Bridge*

Parameter		**Description**
	Insh footbridge – Main Drain NH 80744 01678 US node MD02793us DS node MD02793	Wooden deck footbridge represented using orifice unit. Dimensions and invert levels extracted from topographic survey. No flap valve. No spill used to represent flow over deck due to short width in comparison to floodplain flow.  *Looking upstream from right bank*
	Coull access track – Main Drain NH 82236 03446 US node MD00431us DS node MD00431	Access track culvert represented using orifice unit. Dimensions and invert levels extracted from topographic survey. No flap valve. Spill used to represent flow over deck – deck level of 221.47mAOD used.  *Looking upstream*
Initial conditions	Initial conditions are approximate to or slightly higher than the mean annual flow (see Appendix B) and were set during model development. The initial conditions are stored in the event files. The same initial conditions are used for all model runs (all baseline/option runs for all flows).	

Table C4: Baseline schematisation – 2D

<table>
<tr><th>Parameter</th><th colspan="2">Description</th></tr>
<tr><td>Extent</td><td colspan="2">As shown in Drawing C1. Five simulation polygons used due to representation of tributaries in 1D:
C1 – right floodplain of Spey between River Tromie and Loch Insh (366ha)
C2 – right floodplain of Spey between Ruthven Burn and River Tromie (152ha)
C3 – right floodplain of Spey between A9 and Ruthven Burn (28ha)
C4 – left floodplain of Spey between Raitts Burn and Loch Insh (171ha)
C5 – left floodplain of Spey between A9 and Raitts Burn (71ha)
C6 – right floodplain of Spey between Ruthven Bridge and A9 (5ha)</td></tr>
<tr><td>Floodplain Roughness</td><td colspan="2">0.05 – height-varying grass/ light scrub. Sensitivity testing described in section C4. Roughness not varied across floodplain – areas of higher or lower roughness small in comparison to total area of floodplain.</td></tr>
<tr><td>Boundaries</td><td colspan="2">2D boundaries as vertical walls at all locations, other than 1D-2D boundary (see Table C3).</td></tr>
<tr><td>Porous walls</td><td colspan="2">Used to represent internal floodplain embankments and railway embankment. For baseline scenario, levels taken from ground model.</td></tr>
<tr><td rowspan="2">Structures</td><td>Drainage culvert at Ruthven North</td><td>Flapped culvert represented with orifice unit between 1D-2D connection node in simulation polygon C6 and 1D domain at Gynack Burn confluence. Dimensions from topographic survey.
</td></tr>
<tr><td>Cemetery Marsh culvert</td><td>Culverts through railway and B9152 represented with orifice unit connecting to 1D-2D connection nodes within simulation polygon C5. Dimensions from topographic survey.
</td></tr>
</table>

Parameter		Description
	Lynchat underpass	Underpass through railway at Lynchat village represented with orifice unit connecting to 1D-2D connection nodes within simulation polygon C5. Dimensions from topographic survey. 
	Main Drain culvert between Dell of Killiehuntly Wetland and Insh Fen	Pipe culvert in Main Drain through internal flood embankment represented with orifice unit connecting to 1D-2D connection nodes within simulation polygon C1. Dimensions from topographic survey. Flap valve not included (see discussion in section C.4 above).  *Looking upstream at culvert location*
Initial conditions	No water on floodplain at start of simulation	

C.5. Calibration and Sensitivity Testing

The modelling focused on relatively low magnitude, high frequency flood events which are most likely to affect the ecological interests at the site, and the calibration and sensitivity testing has therefore also focussed on these high frequency events. High magnitude, low frequency flood events (2% AEP and 0.5% AEP including climate change) have also been modelled, however there has been no additional calibration or verification of these more extreme events.

Three events were selected from the gauged records for use in model development and calibration. The events were selected from the River Spey flow record at Invertruim on the basis that the peak flow was of similar magnitude to the design flows of interest. For each event the following approach was used to obtain all the required inflows to the model:

- Hydrograph extracted from the flow record at Invertruim and then scaled by catchment area as per the design flow estimates (see Appendix B) to provide the inflow at the upstream model extent.
- Hydrographs extracted from the Tromie and Feshie flow records and used without alterations.
- Hydrographs for the ungauged inflows (Gynack, Ruthven, Raitts, Main Drain) produced using the hydrograph shape from the Tromie gauged record, but scaling the peak flow by catchment area based on the peak flow on the River Feshie (unaffected by abstractions).

The three events selected were:

- October 2006 flood event
  - From 15:45 on 25/10/06 to 10:00 on 28/10/06.
  - Peak flow with similar magnitude to the predicted 5-POT design flow.
  - Feshie peaks 1.75hrs before Spey.
- January 2000 flood event
  - From 12:30 on 05/01/00 to 7:45 on 07/01/00
  - Peak flow with similar magnitude to the predicted 3-POT design flow.
  - Longer duration hydrographs than the 2006 event. Feshie rises in advance of Spey.
- October 1995 flood event
  - From 9:45 on 24/10/95 to 23:00 on 25/10/95.
  - Peak flow with similar magnitude to the predicted QMED design flow.
  - Feshie and Spey peaks more or less coincident (Feshie peaks ~ 0.75hrs after Spey).

The outputs from the three event runs are shown in Figures C3 – C8. Key observations from these outputs are:

- October 2006 flood event:
  - The modelled outflow provides a good replication of the shape of the recorded hydrograph at Kinrara, although at a reduced magnitude of flow.
  - Modelled peak stage at Kincraig Bridge occurs in advance of the recorded stage but is similar in magnitude (+0.04m).
  - The manually recorded water levels in the Main Drain suggest that the October 2006 event did not affect the Main Drain, although this seems unlikely given the direct connectivity with Loch Insh, and other factors may have influenced the recorded values.
- January 2000 flood event:
  - The modelled outflow provides a reasonable replication of the shape of the recorded hydrograph at Kinrara to the peak, however the receding limb of the modelled outflow is steeper than the recorded hydrograph. The modelled outflow is also lower than recorded.
  - Modelled peak stage at Kincraig Bridge occurs slightly in advance and is within 0.4m of the recorded stage.
  - A similar difference is observed between the recorded and modelled levels in the Main Drain at the peak stage.
- October 1995 event:
  - The modelled outflow provides a reasonable replication of the shape of the recorded hydrograph at Kinrara to the peak, however the rising and receding limb of the modelled outflow are steeper than the recorded hydrograph. The modelled peak outflow is higher than recorded.
  - Modelled peak stage at Kincraig Bridge occurs slightly after and is within 0.2m of the recorded stage.
  - Difference between the recorded and modelled levels in the Main Drain is 0.15 – 0.3m.

These conclusions demonstrate that there is not a consistent difference between modelled and recorded parameters. Key sources of uncertainty are summarised in Table C5. However, the water levels at Kincraig Bridge are known to be a key control on the water surface gradient in the River Spey through the lower part of the Insh Marshes site, and there is a reasonable match between recorded and modelled stage at this location (EA guidance indicates that an accuracy of ±0.5m is acceptable, or ±0.35m for designing flood defence works (Environment Agency, n.d.)).

RSPB staff are familiar with the flood mechanisms within the Insh Marshes and their knowledge has also been used to sense-check the model results. Based on this sense-checking, the comparison with the recorded data and the complexity of the flood mechanisms, it is considered that the model provides an acceptable representation of flood conditions within the site for the purposes of this feasibility study.

Table C5: Key Sources of Uncertainty

Source	Description
Ungauged inflows	• Uncertainty in the magnitude and timing of the hydrographs for ungauged catchments when running recorded events through the model.
Gauging station information	• The Invertruim gauge is ~ 10km upstream of the study area. The Kinrara gauge is ~ 5.5km downstream of the study area. It was beyond the scope of this project to extend the model to each of these gauging stations. • Changes in hydrograph shape, peak, volume and timing between Invertruim and the modelled reach, and between the modelled reach and Kinrara, are unknown and are likely to be contributing to the discrepancies between modelled and observed values at Kincraig and Kinrara. • Gauged data on the River Tromie is only available up to 2009.The events were selected prior to this data to reduce the uncertainty in inflows for the calibration.
Storm duration and timing of peak flows	• Coincident peaks at the inflows were used in the design hydrographs for all scenarios. Other storm durations and relative timings of inflows may produce different results in terms of absolute levels, flows and potential changes in flood risk.
Antecedent conditions	• Flood water can be retained on the floodplain through Insh Marshes for day/ weeks, which will affect the floodplain storage capacity for subsequent events. Antecedent conditions on the floodplain for the modelled events are unknown.
River and floodplain geometry	• The current river and floodplain geometry are well-defined by the topographic survey and LiDAR data, with the exception of downstream of Loch Insh where adverse flow conditions limited the amount of survey that could be obtained at this location. • Previous reports have highlighted this location as the key downstream control on water levels/ gradients through Loch Insh and the River Spey through the lower part of the Insh Marshes reserve. • Initial model runs suggested that the topographic survey did not manage to pick up the key bed control levels (modelled levels at Kincraig Bridge consistently underestimated). • Topographic survey from previous reports (see Figure C2) was used to supplement the 2014 topographic survey in this location, and provided a better calibration at Kincraig Bridge. • The system is dynamic, particularly at the Feshie confluence where the bed levels are influenced by episodic inputs of coarse bedload. The bed levels will therefore change over time. Similarly, there will be changes in breach levels/ extents and channel cross-sectional form (Raitts/ Tromie) over time. The model therefore represents a single geometry scenario for which to compare the baseline and option scenarios.

Source	Description
Roughness/ spill coefficient sensitivity	• During model development, sensitivity analysis was undertaken for the floodplain roughness (0.05 – 0.07) and spill coefficients at the 1D-2D boundaries (0.5 – 0.8). The shape of the hydrograph at the model outflow and stage-time curve at Kincraig Bridge were not affected i.e. these parameters do not have a significant influence on the storage mechanisms represented in the model. Altering either of these variables resulted in ±0.07m difference in water level at Kincraig Bridge.

Structure condition	• As noted in section C4, there is uncertainty regarding the functioning of the flap valve at the Main Drain culvert between Dell of Killiehuntly Wetland and Insh Fen. The baseline modelling does not include a flap valve.
	• Sensitivity testing was undertaken to ascertain the difference in flood levels in these two flood units (H and I) if the flap valve is functioning. Results show:
	  • 5-POT event – water still enters unit H by the breaches on the River Spey. In unit H, there is a slightly smaller flood extent than baseline, maximum depth 0.08m lower.
	  • 3-POT event – water enters unit H by breaches on River Spey and via breach in internal embankment. In unit H, no discernible change in flood extent, maximum depth 0.03m lower.
	  • QMED event – water enters unit H by breaches on River Spey and via breach in internal embankment. In unit H, no discernible change in flood extent, maximum depth 0.03m lower.

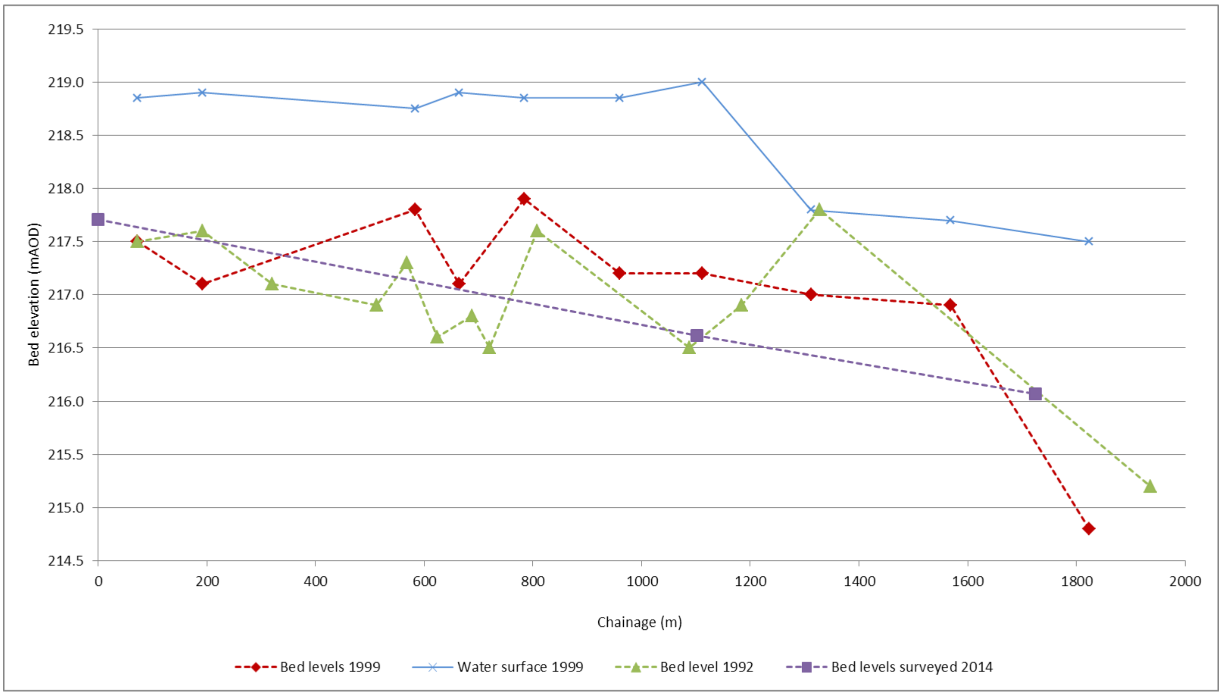


Figure C2: Surveyed bed levels downstream of Loch Insh

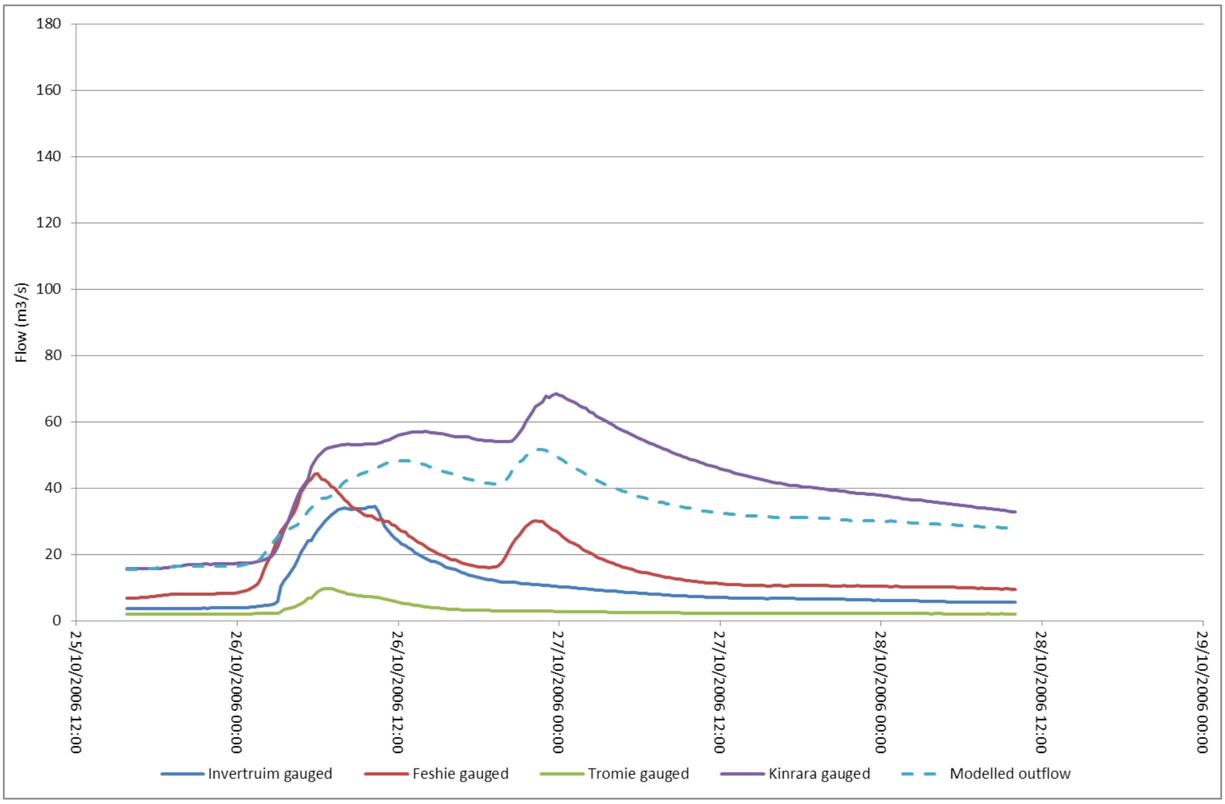


Figure C3: October 2006 event – flow comparison

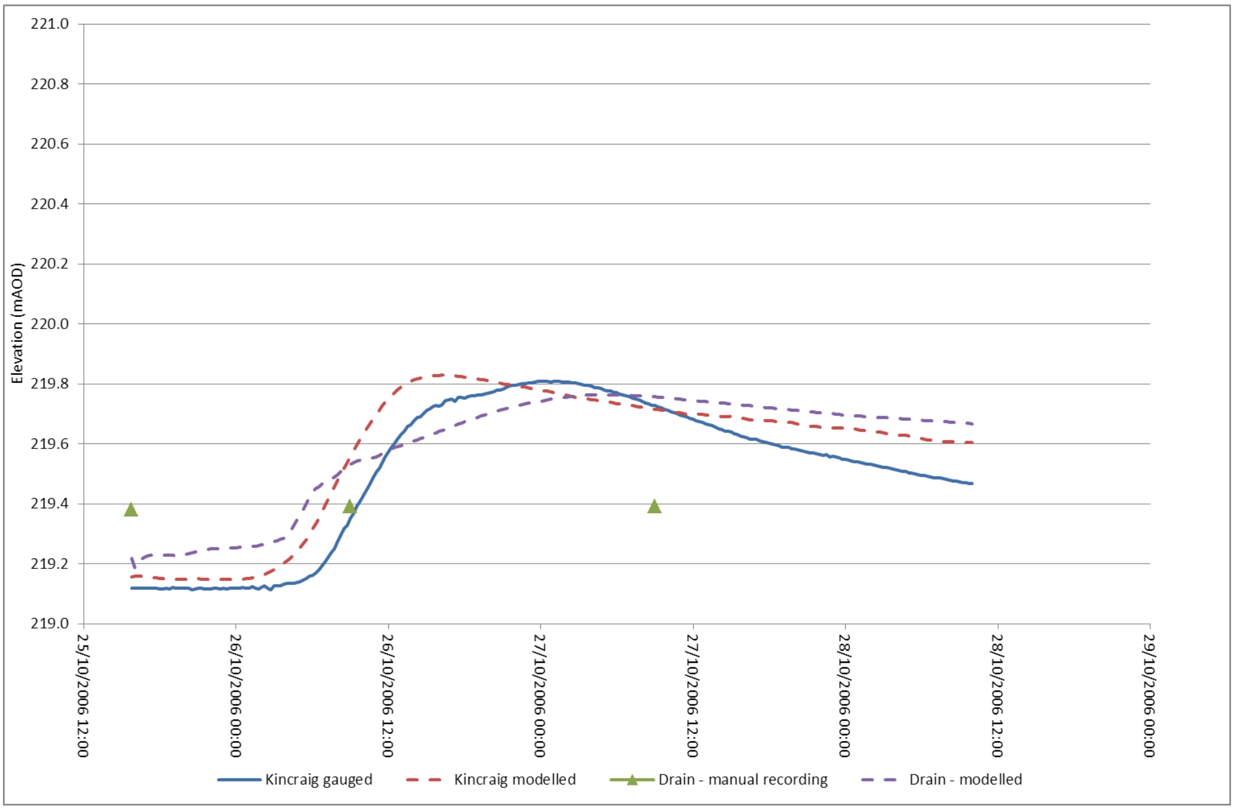


Figure C4: October 2006 event – stage comparison

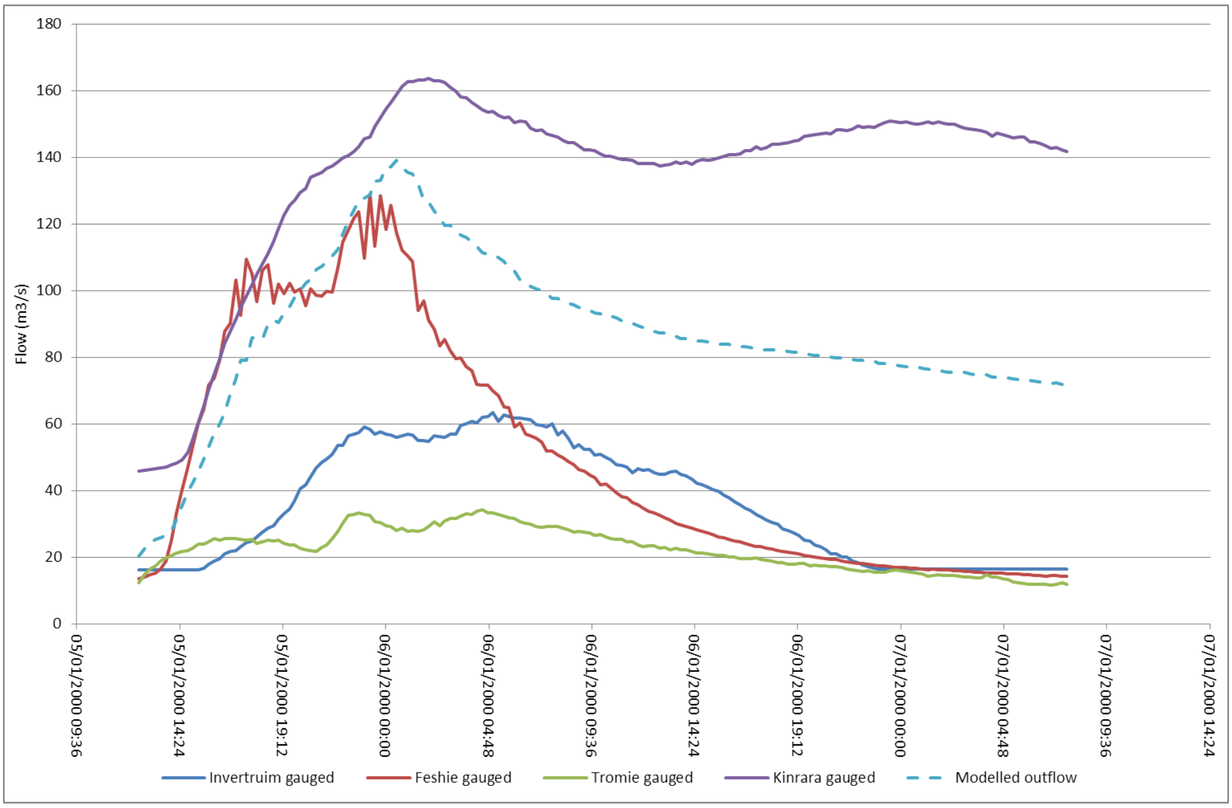


Figure C5: January 2000 event – flow comparison

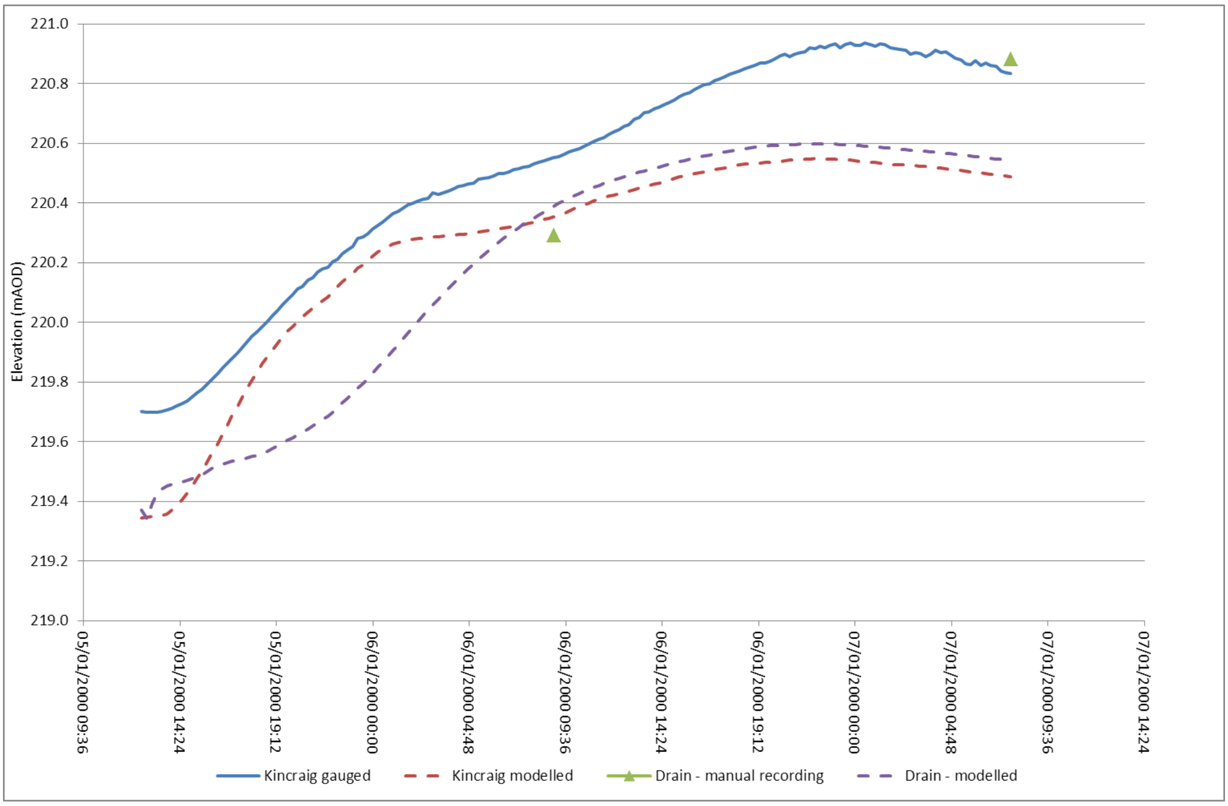


Figure C6: January 2000 event – stage comparison

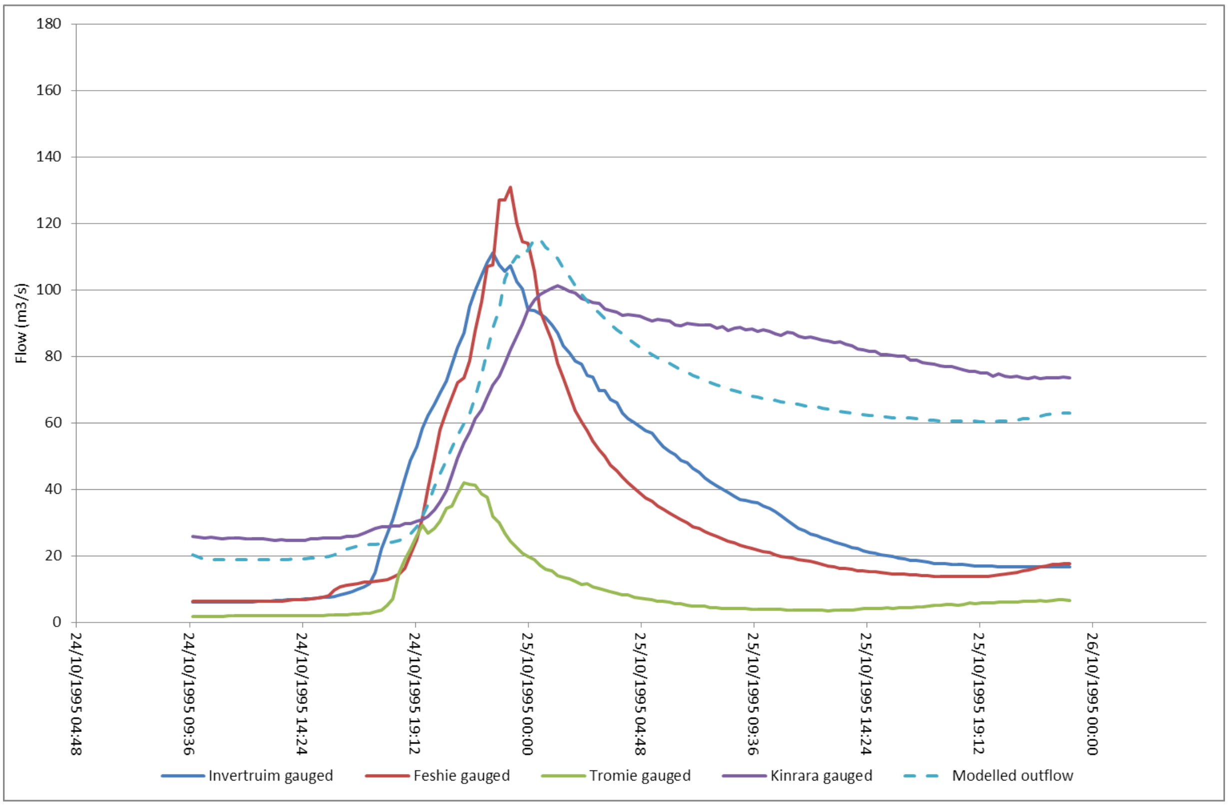


Figure C7: October 1995 event – flow comparison

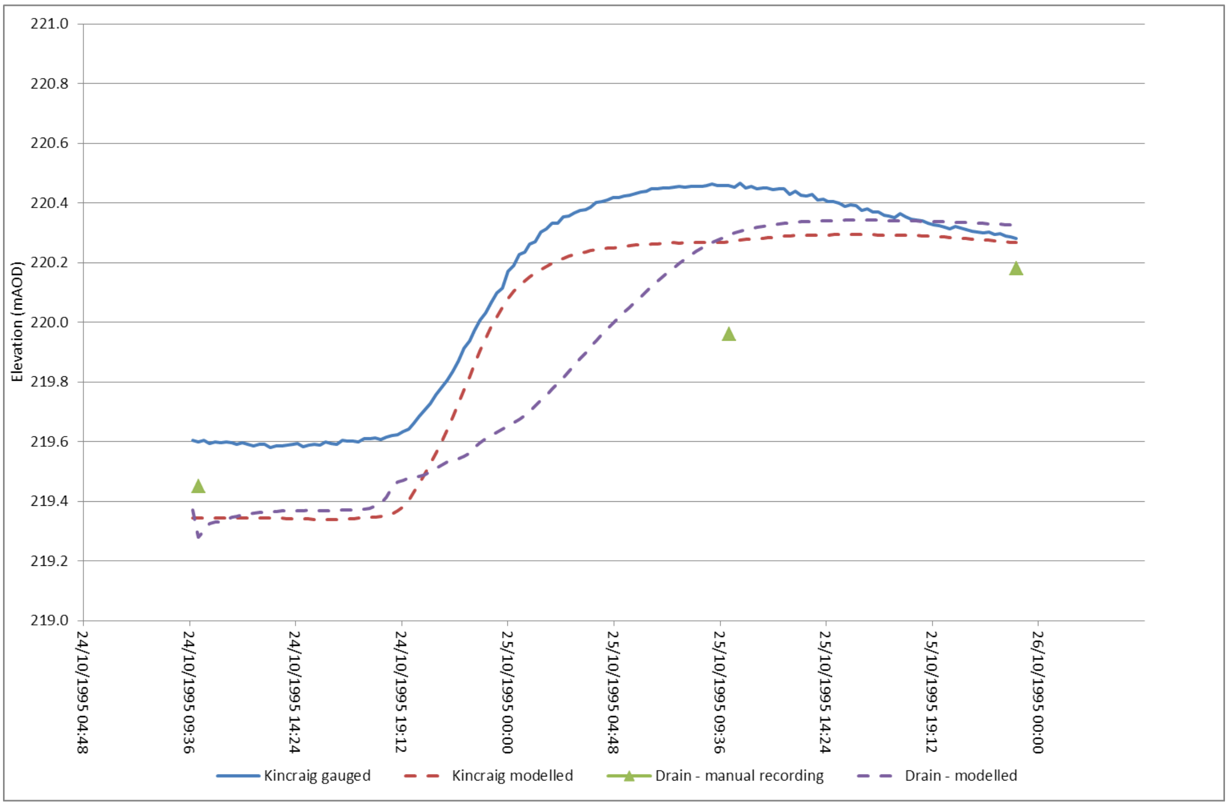


Figure C8: October 1995 event – stage comparison

C.5. Baseline Results

The results presented in this section are as follows –

- Peak water levels for 1D cross-sections are provided in Table C6 and shown in the long profiles in Figures C9 – C12.
- Maximum flood depths and extents for the various flow scenarios are shown in Drawings C2 – C5. These drawings show the maximum depth at any point during the simulation, rather than at a specific time step.
- The sequence of flooding through the site is described in section 3.1 of the main report.
- Further results for the floodplain units are provided in section C7.

Table C6: Baseline 1D cross-section peak water level results (mAOD)

Channel	Node	Description	5-POT	3-POT	QMED	2% AEP	0.5% AEP+CC
Spey	SP15271		222.55	223.09	223.49	224.36	224.95
	SP14908us	Ruthven Bridge	222.32	222.82	223.09	223.66	224.03
	SP14908		222.31	222.80	223.05	223.52	223.78
	SP14769		222.16	222.60	222.98	223.59	223.96
	SP14540	Gynack inflow	221.82	222.24	222.61	223.32	223.78
	SP14423		221.71	222.12	222.48	223.22	223.71
	SP14219		221.54	222.00	222.37	223.12	223.64
	SP13945		221.45	221.90	222.25	222.96	223.43
	SP13882	A9 bridge	221.43	221.87	222.20	222.87	223.29
	SP13863		221.43	221.86	222.18	222.83	223.21
	SP13843		221.43	221.86	222.19	222.85	223.24
	SP13639	Ruthven confluence	221.42	221.86	222.18	222.85	223.26
	SP13146		221.35	221.77	222.03	222.78	223.19
	SP12627		221.27	221.63	221.89	222.72	223.12
	SP12137		221.22	221.57	221.85	222.70	223.09
	SP11911	Tromie confluence	220.92	221.27	221.59	222.46	222.80
	SP11615		220.62	220.96	221.30	222.27	222.59
	SP11052		220.57	220.90	221.23	222.21	222.53
	SP10582	Raitts confluence	220.37	220.66	220.99	221.98	222.29
	SP10053		220.20	220.48	220.80	221.71	222.21
	SP09502		220.16	220.43	220.74	221.54	222.19
	SP08983		220.13	220.38	220.67	221.46	222.19
	SP08596		220.11	220.35	220.63	221.45	222.18
	SP08158		220.09	220.33	220.59	221.45	222.18
	SP07681		220.07	220.30	220.55	221.44	222.17
	SP07330		220.05	220.27	220.53	221.44	222.18
	SP06791		220.01	220.23	220.48	221.44	222.17
	SP06153		219.97	220.18	220.42	221.42	222.15
	SP05211	Loch Insh	219.94	220.15	220.40	221.41	222.14
	SP03045		219.94	220.15	220.40	221.41	222.14
	SP03041	Kincraig Bridge	219.92	220.13	220.38	221.38	222.10
	SP03026		219.92	220.13	220.38	221.38	222.08
	SP01866	Feshie inflow	219.67	219.89	220.19	220.77	221.24
	SP01048		218.06	218.23	218.50	218.87	219.28
Tromie	TR_1441		230.71	230.87	231.23	231.94	232.33
	TR_1297		229.19	229.32	229.68	230.29	230.54
	TR_1070		227.50	227.60	227.78	228.12	228.32
	TR_0850		225.39	225.55	225.81	226.37	226.63
	TR_0651		223.59	223.80	224.25	224.90	225.09
	TR_0460		223.18	223.37	223.65	224.00	224.09

Channel	Node	Description	5-POT	3-POT	QMED	2% AEP	0.5% AEP+CC
	TR_0295		222.71	222.84	223.07	223.32	223.41
	TR_0114_New		221.60	221.70	221.86	222.67	223.07
	TR_0016		220.92	221.27	221.59	222.46	222.80
Ruthven	RU_0738		222.44	222.49	222.63	222.98	223.32
	RU_0637_int		221.69	221.93	222.19	222.77	223.18
	RU_0535		221.45	221.86	222.18	222.80	223.22
	RU_0425_int		221.44	221.86	222.17	222.80	223.22
	RU_0316		221.43	221.86	222.17	222.80	223.22
	RU_0122		221.43	221.86	222.17	222.80	223.21
	RU_0006		221.42	221.86	222.18	222.85	223.26
Raitts	RA_0283		223.01	223.10	223.34	223.73	223.90
	RA_0283_int54		222.60	222.68	222.89	223.17	223.27
	RA_0175		222.09	222.16	222.36	222.60	222.79
	RA_0175_int68		221.23	221.33	221.55	221.97	222.27
	RA_0027		220.44	220.67	220.98	221.97	222.29
	RA_0027!		220.37	220.66	220.99	221.98	222.29
Main Drain	MD03470		219.78	220.02	220.42	221.44	222.18
	MD02793us		219.78	220.02	220.42	221.44	222.18
	MD02793		219.78	220.02	220.42	221.43	222.17
	MD00851		219.78	220.02	220.42	221.43	222.17
	MD00431us		219.78	220.02	220.42	221.43	222.17
	MD00431		219.92	220.14	220.40	221.40	222.14
	MD00000		219.94	220.15	220.40	221.41	222.14

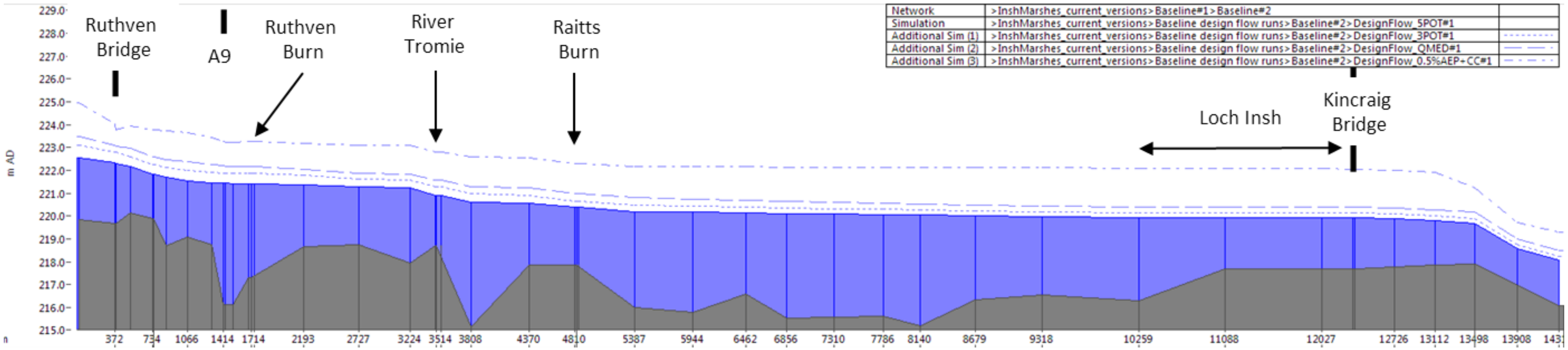


Figure C9: Baseline long profile – peak stage River Spey

Note that a bathymetric survey of Loch Insh was not undertaken and the long profile level at Loch Insh is not representative of actual loch bed levels.

