Appendix 11.3

Flood Risk Assessment

Contents

Tables

Figures

1 Introduction

1.1 A Flood Risk Assessment (FRA) has been carried out by the CH2M/ Fairhurst Joint Venture (CFJV) for Transport Scotland (TS), as part of the Design Manual for Roads and Bridges (DMRB) Stage 3 Environmental Impact Assessment (EIA) for Project 8 - Dalwhinnie to Crubenmore (Central Section) of the A9 Dualling Programme. This FRA report will be included as a supporting appendix to **Chapter 11** of the EIA.

1.2 Project 8 upgrades approximately 11km of the A9 to dual carriageway, linking Dalwhinnie to the existing dualled road at Crubenmore. Project 8 crosses and is close to several ecologically sensitive areas and watercourses, some of which have specific ecological designations.

1.3 In the context of this report, 'Proposed Scheme' describes all permanent works proposed as part of the Dualling Programme within Project 8. These include the Proposed Mainline of the A9 itself, access roads, diversion channels and drainage features. 'Existing Road' is used to refer to the existing A9 road surface within the limits of Project 8 extents.

1.4 In accordance with DMRB (Vol. 5, S.1, Pt.2 TD37/93), Project 8 has been progressed through the DMRB Stage 1 and Stage 2 assessment processes. The Stage 3 assessment considers significant environmental effects in greater detail, including potential impacts on local and downstream flood risk, in accordance with Section 20A and 55A of the Roads (Scotland) Act 1984.

Approach

1.5 In **Section 2** of this appendix the development site and surrounding water environment are introduced, along with the survey information acquired for this assessment. Available information on local flood risk has been reviewed and is summarised in **Section 3**; this includes work done at DMRB Stages 1 and 2, as well as feedback from stakeholders.

1.6 Aspects of the Proposed Scheme that may affect the water environment with regards to flood risk are outlined in **Section 4**.

1.7 **Section 5** outlines potential sources, before pre- and post- development flood risk is assessed for both the Existing Road and the Proposed Scheme in **Section 7**, and is assessed at key locations outwith the Proposed Scheme in **Section 8**. The assessment has been undertaken in accordance with Scottish Environment Protection Agency (SEPA) Technical Flood Risk Guidance for Stakeholders (2016) and DMRB; cognisant of best practice and other planning legislation and design standards where noted.

1.8 Fluvial flood risk is assessed with the aid of a Hydrological and Hydraulic Modelling (H&HM) study, which has been developed with the aid of SEPA consultations and feedback on previous iterations of the modelling study undertaken and consulted at earlier DMRB stages and early in the Stage 3 assessment. This FRA includes a discrete branch of the H&HM study – a 'full-length' model – undertaken to inform the assessment of cumulative changes to the hydraulic environment within Project 8. **Section 6** summarises the H&HM approach ahead of the risk assessment sections introduced above. Further H&HM detail is provided in the appendices to this report.

1.9 Until **Section 9** – *Mitigation*, design proposals are considered as they were in autumn 2016. Flood risk assessment findings have been fed back into the design, and mitigation options have been developed as part of the evolving design. **Section 9** accounts for changes made to the Proposed Scheme since the autumn 2016 design iteration. It outlines mitigation measures recommended to alleviate flood risk and concludes with an assessment of the Proposed Scheme 'post-mitigation', identifying residual flood risks and flood risk impacts elsewhere.

Legislation & Design Standards

1.10 Scottish Planning Policy (SPP, 2014) sets out national planning policies which reflect Scottish Ministers' priorities for the operation of the planning system and for the development and use of land. A precautionary approach to flood risk is promoted. The flood risk hierarchy prioritises avoidance, flood reduction and avoidance of increased surface water flooding. This includes locating development away from 'functional flood plain' and 'Medium to High Risk' areas (0.5% [1:200] probability of flooding in any one year). The flood risk framework included in SPP to guide development includes three categories of flood risk. For areas at Medium to High Risk, the framework notes that undeveloped and sparsely developed locations may be suitable for development that is essential for transport infrastructure *"…which should be designed and constructed to be operational during floods and not impede water flow"*. The Framework goes on to note that where built development is permitted on Medium to High Risk land, *"…measures to protect against or manage flood risk will be required and any loss of flood storage capacity mitigated to achieve a neutral or better outcome"* [built development is not explicitly defined]. SPP also includes a list of factors to take into account in applying the Risk Framework, which include taking into account *"cumulative effects, especially the loss of flood storage capacity*".

1.11 The Flood Risk Management (Scotland) Act 2009 places specific roles and responsibilities on local authorities and SEPA in relation to flood risk management. The Act also requires that all sources of flooding be considered in the assessment of flood risk including fluvial, coastal, pluvial, sewer and groundwater flooding.

1.12 The Highland Council's (THC) general policy on flood risk requires avoidance of flood risk areas and promotes sustainable flood management measures. The Council's Supplementary Guidance for flood risk assessment, adopted Jan 2013, states that, in line with SPP, all new development need to be free from unacceptable flood risk for all flood events up to the 1 in 200 year return period. The Guidance also outlines suggested FRA content and complexity.

1.13 SEPA Technical Flood Risk Guidance for Stakeholders (SS-NFR-P-002) outlines methodologies that may be appropriate for hydrological and hydraulic modelling studies, and sets out what information SEPA requires to be submitted as part of a FRA report.

1.14 DMRB contains requirements and advice relating to works on trunk roads for which one of the Overseeing Organisations (in this case Transport Scotland) is the highway authority. It is written to reflect Highways England standards, and is therefore required to be interpreted with a view to Scottish standards when influencing design in Scotland. Volume 11, Section 3 'Environmental Assessment Techniques' gives guidance for the environmental assessment of projects and covers statutory Environmental Impact Assessment. Chapter 5 'Procedure for Assessing Impacts' includes guidance on how the flooding impacts should be assessed in relation to road projects. Furthermore Chapters 6 and 7 provide additional information on the scope and level of assessment required and the reporting of the assessment process and findings.

1.15 Where design decisions have been particularly influenced by legislation, or follow specific design standards with relation to flood risk, it is noted within the body of this report.

2 Existing Conditions

Location, Topography and Features

2.1 The A9 provides a strategic link between the Highlands and the Central Belt of Scotland. Project 8 of the A9 Dualling Programme is located in the River Truim valley, within the Cairngorms National Park (CNP) and covers approximately 11km of road from the northern edge of the Drumochter Hills around (chainage) ch. 20,000, above 400mAOD, to the existing dual carriageway at Crubenmore around ch. 31