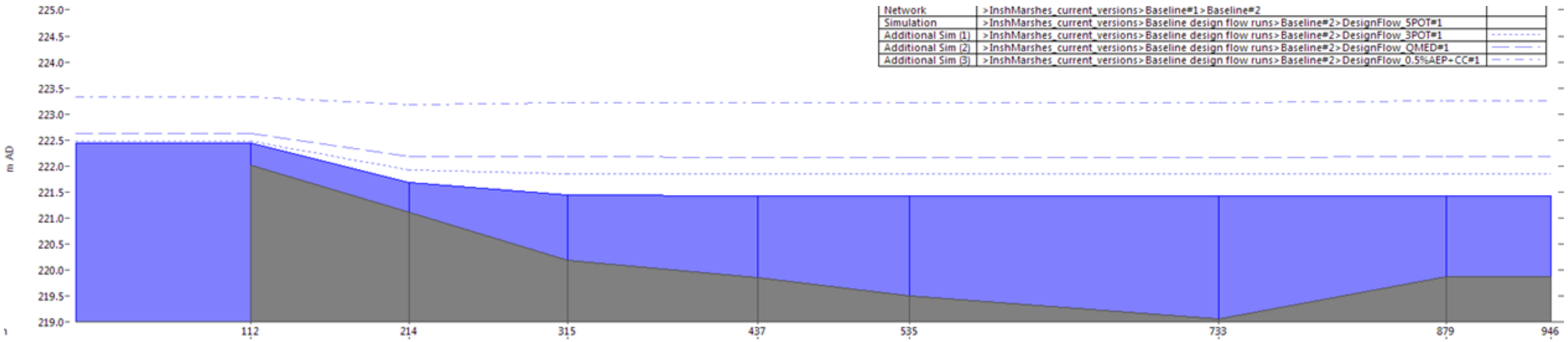


Figure C10: Baseline long profile – peak stage Ruthven Burn

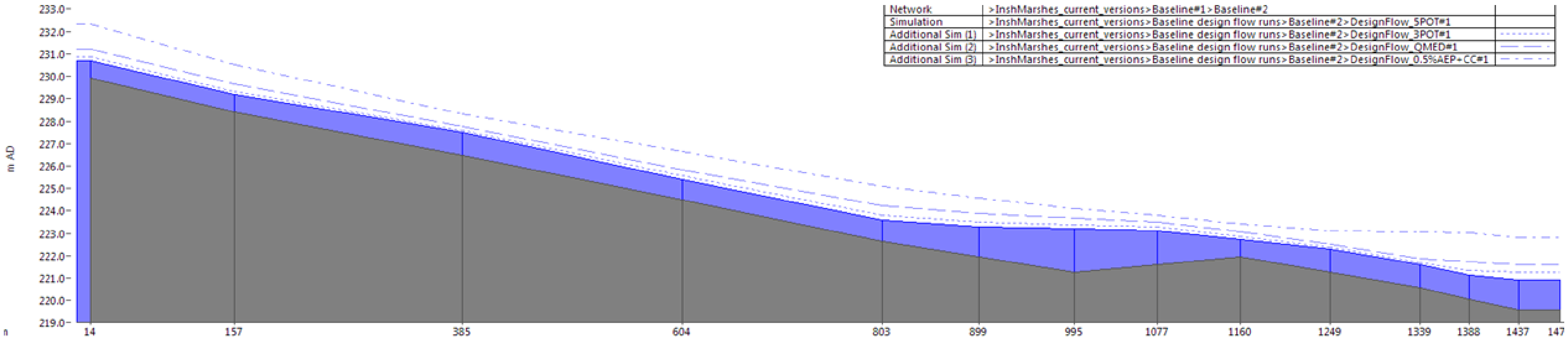


Figure C11: Baseline long profile – peak stage River Tromie

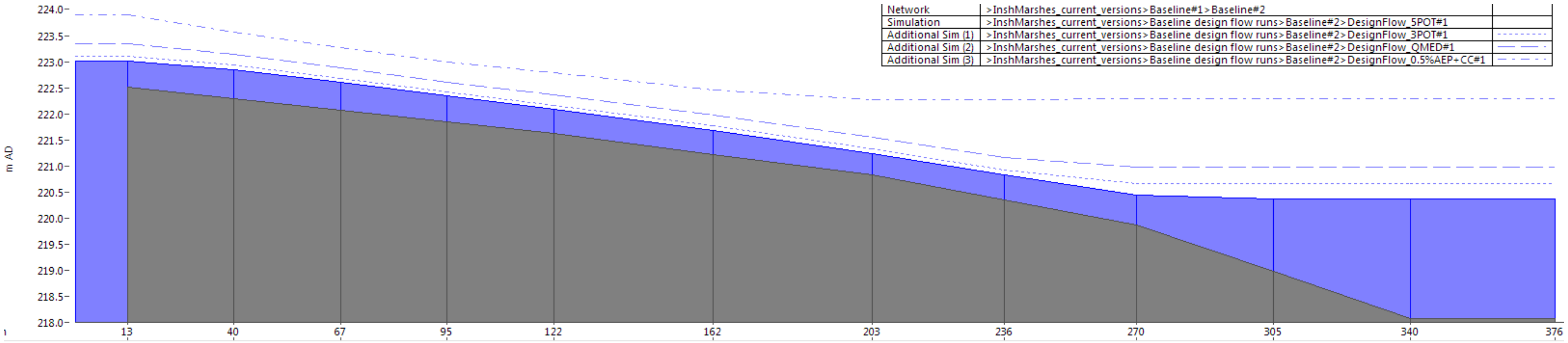


Figure C12: Baseline long profile – peak stage Raitts Burn

C.6. Option Scenarios Model Schematisation

Option descriptions and assumptions are provided in section 4 of the main report. The baseline model was amended for a number of the option scenarios, which are summarised in Table C7. Changes to the ground model used in the 2D model domain are also described. One of the key assumptions in the modelling of the options is that the existing breaches were not altered in the model except where explicitly stated (i.e. assumed that these will not be repaired).

Table C7: Modelled Options Summary

Option	Geometry changes	Ground model (DTM) changes
3. Full repair of embankments	• Lateral spill units at 1D-2D boundary – all existing breach levels raised to similar level as adjacent embankment. • Porous walls representing internal embankments set to an appropriate level to represent conditions if breaches are repaired. • Flap valve added to Main Drain culvert between Dell of Killiehuntly (unit H) and Insh Fen (unit I).	None
4a. Full removal of embankments	• Lateral spill units at 1D-2D boundary – spill levels updated at all embankment locations with revised DTM data (except at breach locations which remain unchanged). • Where embankments are set-back, ground levels in the revised DTM could be lower than bank levels. This applies to Ruthven North & South and Gordonhall (units A, B and C), and spill units here were manually checked and updated where necessary to ensure that overtopping into the floodplain is not overestimated. • Porous walls representing internal embankments set to an appropriate level based on the revised DTM. • Orifice representing culvert draining Ruthven North (unit A) removed. • Cross-sections for Raitts and Ruthven Burns adjusted to represent restoration to a more natural channel. No change in planform –channel cross-section geometry altered including bed levels to provide a more natural width/depth ratio and ~ conveyance of QMED flow in free-flowing conditions. Resulting bed gradient similar to baseline. Cross-sections altered are RU_0738, RU_0637_int, RA_0283, RA_0283_int54, RA_0175, RA_0175_int68, RA_0027.	LiDAR DTM amended – embankments removed (all including internal embankments) and ground levels either side of embankment interpolated to provide updated ground levels.

Option	Geometry changes	Ground model (DTM) changes
4b. Removal at Lynchat	• Lateral spill units at 1D-2D boundary –spill levels updated with revised DTM data at Lynchat - unit L and M only (except at breach locations which remain unchanged). Includes right bank of Raitts Burn. • Porous wall representing internal embankment at western end of unit L set to an appropriate level based on the revised DTM. • Cross-sections for Raitts Burn adjusted to represent restoration to a more natural channel. No change in planform –channel cross-section geometry altered including bed levels to provide a more natural width/depth ratio and ~ conveyance of QMED flow in free-flowing conditions. Resulting bed gradient similar to baseline. Cross-sections altered are RA_0283, RA_0283_int54, RA_0175, RA_0175_int68, RA_0027.	LiDAR DTM amended – as per option 4a but for embankments at unit L and M only.
4c. Removal at Lynchat, Dell, Insh and Coull	• Lateral spill units at 1D-2D boundary –spill levels updated with revised DTM data at Lynchat, Dell, Insh and Coull - units L, M, G, H, I and J (except at breach locations which remain unchanged). Includes right bank of Raitts Burn but excludes right bank of Tromie. • Porous wall representing internal embankment at western end of unit L, between unit H and I and at southern end of unit J set to an appropriate level based on the revised DTM. • Cross-sections for Raitts Burn adjusted to represent restoration to a more natural channel. No change in planform –channel cross-section geometry altered including bed levels to provide a more natural width/depth ratio and ~ conveyance of QMED flow in free-flowing conditions. Resulting bed gradient similar to baseline. Cross-sections altered are RA_0283, RA_0283_int54, RA_0175, RA_0175_int68, RA_0027.	LiDAR DTM amended – as per option 4a but for embankments at units L, M, G, H, I and J only.
5. Increased breaching of embankments	• Lateral spill units at 1D-2D boundary – a number of existing breaches in unit G, H and I widened and 1 additional breach added into unit J.	None
10b. Reduce connectivity between Main Drain and Loch Insh	• Blockage of Main Drain represented using an in-line spill unit at MD00851. Spill level set to same as lowest bank level at this location. Spill coefficient same and 1D-2D boundary (0.5).	None

C.7. Option Scenario Results

The results presented in this section are as follows –

- Change in peak water levels for 1D cross-sections for each scenario are provided in Table C8.
- Comparisons between the baseline, repair (option 3) and full removal (option 4a) peak water levels are also shown in the long profiles for a selection of flow events in Figures C13 – C17.
- Maximum flood depths and extents in the 2D domain are provided for option scenarios where the change is visibly discernible (Option 3, 4a, 4b, 4c and 5 for 5-POT, 3-POT and QMED). These drawings show the maximum depth at any point during the simulation, rather than at a specific time step.
- For the purposes of the ecological assessment, the maximum flood depth was extracted from each of the hydrological units (see Figure 2-1) for each option/ flow scenario. These are detailed in Table C9.

Table C8: Change in 1D cross-section peak water level results for modelled option scenarios (mAOD) – each compared to baseline results presented in Table C6

Yellow results are higher than baseline, green italicised are lower than baseline.

	3. Full repair					4a. Full removal					4b. Remove at Lynchat				4c. Remove at Lynchat, Dell, Coull, Insh				5. Increased breaching				10b. Reduce connectivity between Main Drain and Loch Insh			
Node	5POT	3POT	QMED	2% AEP	0.5% AEP+CC	5POT	3POT	QMED	2% AEP	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC
SP15271	0.00	0.01	0.01	0.01	0.00	0.00	-0.01	*-0.01*	*-0.02*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
SP14908us	0.00	0.01	0.02	0.03	0.04	0.00	*-0.02*	*-0.04*	*-0.13*	*-0.09*	0.00	0.00	0.00	*-0.02*	0.00	0.00	0.00	*-0.02*	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	0.00
SP14908	0.00	0.01	0.03	0.04	0.06	0.00	*-0.02*	*-0.04*	*-0.17*	*-0.15*	0.00	0.00	0.00	*-0.03*	0.00	0.00	0.00	*-0.04*	0.00	0.00	0.00	*-0.01*	0.00	0.00	0.00	0.00
SP14769	0.00	0.03	0.04	0.04	0.05	0.00	*-0.05*	*-0.10*	*-0.20*	*-0.16*	0.00	0.00	0.00	*-0.03*	0.00	0.00	0.00	*-0.04*	0.00	0.00	0.00	*-0.01*	0.00	0.00	0.00	0.00
SP14540	0.00	0.03	0.05	0.06	0.07	*-0.02*	*-0.06*	*-0.15*	*-0.19*	*-0.15*	0.00	*-0.01*	0.00	*-0.05*	0.00	*-0.01*	0.00	*-0.08*	0.00	0.00	0.00	*-0.02*	0.00	0.00	0.00	0.00
SP14423	0.00	0.03	0.06	0.08	0.07	*-0.03*	*-0.06*	*-0.15*	*-0.17*	*-0.16*	-0.01	*-0.01*	-0.01	*-0.05*	-0.01	*-0.01*	-0.01	*-0.10*	0.00	0.00	0.00	*-0.03*	0.00	0.00	0.00	0.00
SP14219	0.00	0.04	0.07	0.09	0.08	*-0.05*	*-0.16*	*-0.21*	*-0.19*	*-0.18*	*-0.01*	*-0.03*	*-0.01*	*-0.06*	*-0.01*	*-0.03*	*-0.01*	*-0.12*	0.00	0.00	0.00	*-0.03*	0.00	0.00	0.00	0.00
SP13945	0.00	0.05	0.10	0.11	0.10	*-0.06*	*-0.20*	*-0.25*	*-0.25*	*-0.26*	*-0.01*	*-0.04*	*-0.01*	*-0.08*	*-0.02*	*-0.04*	*-0.01*	*-0.17*	0.00	0.00	0.00	*-0.04*	0.00	0.00	0.00	0.00
SP13882	0.00	0.05	0.11	0.12	0.12	*-0.06*	*-0.21*	*-0.26*	*-0.32*	*-0.33*	*-0.01*	*-0.04*	*-0.01*	*-0.10*	*-0.01*	*-0.04*	*-0.02*	*-0.22*	0.00	0.00	0.00	*-0.05*	0.00	0.00	0.00	0.00
SP13863	0.00	0.06	0.11	0.13	0.13	*-0.06*	*-0.21*	*-0.27*	*-0.35*	*-0.37*	*-0.01*	*-0.04*	*-0.01*	*-0.11*	*-0.02*	*-0.04*	*-0.02*	*-0.25*	0.00	0.00	0.00	*-0.05*	0.00	0.00	0.00	0.00
SP13843	0.00	0.06	0.11	0.13	0.12	*-0.06*	*-0.22*	*-0.27*	*-0.35*	*-0.36*	*-0.01*	*-0.04*	*-0.01*	*-0.11*	*-0.01*	*-0.04*	*-0.01*	*-0.23*	0.00	0.00	0.00	*-0.05*	0.00	0.00	0.00	0.00
SP13639	0.00	0.06	0.12	0.13	0.13	*-0.06*	*-0.22*	*-0.26*	*-0.32*	*-0.34*	*-0.02*	*-0.04*	*-0.01*	*-0.11*	*-0.02*	*-0.04*	*-0.02*	*-0.24*	0.00	0.00	0.00	*-0.05*	0.00	0.00	0.00	0.00
SP13146	0.00	0.05	0.13	0.14	0.12	*-0.06*	*-0.21*	*-0.18*	*-0.33*	*-0.36*	*-0.02*	*-0.06*	*-0.03*	*-0.13*	*-0.02*	*-0.06*	*-0.03*	*-0.32*	0.00	0.00	0.00	*-0.05*	0.00	0.00	0.00	0.00
SP12627	0.00	0.05	0.17	0.15	0.13	*-0.06*	*-0.20*	*-0.15*	*-0.40*	*-0.42*	*-0.02*	*-0.09*	*-0.16*	*-0.13*	*-0.02*	*-0.09*	*-0.17*	*-0.38*	0.00	0.00	*-0.02*	*-0.07*	0.00	0.00	0.00	0.00
SP12137	0.00	0.05	0.19	0.16	0.14	*-0.06*	*-0.19*	*-0.17*	*-0.47*	*-0.50*	*-0.03*	*-0.10*	*-0.20*	*-0.19*	*-0.03*	*-0.10*	*-0.23*	*-0.45*	0.00	-0.01	*-0.03*	*-0.06*	0.00	0.00	0.00	0.00
SP11911	0.03	0.10	0.25	0.18	0.15	*-0.07*	*-0.20*	*-0.22*	*-0.59*	*-0.52*	*-0.03*	*-0.02*	*-0.07*	*-0.07*	*-0.04*	*-0.09*	*-0.24*	*-0.47*	*-0.02*	*-0.06*	*-0.13*	*-0.20*	0.00	0.00	0.00	0.00
SP11615	0.05	0.15	0.33	0.21	0.20	*-0.08*	*-0.22*	*-0.29*	*-0.73*	*-0.37*	*-0.03*	0.03	0.03	-0.01	*-0.05*	*-0.13*	*-0.32*	*-0.37*	*-0.03*	*-0.12*	*-0.25*	*-0.34*	0.00	0.00	0.00	0.00
SP11052	0.05	0.16	0.31	0.16	0.18	*-0.08*	*-0.21*	*-0.28*	*-0.68*	*-0.33*	*-0.02*	0.06	0.06	0.02	*-0.05*	*-0.11*	*-0.30*	*-0.33*	*-0.04*	*-0.12*	*-0.25*	*-0.27*	0.00	0.00	0.00	0.00
SP10582	0.05	0.18	0.37	0.19	0.30	*-0.09*	*-0.23*	*-0.33*	*-0.46*	*-0.09*	*-0.01*	0.04	0.06	0.03	*-0.06*	*-0.16*	*-0.30*	*-0.09*	*-0.06*	*-0.14*	*-0.24*	*-0.05*	0.00	0.00	0.00	0.00
SP10053	0.06	0.20	0.39	0.20	0.21	*-0.11*	*-0.28*	*-0.29*	*-0.19*	0.02	*-0.01*	0.04	0.05	0.04	*-0.10*	*-0.23*	*-0.25*	0.02	*-0.09*	*-0.17*	*-0.22*	0.03	0.00	0.00	0.00	0.04
SP09502	0.06	0.20	0.40	0.21	*-0.02*	*-0.12*	*-0.28*	*-0.23*	*-0.03*	0.04	-0.01	0.04	0.04	0.05	*-0.10*	*-0.25*	*-0.21*	0.03	*-0.10*	*-0.17*	*-0.19*	0.03	0.00	0.00	0.00	0.04
SP08983	0.06	0.21	0.40	0.15	*-0.04*	*-0.12*	*-0.26*	*-0.17*	0.04	0.04	-0.01	0.03	0.04	0.05	*-0.10*	*-0.24*	*-0.15*	0.03	*-0.10*	*-0.18*	*-0.15*	0.03	0.00	0.00	0.00	0.04
SP08596	0.07	0.21	0.40	0.03	*-0.04*	*-0.12*	*-0.25*	*-0.14*	0.05	0.04	-0.01	0.03	0.03	0.05	*-0.11*	*-0.22*	*-0.12*	0.03	*-0.11*	*-0.18*	*-0.13*	0.03	0.00	0.00	0.00	0.04
SP08158	0.07	0.20	0.40	*-0.08*	*-0.04*	*-0.12*	*-0.23*	*-0.10*	0.06	0.05	-0.01	0.03	0.03	0.05	*-0.11*	*-0.20*	*-0.08*	0.03	*-0.11*	*-0.17*	*-0.10*	0.03	0.00	0.00	0.00	0.04
SP07681	0.07	0.20	0.42	*-0.09*	*-0.04*	*-0.12*	*-0.21*	*-0.06*	0.06	0.04	0.00	0.03	0.03	0.04	*-0.11*	*-0.17*	*-0.04*	0.03	*-0.12*	*-0.16*	*-0.07*	0.03	0.00	0.00	0.00	0.04
SP07330	0.06	0.20	0.41	*-0.14*	*-0.04*	*-0.12*	*-0.19*	*-0.04*	0.06	0.05	0.00	0.02	0.03	0.05	*-0.11*	*-0.15*	*-0.02*	0.03	*-0.12*	*-0.15*	*-0.05*	0.03	0.00	0.00	0.00	0.04
SP06791	0.05	0.20	0.41	*-0.15*	*-0.04*	*-0.12*	*-0.16*	0.01	0.06	0.04	0.00	0.02	0.02	0.05	*-0.11*	*-0.12*	0.03	0.03	*-0.12*	*-0.13*	*-0.01*	0.03	0.00	0.00	0.00	0.04
SP06153	0.05	0.20	0.43	*-0.16*	*-0.03*	*-0.10*	*-0.13*	0.05	0.06	0.05	0.00	0.02	0.01	0.05	*-0.10*	*-0.09*	0.07	0.04	*-0.11*	*-0.10*	0.03	0.03	0.01	0.00	-0.01	0.04
SP05211	0.04	0.21	0.43	*-0.16*	*-0.05*	*-0.10*	*-0.12*	0.05	0.06	0.05	0.00	0.01	0.01	0.05	*-0.09*	*-0.08*	0.07	0.03	*-0.10*	*-0.09*	0.03	0.03	0.01	0.00	-0.01	0.04
SP03045	0.04	0.21	0.43	*-0.16*	*-0.05*	*-0.10*	*-0.12*	0.05	0.06	0.05	0.00	0.01	0.01	0.05	*-0.09*	*-0.08*	0.07	0.03	*-0.10*	*-0.09*	0.03	0.03	0.01	0.00	-0.01	0.04
SP03041	0.04	0.21	0.43	*-0.16*	*-0.05*	*-0.10*	*-0.12*	0.05	0.06	0.05	-0.01	0.02	0.01	0.04	*-0.09*	*-0.08*	0.07	0.03	*-0.10*	*-0.09*	0.03	0.03	0.01	0.00	-0.01	0.04
SP03026	0.04	0.21	0.43	*-0.16*	*-0.04*	*-0.09*	*-0.12*	0.05	0.06	0.05	0.00	0.02	0.01	0.04	*-0.09*	*-0.08*	0.07	0.03	*-0.10*	*-0.09*	0.03	0.03	0.01	0.00	-0.01	0.04
SP01866	0.00	0.04	0.08	0.19	0.00	*-0.01*	*-0.04*	*-0.13*	0.01	0.06	0.00	0.00	0.01	0.02	*-0.01*	*-0.04*	*-0.10*	0.09	*-0.02*	*-0.04*	*-0.08*	0.03	0.00	0.00	0.00	0.00
SP01048	0.00	0.03	0.08	0.17	0.00	*-0.01*	*-0.03*	*-0.13*	0.01	0.05	0.00	0.00	0.01	0.02	*-0.01*	*-0.03*	*-0.10*	0.07	*-0.02*	*-0.03*	*-0.07*	0.03	0.00	0.00	0.00	0.00
TR_1441	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TR_1297	0.00	0.00	0.00	0.00	0.00	0.00	-0.01	*-0.03*	*-0.10*	*-0.07*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TR_1070	0.00	0.00	0.00	0.00	0.01	0.00	*-0.02*	*-0.05*	*-0.12*	*-0.17*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TR_0850	0.00	0.00	0.00	0.00	0.01	-0.01	*-0.03*	*-0.09*	*-0.29*	*-0.39*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TR_0651	0.00	0.00	0.00	0.00	0.01	-0.01	*-0.05*	*-0.15*	*-0.25*	*-0.25*	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Node	3. Full repair					4a. Full removal					4b. Remove at Lynchat				4c. Remove at Lynchat, Dell, Coull, Insh				5. Increased breaching				10b. Reduce connectivity between Main Drain and Loch Insh			
	5POT	3POT	QMED	2% AEP	0.5% AEP+CC	5POT	3POT	QMED	2% AEP	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC	5POT	3POT	QMED	0.5% AEP+CC
TR_0460	0.00	0.00	0.01	0.04	0.06	-0.01	-0.05	-0.09	-0.14	-0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
TR_0295	0.00	0.00	0.02	0.01	0.06	0.00	-0.02	-0.03	-0.05	-0.11	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	-0.01	0.00	0.00	0.00	-0.02	0.00	0.00	0.00	0.00
TR_0114_New	0.00	0.01	0.16	0.16	0.13	-0.03	-0.07	-0.09	-0.48	-0.51	0.00	0.00	-0.01	-0.13	0.00	0.00	-0.02	-0.42	0.00	0.00	-0.01	-0.07	0.00	0.00	0.00	0.00
TR_0016	0.03	0.10	0.25	0.18	0.15	-0.07	-0.20	-0.22	-0.59	-0.52	-0.03	-0.02	-0.07	-0.07	-0.04	-0.09	-0.24	-0.47	-0.02	-0.06	-0.13	-0.20	0.00	0.00	0.00	0.00
RU_0738	0.00	0.01	0.02	0.06	0.09	-0.20	-0.24	-0.39	-0.44	-0.47	0.00	0.00	0.00	-0.08	0.00	0.00	0.00	-0.13	0.00	0.00	0.00	-0.04	0.00	0.00	0.00	-0.01
RU_0637_int	0.00	0.05	0.11	0.15	0.13	-0.26	-0.31	-0.32	-0.32	-0.33	0.00	-0.02	-0.01	-0.13	0.00	-0.02	-0.01	-0.27	0.00	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
RU_0535	0.00	0.06	0.12	0.14	0.13	-0.10	-0.26	-0.30	-0.33	-0.39	-0.01	-0.04	-0.01	-0.12	-0.01	-0.04	-0.01	-0.28	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00
RU_0425_int	0.00	0.06	0.12	0.14	0.13	-0.09	-0.26	-0.30	-0.34	-0.38	-0.01	-0.05	-0.01	-0.12	-0.01	-0.04	-0.01	-0.26	0.00	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
RU_0316	0.00	0.06	0.12	0.14	0.13	-0.09	-0.26	-0.31	-0.35	-0.38	-0.01	-0.04	-0.01	-0.12	-0.01	-0.04	-0.01	-0.26	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00
RU_0122	0.00	0.06	0.12	0.14	0.13	-0.09	-0.26	-0.31	-0.35	-0.38	-0.01	-0.04	-0.01	-0.12	-0.01	-0.04	-0.01	-0.26	0.00	0.00	0.00	-0.06	0.00	0.00	0.00	0.00
RU_0006	0.00	0.06	0.12	0.13	0.13	-0.06	-0.22	-0.26	-0.32	-0.34	-0.02	-0.04	-0.01	-0.11	-0.02	-0.04	-0.02	-0.24	0.00	0.00	0.00	-0.05	0.00	0.00	0.00	0.00
RA_0283	0.00	0.00	0.00	0.00	0.00	-0.26	-0.36	-0.60	-0.99	-1.15	-0.26	-0.36	-0.60	-1.15	-0.26	-0.36	-0.60	-1.15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RA_0283_int54	0.00	0.00	0.00	0.00	0.00	-0.23	-0.31	-0.52	-0.80	-0.90	-0.23	-0.31	-0.52	-0.76	-0.23	-0.31	-0.52	-0.90	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
RA_0175	0.00	0.00	0.00	0.01	0.08	-0.20	-0.28	-0.48	-0.72	-0.57	-0.20	-0.28	-0.48	-0.30	-0.20	-0.28	-0.48	-0.58	0.00	0.00	0.00	-0.04	0.00	0.00	0.00	0.00
RA_0175_int68	0.00	0.00	0.00	0.18	0.30	-0.23	-0.33	-0.55	-0.46	-0.07	-0.23	-0.33	-0.50	0.03	-0.23	-0.33	-0.55	-0.06	0.00	0.00	0.00	-0.03	0.00	0.00	0.00	0.00
RA_0027	0.03	0.17	0.37	0.19	0.31	-0.15	-0.23	-0.33	-0.46	-0.08	-0.08	0.04	0.06	0.03	-0.13	-0.16	-0.30	-0.08	-0.01	-0.10	-0.20	-0.04	0.00	0.00	0.00	0.00
RA_0027!	0.05	0.18	0.37	0.19	0.30	-0.09	-0.23	-0.33	-0.46	-0.09	-0.01	0.04	0.06	0.03	-0.06	-0.16	-0.30	-0.09	-0.06	-0.14	-0.24	-0.05	0.00	0.00	0.00	0.00
MD03470	-0.08	-0.17	-0.33	-0.17	-0.04	0.06	0.07	0.08	0.07	0.06	0.00	0.02	0.01	0.05	0.07	0.11	0.11	0.05	0.08	0.09	0.08	0.03	-0.01	0.00	-0.01	0.03
MD02793us	-0.08	-0.17	-0.33	-0.16	-0.04	0.06	0.06	0.07	0.07	0.06	0.00	0.02	0.01	0.05	0.07	0.11	0.10	0.05	0.08	0.09	0.06	0.03	-0.01	0.00	-0.02	0.04
MD02793	-0.08	-0.17	-0.33	-0.16	-0.04	0.06	0.06	0.07	0.07	0.05	0.00	0.02	0.01	0.05	0.07	0.11	0.09	0.04	0.08	0.09	0.06	0.03	-0.01	0.00	-0.02	0.04
MD00851	-0.08	-0.17	-0.32	-0.16	-0.03	0.05	0.06	0.06	0.07	0.06	0.00	0.01	0.01	0.06	0.07	0.10	0.09	0.04	0.08	0.09	0.06	0.03	-0.01	-0.01	-0.01	0.04
MD00431us	-0.08	-0.17	-0.32	-0.16	-0.03	0.05	0.06	0.06	0.07	0.06	0.00	0.01	0.01	0.06	0.07	0.10	0.09	0.04	0.08	0.09	0.06	0.03	0.00	-0.01	-0.01	0.04
MD00431	0.04	0.21	0.42	-0.16	-0.02	-0.09	-0.11	0.05	0.06	0.05	0.00	0.02	0.01	0.06	-0.08	-0.07	0.07	0.03	-0.09	-0.08	0.03	0.03	0.01	0.00	-0.01	0.05
MD00000	0.04	0.21	0.43	-0.16	-0.05	-0.10	-0.12	0.05	0.06	0.05	0.00	0.01	0.01	0.05	-0.09	-0.08	0.07	0.03	-0.10	-0.09	0.03	0.03	0.01	0.00	-0.01	0.04

Table C9: Change in 2D flood depths at representative points for each floodplain unit (m) – each compared to baseline results

Yellow results are higher than baseline, green italicised are lower than baseline.

Option	A - Ruthven North			B - Ruthven South			C - Gordonhall			D - Invertromie Fen			H - Dell of Killiehuntly - lower			I - Insh			J - Coull			K - Cemetery Marsh			L - Lynchat upper			M - Lynchat lower			N - Balavil		
	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED	5POT	3POT	QMED
Baseline	**0.00**	**0.41**	**0.73**	**0.00**	**0.33**	**0.94**	**0.00**	**0.17**	**0.88**	**0.05**	**0.28**	**1.05**	**0.13**	**0.41**	**0.87**	**0.29**	**0.53**	**0.94**	**0.48**	**0.72**	**1.13**	**0.00**	**0.64**	**0.97**	**0.00**	**0.03**	**0.49**	**0.25**	**0.57**	**0.95**	**0.02**	**0.23**	**0.56**
Opt3.	0.00	0.00	0.00	0.00	0.00	0.16	0.00	0.00	0.83	0.07	0.39	1.24	0.00	0.00	0.00	0.21	0.36	0.65	0.40	0.55	0.84	0.00	0.69	1.13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02
Difference	0.00	-0.41	-0.73	0.00	-0.33	-0.78	0.00	-0.17	-0.05	0.01	0.11	0.18	-0.13	-0.41	-0.87	-0.08	-0.17	-0.29	-0.08	-0.17	-0.29	0.00	0.05	0.16	0.00	-0.03	-0.49	-0.25	-0.57	-0.95	-0.02	-0.23	-0.53
Opt4a.	0.00	0.21	0.55	0.32	0.58	0.86	0.00	0.37	0.86	0.04	0.55	1.02	0.18	0.48	0.98	0.35	0.60	1.01	0.54	0.78	1.19	0.00	0.15	0.54	0.01	0.20	0.57	0.16	0.44	0.69	0.03	0.17	0.62
Difference	0.00	-0.20	-0.18	0.32	0.25	-0.08	0.00	0.20	-0.02	-0.01	0.27	-0.03	0.04	0.07	0.11	0.06	0.06	0.07	0.06	0.06	0.07	0.00	-0.49	-0.43	0.01	0.17	0.08	-0.08	-0.13	-0.27	0.00	-0.06	0.06
Opt4b.	0.00	0.41	0.73	0.00	0.28	0.86	0.00	0.13	0.67	0.05	0.23	0.82	0.13	0.43	0.88	0.29	0.55	0.95	0.48	0.74	1.14	0.00	0.33	0.69	0.05	0.39	0.71	0.27	0.68	1.02	0.02	0.24	0.56
Difference	0.00	0.00	0.00	0.00	-0.05	-0.08	0.00	-0.04	-0.22	-0.01	-0.06	-0.23	-0.01	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	-0.32	-0.28	0.05	0.36	0.22	0.02	0.12	0.07	0.00	0.01	0.01
Opt4c.	0.00	0.41	0.73	0.00	0.28	0.85	0.00	0.13	0.60	0.04	0.21	0.75	0.16	0.59	1.00	0.36	0.64	1.03	0.54	0.81	1.20	0.00	0.30	0.57	0.05	0.32	0.53	0.24	0.52	0.67	0.00	0.09	0.51
Difference	0.00	0.00	0.00	0.00	-0.05	-0.09	0.00	-0.04	-0.28	-0.01	-0.08	-0.31	0.03	0.18	0.14	0.07	0.11	0.10	0.06	0.09	0.08	0.00	-0.35	-0.40	0.05	0.29	0.04	-0.01	-0.04	-0.29	-0.02	-0.15	-0.04
Opt5.	0.00	0.41	0.73	0.00	0.32	0.94	0.00	0.17	0.86	0.05	0.26	1.03	0.20	0.56	1.13	0.37	0.62	1.00	0.56	0.81	1.18	0.00	0.64	0.95	0.00	0.03	0.26	0.20	0.44	0.69	0.00	0.12	0.51
Difference	0.00	0.00	0.00	0.00	0.00	-0.01	0.00	0.00	-0.03	-0.01	-0.03	-0.03	0.06	0.15	0.26	0.08	0.09	0.06	0.08	0.09	0.05	0.00	-0.01	-0.02	0.00	0.00	-0.23	-0.05	-0.13	-0.27	-0.02	-0.11	-0.05
Opt10b.	0.00	0.41	0.73	0.00	0.33	0.94	0.00	0.17	0.88	0.05	0.28	1.05	0.12	0.41	0.86	0.28	0.53	0.92	0.47	0.72	1.11	0.00	0.64	0.97	0.00	0.03	0.49	0.25	0.57	0.96	0.03	0.23	0.55
Difference	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.02	0.00	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	-0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	-0.01

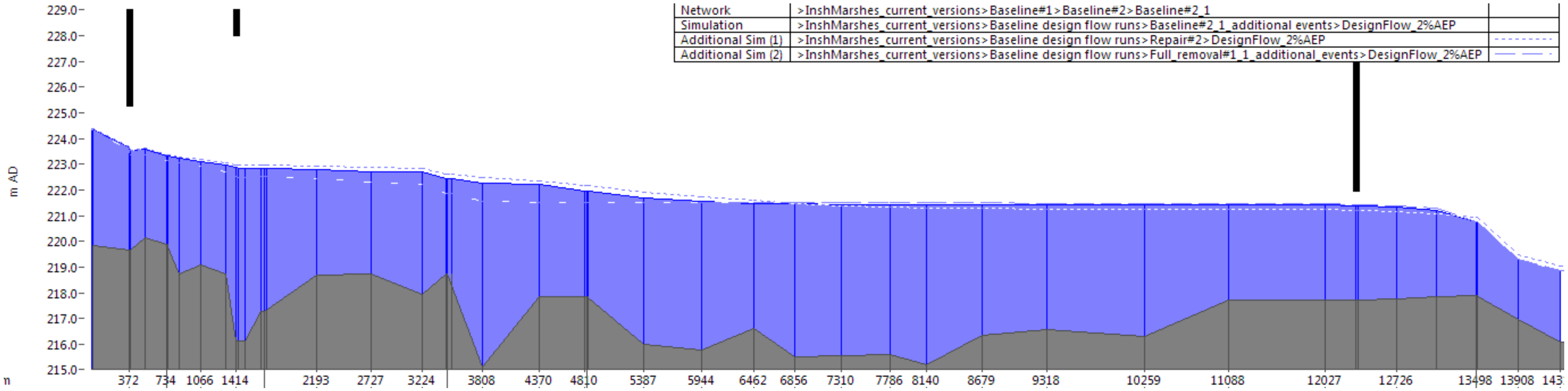


Figure C13: Long profile peak stage – baseline (blue), option 3 repair (fine dotted) and option 4a full removal (wide dotted) – River Spey 2% AEP

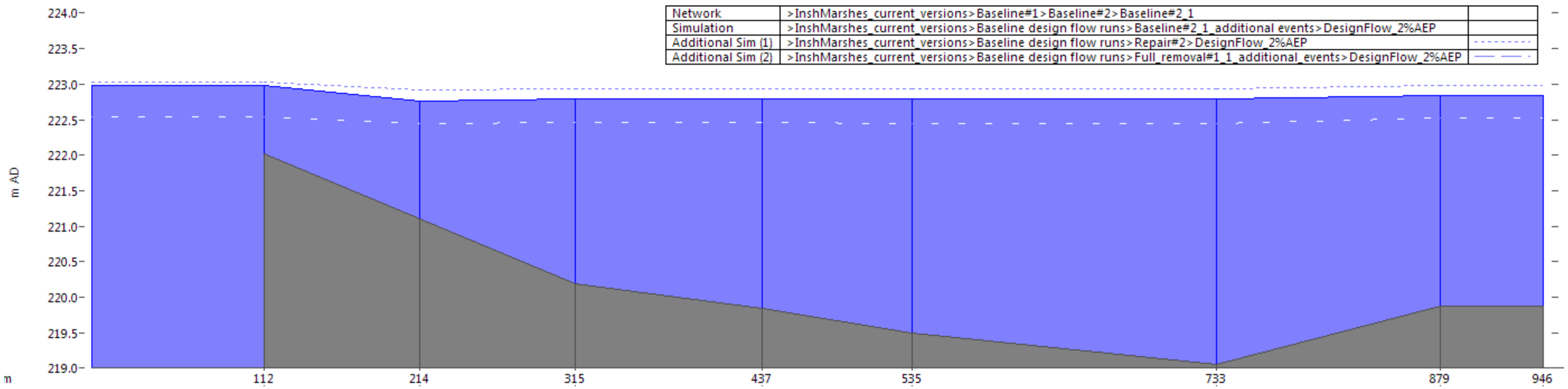


Figure C14: Long profile peak stage – baseline (blue), option 3 repair (fine dotted) and option 4a full removal (wide dotted) – Ruthven Burn 2% AEP

Note that in option 4a bed levels have been lowered, influencing the peak water levels

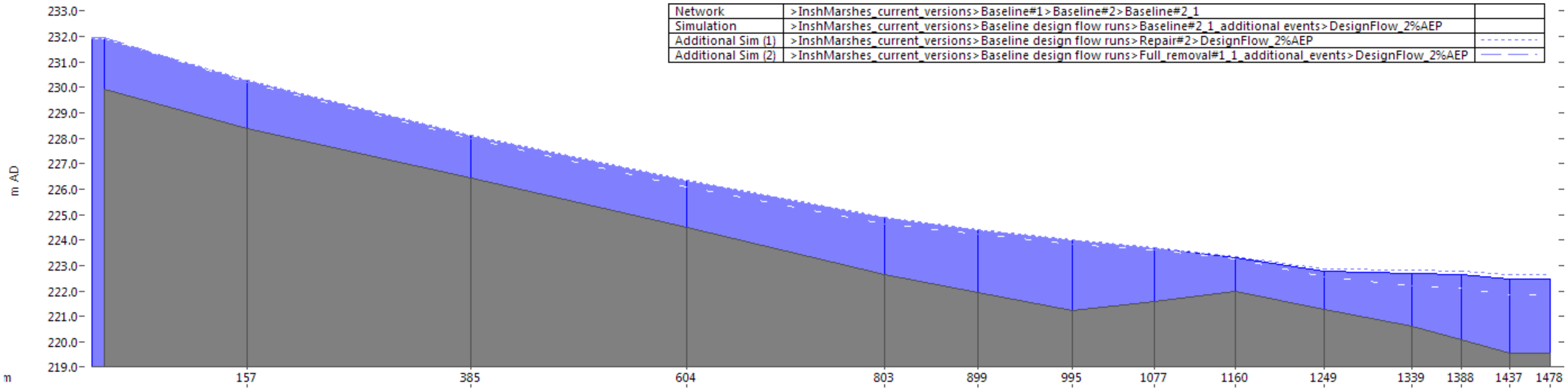


Figure C15: Long profile peak stage – baseline (blue), option 3 repair (fine dotted) and option 4a full removal (wide dotted) – River Tromie 2% AEP

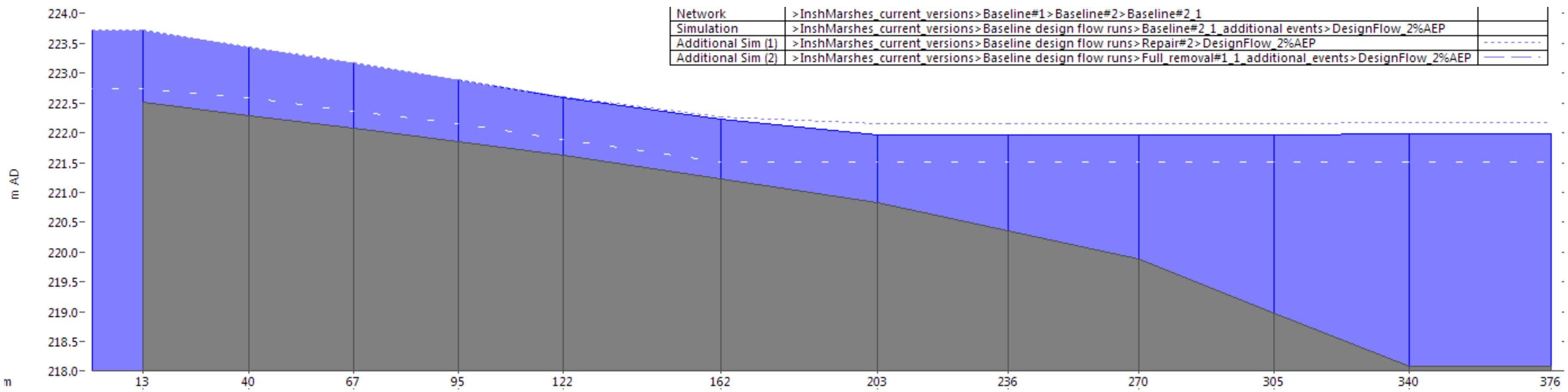


Figure C16: Long profile peak stage – baseline (blue), option 3 repair (fine dotted) and option 4a full removal (wide dotted) – Raitts Burn 2% AEP

Note that in option 4a bed levels have been lowered, influencing the peak water levels

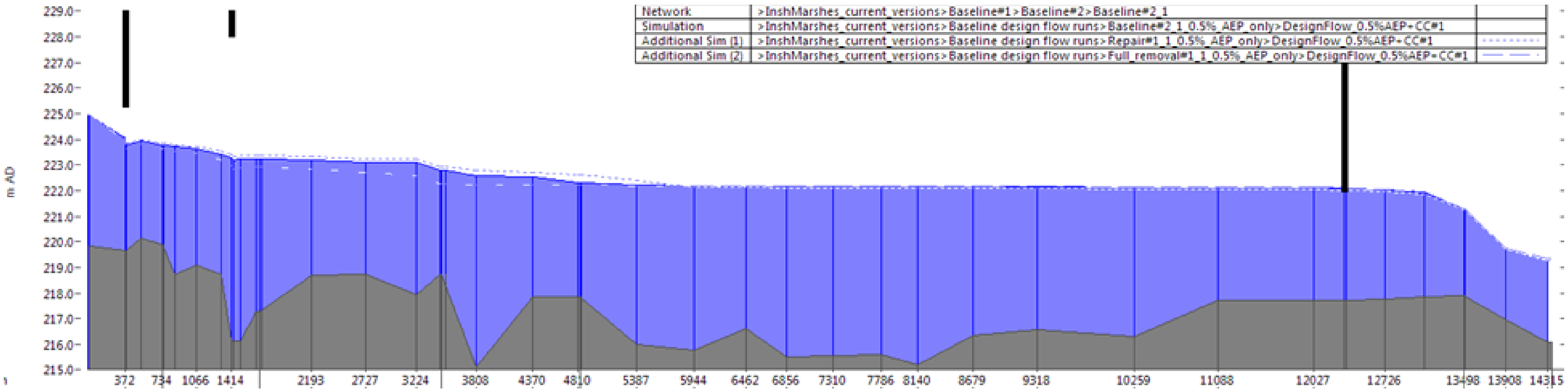


Figure C17: Long profile peak stage – baseline (blue), option 3 repair (fine dotted) and option 4a full removal (wide dotted) – River Spey 0.5% AEP+CC

C.8. Assessment of Flood Risk

Potential receptors adjacent to the study area (termed local receptors in this report) at risk of flooding from the River Spey, Ruthven Burn, River Tromie and Raitts Burn were identified using historic flood records (see section 3.1.4 of the report) and the model results. The identified receptors are shown in Figure C18 and detailed in Table C10. The list of potential receptors is not exhaustive but provides sufficient information to assess the implications of the options on flood risk. Other sources of flood risk are excluded from the assessment (for example, tributaries outside of the study area such as the Gynack Burn/ surface water runoff).

Change in potential flood risk to local receptors is detailed in Table C10 using the model results in Table C8 and the 2D maximum flood depths shown in the relevant Drawings.

Change in potential flood risk to downstream receptors is assessed through consideration of changes to the hydrograph at Kincraig (Figure C19 – C20, Table C11). The change in peak flows at the downstream model boundary is presented in Table C12 for comparison to demonstrate how the change in timing of the peak on the Spey can influence peak flows downstream of the Feshie confluence.

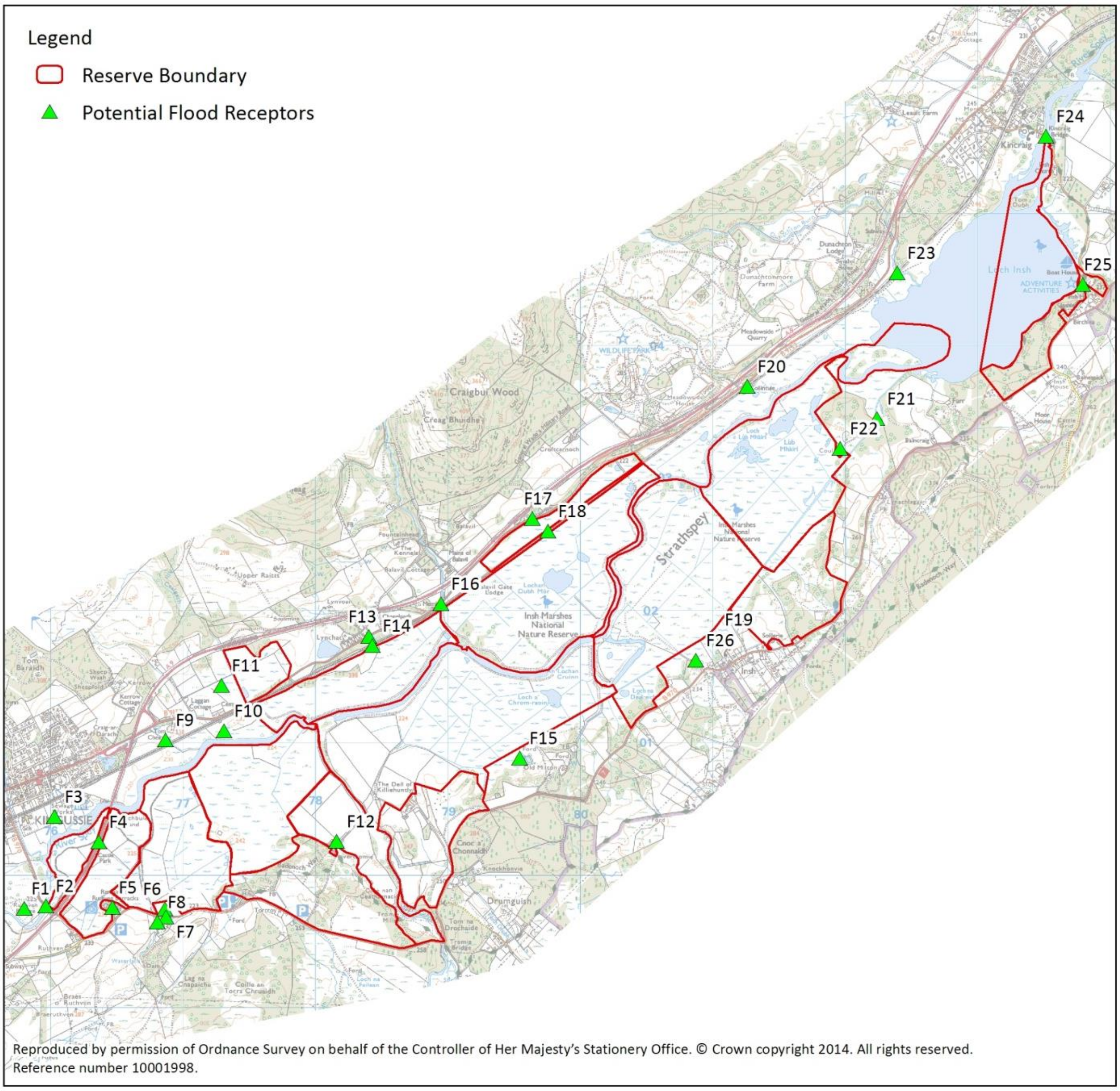


Figure C18: Potential Flood Risk Receptors

Table C10: Identified Potential Flood Risk Receptors

Potential Receptor		Potential Flood Risk - Baseline		Potential Change in Flood Risk at 0.5% AEP+CC Event (max flood levels)					
				3. Full repair	4a. Full removal	4b. Remove at Lynchat	4c. Remove at Lynchat, Dell, Coull, Insh	5. Increased breaching	10b. Reduce connectivity between Main Drain and Loch Insh
F1	Land on left floodplain upstream of Ruthven Bridge, incl. shinty pitch, B970 and properties at southern extent of Kingussie	Y	Minor overtopping onto adjacent land at QMED B970 and properties at risk at 2% AEP	Negligible increase (0.02m)	Negligible decrease (0.03m)	-	-	-	-
F2	B970 at Ruthven Bridge	N	Predicted flood level below soffit including at 0.5% AEP+CC	-	-	-	-	-	-
F3	Land on LFP at Kingussie, incl. school, sewage treatment works and railway. Potential flow route through underpass in railway to Kingussie to north. Sewage treatment works flooded in 1990 event.	Y	Land at risk at QMED. Sewage works at risk at 2% AEP. Flow route potentially active at 2% AEP.	Minor increase (<0.1m)	Decrease (0.1 – 0.2m)	Minor decrease (<0.1m)	Minor decrease (<0.1m)	Negligible decrease (0.02m)	-
F4	A9	N	Predicted level at 0.5% AEP+CC below road level	-	-	-	-	-	-
F5	Ruthven Barracks - SAM	N	Predicted level at 0.5% AEP+CC below level of built remains	-	-	-	-	-	-
F6	Land outwith RSPB boundary - south of Gordonhall	Y	Inundated to max. depth of 0.5m at QMED	Increase (0.1 – 0.2m) (note max depth reduced by <0.1m at QMED)	Decrease (0.2 – 03m) (note no change at QMED)	Minor decrease (<0.1m)	Decrease (0.2 – 03m)	-	-
F7	B970 at Gordonhall	Y	Small section of road at risk at 0.5% AEP+CC	Increase (0.1 – 0.2m)	Decrease (0.3 -0.4m). Road no longer predicted to be at risk.	Decrease (0.1 – 0.2m)	Decrease (0.3 -0.4m). Road no longer predicted to be at risk.	Minor decrease (<0.1m)	-
F8	Properties adjacent to Ruthven Burn	-	Baseline risk not assessed - potential increase in upstream levels from options assessed based on changing flood levels within the study area.	Minor increase (<0.1m)	Decrease due to bed lowering.	Minor decrease (<0.1m)	Decrease (0.1 – 0.2m	Minor decrease (<0.1m)	-
F9	Land to north of railway at Tom Cheireag	Y	Levels within study area higher than ground to north of railway which is connected via a drain – potential flooding at QMED.	Increase (0.1 – 0.2m)	Decrease (0.3 – 0.4m)	Decrease (0.1 – 0.2m)	Decrease (0.3 – 0.4m)	Minor decrease (<0.1m)	-
F10	Land outwith RSPB boundary - west of Lynchat	Y	Inundated to max. depth of 0.6-1.0m at QMED	Increase (0.1 – 0.2m)	Decrease (0.3 – 0.4m)	Decrease (0.1 – 0.2m)	Decrease (0.3 – 0.4m)	Minor decrease (<0.1m)	-
F11	Land outwith RSPB boundary - west of Cemetery Marsh	Y	Inundated to max. depth of 0.3 - >1.0m at QMED. Cemetery not at risk at 0.5% AEP+CC	Increase (0.1 – 0.2m)	Decrease (0.4 – 0.5m)	Decrease (0.1 – 0.2m)	Decrease (0.3 – 0.4m)	Minor decrease (<0.1m)	-
F12	Invertromie Farm properties	Y	Potential risk from overland flow from overtopping of Tromie at 2% AEP. Property has been subject to individual FRA and mitigation for re-development.	No change	Negligible increase (0.03m)	-	-	-	-
F13	Lynchat - properties, land outwith RSPB ownership, B9152. Flooded in 1990.	Y	Land to north of railway predicted to flood at QMED. Properties and B9152 predicted to be at risk at 2% AEP.	Increase (0.1 – 0.2m)	Decrease (0.4 – 0.5m)	Decrease (0.1 – 0.2m)	Decrease (0.4 – 0.5m)	Minor decrease (<0.1m)	-

Potential Flood Risk - Baseline				Potential Change in Flood Risk at 0.5% AEP+CC Event (max flood levels)					
Potential Receptor				3. Full repair	4a. Full removal	4b. Remove at Lynchat	4c. Remove at Lynchat, Dell, Coull, Insh	5. Increased breaching	10b. Reduce connectivity between Main Drain and Loch Insh
F14	Railway - Lynchat	N	Predicted level at 0.5% AEP+CC below railway level	-	-	-	-	-	-
F15	Land outwith RSPB boundary - south of Dell of Killiehuntly Wetland	Y	Low-lying ground inundated to max. depth of 0.6m at QMED	Increase (0.2 – 0.3m) (note reduced frequency of flooding, no longer at risk in QMED event).	-	-	-	-	-
F16	B9152 and railway at Raitts Burn Flooded during 1990 event Balavil Gate Lodge	N	Not at risk from flood levels within study area at 0.5% AEP+CC – Raitts Burn upstream of study area assumed to be source of flood risk	-	Significant decrease in max levels due to bed regrading – dependent on design	Significant decrease in max levels due to bed regrading – dependent on design	Significant decrease in max levels due to bed regrading – dependent on design	-	-
F17	B9152 at Balavil North	Y	Max flood level within study area higher than ground to north of railway – potential for back-up via drainage connections into Balavil North at QMED. Road potentially at risk at 0.5% AEP+CC	Minor decrease (<0.1m)	-	-	-	-	-
F18	Railway at Balavil North	N	Not at risk from flood levels within study area at 0.5% AEP+CC	-	-	-	-	-	-
F19	Land outwith RSPB ownership - north of Insh Village	Y	Low-lying ground inundated to max. depth of 0.6-1.0m at QMED	Minor decrease (<0.1m) (note larger decrease at QMED)	-	-	Minor increase (<0.1m)	-	-
F20	Railway, B9152 and property at entrance to Wildlife Park. Cottage at entrance to Wildlife Park and the B9152 flooded in 1990.	Y	B9152 and cottage potentially at risk in 0.5%AEP+CC. Railway higher. Influence of tributary to west of cottage not considered in this assessment.	Minor decrease (<0.1m)	-	-	-	-	-
F21	Access to Coull	Y	2% AEP	Negligible decrease (0.03m) (note larger decrease at 2% AEP)	Minor increase (<0.1m)	Minor increase (<0.1m)	Minor increase (<0.1m)	Negligible increase (0.03m)	Minor increase (<0.1m)
F22	Property at Coull	N	Not at risk from flood levels within study area at 0.5% AEP+CC	-	-	-	-	-	-
F23	Railway at Dunachton Burn, property and B9152	Y	B9152 and low-lying ground at risk from levels in Loch Insh at 2% AEP. Property/ railway not at risk at 0.5% AEP+CC from flood levels in study area. Flood risk from Dunachton Burn not assessed.	Minor decrease (<0.1m) (note substantial increase at QMED of >0.4m but road not likely to be affected).	Negligible increase (0.01m)	Negligible increase (0.01m)	-	-	-
F24	Kincraig property and road Road flooded in 1990 event	Y	Roads at risk at 0.5% AEP+CC. Note that blockage of Kincraig Bridge not modelled.	Minor decrease (<0.1m) (note substantial increase at QMED of >0.4m but road not likely to be affected).	Minor increase (<0.1m)	Minor increase (<0.1m)	Negligible increase (0.03m)	Negligible increase (0.03m)	Minor increase (<0.1m)
F25	Loch Insh Watersports Building flooded in 1990.	Y	Building at risk at 0.5% AEP+CC	Minor decrease (<0.1m	Negligible increase (0.01m)	Negligible increase (0.01m)	-	-	-
F26	Insh WWTW	N	LiDAR suggests infrastructure located above 0.5% AEP+CC level.	-	-	-	-	-	-

Table C11: Change in peak flow at Kincraig

Option	5POT	3POT	QMED	2% AEP	0.5% AEP+CC
Peak flow m³/s					
Baseline	29	38	51	116	196
Change in peak flow in m³/s (% of baseline)					
3. Full repair of embankments	+2 (6%)	+11 (28%)	+27 (52%)	-11 (9%)	-12 (6%)
4a. Full removal of embankments	*-4 (13%)*	*-5 (14%)*	*+3 (5%)*	+8 (7%)	+4 (2%)
4b. Removal at Lynchat	0 (-)	+1 (2%)	+1 (2%)	-	+1 (1%)
4c. Removal at Lynchat, Dell, Insh and Coull	*-4 (13%)*	*-4 (9%)*	*+4 (8%)*	-	+1 (<1%)
5. Increased breaching of embankments	*-4 (13%)*	*-4 (10%)*	*+2 (3%)*	-	0 (-)
10b. Reduce connectivity between Main Drain and Loch Insh	0 (-)	0 (-)	0 (-)	-	-1 (<1%)

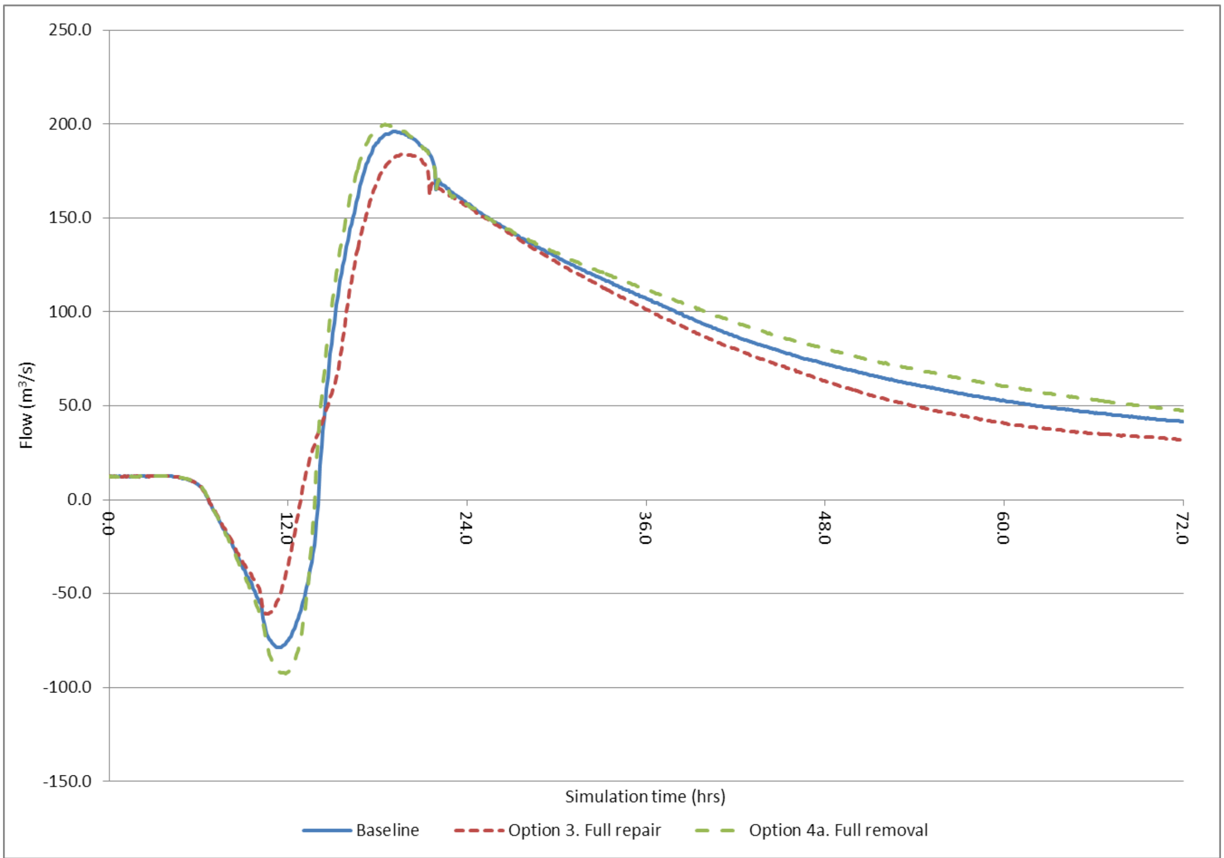


Figure C19: Hydrograph at Kincraig Bridge (SP03026) – 0.5% AEP+CC

Table C12: Change in peak flow at downstream model boundary

Option	5POT	3POT	QMED	2% AEP	0.5% AEP+CC
Peak flow m^3/s					
Baseline	63	89	139	224	355
Change in peak flow in m^3/s (% of baseline)					
3. Full repair of embankments	0 (-)	+5 (6%)	+17 (12%)	+47 (21%)	0 (-)
4a. Full removal of embankments	*-1 (2%)*	*-6 (7%)*	*-24 (17%)*	+2 (1%)	+17 (5%)
4b. Removal at Lynchat	0 (-)	0 (-)	2 (1%)	-	+6 (2%)
4c. Removal at Lynchat, Dell, Insh and Coull	*-1 (2%)*	*-6 (7%)*	*-19 (14%)*	-	+25 (7%)
5. Increased breaching of embankments	*-2 (3%)*	*-5 (6%)*	*-15 (11%)*	-	+10 (3%)
10b. Reduce connectivity between Main Drain and Loch Insh	0 (-)	+1 (1%)	+1 (1%)	-	0 (-)

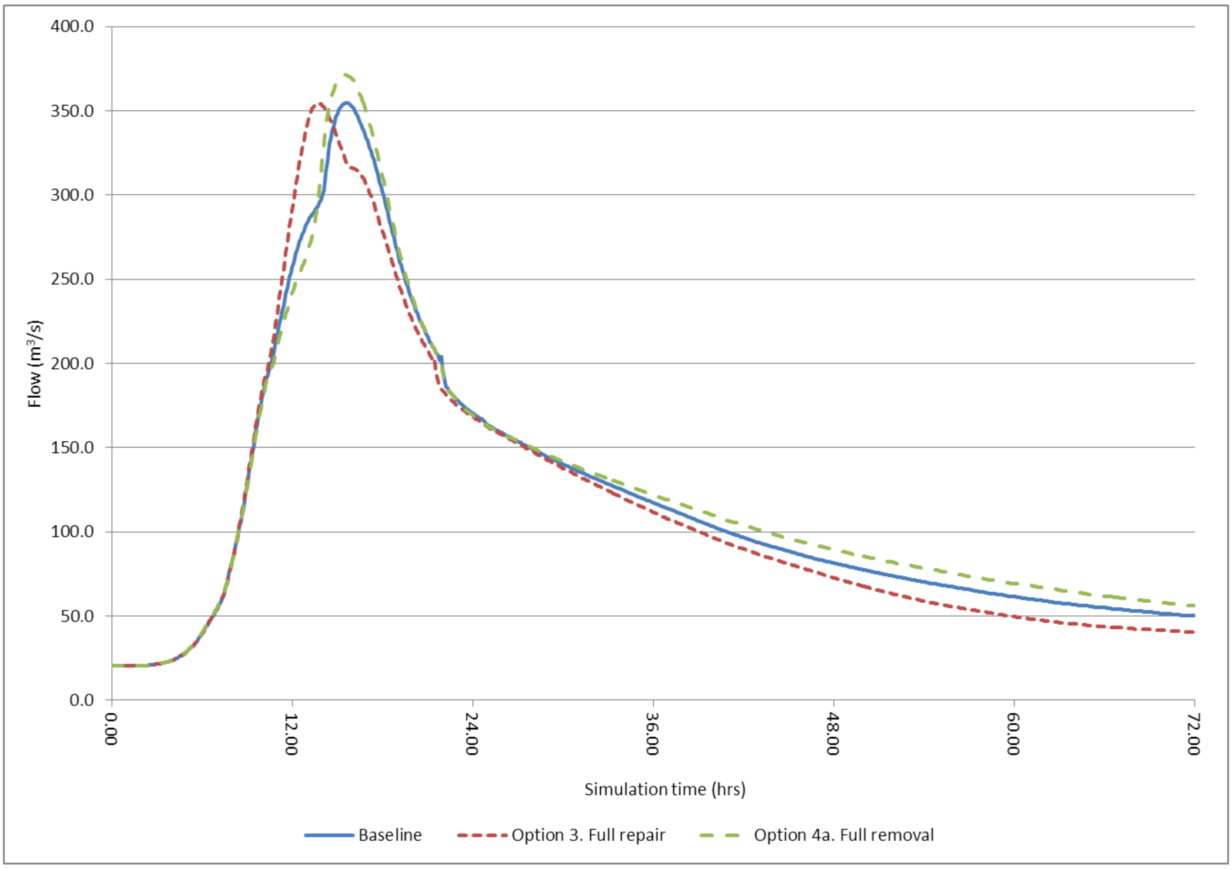
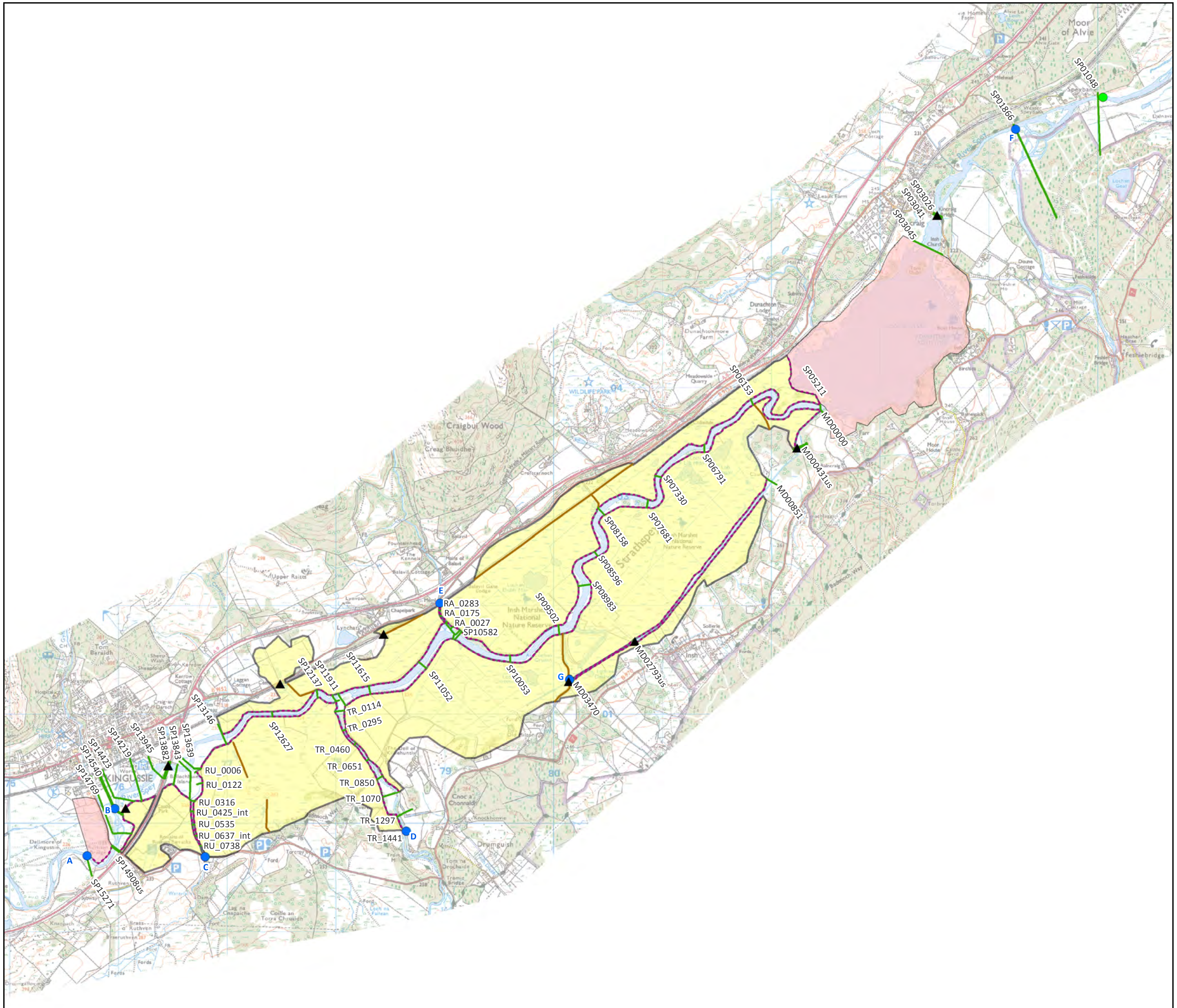


Figure C20: Hydrograph at downstream model boundary – 0.5% AEP+CC



Legend

- Inflows
- Downstream boundary
- Channel cross-sections
- Structures
- Spill units - 1D-2D boundary
- 2D domain - porous walls
- 1D storage area
- 2D domain

Notes

1. Interpolated nodes in Raitts Burn and Main Drain not labelled

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C1 Model Schematisation
Status	FINAL
Drawing No.	166050_011
Revision	
Scale	1:35,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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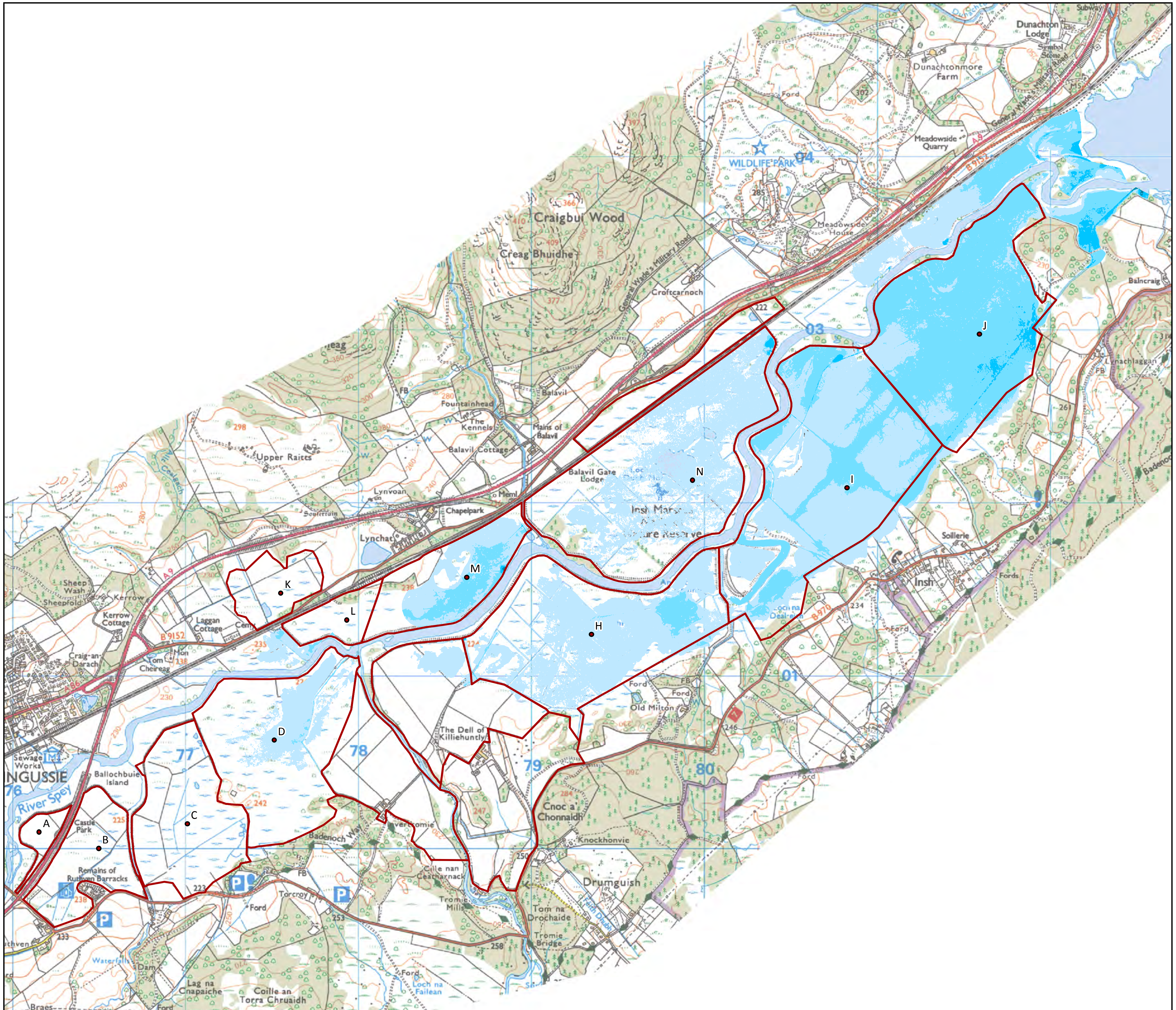

Legend

Assessment units

Representative points

Maximum depth

0.01 - 0.3m

0.3 - 0.6m

0.6 - 1.0m

>1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).

2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C2 Maximum Flood Depth Baseline 5 POT
Status	FINAL
Drawing No.	166050_013
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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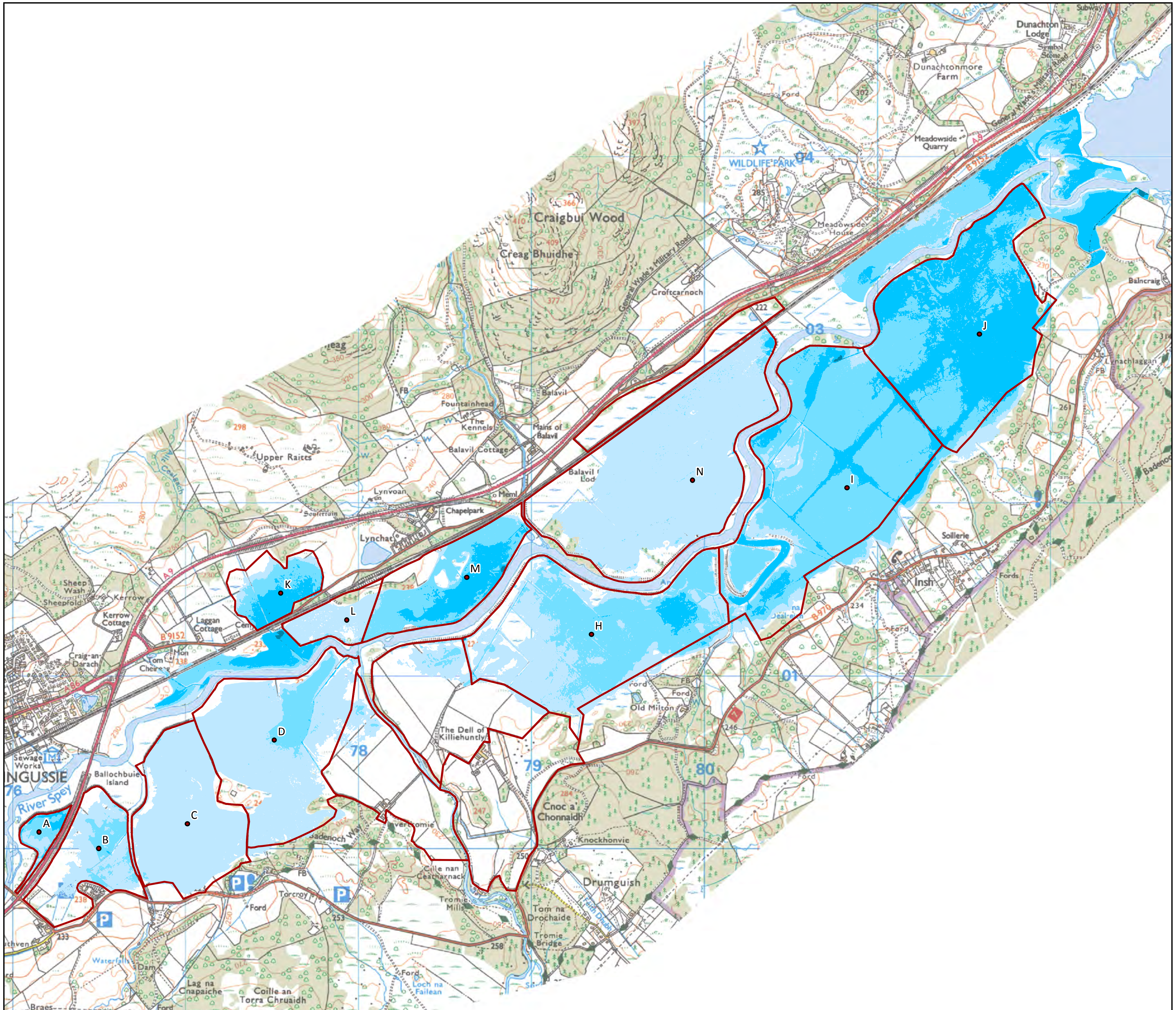

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client
RSPB

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing C3
Maximum Flood Depth
Baseline 3 POT

Status
FINAL

Drawing No.	Revision
166050_014	

Scale		Date
1:22,000	A3	28 Aug 2015

Drawn	Checked	Approved
HR	FH	FH

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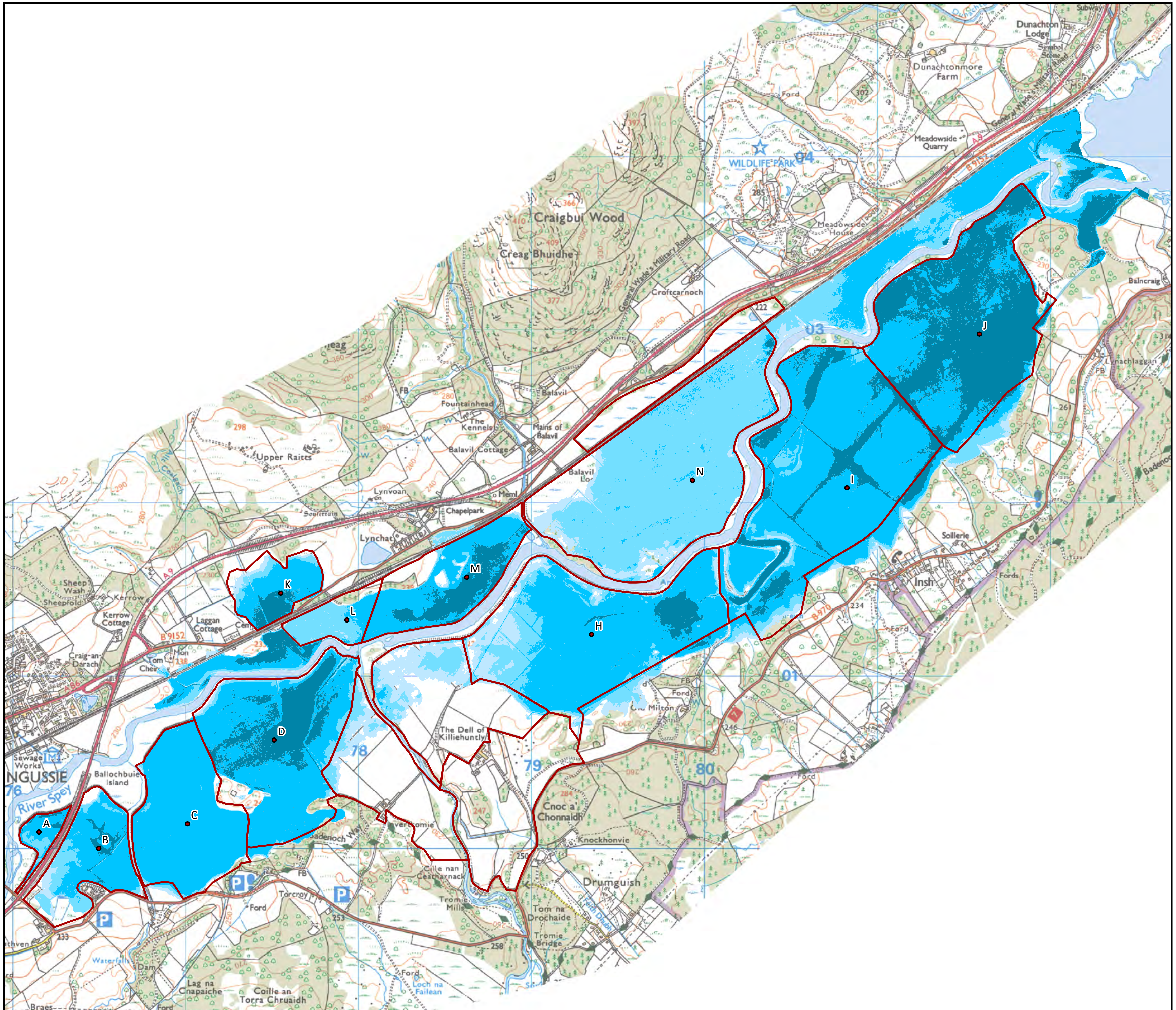

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C4 Maximum Flood Depth Baseline QMED
Status	FINAL
Drawing No.	166050_015
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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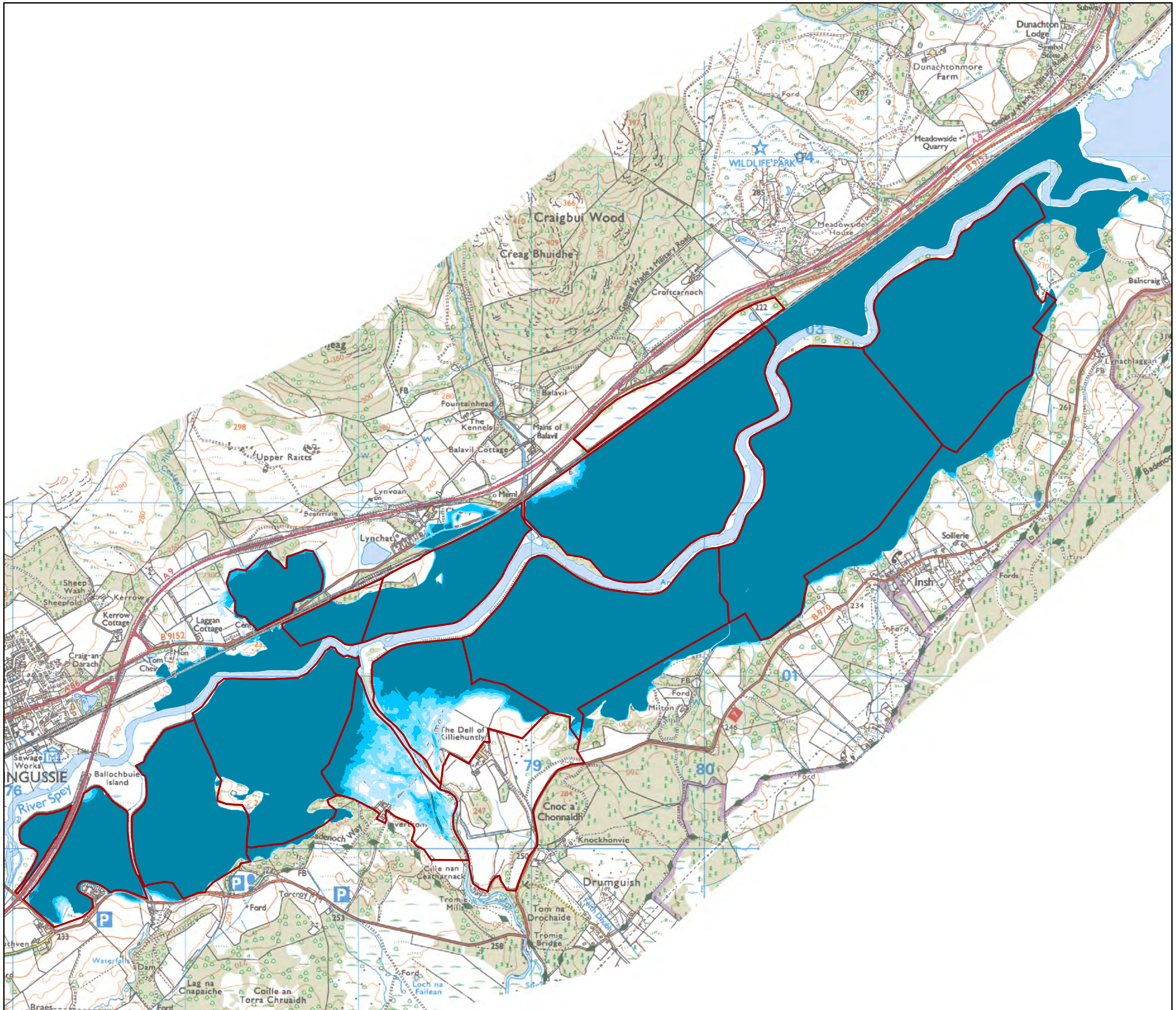

Legend

Assessment units

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C5 Maximum Flood Depth Baseline 0.5% AEP plus climate change
Status	FINAL
Drawing No.	166050_016
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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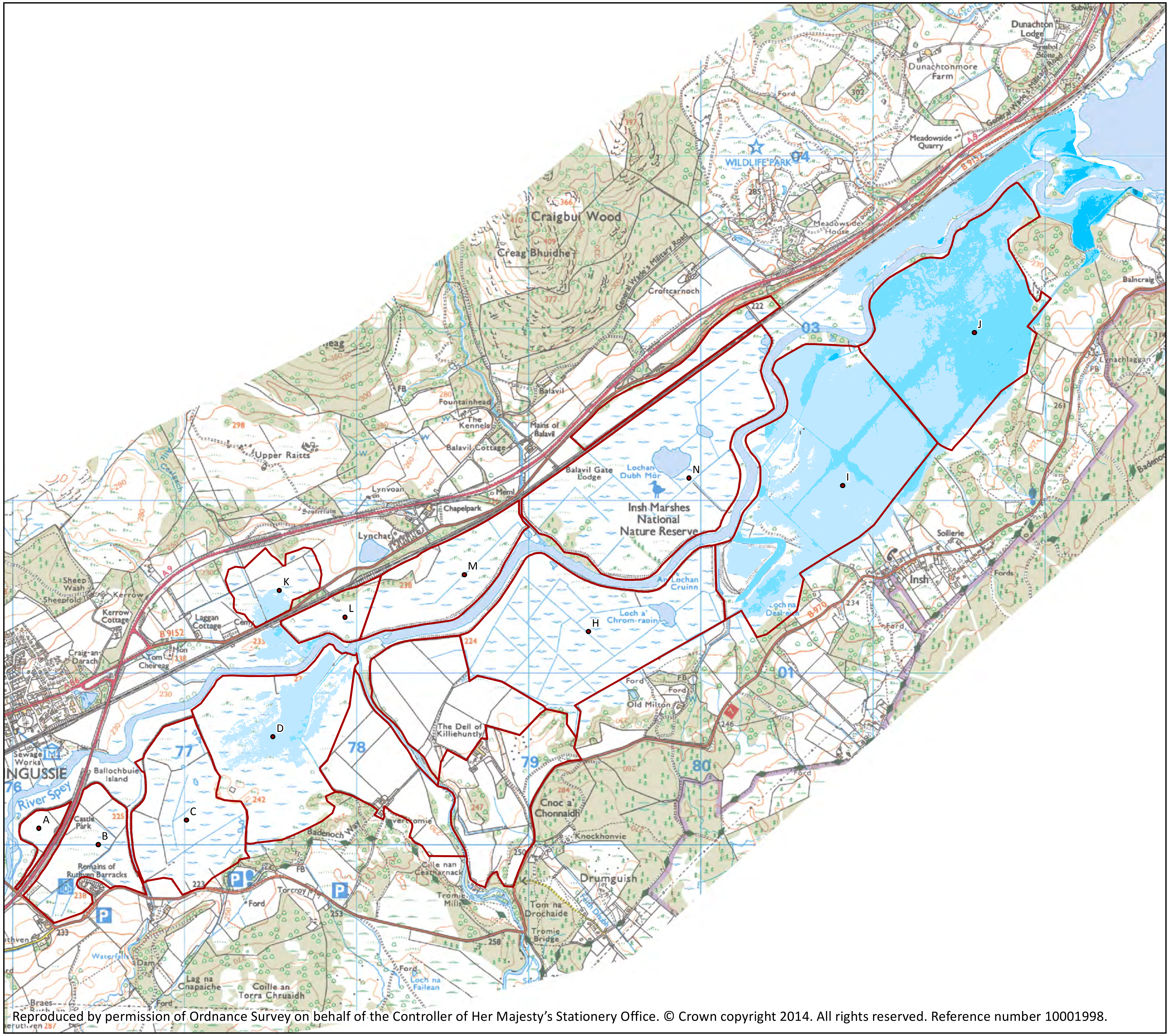

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C6 Maximum Flood Depth Option 3: Full Repair 5 POT
Status	FINAL
Drawing No.	166050_033
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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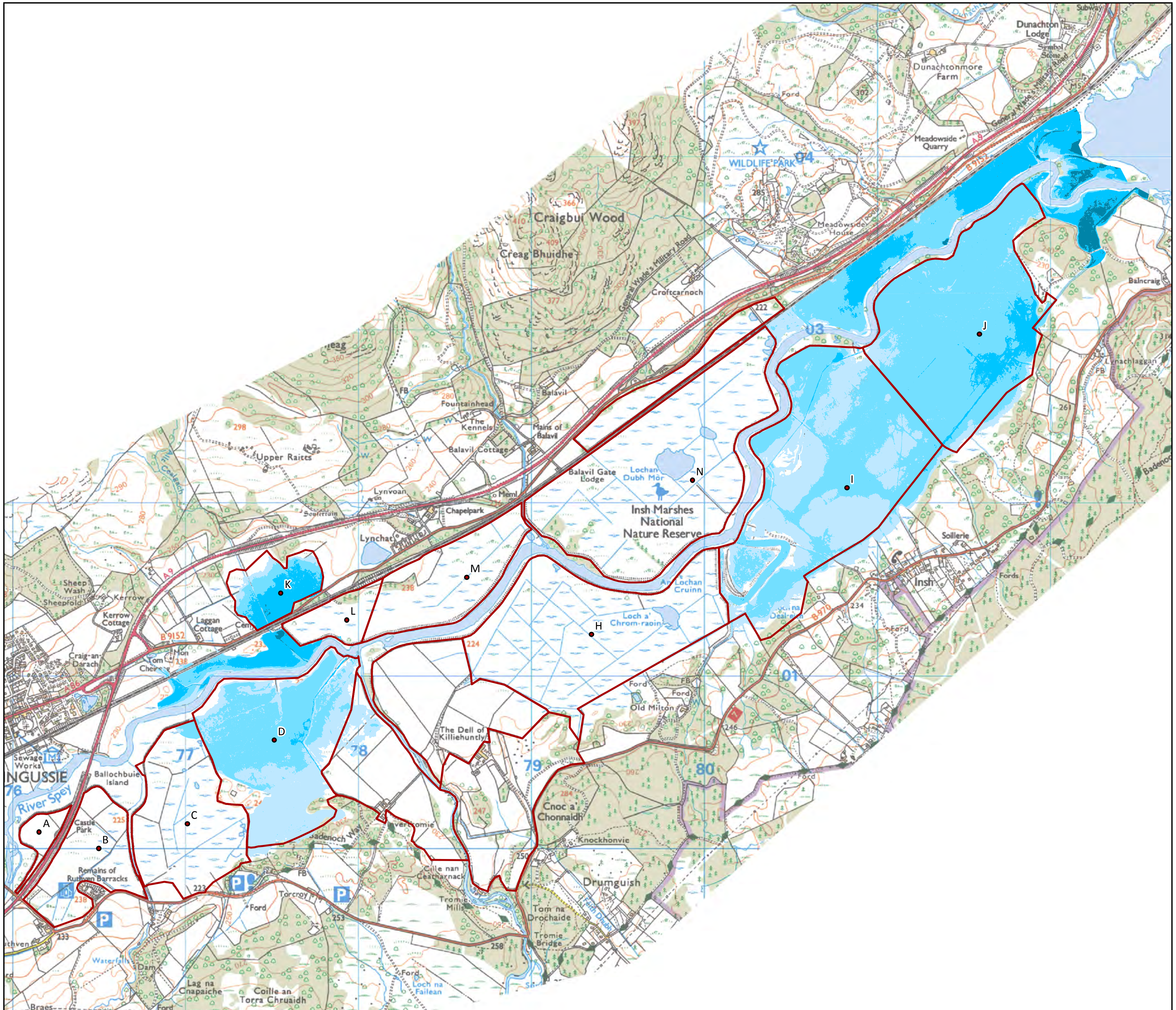

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C7 Maximum Flood Depth Option 3: Full Repair 3 POT
Status	FINAL
Drawing No.	166050_028
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
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Approved	FH

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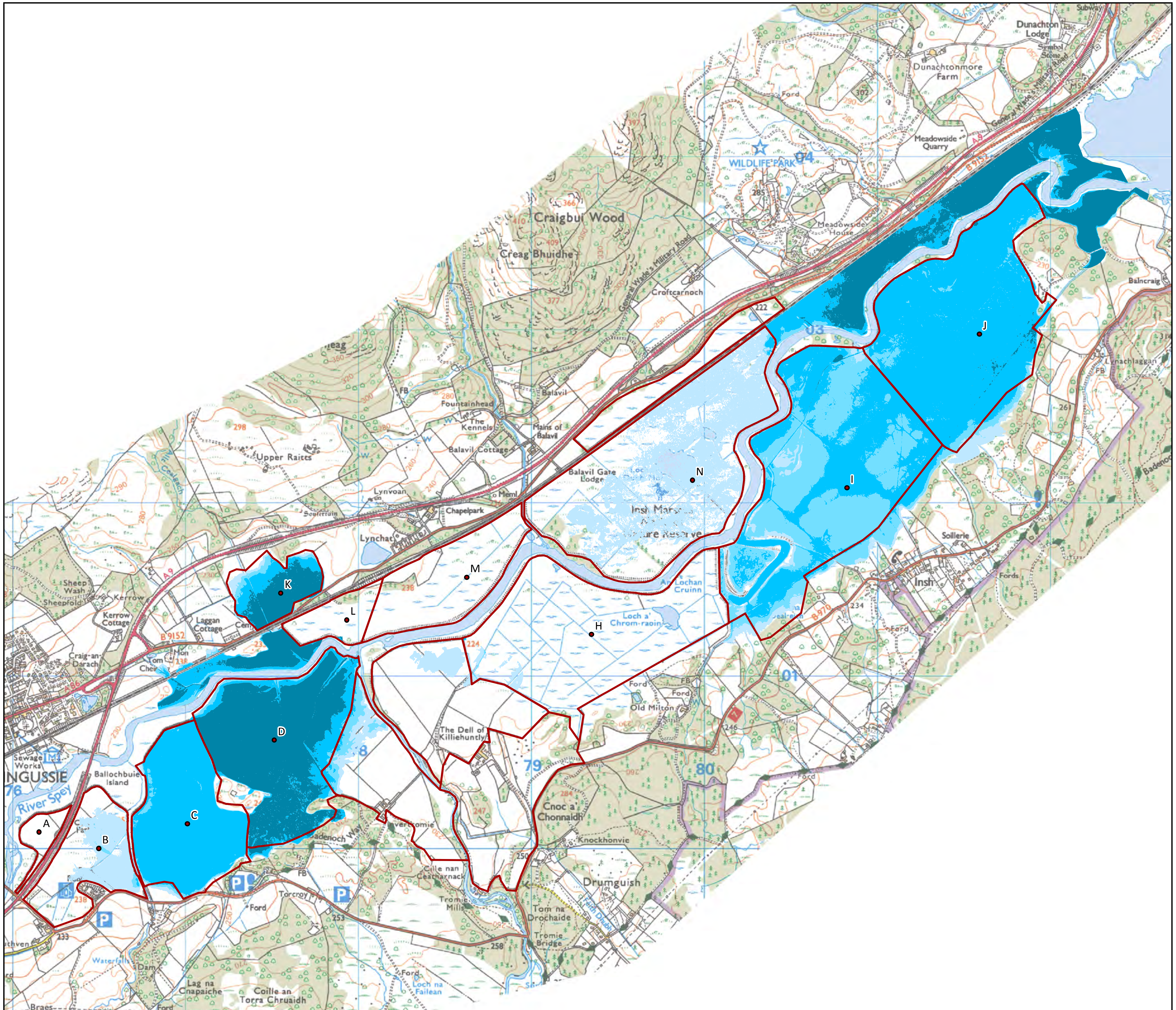

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C8 Maximum Flood Depth Option 3: Full Repair QMED
Status	FINAL
Drawing No.	166050_034
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
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Approved	FH

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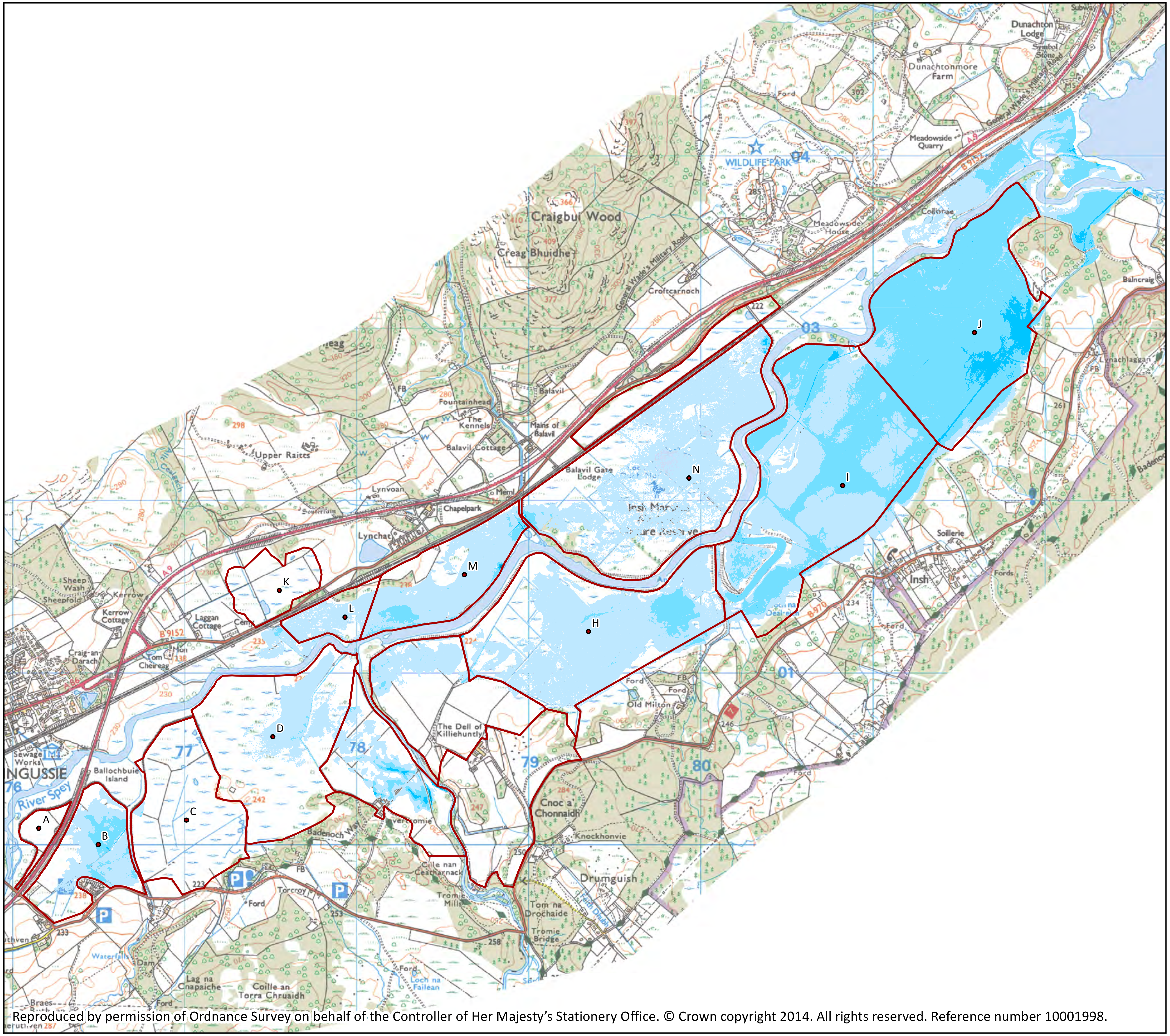

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client
RSPB

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing C9
Maximum Flood Depth
Option 4a: Full removal 5 POT

Status
FINAL

Drawing No.	Revision
166050_035	

Scale		Date
1:22,000	A3	28 Aug 2015

Drawn	Checked	Approved
HR	FH	FH

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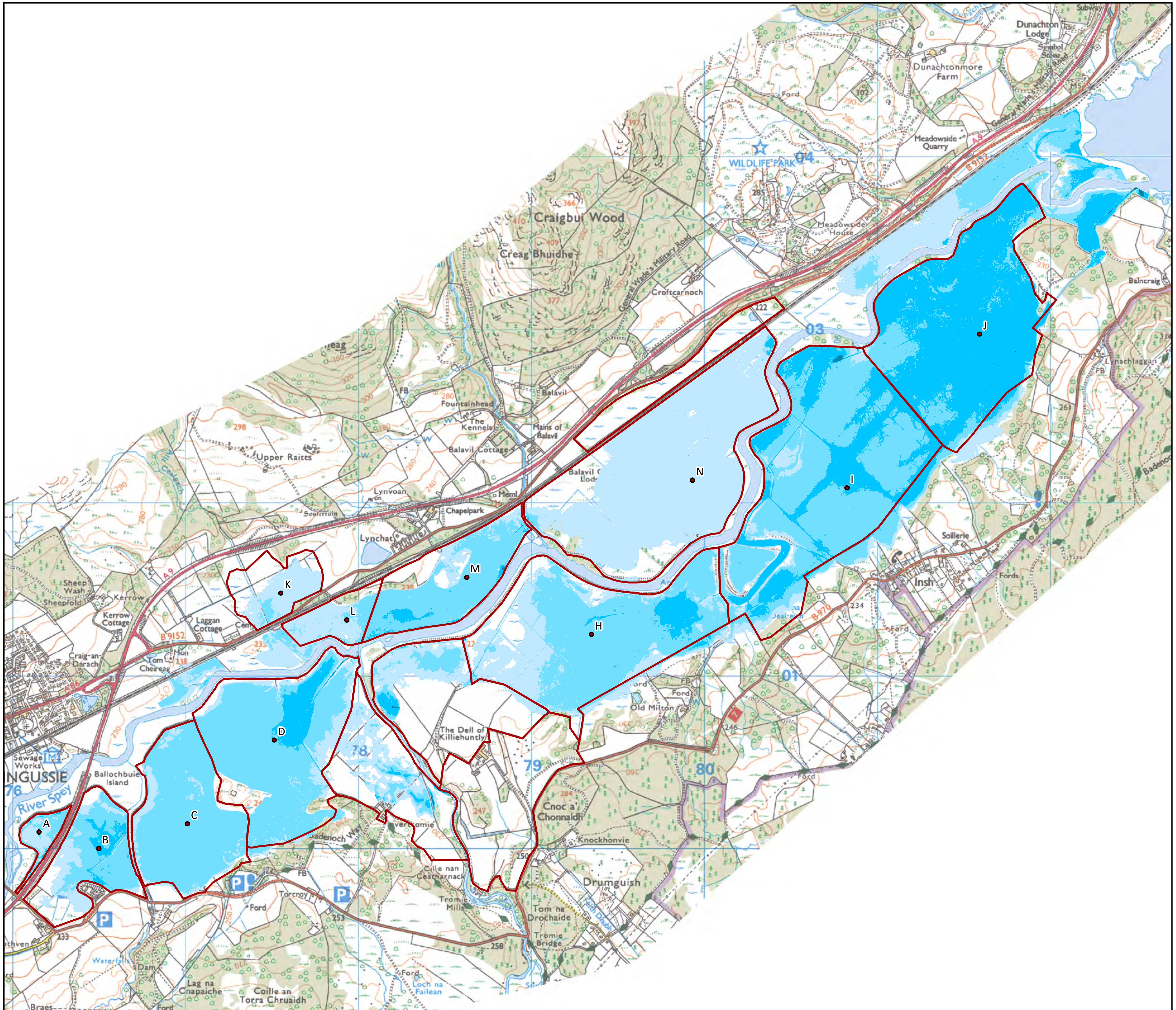

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C10 Maximum Flood Depth Option 4a: Full removal 3 POT
Status	FINAL
Drawing No.	166050_029
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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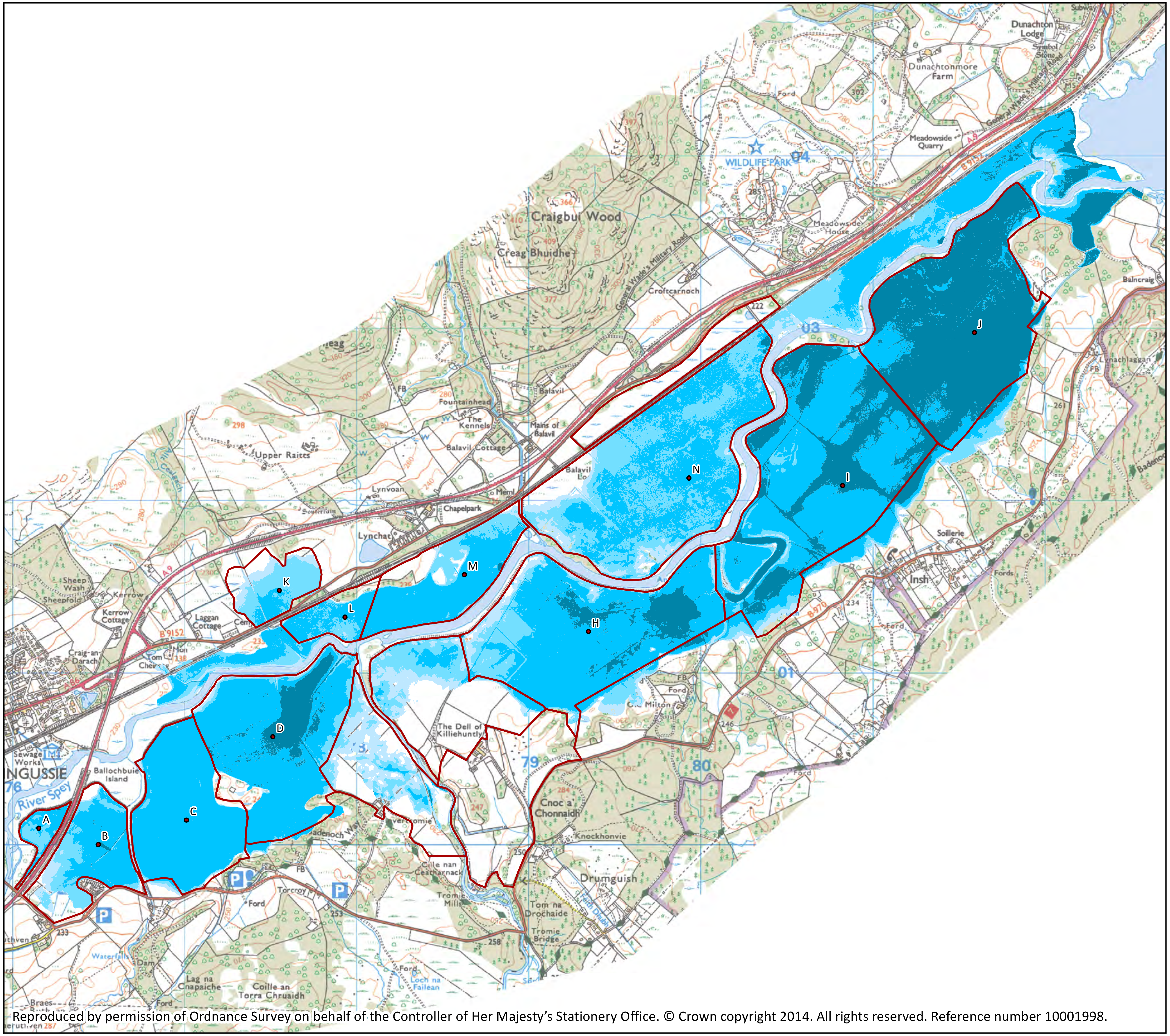

Legend

Assessment units

Representative points

Maximum depth

0.01 - 0.3m

0.3 - 0.6m

0.6 - 1.0m

>1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C11 Maximum Flood Depth Option 4a: Full removal QMED
Status	FINAL
Drawing No.	166050_036
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
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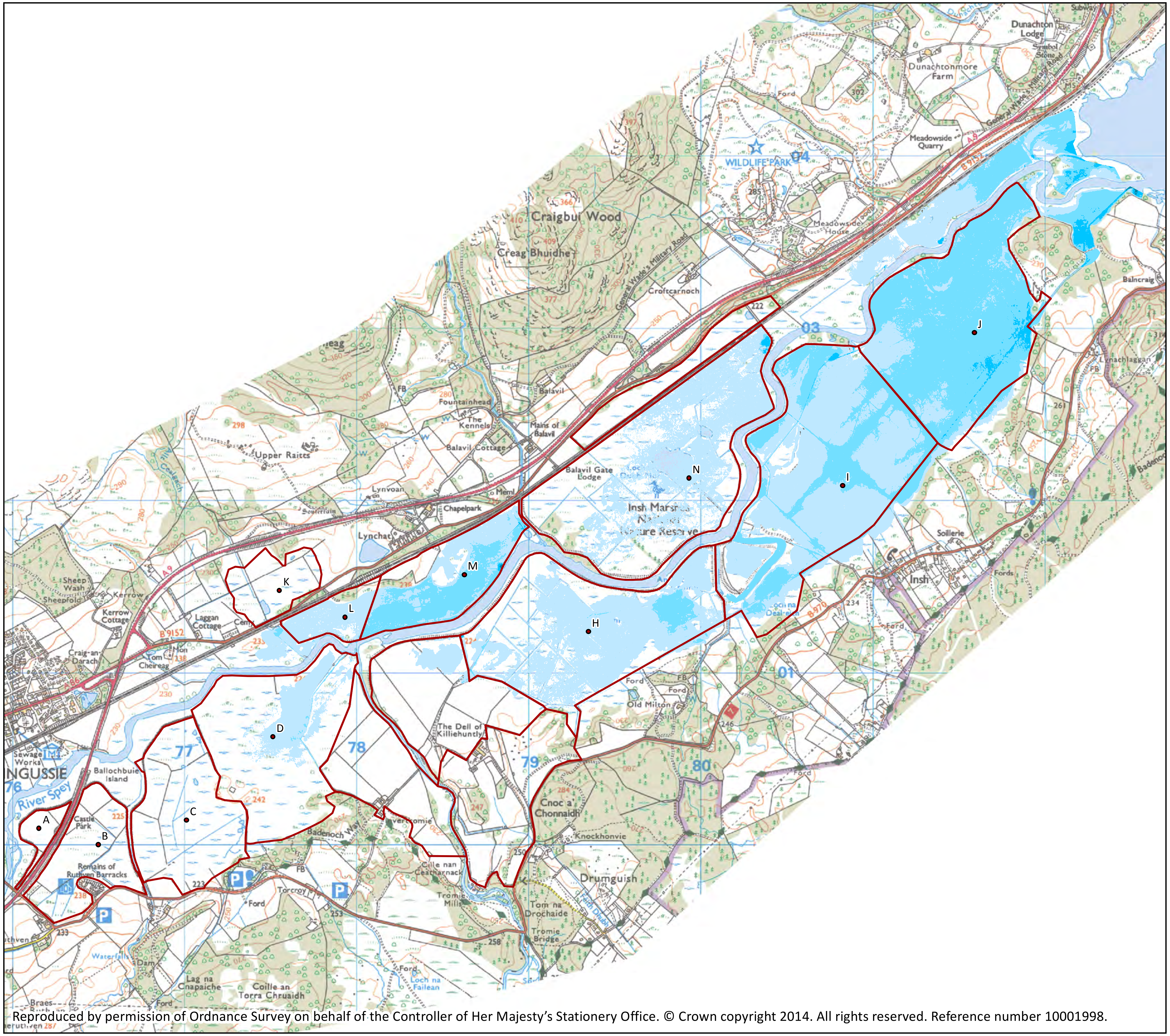

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C12 Maximum Flood Depth Option 4b: Removal at Lynchat 5 POT
Status	FINAL
Drawing No.	166050_037
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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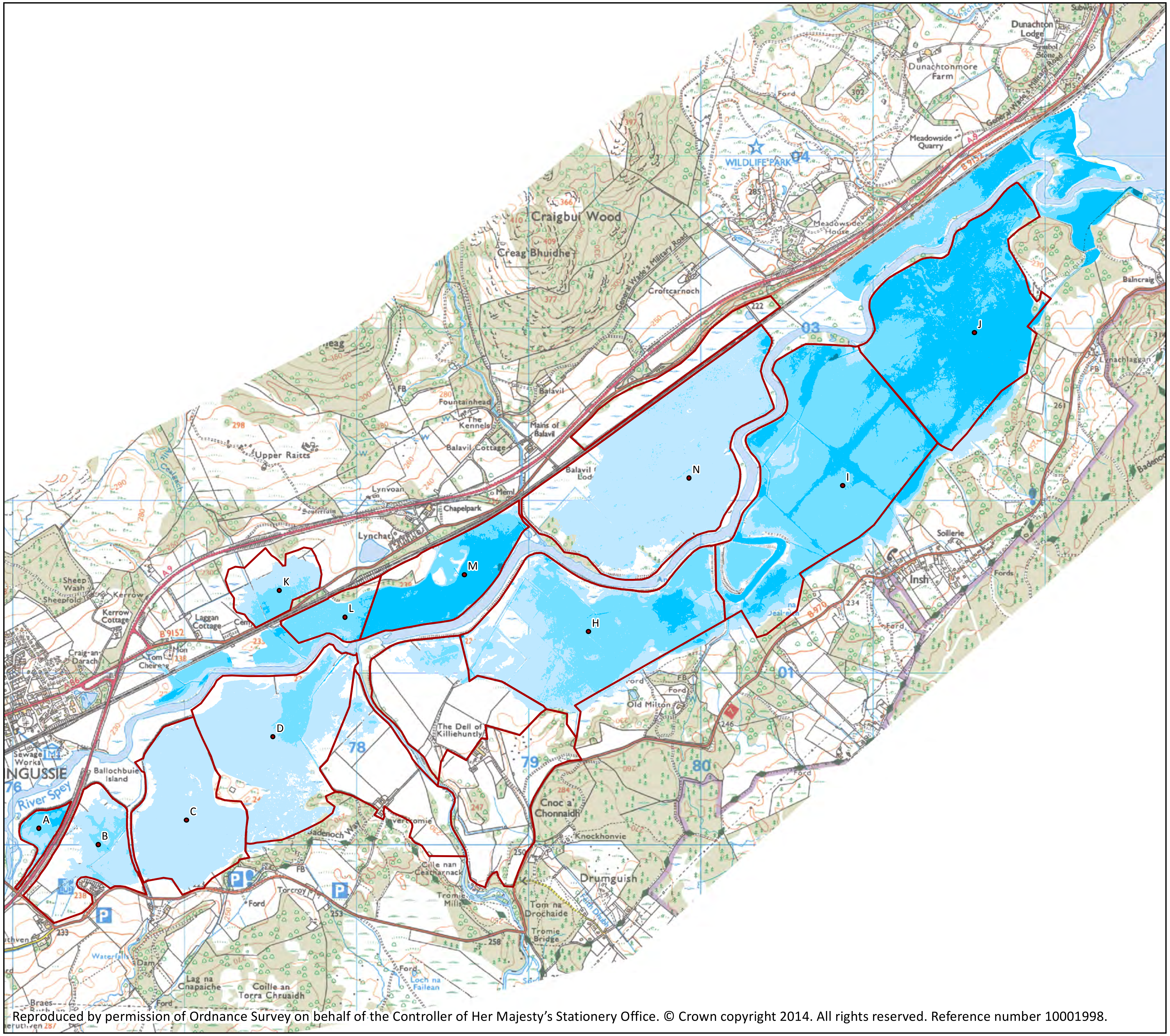

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C13 Maximum Flood Depth Option 4b: Removal at Lynchat 3 POT
Status	FINAL
Drawing No.	166050_030
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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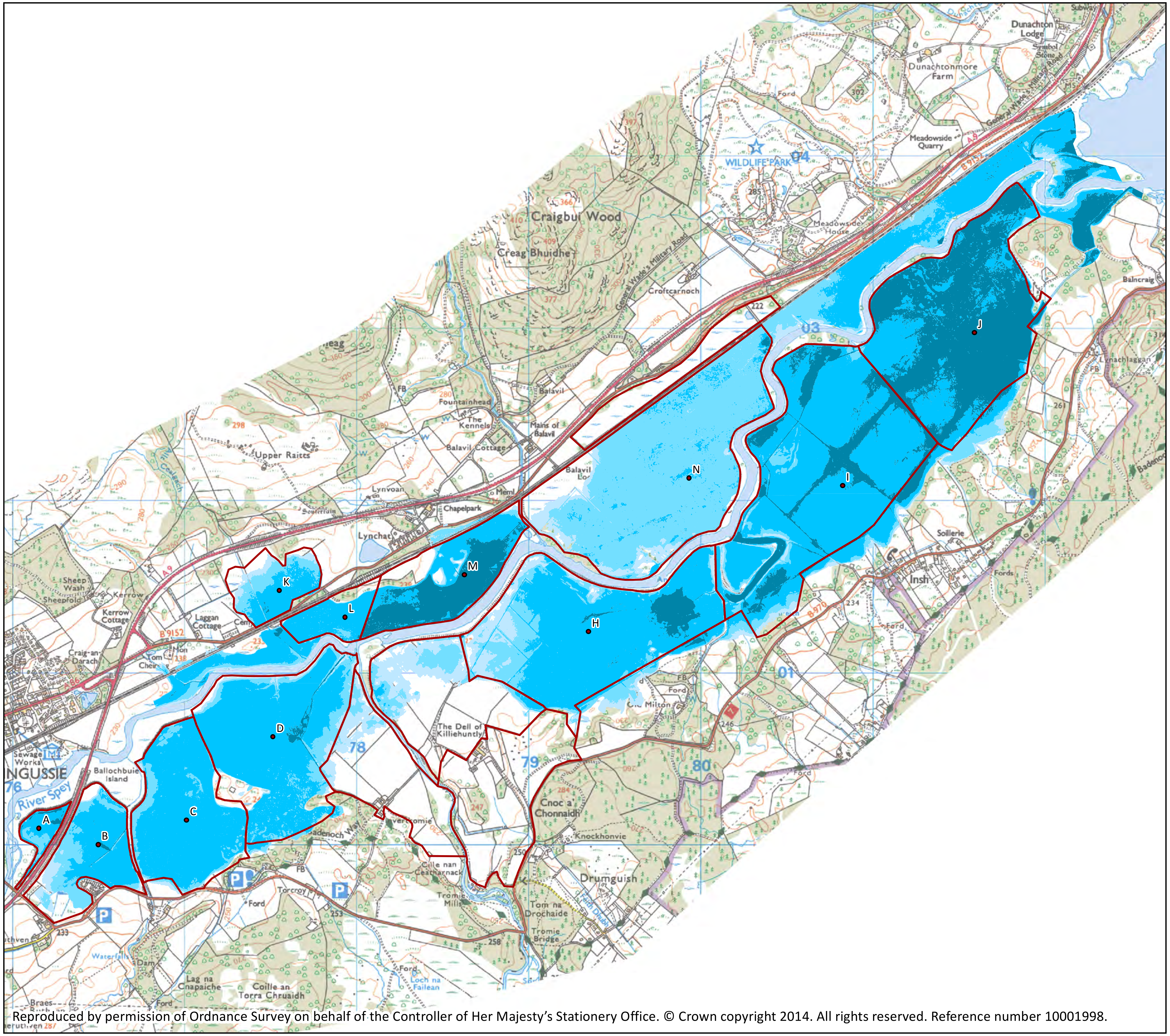

Legend

Assessment units

Representative points

Maximum depth

0.01 - 0.3m

0.3 - 0.6m

0.6 - 1.0m

>1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C14 Maximum Flood Depth Option 4b: Removal at Lynchat QMED
Status	FINAL
Drawing No.	166050_038
Revision	
Scale	1:22,000
	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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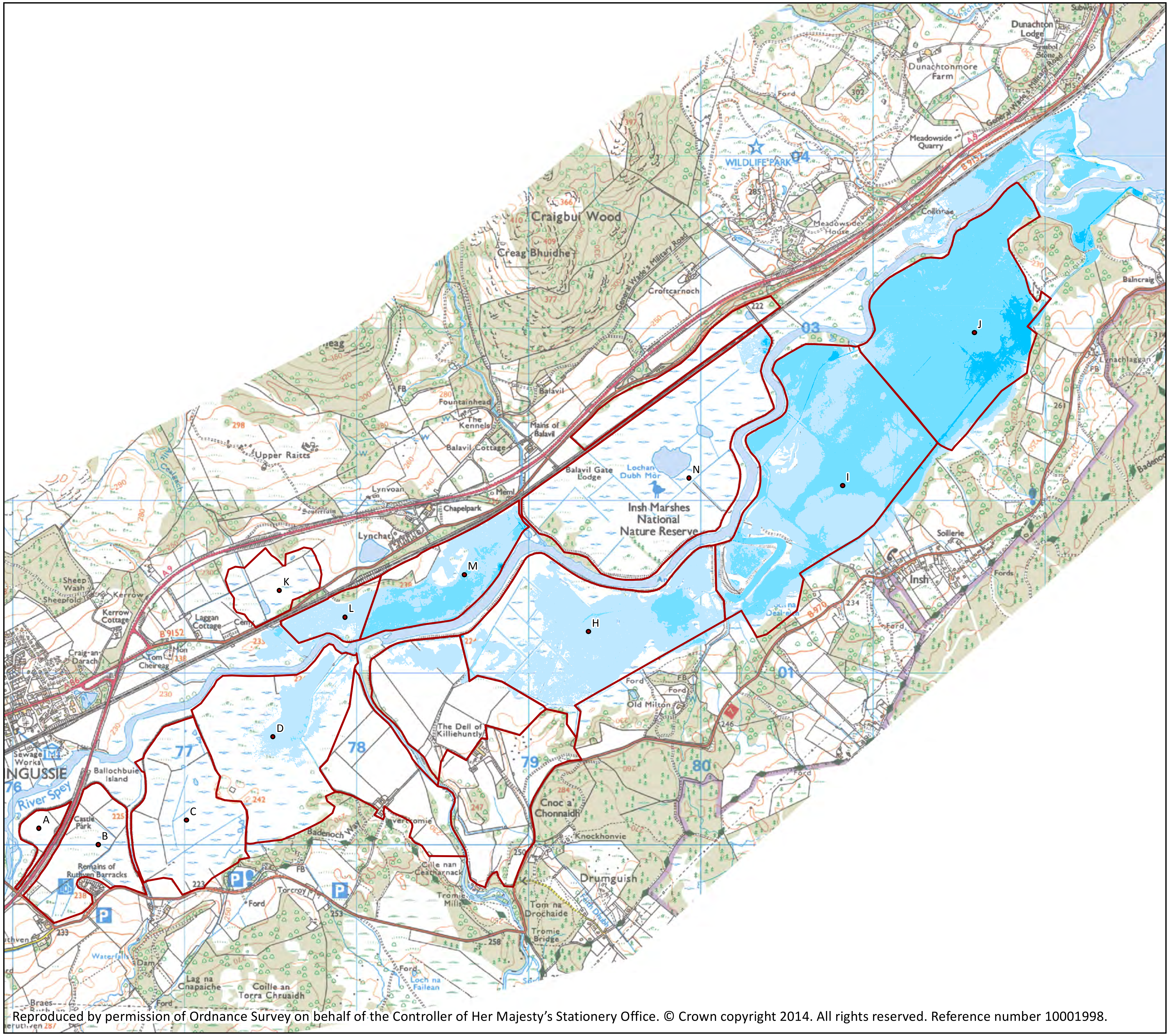

Legend

Assessment units

Representative points

Maximum depth

0.01 - 0.3m

0.3 - 0.6m

0.6 - 1.0m

>1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C15 Maximum Flood Depth Option 4c: Removal at Units L, M, H, I and J 5 POT
Status	FINAL
Drawing No.	166050_039
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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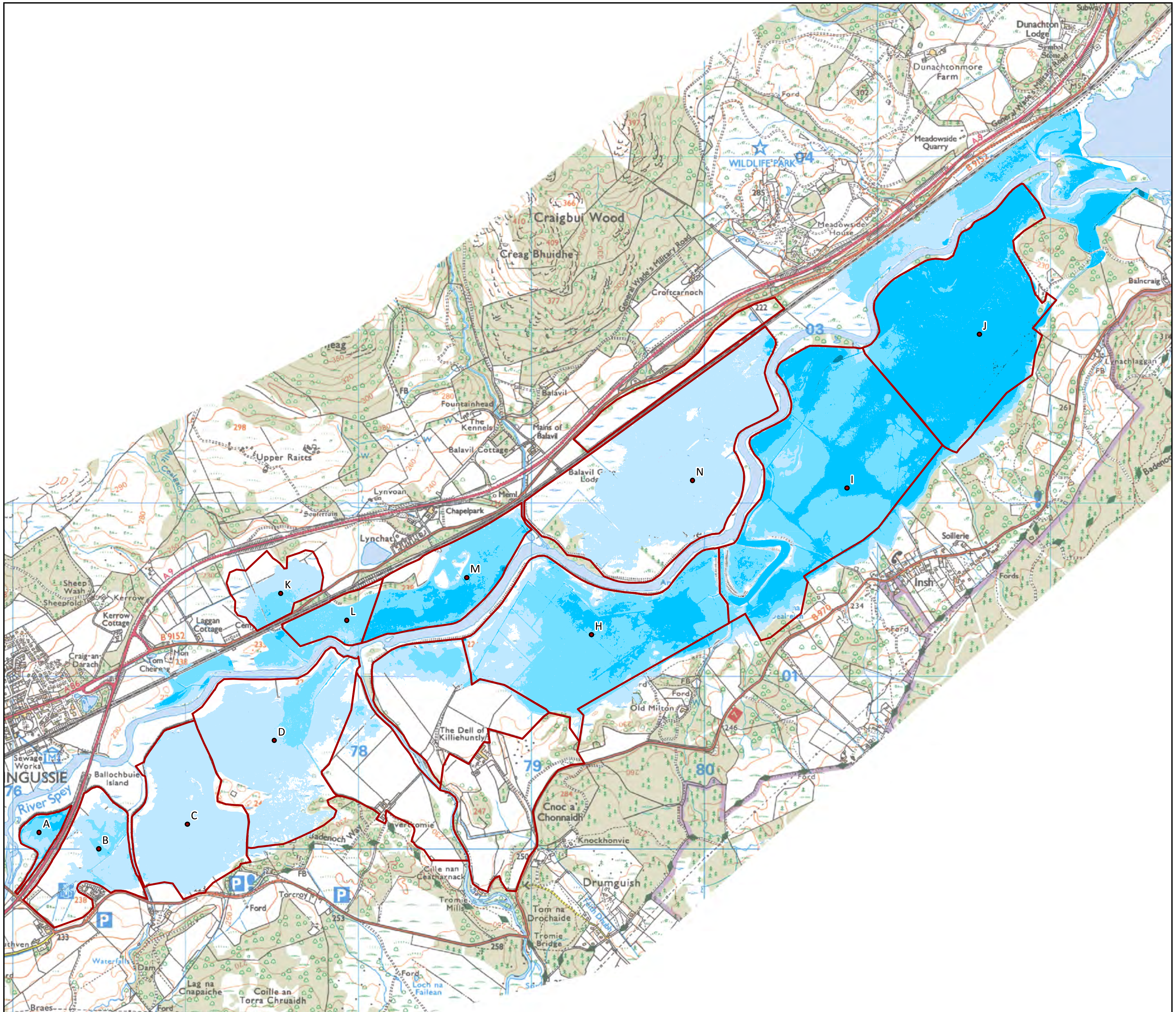

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C16 Maximum Flood Depth Option 4c: Removal at Units L, M, H, I and J 3 POT
Status	FINAL
Drawing No.	166050_031
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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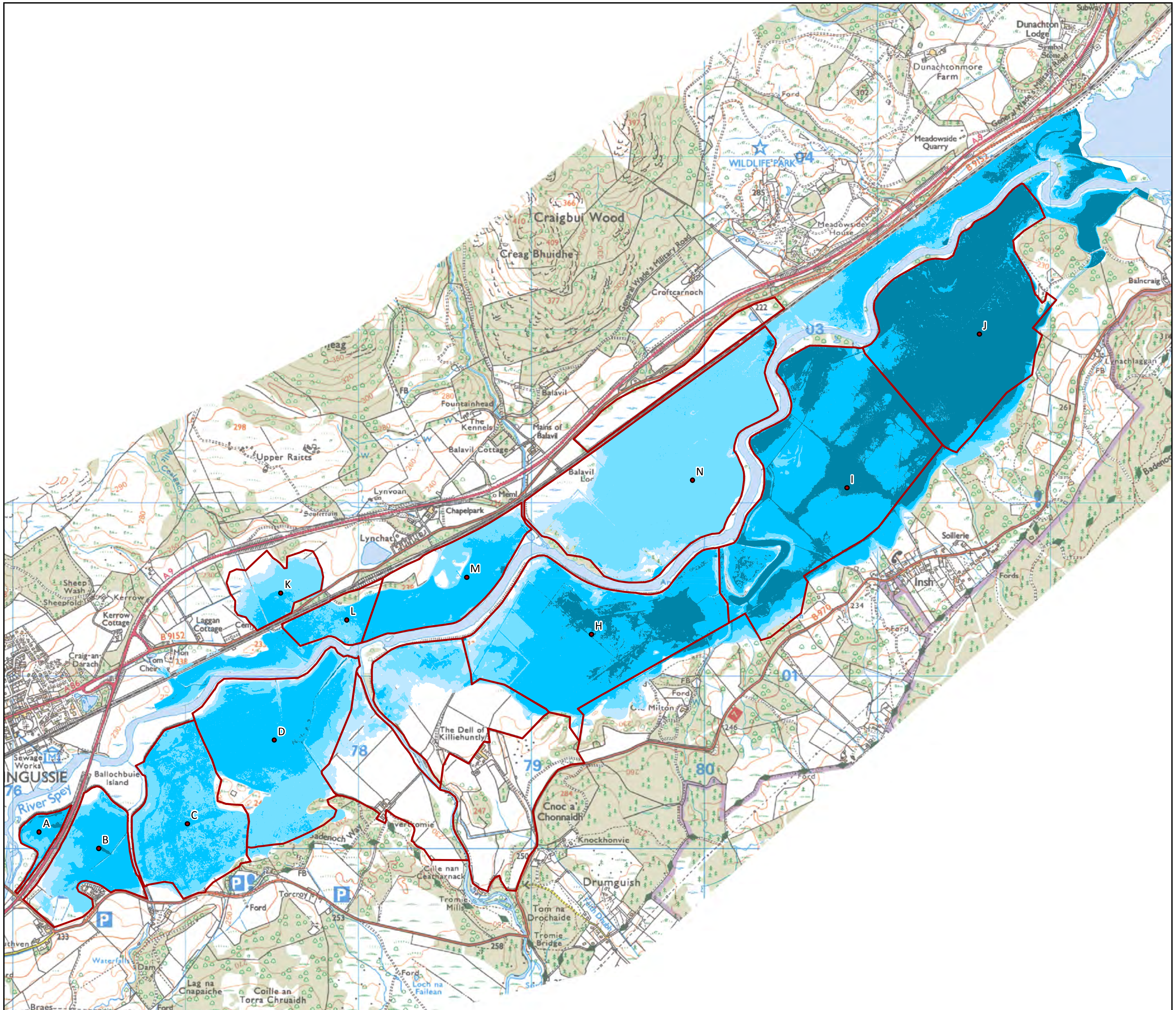

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	
RSPB	

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing C17
Maximum Flood Depth
Option 4c: Removal at Units L, M, H, I and J QMED

Status
FINAL

Drawing No.	Revision
166050_040	

Scale		Date
1:22,000	A3	28 Aug 2015

Drawn	Checked	Approved
HR	FH	FH

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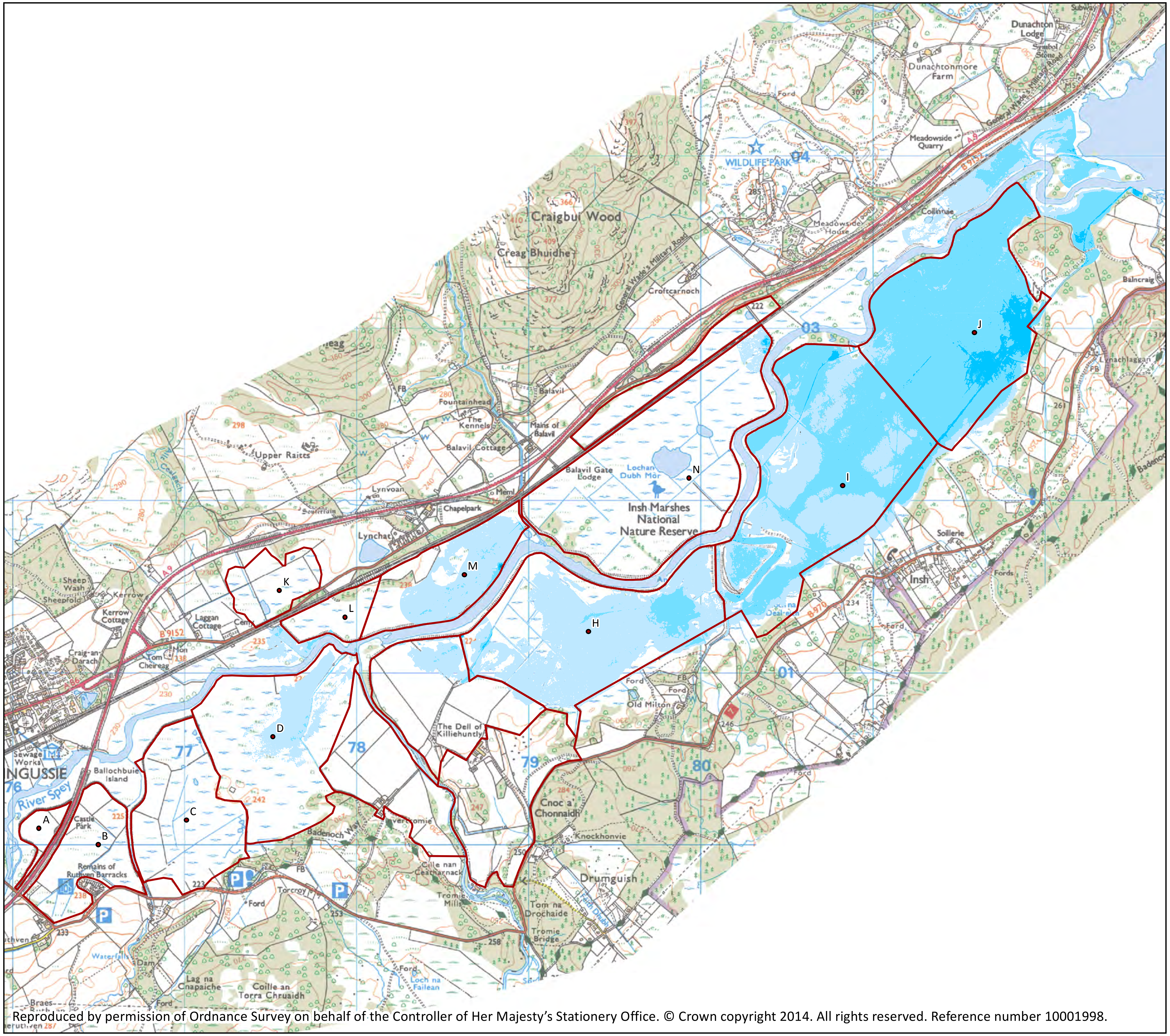

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C18 Maximum Flood Depth Option 5: Increased breaching 5 POT
Status	FINAL
Drawing No.	166050_041
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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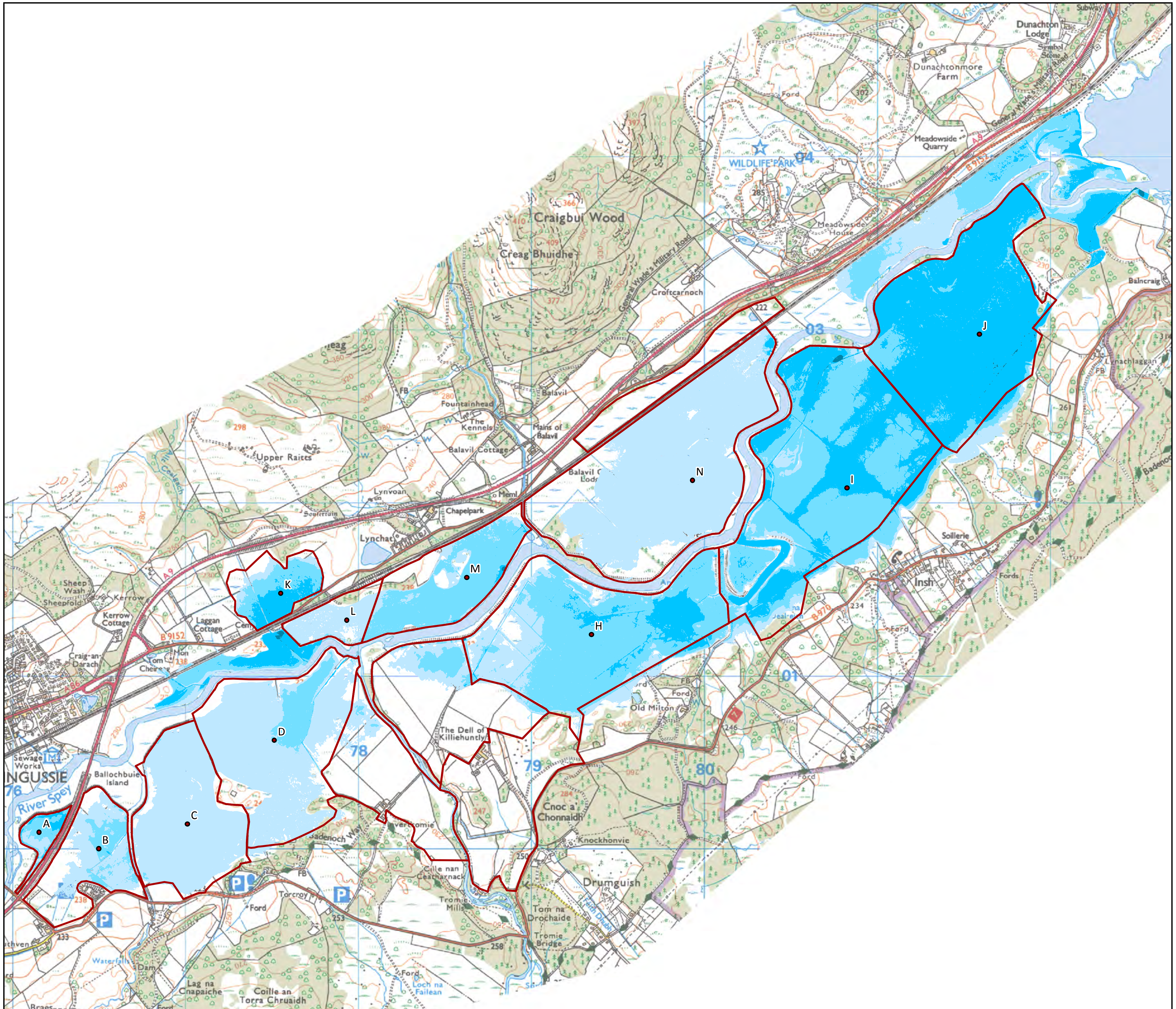

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client
RSPB

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing C19
Maximum Flood Depth
Option 5: Increased breaching 3 POT

Status
FINAL

Drawing No.	Revision
166050_032	

Scale		Date
1:22,000	A3	28 Aug 2015

Drawn	Checked	Approved
HR	FH	FH

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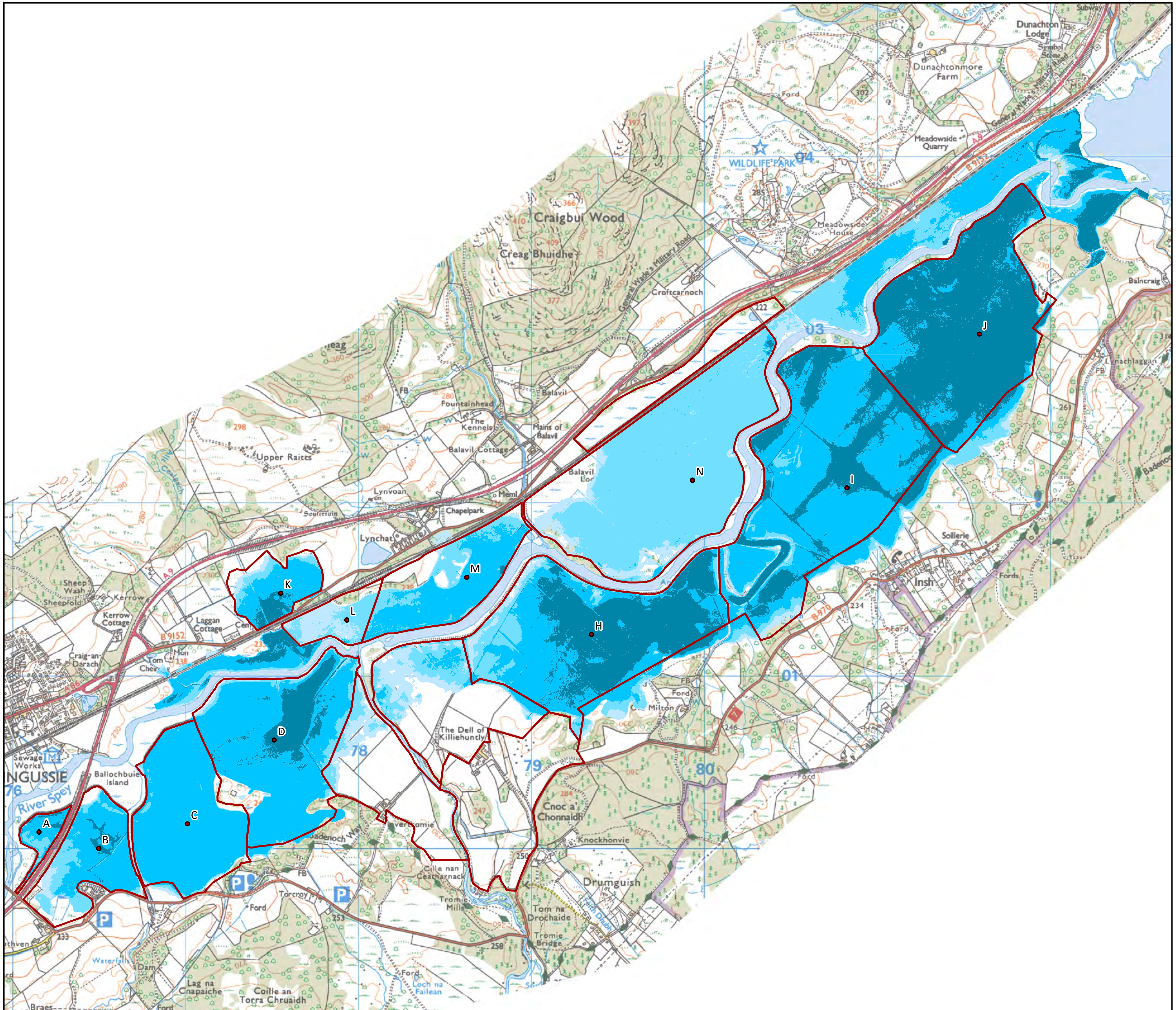

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:
1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C20 Maximum Flood Depth Option 5: Increased breaching QMED
Status	FINAL
Drawing No.	166050_042
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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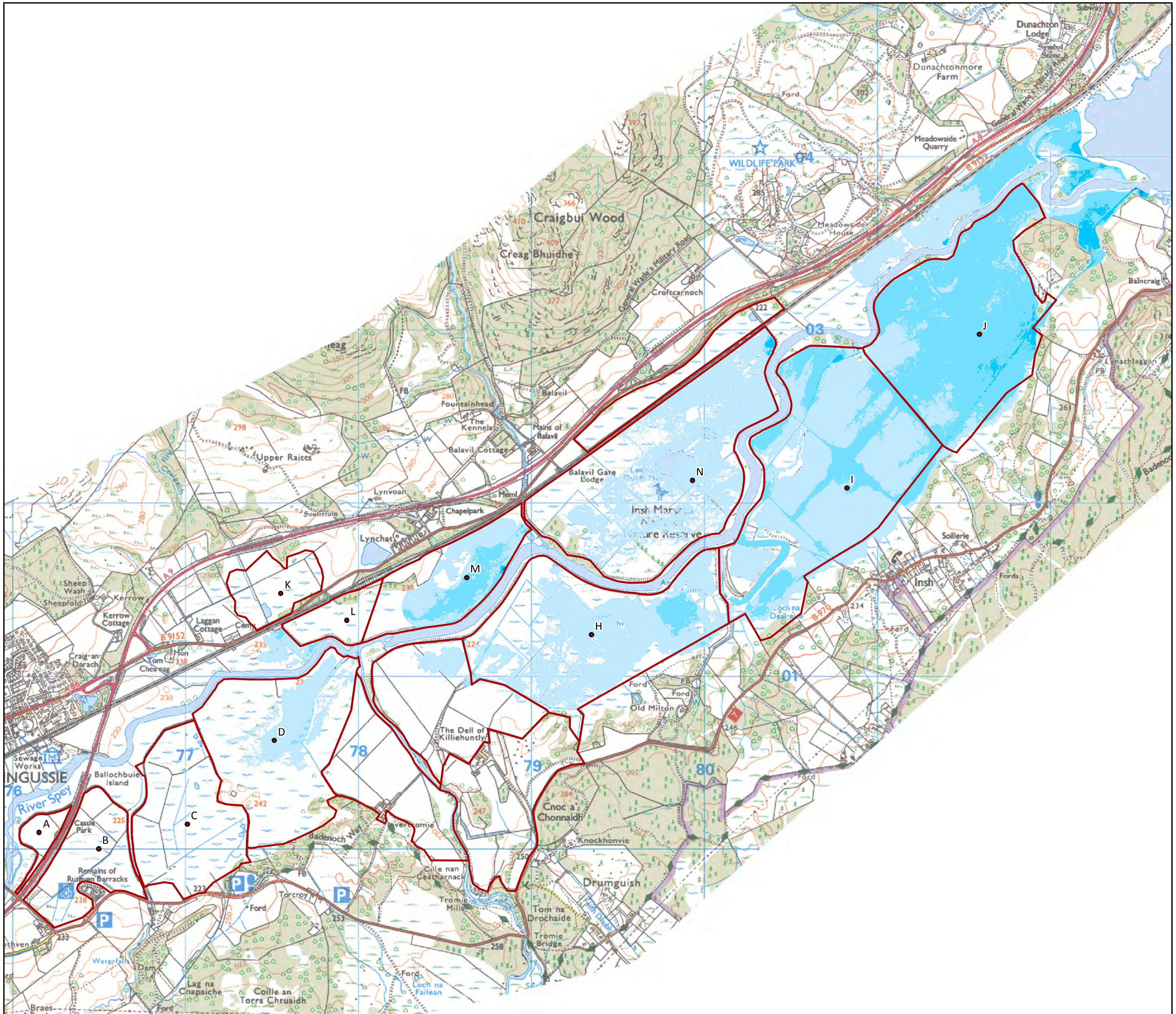

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C21 Maximum Flood Depth Option 10b: Block Main Drain 5-POT
Status	FINAL
Drawing No.	166050_049
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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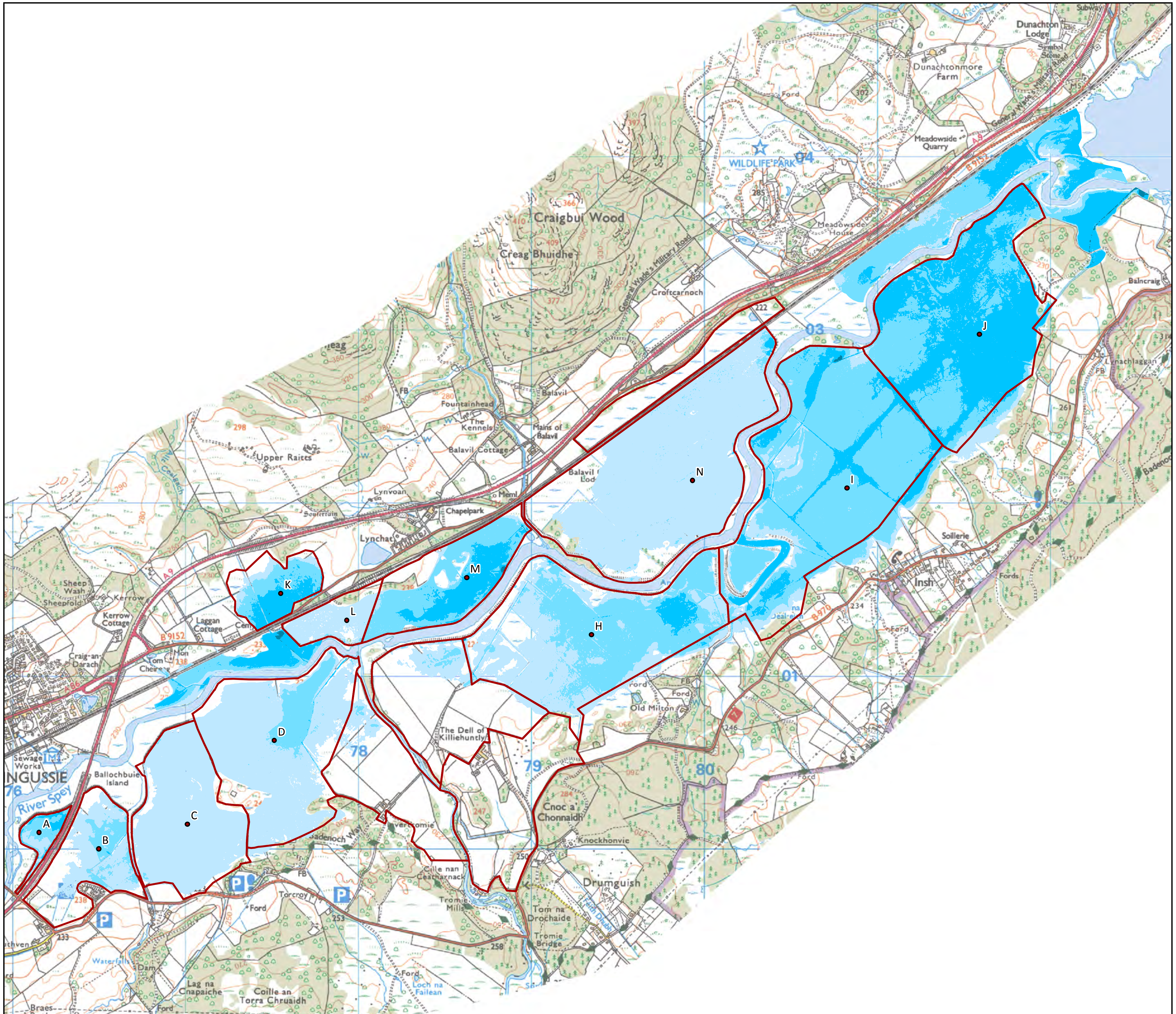

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C22 Maximum Flood Depth Option 10b: Block Main Drain 3-POT
Status	FINAL
Drawing No.	166050_050
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
Approved	FH

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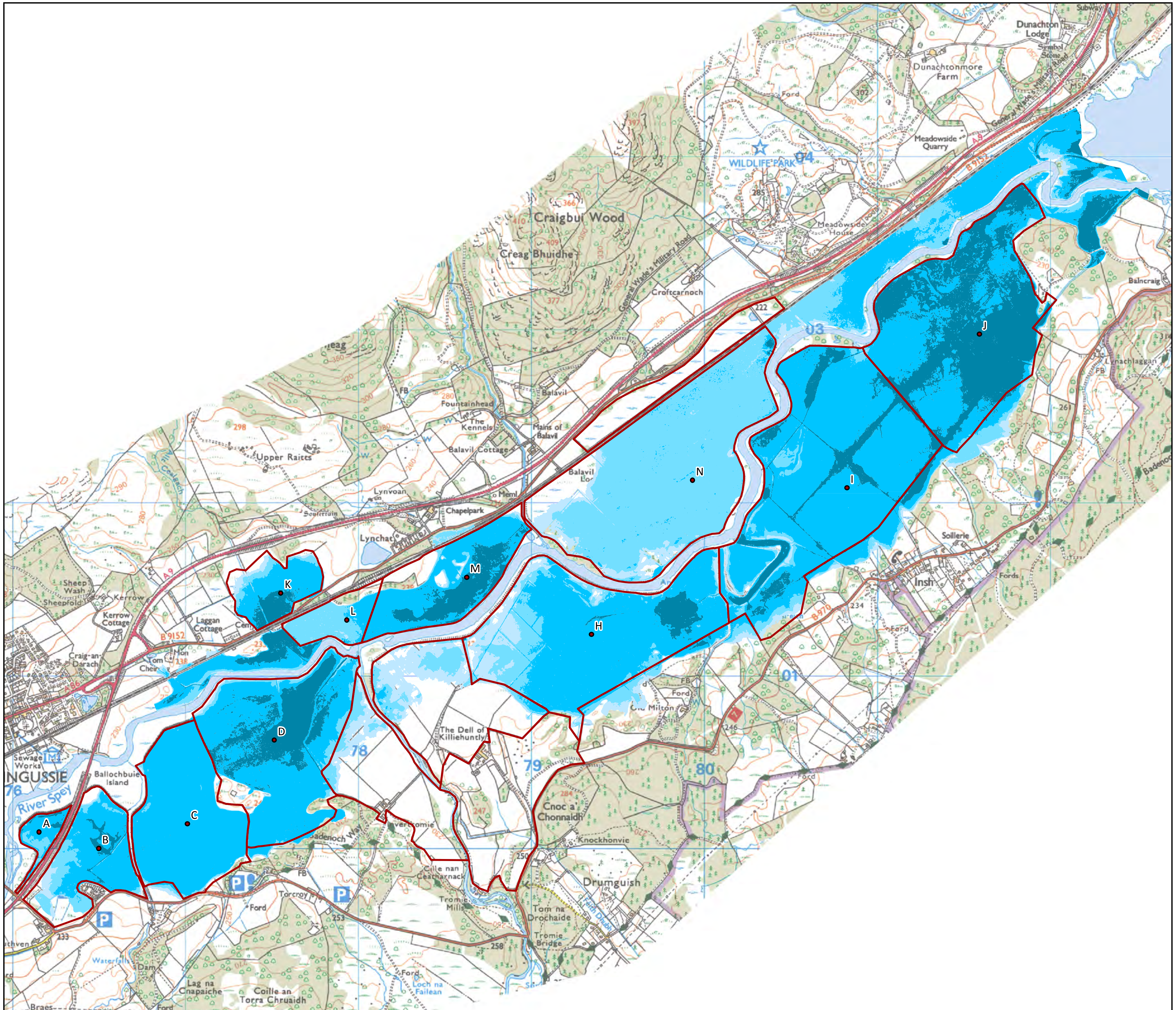

Legend

- Assessment units
- Representative points

Maximum depth

- 0.01 - 0.3m
- 0.3 - 0.6m
- 0.6 - 1.0m
- >1.0m

Notes:

1. Flood depth map only shows outputs from 2D model domain (does not include depth in-channel or on floodplain which is modelled in 1D domain).
2. Depths correspond to the maximum at any point during the model simulation and are not representative of a particular point in time.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing C23 Maximum Flood Depth Option 10b: Block Main Drain QMED
Status	FINAL
Drawing No.	166050_051
Revision	
Scale	1:22,000
Size	A3
Date	28 Aug 2015
Drawn	HR
Checked	FH
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D MORPHOLOGICAL ASSESSMENT

D.1. Desk-based Review

The geomorphology of the River Feshie has been well documented in previous studies (see Appendix A) and is considered within the current study only in terms of its influence on water levels within the NNR, and its geomorphology is therefore not discussed in detail within this report.

A desk-based review has been undertaken of existing information sources and previous studies, which are summarised in Appendix A. A review of historic mapping (NLS, n.d.) and aerial photography (RCAHMS, n.d.) has been undertaken and is summarised in Drawing D1.

D.2. Field Survey Outputs

A fluvial audit was undertaken along the River Spey, Ruthven Burn, River Tromie and Raitts Burn within the study area. The outputs from the fluvial audit are shown in Drawing D2 and are summarised in Table D2. A limited number of Wolman counts were undertaken to provide an indication of sediment size distribution (Table D1).

The River Spey main stem has been split into two reaches for the purposes of data interpretation. Reach 1 is from the upstream walkover extent to the confluence with the Ruthven Burn, whilst Reach 2 is from this confluence to Loch Insh. The walkover survey extended downstream of Loch Insh to observe conditions at the confluence with the River Feshie, however the morphology was not mapped in detail here. Loch Insh will act as a discontinuity in the transport of sediment downstream, and the main focus of the study downstream of Loch Insh is in the hydraulic control on upstream water levels, and potential changes in downstream hydrology and flood risk as a result of proposed options.

Topographic descriptors are provided in Table D3 and bed long profiles are provided in Figures D1 – D5.

Table D1: Sediment Size Distribution from Wolman Counts

Location ID	NGR	Description	Sediment size (mm)		
			D_{16}	D_{50}	D_{84}
W1	279014, 801846	Raitts Burn, medial bar	15	34	66
W2	275978, 799804	River Spey, bar d/s of Ruthven Bridge	27	51	87
W3	278438, 800375	River Tromie, lateral bar	18	56	106
W4	276791, 799716	Ruthven Burn, bar d/s of B970	19	40	75

D_{50} is median sediment size. 16% of the sample was smaller than the D_{16} size and 84% smaller than the D_{84} size.

Table D2: Fluvial Audit Overview

	Spey Reach 1	Spey Reach 2	River Tromie	Ruthven Burn	Raitts Burn
Reach extents	275203, 799230 to 276659, 800511	276659, 800511 to 282520, 803831	278640, 799911 to 278013, 801152	276804, 799697 to 276659, 800511	278954, 802014 to 279109, 801729
Length surveyed (m)	2,953	7,827	1,535	867	340
Bar area exposed during survey (m^2)	9,807	2,102	3,100	3	201
Bar area as % of total channel area[a]	9%	1%	10%	0%	14%
Bank erosion length[b]	790	1,177	298	10	100
Bank erosion as % of total bank length	15%	8%	10%	1%	14%
Flow type distribution as % of total channel length					
Rapid	0%	0%	27%	0%	0%
Run	24%	3%	40%	26%	36%
Riffle	16%	0%	23%	1%	38%
Glide	43%	96%	10%	72%	22%
Pool	17%	1%	0%	0%	4%

a. Approximate, based on an average channel width through the reach.
b. Minor erosion excluded from this total. Breaches in embankments included in total where adjacent to bank (i.e. breaches in set-back embankments not included).

Table D3: Reach-averaged Channel Descriptors from Topographic Survey

	Spey Reach 1	Spey Reach 2	River Tromie	Ruthven Burn	Raitts Burn	Main Drain
Water surface slope (m/m)[a]	0.0009 (~1 in 1100)	0.0003 (~1 in 3200)	0.0065 (~1 in 150)	0.0041 (~1 in 1350)	0.0073 (~1 in 140)	-0.0001 (Neligible)
Sinuosity	1.4	1.2	1.1	1.1	1.1	1.0
Bankfull width (m)[b]	42 (17-70)	71 (33-133)	39 (19-92)	27 (9-53)	13 (9-20)	10 (8-13)
Maximum depth (m)[c]	3.2 (2.2-4.7)	4.8 (2.9-7.2)	1.9 (1.0-2.7)	1.9 (0.7-2.9)	1.1 (0.9-1.2)	1.5 (1.2-1.8)

a. Bed slope from topographic survey not a good indicator of gradient for this study area, therefore reach averaged water surface slope at QMED flow presented (as determined from hydrodynamic modelling results).
b. Bankfull width to point of overtopping onto floodplain. Taken as width between embankment crests where embankment is present.
c. Maximum depth from point of overtopping onto floodplain. Taken as depth from embankment crest where embankments are present on both banks.

The long profiles extracted from the topographic survey are shown in Figures D1 – D5. The same scale on the vertical axis has been used for comparison between each long profile. The bed profile through the River Spey shows several very deep pools. The deepness of the River Spey through the NNR has been observed in previous studies, for example the topographic survey undertaken in the early 1950's failed to survey the deepest bed levels at 11 locations through this reach (Cuthbertson & Partners, 1990). It is probable that these deep pools are relict features and are not reflective of the current morphological regime, for example it has been speculated that they are kettle holes or were formed at a time when levels in the Loch Insh were lower (Document 32, Appendix A). There is an almost negligible bed gradient between the confluence with Raitts Burn and Kincraig Bridge.

The River Tromie has a relatively uniform gradient through the surveyed reach until the downstream section where it reaches the flatter valley bottom of the River Spey.

The Ruthven Burn has a reasonable gradient (~1 in 110) until it enters the old meander at Ballochbuie Island, at which point the gradient is governed by this former channel. Only a short reach of the Raitts Burn has been surveyed.

Several cross-sections were also surveyed on the main drain. The bed levels at the upper cross-section, near to the ox-bow lake, are lower than at the entrance to Loch Insh resulting in a negligible negative bed gradient.

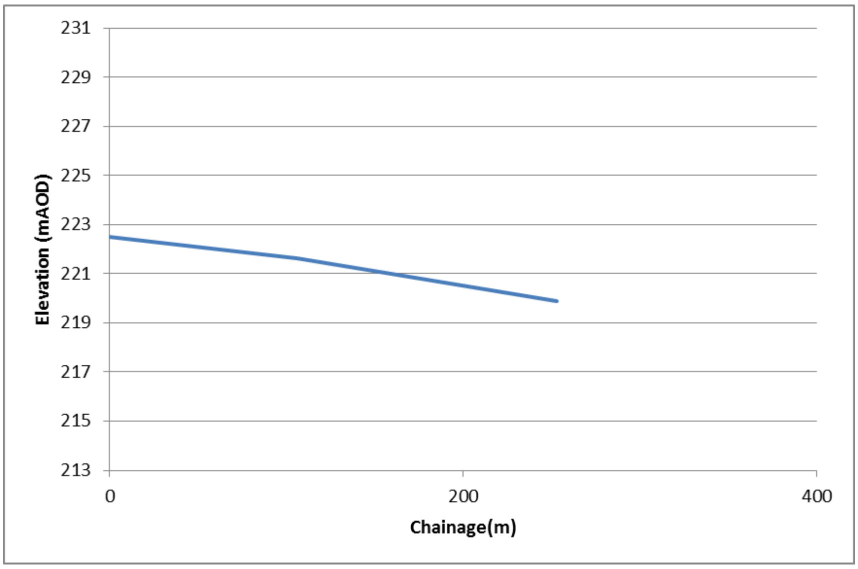


Figure D1: Long Profile – Raitts Burn

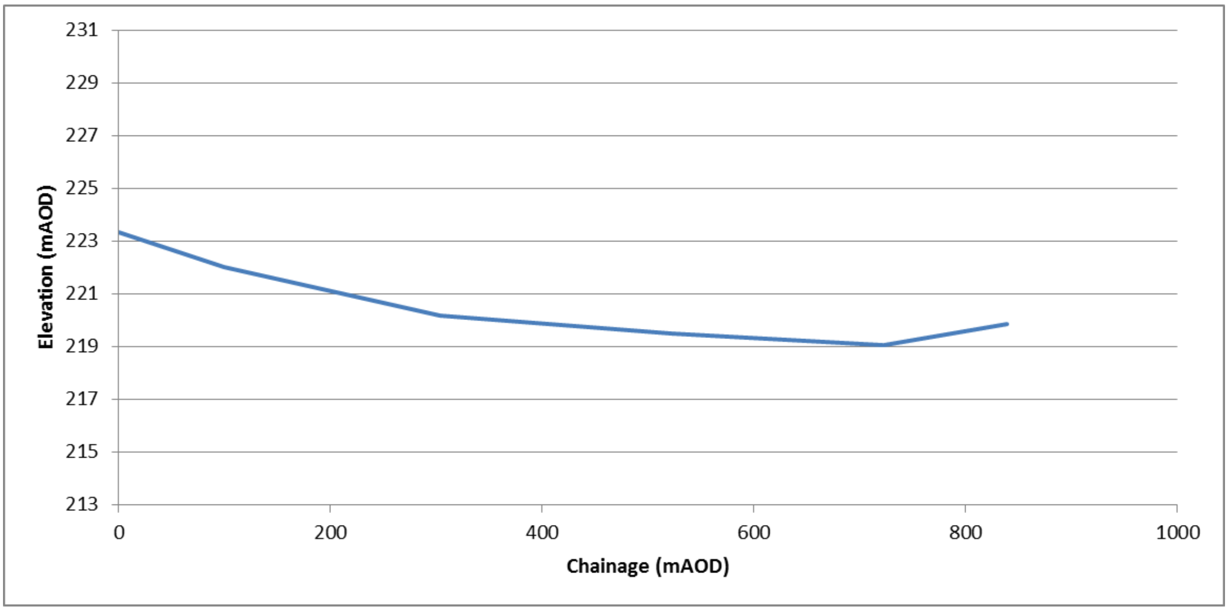


Figure D2: Long Profile – Ruthven Burn

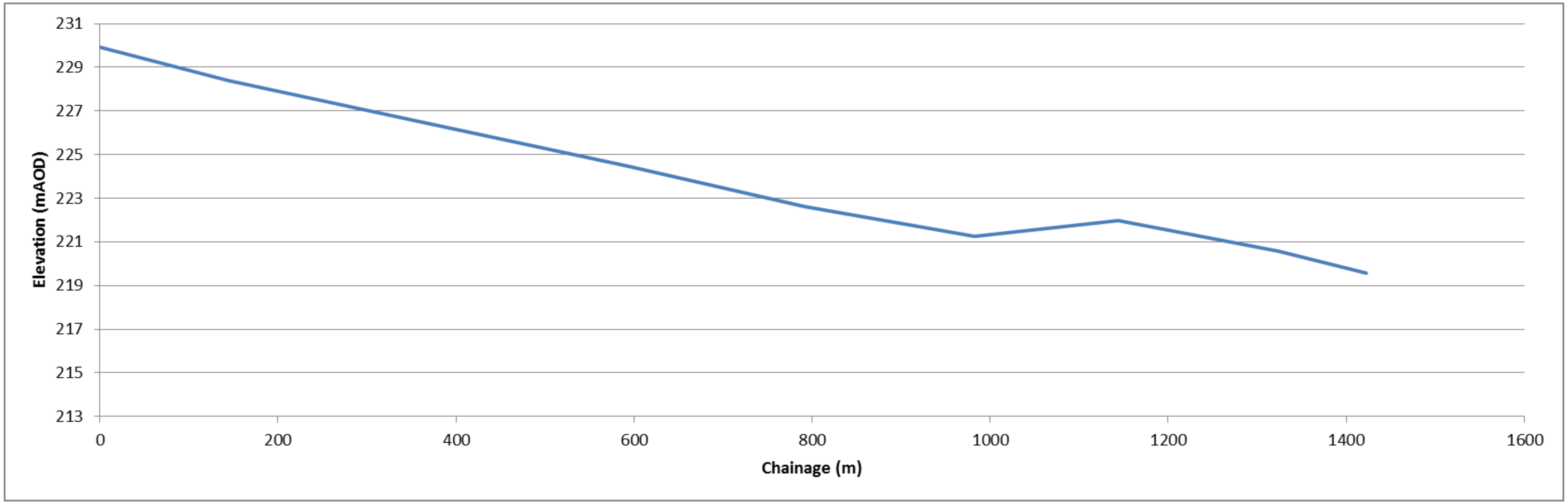


Figure D3: Long Profile – River Tromie

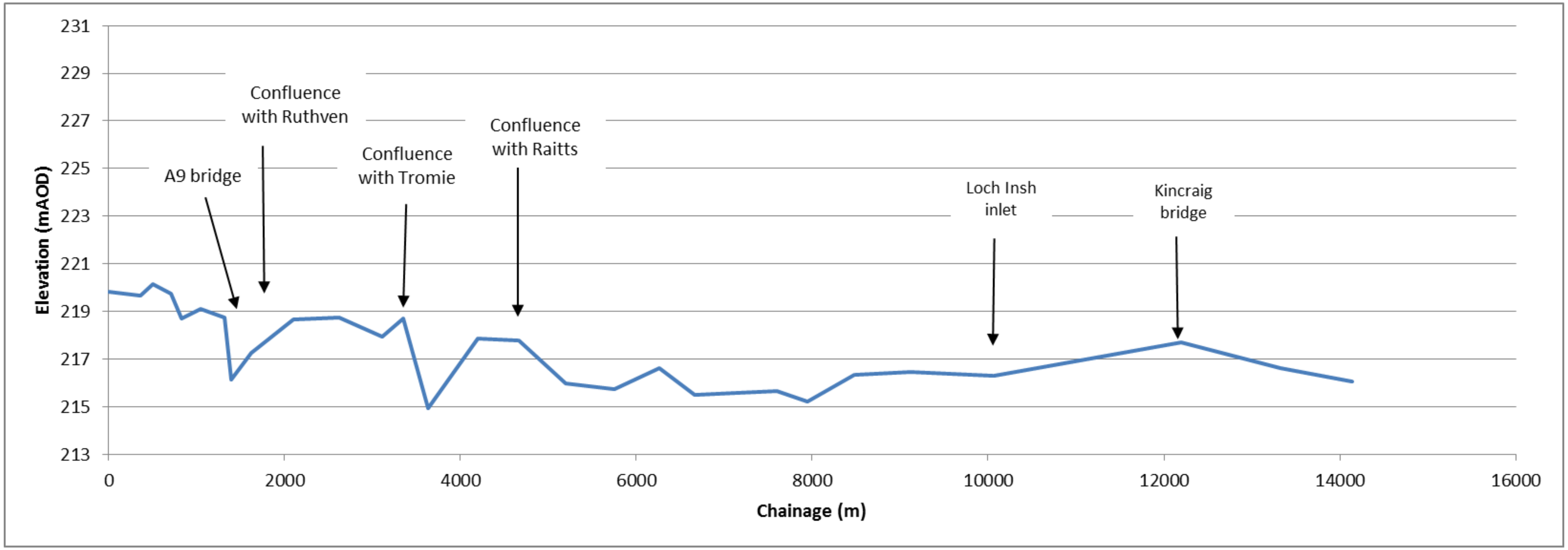


Figure D4: Long Profile – River Spey

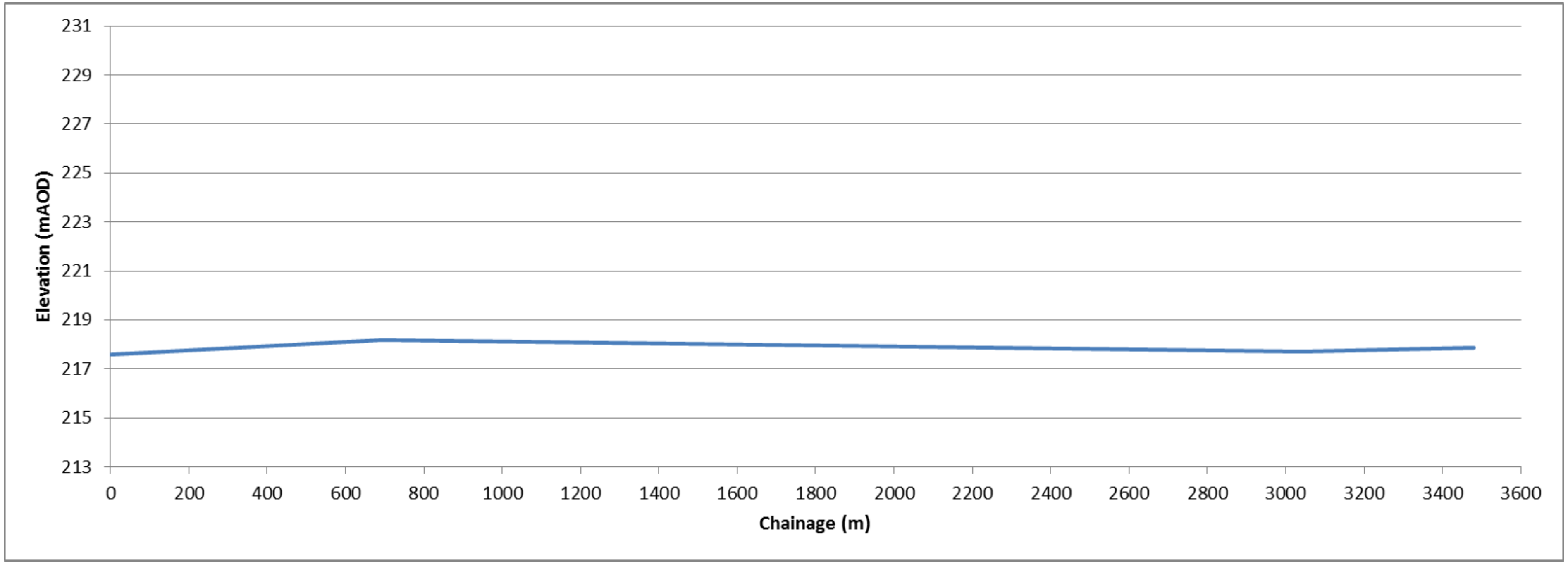


Figure D5: Long Profile – Main Drain

D.3. Morphological Calculations

The results from the hydrodynamic modelling (Appendix C) were used to calculate indicators of channel processes for the QMED flow for the baseline and option scenarios:

- Morphological theory suggests that the morphology of a stable alluvial channel largely arises from processes operating at low to moderate return period flows. The dominant 'channel-forming' flow is often taken as being approximate to the bankfull discharge, typically having a return period of 1 in 1 to 1 in 3 years. The QMED flow is slightly larger than bankfull on the Spey and slightly smaller than bankfull on some of the tributaries, based on the modelling results and provides a representative flow with which to compare conditions across the study area.
- Specific stream power provides a measure of channel energy per unit channel width, and is calculated using the water surface slope extracted from the hydrodynamic modelling at the maximum water levels (Table D4). This provides a consistent scenario to compare results spatially and between option scenarios. Specific stream power is also mapped in Drawing D3. Channel width is defined as an average width rather than the full bankfull width presented in Table D3.
- The maximum size of sediment predicted to be transported at the QMED flow is calculated using Shield's parameter (Table D5).

Table D4: Specific Stream Power (W/m^2)

Watercourse	Node	Baseline	Opt3	Opt4a	Opt4b	Opt4c	Opt5
Spey – reach 1	SP14908us	**34**	33	37	34	34	34
	SP14769	**46**	37	72	45	46	45
	SP14540	**53**	54	52	54	54	53
	SP14423	**35**	34	28	35	35	34
	SP14219	**18**	17	26	19	19	19
	SP13945	**8**	6	11	8	8	8
	SP13882	**24**	19	29	25	25	25
	SP13843	**13**	8	17	13	12	11
Spey – reach 2	SP13639	**1**	1	0	1	2	2
	SP13146	**7**	7	2	7	7	7
	SP12627	**6**	5	4	14	14	7
	SP12137	**2**	1	2	3	4	2
	SP11911	**41**	35	43	16	37	58
	SP11615	**21**	17	19	9	19	31
	SP11052	**2**	3	1	1	1	2
	SP10582	**12**	12	13	14	11	10
	SP10053	**8**	8	5	9	5	5
	SP09502	**2**	3	0	3	1	1
	SP08983	**2**	2	0	3	0	1
	SP08596	**2**	3	0	3	0	1
	SP08158	**2**	3	0	2	0	0
	SP07681	**2**	1	0	2	0	0
	SP07330	**2**	4	0	2	0	0
	SP06791	**2**	4	0	3	0	0
	SP06153	**2**	2	0	2	0	0
	SP05211	**0**	0	0	0	0	0
Tromie	TR_1297	**256**	256	264	256	256	256
	TR_1070	**123**	123	105	123	123	123
	TR_0850	**107**	107	90	107	107	107
	TR_0651	**245**	245	210	245	245	245
	TR_0460	**78**	77	57	78	78	78

Watercourse	Node	Baseline	Opt3	Opt4a	Opt4b	Opt4c	Opt5
	TR_0295	**74**	73	56	74	75	74
	TR_0114_New	**49**	44	39	50	50	50
	TR_0016	**59**	47	76	64	98	85
Ruthven	RU_0637_int	**35**	33	9	37	37	35
	RU_0535	**2**	1	0	2	3	2
	RU_0425_int	**0**	0	0	0	0	0
	RU_0316	**0**	0	0	0	0	0
	RU_0122	**0**	0	0	0	0	0
	RU_0006	**0**	0	0	0	0	0
Raitts	RA_0283_int54	**75**	75	70	70	70	75
	RA_0175	**89**	89	81	81	81	89
	RA_0175_int68	**102**	102	111	118	111	102
	RA_0027	**98**	34	60	1	54	132
	RA_0027!	**0**	0	0	1	0	7

Table D5: Maximum Mobilised Sediment Size (mm)

Watercourse	Node	Baseline	Opt3	Opt4a	Opt4b	Opt4c	Opt5
Spey – reach 1	SP14908us	**21**	21	22	21	21	21
	SP14769	**5**	5	7	5	5	5
	SP14540	**20**	16	22	20	20	20
	SP14423	**11**	10	9	11	11	11
	SP14219	**5**	5	6	5	5	5
	SP13945	**12**	10	18	12	12	12
	SP13882	**8**	7	11	9	9	8
	SP13843	**4**	2	4	4	3	3
Spey – reach 2	SP13639	**1**	1	<1	1	1	1
	SP13146	**4**	4	3	4	4	4
	SP12627	**8**	6	6	15	15	9
	SP12137	**3**	2	4	5	6	3
	SP11911	**12**	10	16	6	14	17
	SP11615	**51**	40	61	34	62	70
	SP11052	**3**	4	2	1	2	3
	SP10582	**10**	9	12	11	10	10
	SP10053	**14**	13	10	14	9	11
	SP09502	**4**	4	1	4	2	2
	SP08983	**3**	3	<1	3	<1	1
	SP08596	**5**	5	<1	6	<1	2
	SP08158	**3**	3	<1	3	<1	1
	SP07681	**3**	1	<1	3	<1	1
	SP07330	**2**	4	<1	3	<1	1
	SP06791	**2**	3	<1	3	<1	1
	SP06153	**3**	2	1	3	1	1
	SP05211	**1**	1	1	1	1	1
Tromie	TR_1297	**125**	124	125	124	124	124
	TR_1070	**46**	46	43	46	46	46
	TR_0850	**64**	64	60	64	64	64
	TR_0651	**110**	110	110	110	110	110
	TR_0460	**54**	54	46	54	54	54

Watercourse	Node	Baseline	Opt3	Opt4a	Opt4b	Opt4c	Opt5
	TR_0295	**35**	35	30	35	35	35
	TR_0114_New	**41**	47	38	41	41	41
	TR_0016	**34**	28	49	39	59	43
Ruthven	RU_0637_int	**22**	20	19	22	22	22
	RU_0535	**2**	1	<1	2	3	2
	RU_0425_int	**<1**	<1	<1	<1	<1	<1
	RU_0316	**<1**	<1	<1	<1	<1	<1
	RU_0122	**<1**	<1	<1	<1	<1	<1
	RU_0006	**<1**	<1	<1	<1	<1	<1
Raitts	RA_0283_int54	**46**	46	40	44	40	46
	RA_0175	**54**	54	49	67	50	54
	RA_0175_int68	**56**	56	53	81	54	56
	RA_0027	**60**	18	39	1	37	69
	RA_0027!	**<1**	<1	<1	<1	<1	8

D.4. MImAS Calculations

Calculations of the impact of man-made pressures on the channel morphology have been undertaken using SEPA's Morphological Impact Assessment approach (MImAS) for the baseline and options scenarios.

The pressures used in the MImAS calculations are shown in Drawing D4. MImAS calculations in Table D7 are for the reaches included in the study area, as defined in Table D2.

Key assumptions used in the calculations are provided in Table D6.

Table D6: MImAS calculation assumptions

Option	Assumptions
Baseline	• Embankments for the purposes of MImAS are defined as being within 10m or 1 channel width (whichever is greater) from the channel bank. • Set-back embankments for the purposes of MImAS are defined as being more than 10m or 1 channel width (whichever is greater) and less than 50m from the channel bank. • The average reach width has been used to define the embankments as being 'embankments', 'set-back embankments' or not a pressure (>50m). • SEPA confirmed that embankments >50m are not classified as a pressure, even where the channel width approaches 50m (as for the parts of the Spey)1. • Low-level revetments in reach 2 of the Spey are not included as a pressure as the length is unknown (visible only at lower flows). • The lower 800m of the River Tromie through the NNR is classified as high impact realignment. The channel is straightened with limited recovery of natural sequences of bedforms and a general lack of active erosional and depositional features. It is likely that the change in flow and sediment regime caused by the upstream HEP impoundment has contributed to the lack of recovery of this channel. • The full length of the Raitts Burn considered in the study (i.e. downstream of the railway, 340m) is classified as high impact realignment (straightened, confined within embankments, perched bed).
1. Do Nothing	• MImAS capacity release is likely but not calculated due to uncertainties in when changes would occur, and how an uncontrolled breach of the Raitts Burn would be assessed through the MImAS approach.
2. Maintain according to obligations	• No change to MImAS capacity
3. Full repair	• Capacity increase due to small increase in embankment length
4. Removal options (a, b and c)	• Capacity release from reduced embankment length and mitigation of high impact realignment pressure at Raitts Burn to low impact realignment. • It is anticipated that in the longer term the proposed restoration works have the potential to completely alleviate the realignment pressure. • Options 4b and 4c assume that the left embankment along the Raitts Burn is not removed.
5. Increased breaching	• Small capacity release from slight reduction in embankment length
6. Remove bank protection	• Small capacity release from removal of hard bank protection at confluence of River Tromie and River Spey
7. In-channel restoration measures	• Capacity release not calculated for Raitts Burn as it is anticipated that in-channel measures would initiate an uncontrolled breach (similar to opt1). • Capacity release for River Tromie assumes mitigation from high impact to low impact realignment. • This is considered to be a best case scenario, as changes to the natural flow and sediment regime caused by the upstream HEP impoundment may limit morphological recovery.

[1] Personal communication with Tim Meadows

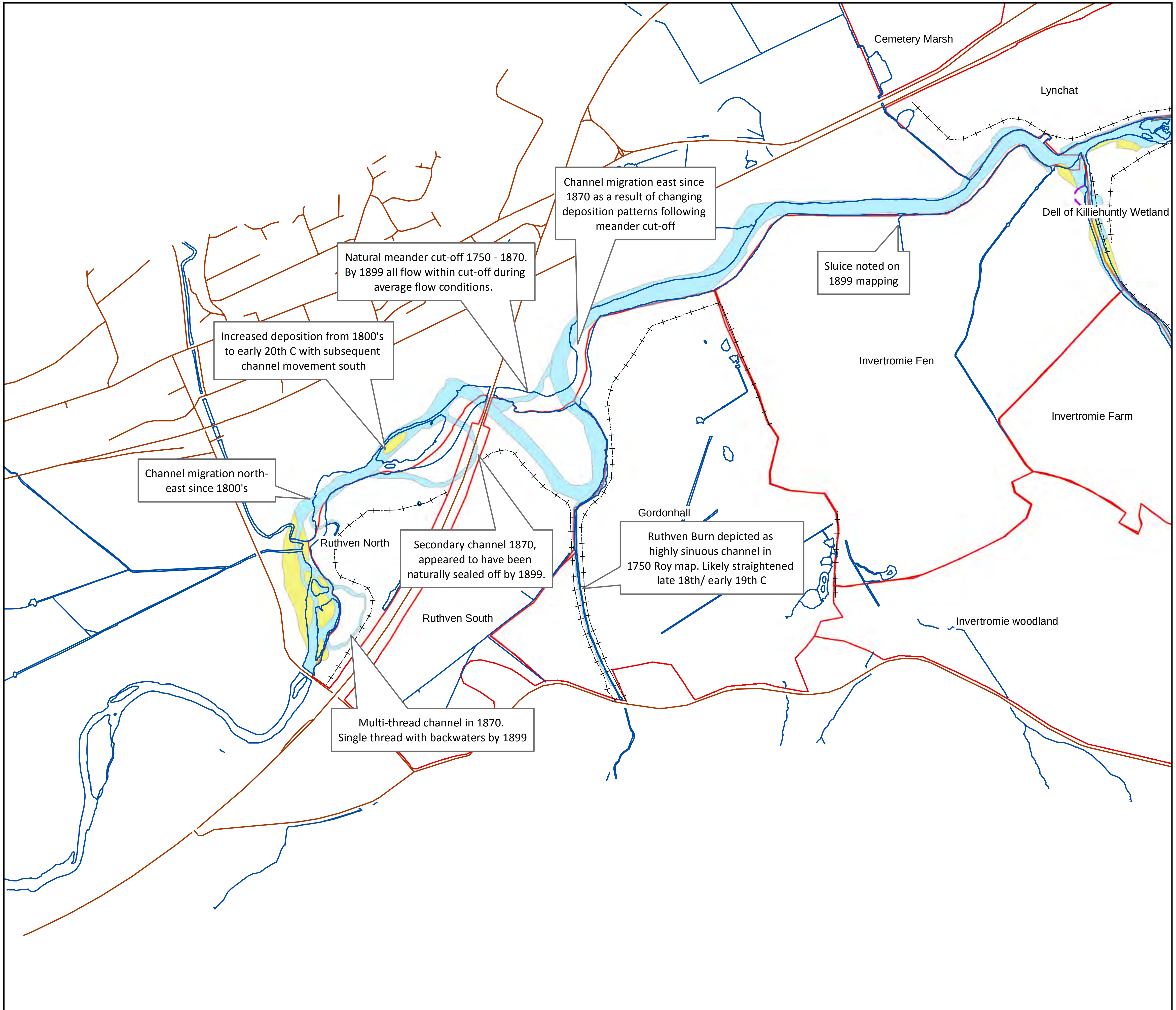
Option	Assumptions
8. Channel realignment/ re-meandering	• Capacity release assumes that embankments no longer act as a pressure (i.e. removed or new channel created outwith the influence of the embankments) and mitigation from high impact to low impact realignment for the Raitts Burn and River Tromie. • Full morphological recovery of the River Tromie is potentially limited by changes to the natural flow and sediment regime caused by the upstream HEP impoundment. • It is anticipated that in the longer term the proposed restoration works have the potential to completely alleviate the realignment pressure for the Raitts Burn.
9. Reinstatement of stream diversions	• No change
10. Reduce internal drainage (a and b)	• No change

Table D7: Baseline Percentage MImAS Capacity Used (%)

	Spey Reach 1	Spey Reach 2	Tromie	Raitts
Typology	C	F	C	C
Embankment	0.8	7.7	6.9	4.0
Set-back embankment	-	-	0.0	0.1
Hard bank protection	0.2	0.0	0.7	0.1
High impact realignment	-	-	10.0	5.5
TOTAL	**(Spey combined)**	**8.7**	**17.6**	**9.7**

Table D8: Percentage MImAS Capacity Released by Options (%)

Option	Spey	Tromie	Raitts	Total
1	-	-	-	-
2	0.0	0.0	0.0	0.0
3	-0.3	0.0	0.0	-0.3
4a	8.5	6.9	8.7	24.1
4b	1.1	0.0	6.4	7.5
4c	5.5	0.0	6.4	11.9
5	0.3	0.0	0.0	0.3
6	0.0	0.7	0.0	0.7
7	0.0	8.1	-	8.1
8	0.0	12.1	8.7	20.8
9	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0



Legend

- RSPB compartments
- Road/ railway infrastructure

Historic alignments

- 1870 channel alignment
- 1870 deposition features
- Historic tributary alignments
- Recent channel migration
- Existing channel alignment
- Embankment

Notes

1. Majority of embankments constructed late 18th and early 19th C to protect adjacent land from flooding.
2. Internal drainage of marshes believed to have occurred at a similar time.
3. Suggestion in historic records that attempts were made to lower the level of Loch Insh by dredging at the outlet to a depth of several feet prior to 1790.
4. A previous author has suggested that the meander cut-off's may have been initiated by this change in base level.
5. Significant reduction in flows in the Spey and the Tromie due to flow diversions out of the catchment for HEP schemes (Alcan/ Tummel) from 1940's/ 1950's.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D1 Historic Change 1 of 3
Status	FINAL
Drawing No.	166050_006
Revision	
Scale	1:10,000
Size	A3
Date	11 June 2015
Drawn	HB
Checked	KMD
Approved	KMD

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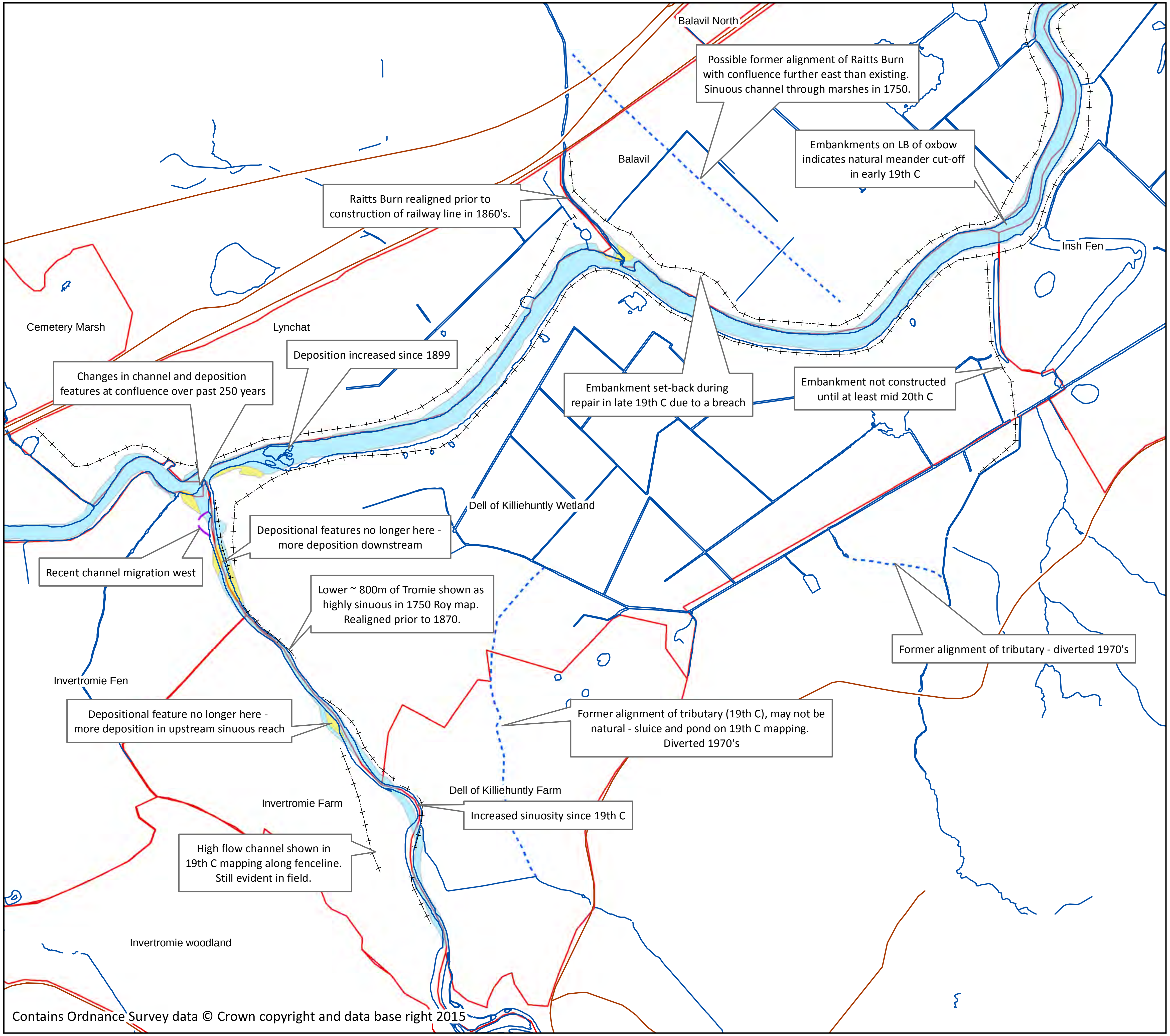

Legend

- RSPB compartments
- Road/ railway infrastructure

Historic alignments

- 1870 channel alignment
- 1870 deposition features
- Historic tributary alignments
- Recent channel migration
- Existing channel alignment
- Embankment

Notes

1. Majority of embankments constructed late 18th and early 19th C to protect adjacent land from flooding.
2. Internal drainage of marshes believed to have occurred at a similar time.
3. Suggestion in historic records that attempts were made to lower the level of Loch Insh by dredging at the outlet to a depth of several feet prior to 1790.
4. A previous author has suggested that the meander cut-off's may have been initiated by this change in base level.
5. Significant reduction in flows in the Spey and the Tromie due to flow diversions out of the catchment for HEP schemes (Alcan/ Tummel) from 1940's/ 1950's.

Do not scale this map

Client
RSPB

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing D1
Historic Change
2 of 3

Status
FINAL

Drawing No.	Revision
166050_007	

Scale		Date
1:10,000	A3	11 June 2015

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HB	KMD	KMD

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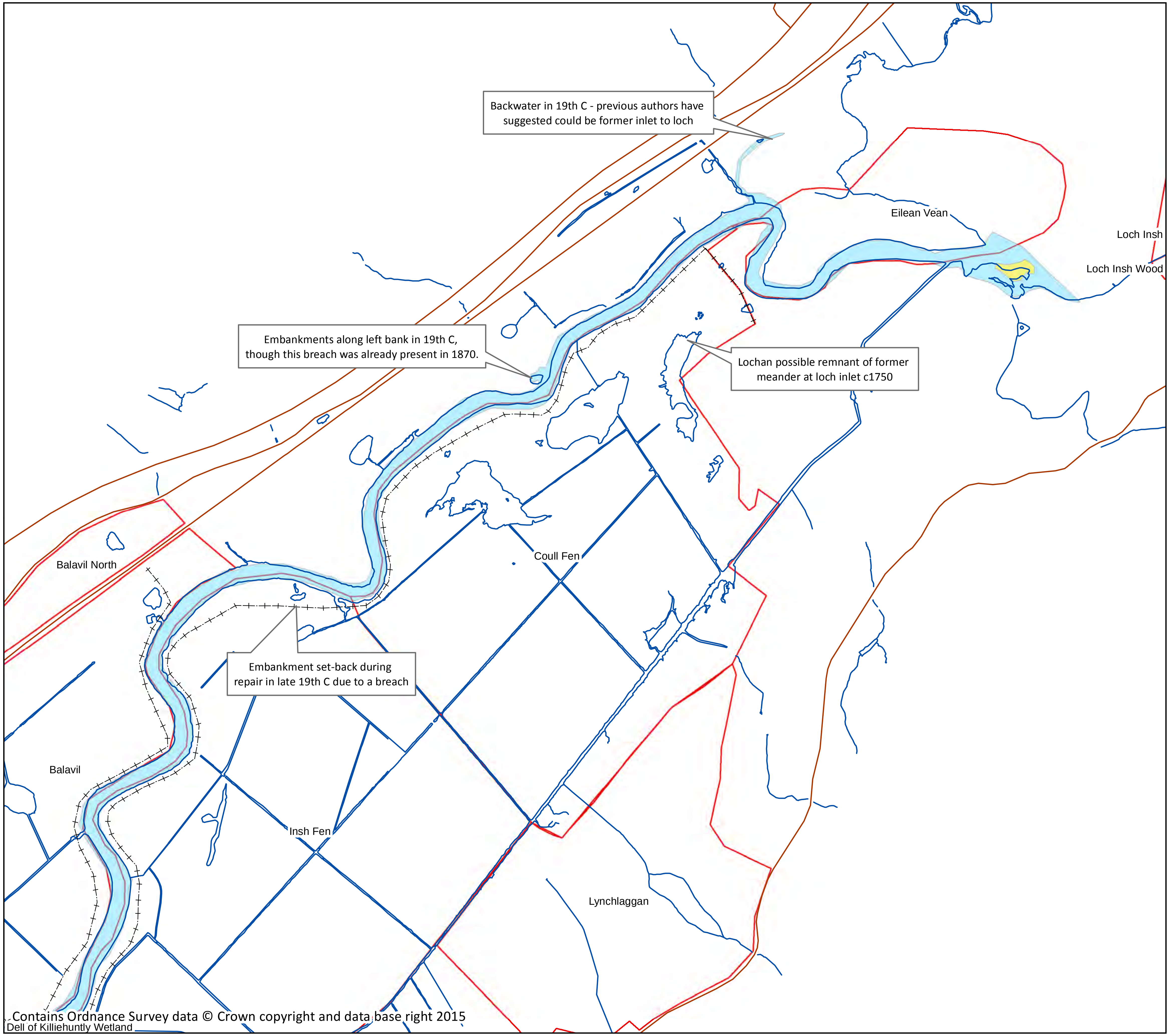

Legend

- RSPB compartments
- Road/ railway infrastructure

Historic alignments

- 1870 channel alignment
- 1870 deposition features
- Historic tributary alignments
- Recent channel migration
- Existing channel alignment
- Embankment

Notes

1. Majority of embankments constructed late 18th and early 19th C to protect adjacent land from flooding.
2. Internal drainage of marshes believed to have occurred at a similar time.
3. Suggestion in historic records that attempts were made to lower the level of Loch Insh by dredging at the outlet to a depth of several feet prior to 1790.
4. A previous author has suggested that the meander cut-off's may have been initiated by this change in base level.
5. Significant reduction in flows in the Spey and the Tromie due to flow diversions out of the catchment for HEP schemes (Alcan/ Tummel) from 1940's/ 1950's.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D1 Historic Change 3 of 3
Status	FINAL
Drawing No.	166050_008
Revision	
Scale	1:10,000
Size	A3
Date	11 June 2015
Drawn	HB
Checked	KMD
Approved	KMD

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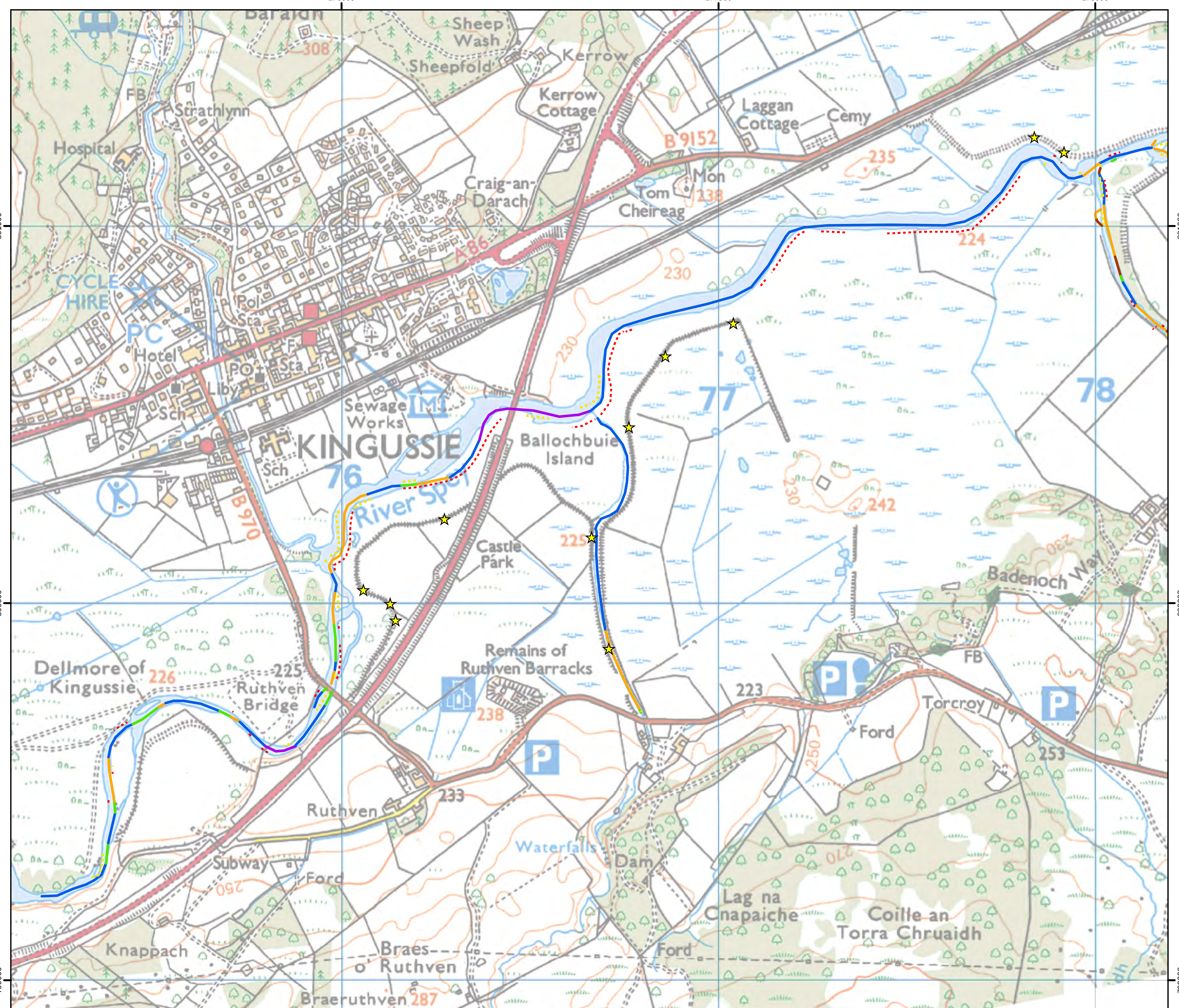

Legend

- Erosion
- Deposition

Flow type

- Rapid
- Run
- Riffle
- Glide
- Pool
- ★ Breaches

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D2 Morphological Survey Outputs 1 of 3
Status	FINAL
Drawing No.	166050_001
Revision	
Scale	1:10,000
Size	A3
Date	25 Feb 2015
Drawn	HB
Checked	KMD
Approved	KMD

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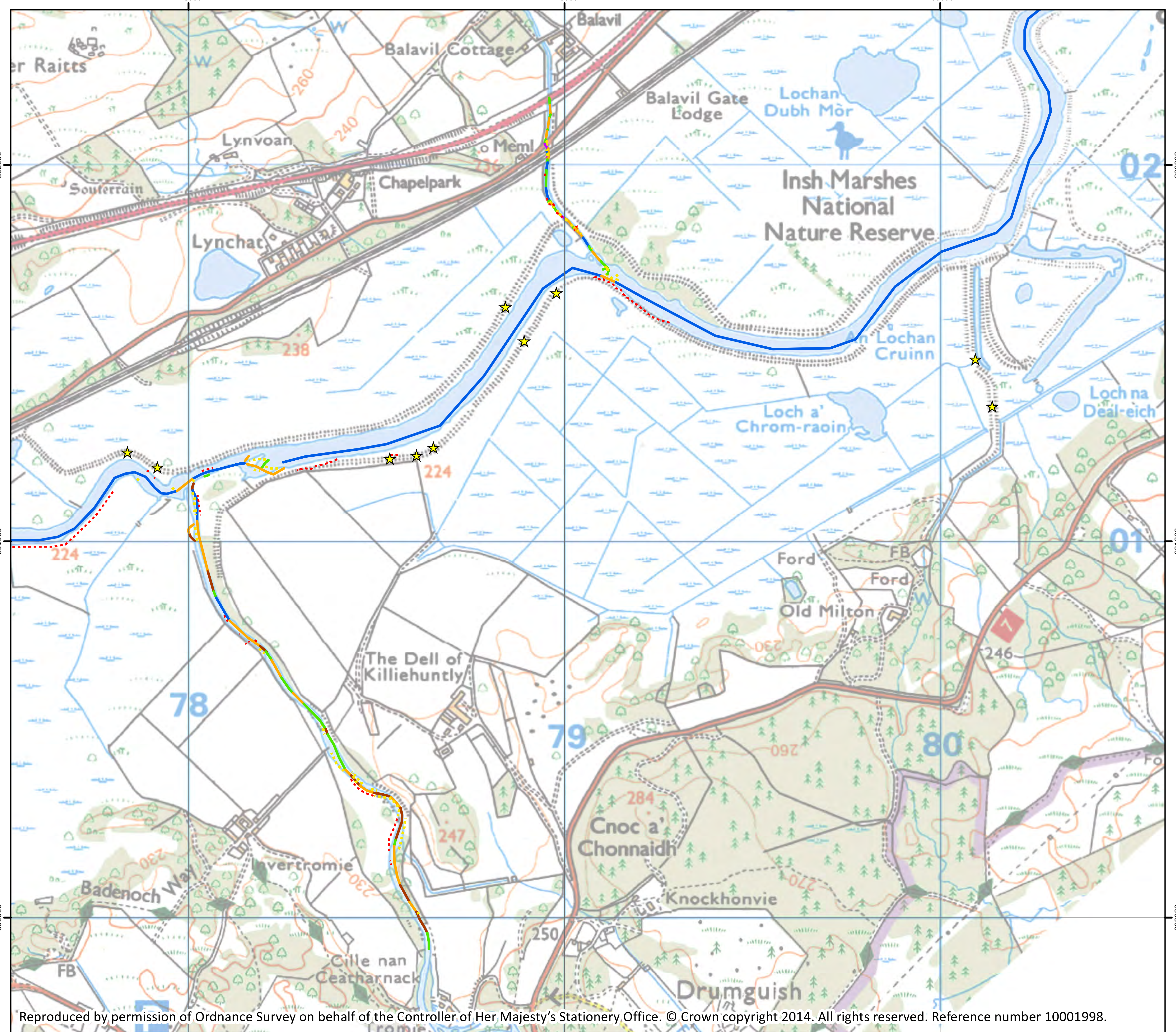

Legend

- Erosion
- Deposition

Flow type

- Rapid
- Run
- Riffle
- Glide
- Pool
- ☆ Breaches

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D2 Morphological Survey Outputs 2 of 3
Status	FINAL
Drawing No.	166050_002
Revision	
Scale	1:10,000
Size	A3
Date	25 Feb 2015
Drawn	HB
Checked	KMD
Approved	KMD

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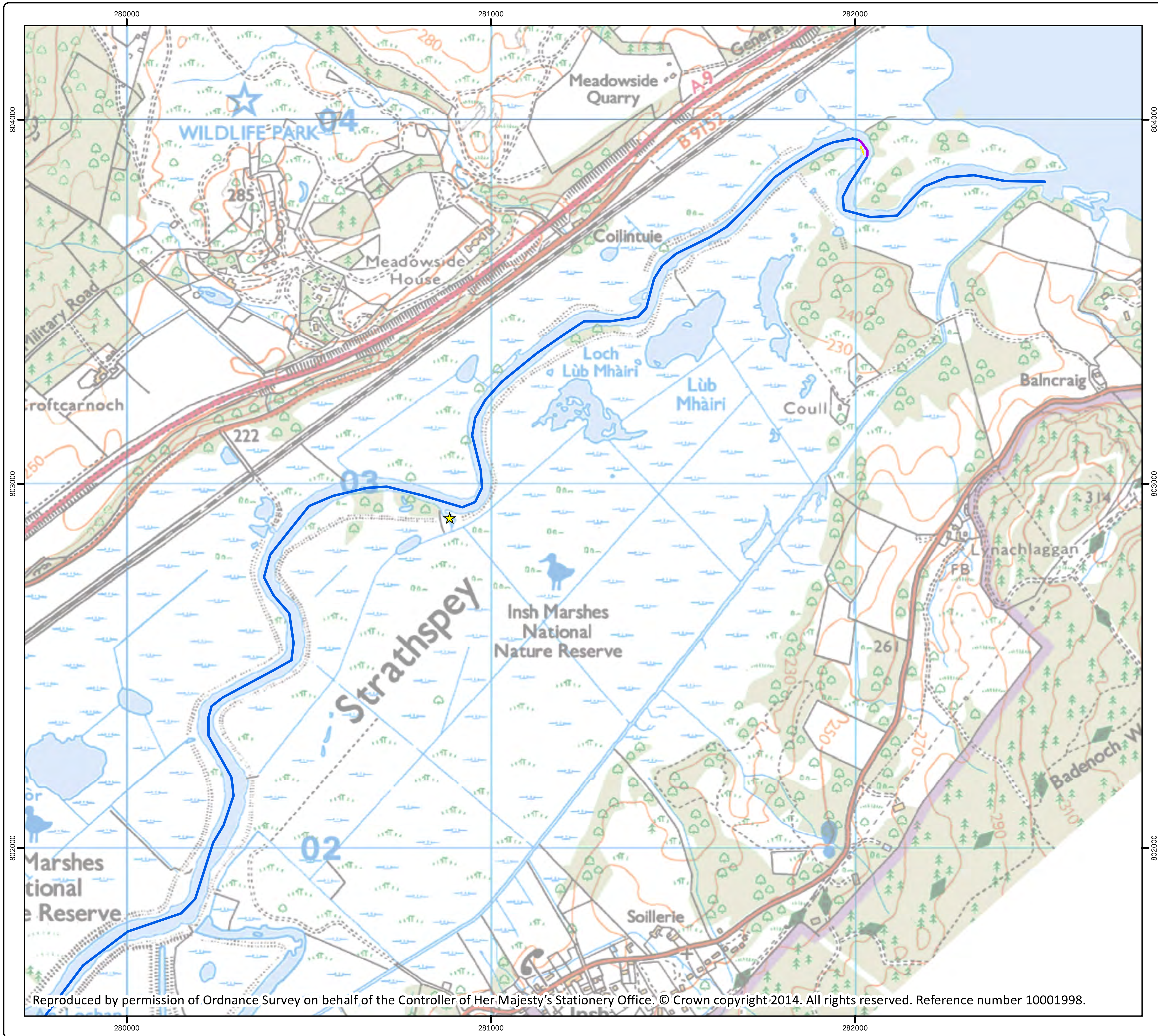

Legend

- Erosion
- Deposition

Flow type

- Rapid
- Run
- Riffle
- Glide
- Pool
- ☆ Breaches

Do not scale this map

Client
RSPB

Project
Insh Marshes National Nature Reserve:
River Restoration Feasibility Study

Title
Drawing D2
Morphological Survey Outputs
3 of 3

Status
FINAL

Drawing No.	Revision
166050_003	

Scale		Date
1:10,000	A3	25 Feb 2015

Drawn	Checked	Approved
HB	KMD	KMD

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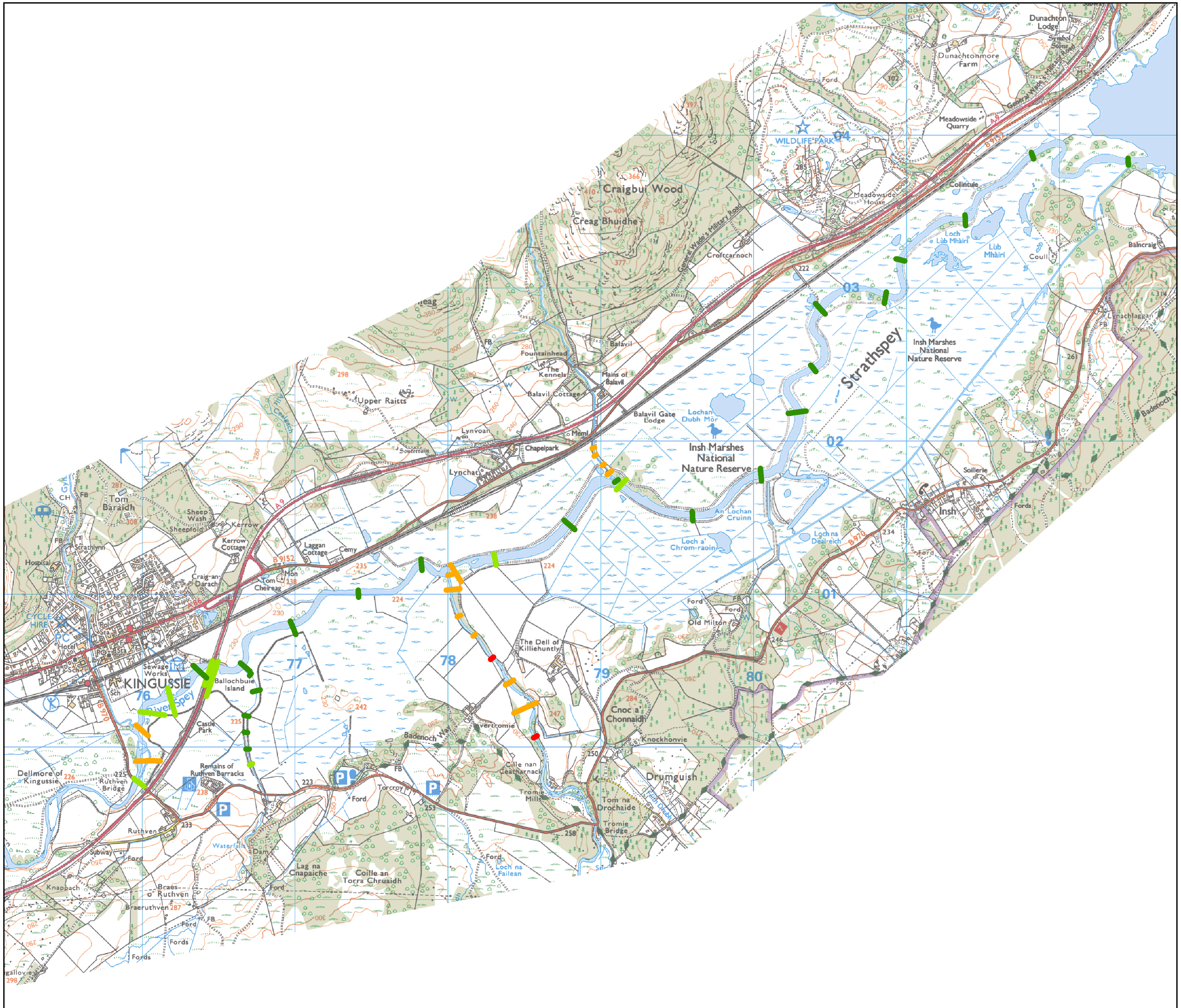

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Legend

Stream Power at Modelled Cross-sections

QMED event

- Very low (<10 W/m2)
- Low (10 - 35 W/m2)
- Low-medium (36 - 150 W/m2)
- Medium-high (150 - 300 W/m2)

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D3 Stream Power at QMED
Status	FINAL
Drawing No.	166050_009
Revision	A
Scale	1:25,000
Size	A3
Date	01 Sept 2015
Drawn	HR
Checked	KMD
Approved	KMD

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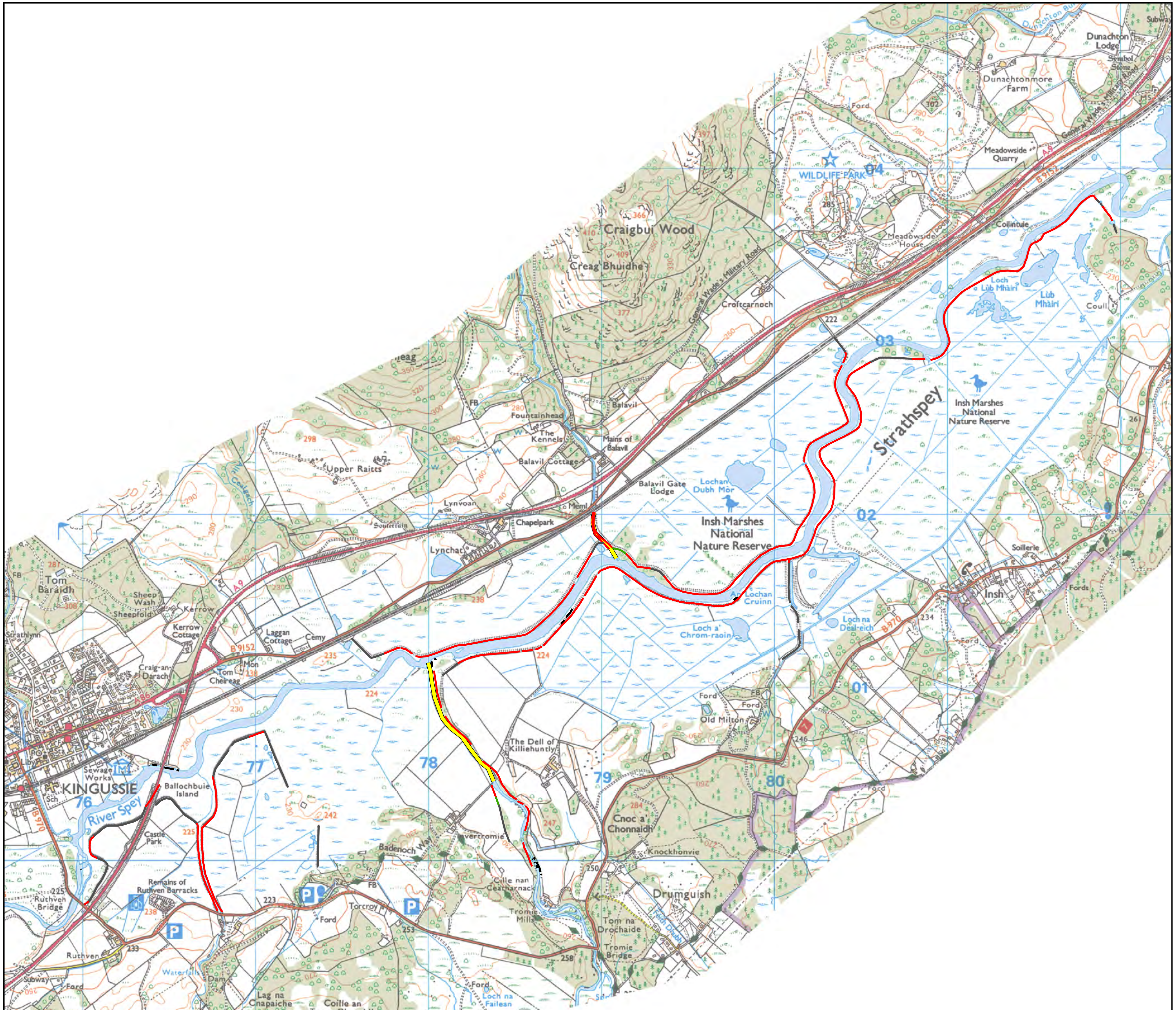

Legend

- High impact realignment
- Hard bank reinforcement

Embankments for MImAS calcs

- >50m from bank
- Embankment
- Set-back

Notes

1. Pressures not shown:
- Bridges
- Low-level revetments along Spey (extent unknown)
2. Spey and Tromie within reserve are heavily modified due to impact of upstream abstractions

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing D4 MImAS Pressures
Status	FINAL
Drawing No.	166050_018
Revision	
Scale	1:22,000
Size	A3
Date	01 Sept 2015
Drawn	HR
Checked	KMD
Approved	KMD

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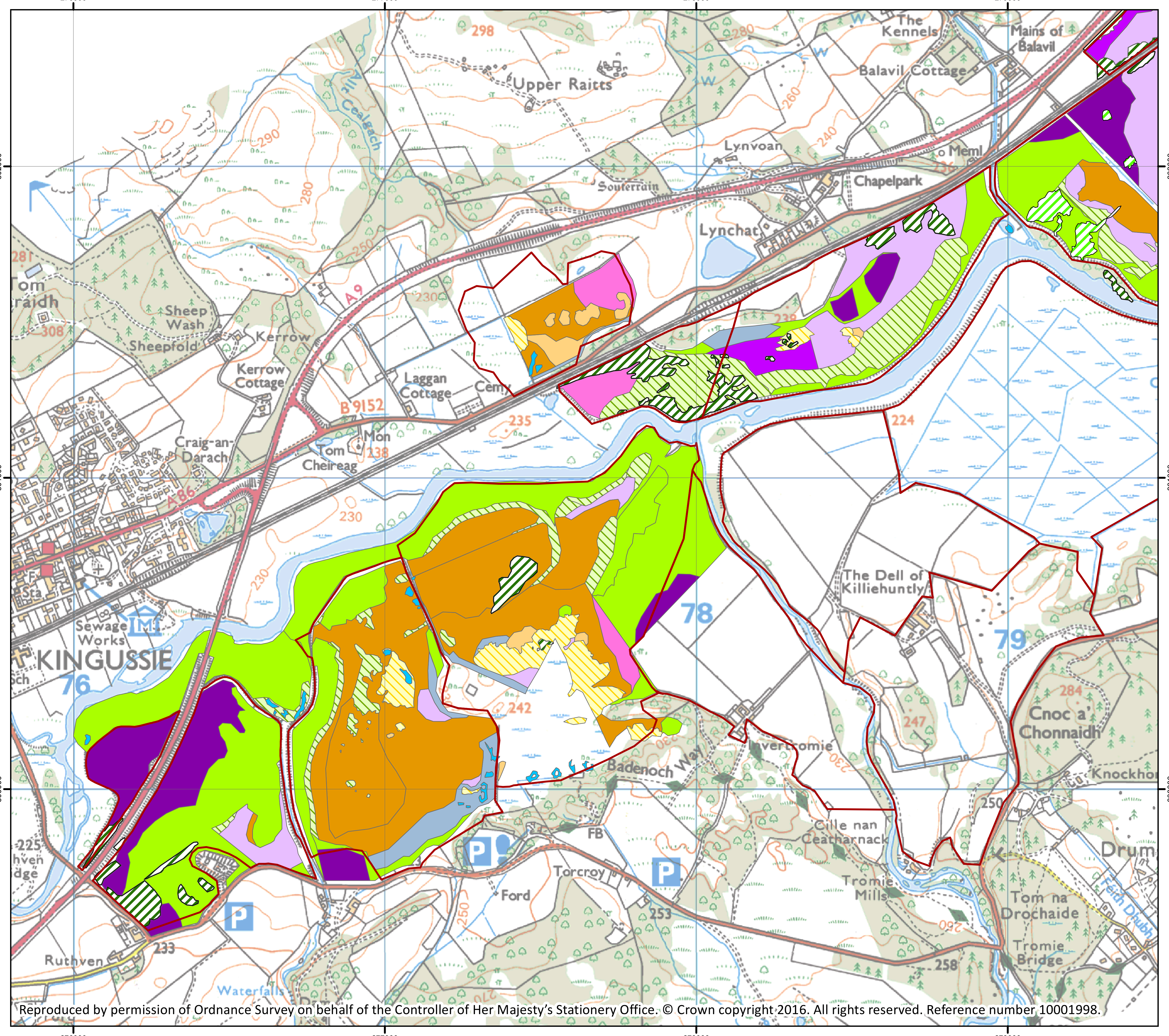
E HABITAT MAPS



Legend

- Assessment units

Composite Habitats

- Carex rostrata swamp mosaic
- Carex lasiocarpa
- Dry grassland
- Fen meadow
- Mixed sedge swamp
- Molinia caerulea mire mosaic
- Reedbed
- Rush pasture mosaic
- Species-poor tall sedge mosaic
- Sphagnum dominated
- Open water
- Pine plantation
- Woodland/scrub

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E1 Composite Habitat (2002) Map 1 of 2
Status	Final
Drawing No.	166050-042
Revision	
Scale	1:12,000
	A3
Date	09 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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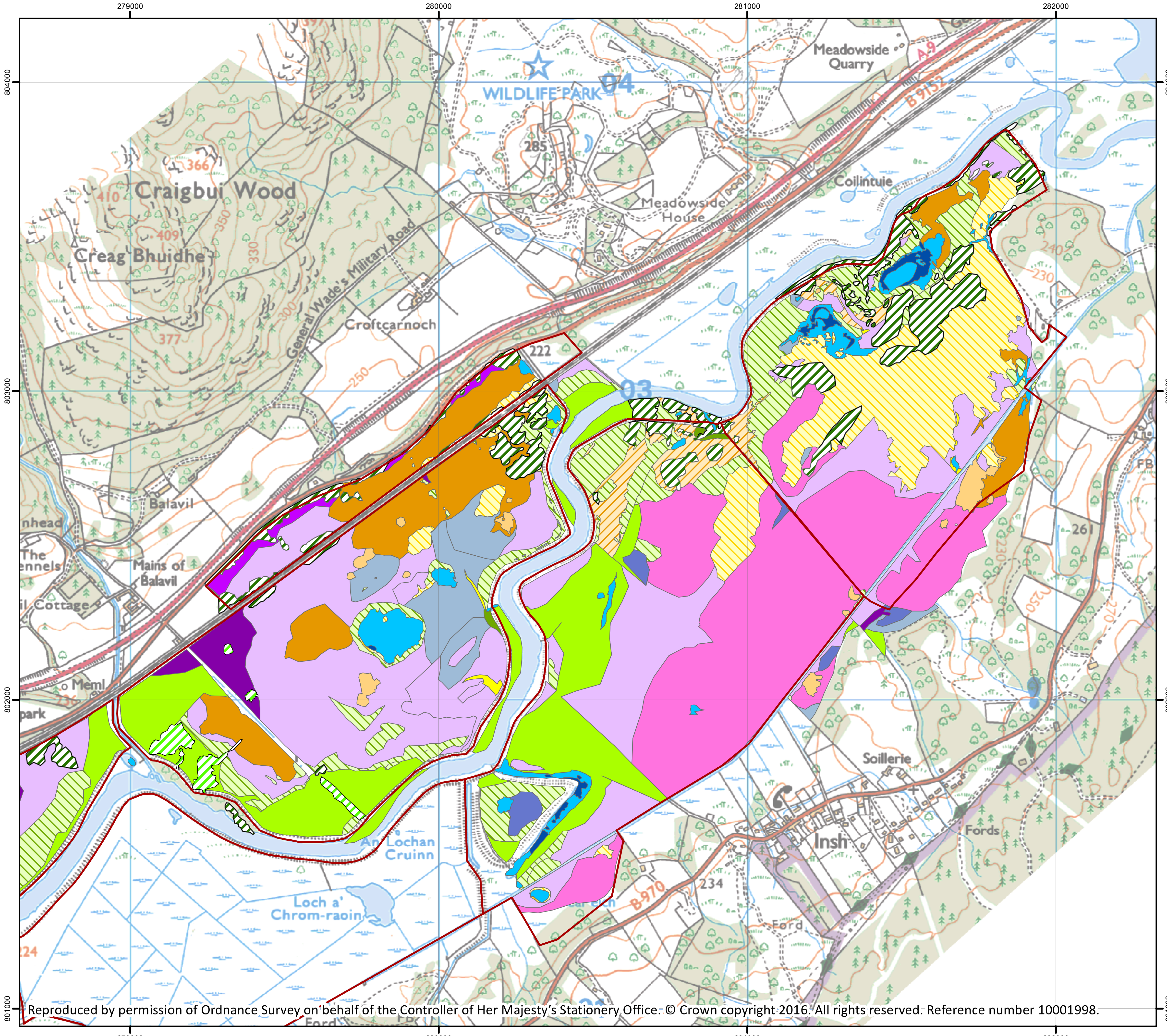
Fax: 0141 341 5045



Legend

Assessment units

Composite Habitats

- Carex rostrata swamp mosaic
- Carex lasiocarpa
- Dense Deschampsia cespitosa
- Dry grassland
- Fen meadow
- Mixed sedge swamp
- Molinia caerulea mire mosaic
- Phalaris arundinacea
- Reedbed
- Ruderal
- Rush pasture mosaic
- Species-poor tall sedge mosaic
- Deep water swamp
- Species-rich low sedge mire
- Sphagnum dominated
- Open water
- Pine plantation
- Woodland/scrub

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E1 Composite Habitat (2002) Map 2 of 2
Status	Final
Drawing No.	166050-043
Revision	
Scale	1:12,000
Size	A3
Date	09 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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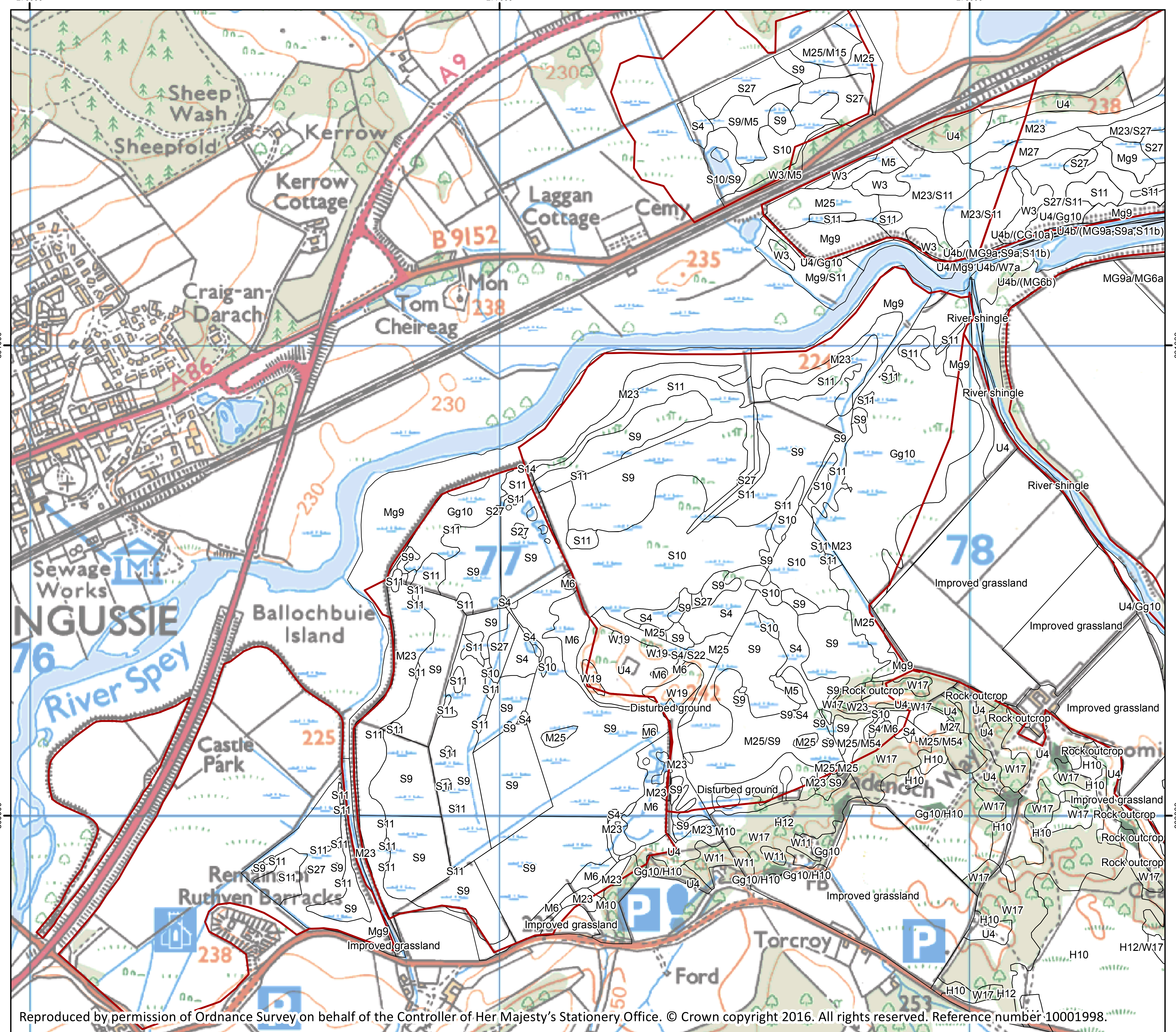
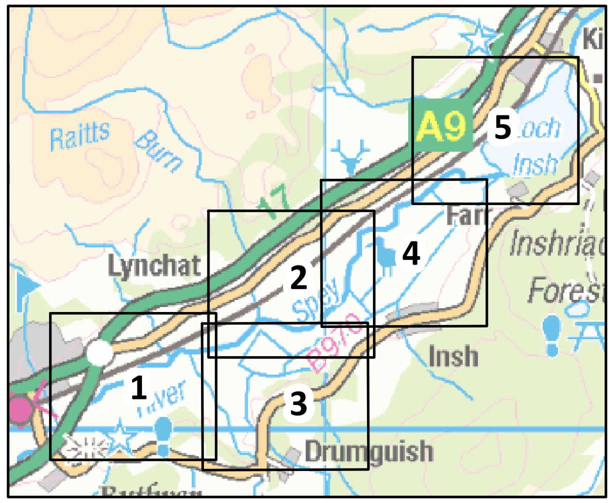


Legend

Assessment units

NVC Habitats



Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E2 NVC Communities (various dates) 1 of 5
Status	Final
Drawing No.	166050-044
Revision	
Scale	1:8,000
Size	A3
Date	10 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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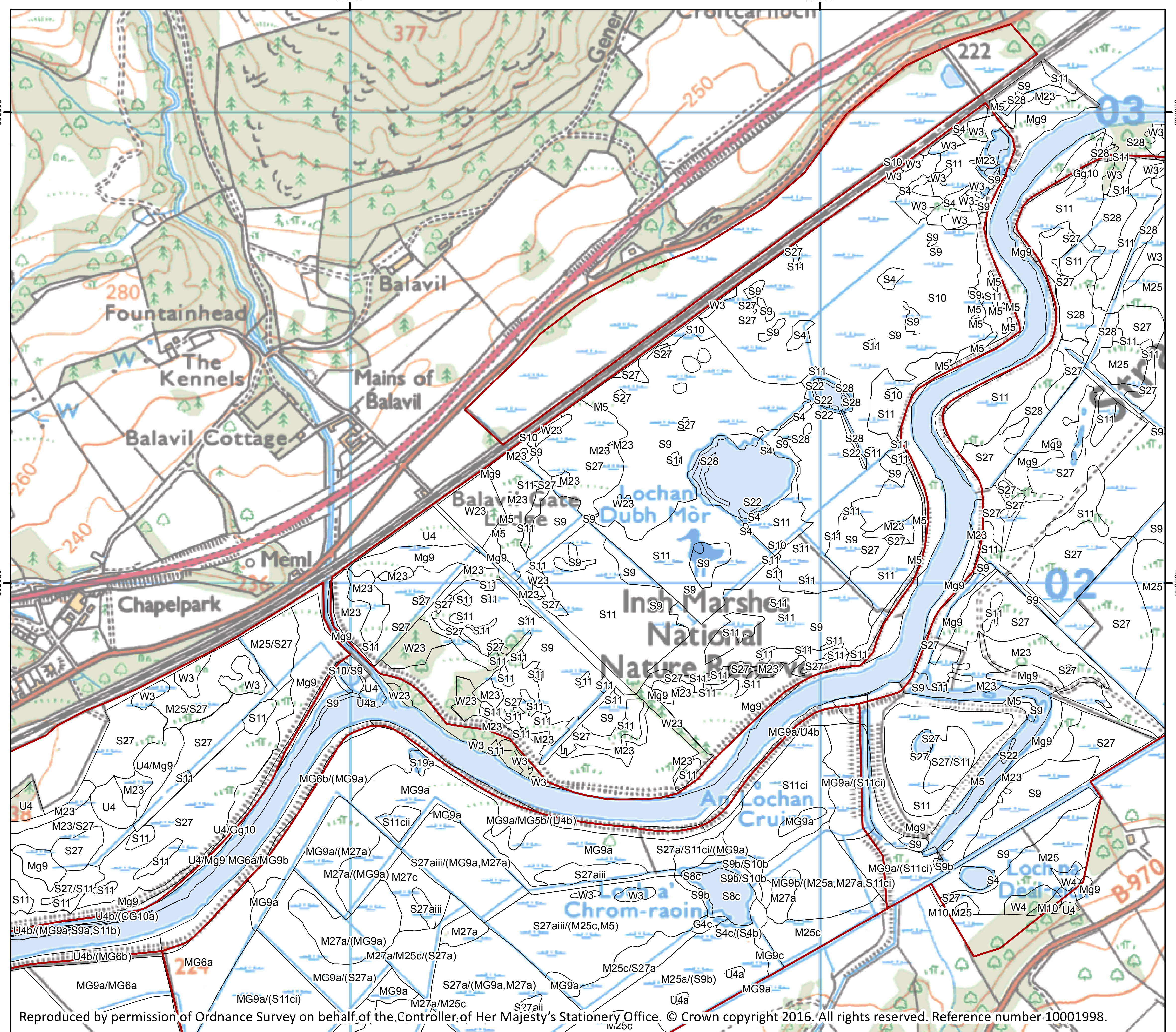
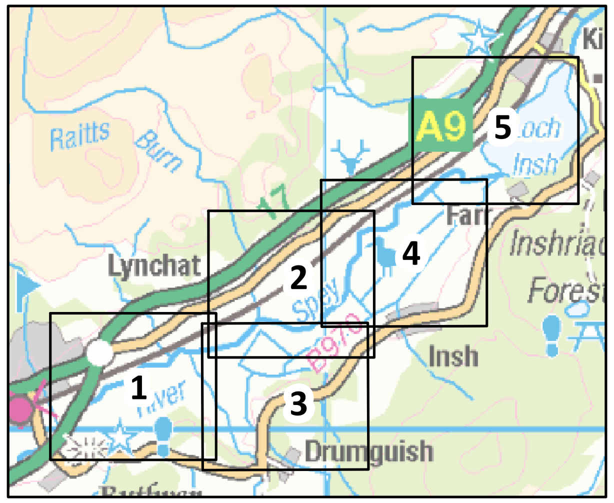


Legend

- Assessment units
- NVC Habitats



Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E2 NVC Communities (various dates) 2 of 5
Status	Final
Drawing No.	166050-045
Revision	
Scale	1:8,000
Size	A3
Date	10 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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Tel: 0141 341 5040
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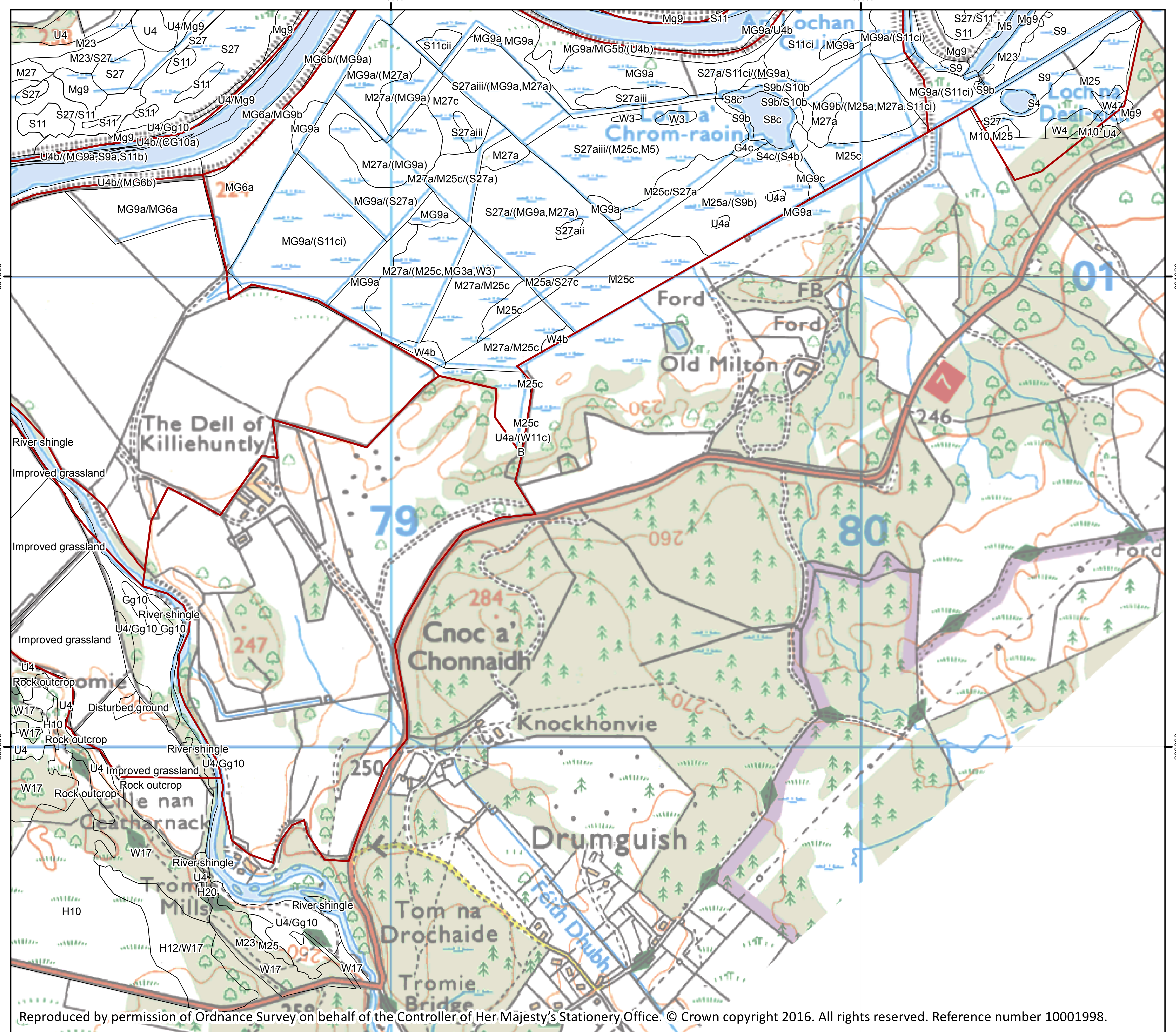
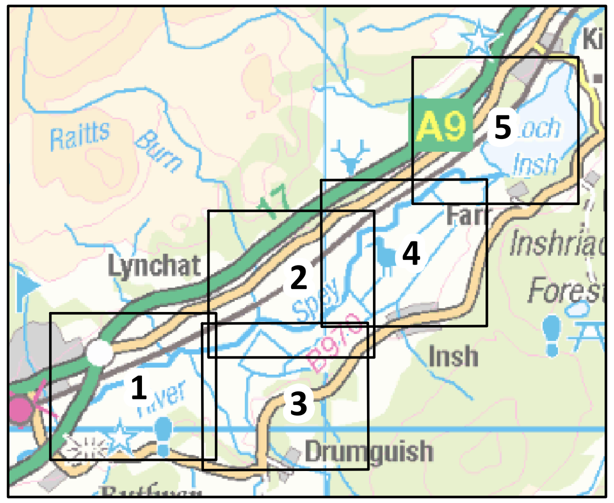
Legend

- Assessment units
- NVC Habitats





Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E2 NVC Communities (various dates) 3 of 5
Status	Final
Drawing No.	166050-046
Revision	
Scale	1:8,000
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Date	10 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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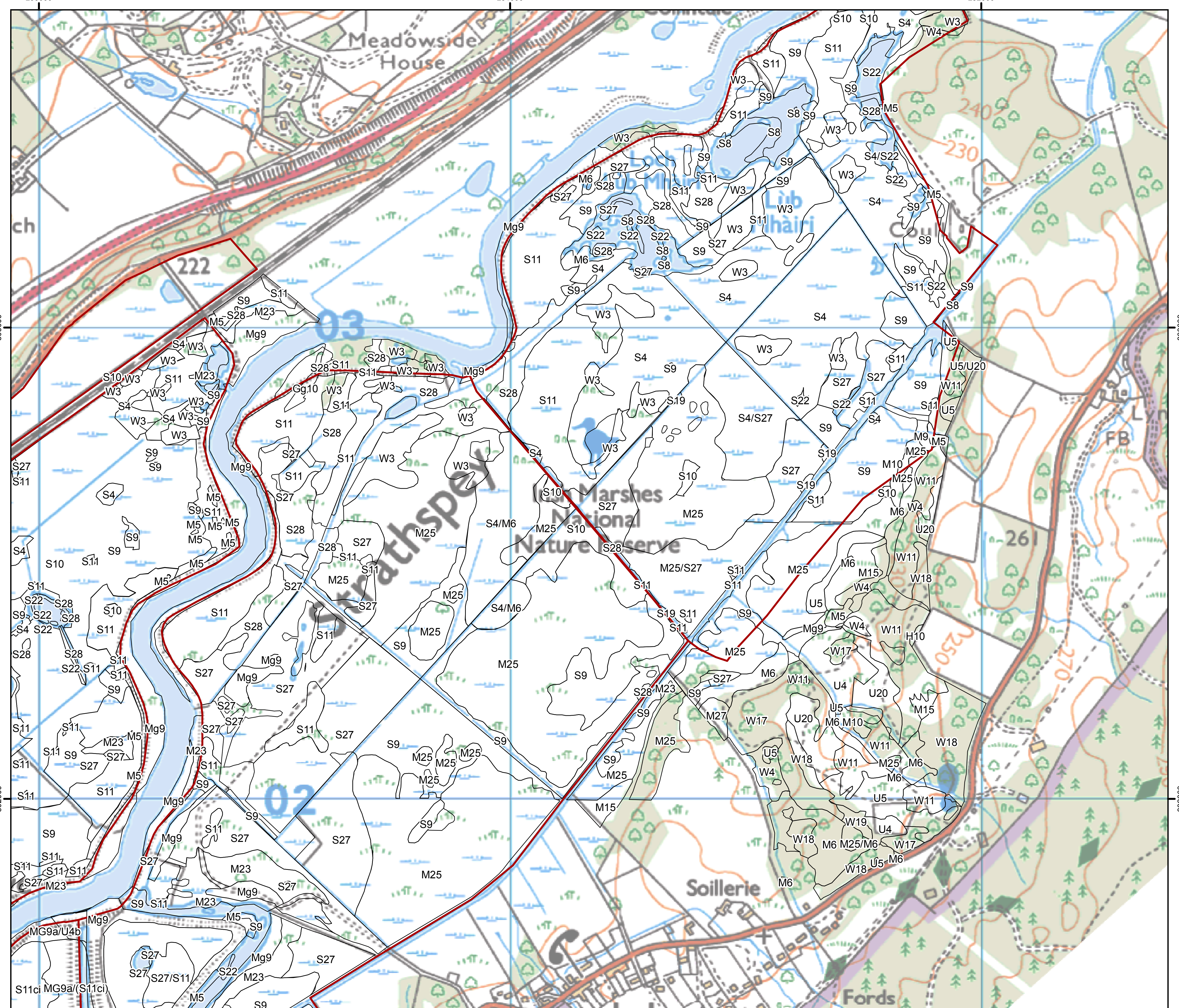
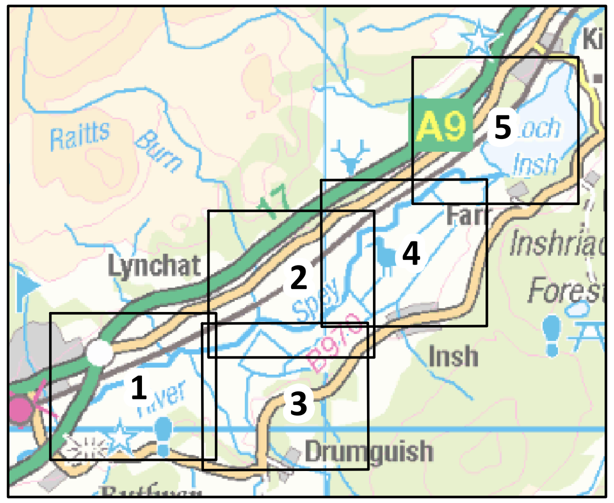


Legend

- Assessment units
- NVC Habitats



Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E2 NVC Communities (various dates) 4 of 5
Status	Final
Drawing No.	166050-047
Revision	
Scale	1:8,000
Size	A3
Date	10 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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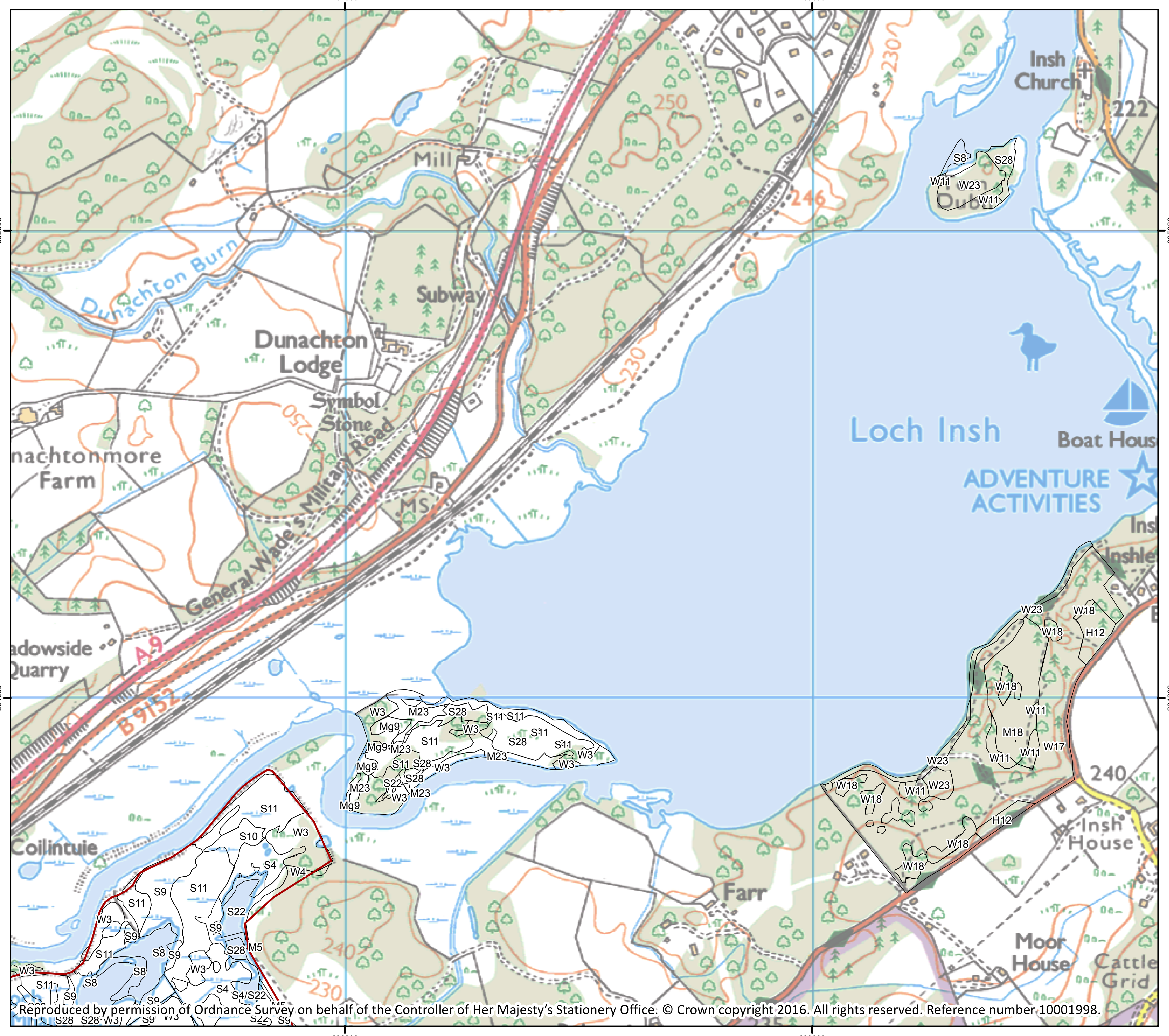
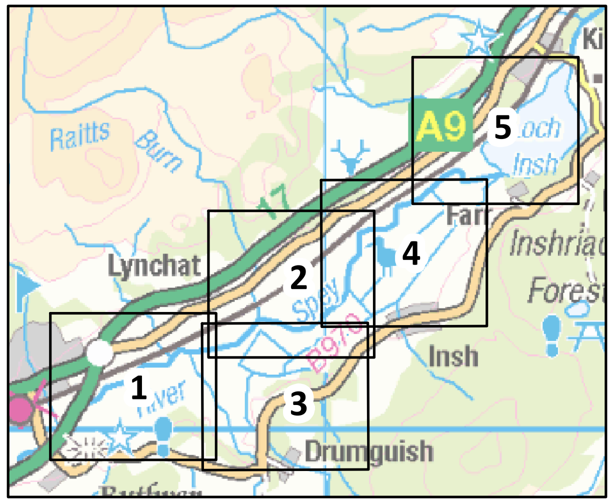


Legend

- Assessment units
- NVC Habitats



Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing E2 NVC Communities (various dates) 5 of 5
Status	Final
Drawing No.	166050-048
Revision	
Scale	1:8,000
	A3
Date	10 Feb 2016
Drawn	JI
Checked	HR
Approved	KMD

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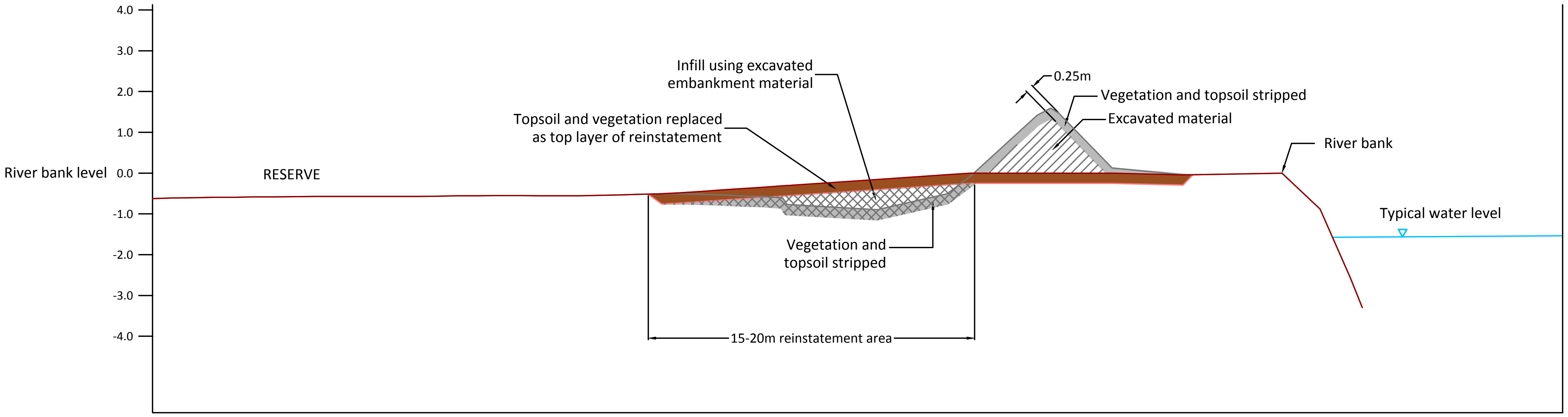
F OUTLINE DESIGN DRAWINGS



(Vertical exaggeration x 2)

Notes

1. Levels and width of reinstatement area to be confirmed on site.
2. Appropriate pollution prevention measures and incident response procedures should be included in construction method statements.
3. Area of works will become inundated during flood events.
4. Absence of services to be confirmed prior to works commencing.
5. Works should be supervised by a suitably qualified professional.

Do not scale this drawing

Rev	Date	Amendment	Initials

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Tel: 0141 341 5040
Fax: 0141 341 5045

Client
RSPB

Project
Insh Marshes National Nature Reserve: River Restoration Feasibility Study

Title
Drawing F1
Outline Design: Embankment Removal
Typical Cross-section Detail

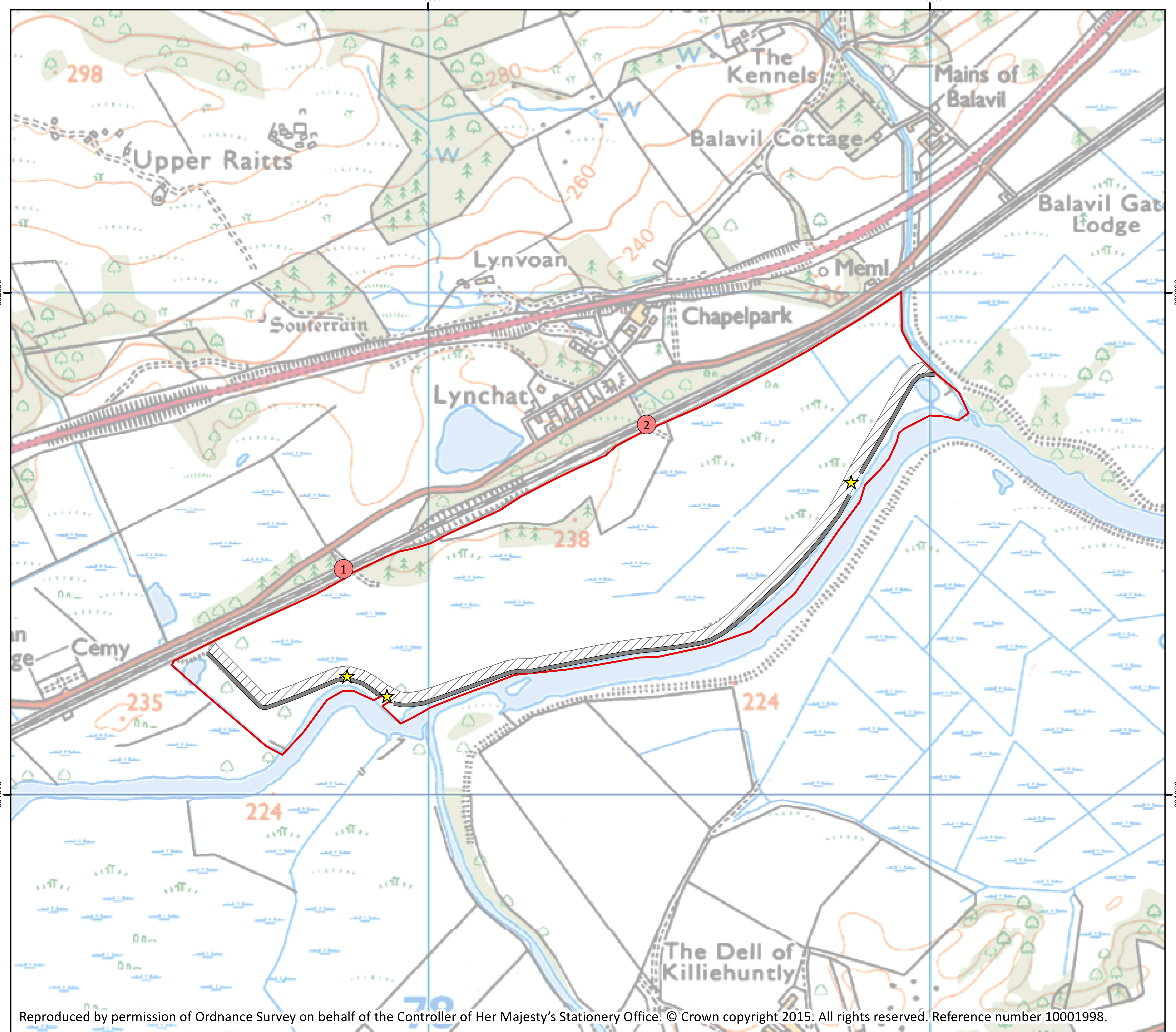
Status
DRAFT

Drawing No. 166050-052
Revision

File path:k:\166050j\drgs\cad

Scale: See Drawing | A3 | Date: 02 February 2016

Drawn: CM | Checked: HR | Approved: KMD



Legend

- ★ Existing breaches: hazard from deep scour hole in bank
- Railway crossing points:
  1. Access over railway, no weight limit.
  2. Access via underpass, max. height 2.97m, max width 3.09m.
- RSPB ownership for Lynchat compartment

Outline design details

- Remove embankment (1700m) in accordance with Drawing F1 (166050-052)
- Typical zone for slope re-grading (15 - 25m width)

Notes:

1. Access will be from B9152. Within the site, routes and approach to be agreed with RSPB.
2. Appropriate pollution prevention measures and incident response procedures should be included in construction method statements.
3. Embankment is situated within the River Spey floodplain and compartment becomes fully inundated during flood events.
4. Absence of services to be confirmed prior to works commencing.
5. Works should be supervised by a suitably qualified professional.

Do not scale this map

Client	RSPB
Project	Insh Marshes National Nature Reserve: River Restoration Feasibility Study
Title	Drawing F2 Outline Design: Pilot 1 at Lynchat Plan
Status	FINAL
Drawing No.	166050_053
Revision	
Scale	1:7,500
Size	A3
Date	18 Feb 2016
Drawn	HR
Checked	KMD
Approved	KMD

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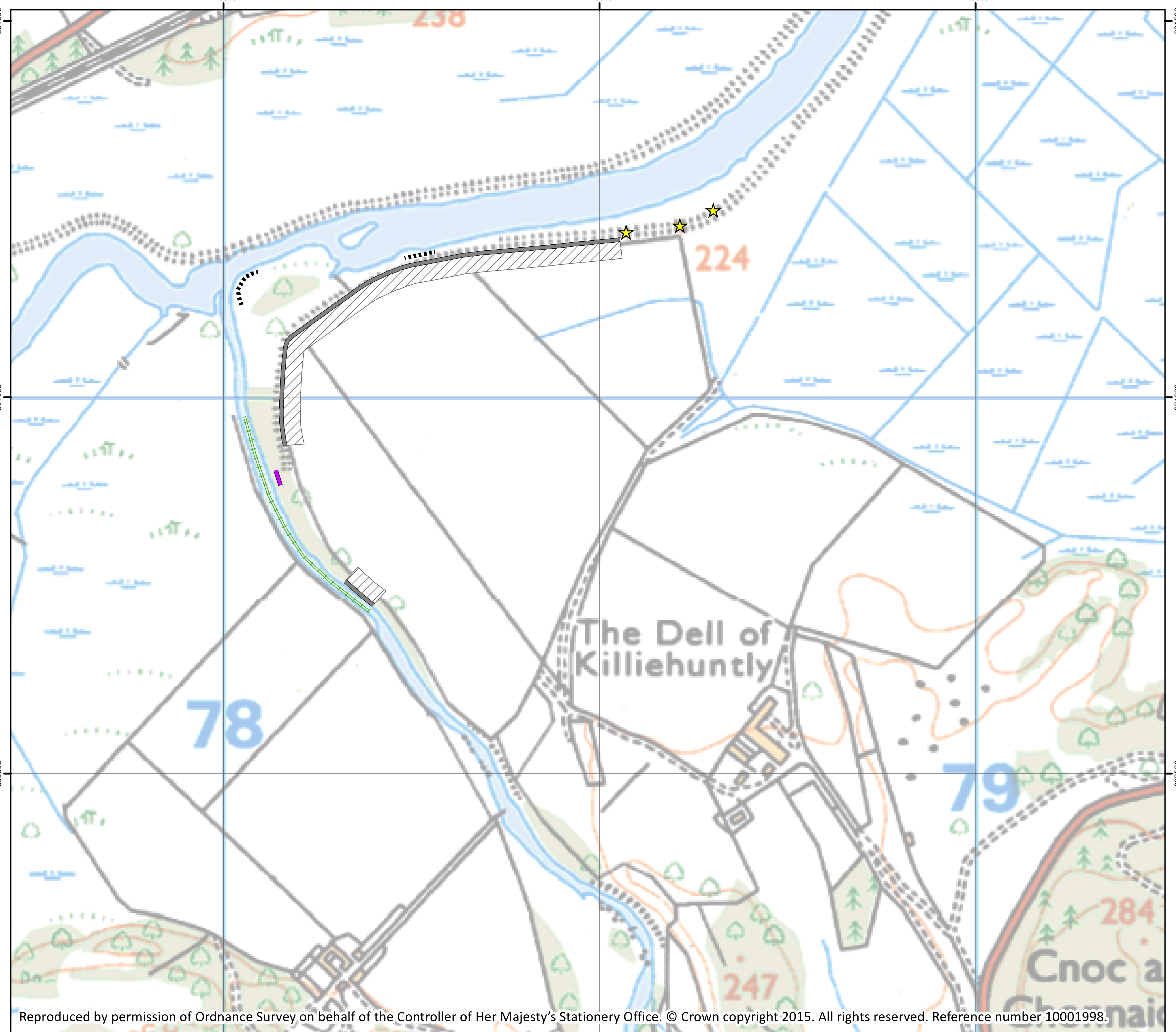

Legend

★ Existing breaches: hazard from deep scour hole in bank

Outline design details

- Remove embankment (665m) in accordance with Drawing F1 (166050-052)
- Lower bank (10-20m length) by 0.3m
- Remove hard bank protection in accordance with Drawing F4 (166050-055)
- Installation of LWD within this reach. Typical spacing 100 - 140m. Exact locations to be determined based on morphological conditions at the time of installation
- Typical zone for slope re-grading (15-25m width)

Notes:

1. Access will be from B970 and via Dell of Killiehuntly Farm. Within the site, routes and approach to be agreed with RSPB.
2. Appropriate pollution prevention measures and incident response procedures should be included in construction method statements.
3. Area of works will become inundated during flood events.
4. Absence of services to be confirmed prior to works commencing.
5. Works should be supervised by a suitably qualified professional.
6. All proposed works are within RSPB landownership

Do not scale this map

Client: RSPB			
Project: Insh Marshes National Nature Reserve: River Restoration Feasibility Study			
Title: Drawing F3 Outline Design: Pilot 2 at Dell of Killiehuntly Plan			
Status: FINAL			
Drawing No.: 166050_054		Revision:	
Scale: 1:5,000	A3	Date: 18 Feb 2016	
Drawn: HR	Checked: KMD	Approved: KMD	

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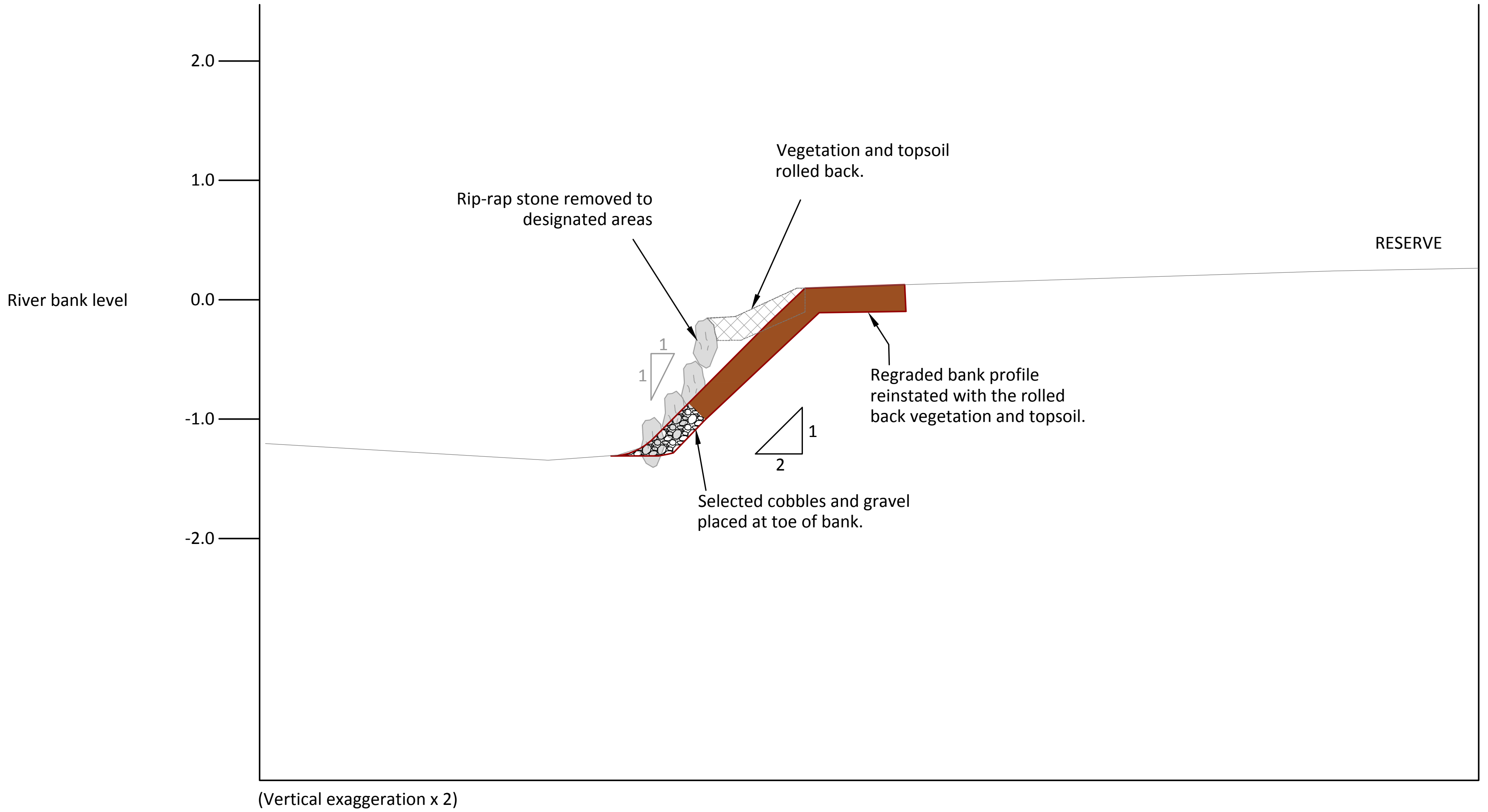

Horizontal Scale: 1:100
Vertical Scale 1:50

Notes

1. Levels to be confirmed on site.
2. Appropriate pollution prevention measures and incident response procedures should be included in construction method statements.
3. Area of works will become inundated during flood events.
4. Absence of services to be confirmed prior to works commencing.
5. Works should be supervised by a suitably qualified professional.

Do not scale this drawing

Rev	Date	Amendment	Initials

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Tel: 0141 341 5040
Fax: 0141 341 5045

Client
RSPB

Project
Insh Marshes National Nature Reserve: River Restoration Feasibility Study

Title
Drawing F4
Outline Design: Rip-rap Removal
Typical Cross-section Detail

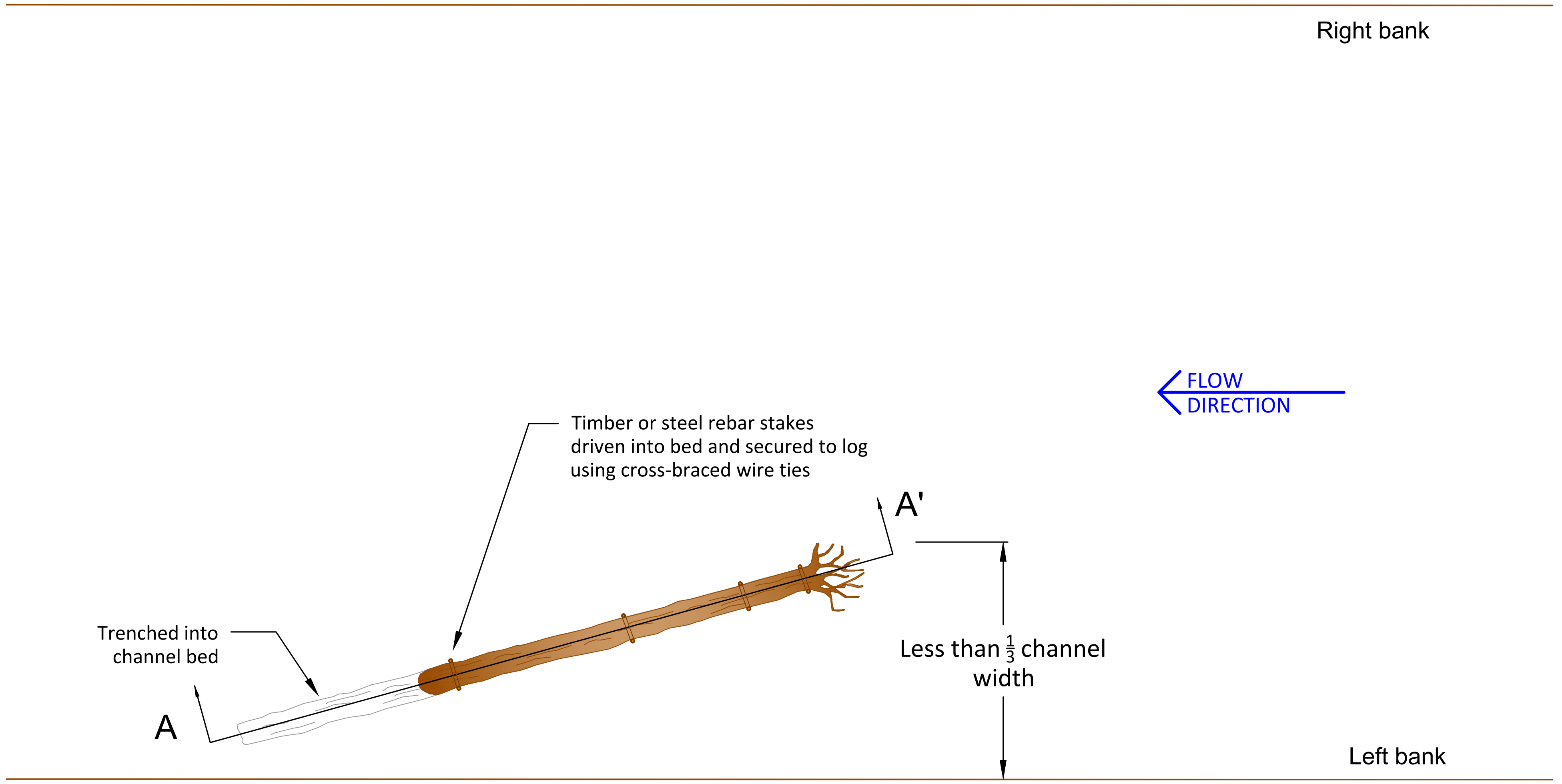
Status
DRAFT

Drawing No.
166050-055

Revision

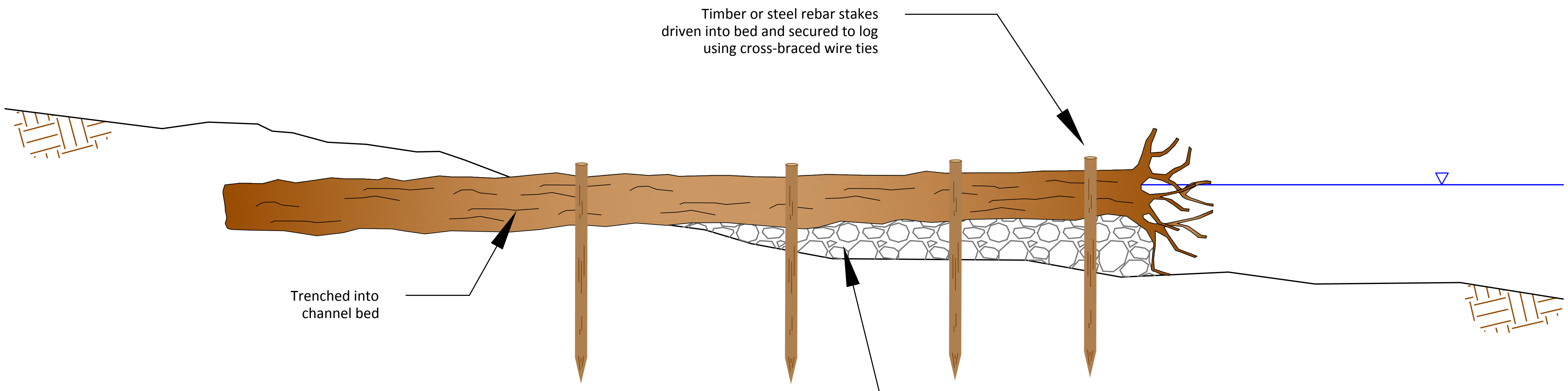
File path:k:\166050j\drgs\cad

Scale		Date
See Drawing	A3	02 February 2016
Drawn	Checked	Approved
CM	HR	KMD



PLAN

Not to Scale.



CROSS-SECTION A - A'

Not to Scale.

Notes

1. Levels to be confirmed on site.
2. Logs to be sourced on-site from felling required for bank lowering/ embankment removal.
3. Appropriate pollution prevention measures and incident response procedures should be included in construction method statements.
4. Area of works will become inundated during flood events.
5. Absence of services to be confirmed prior to works commencing.
6. Works should be supervised by a suitably qualified professional.

Do not scale this drawing

Rev	Date	Amendment	Initials

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Tel: 0141 341 5040
Fax: 0141 341 5045

Client
RSPB

Project
Insh Marshes National Nature Reserve: River Restoration Feasibility Study

Title
Drawing F5
Outline Design: Large Woody Material Typical Details

Status
FINAL

Drawing No.
166050-056

Revision

File path:k:\166050j\drgs\cad

Scale		Date
N.T.S.	A3	02 February 2016

Drawn	Checked	Approved
CM	HR	KMD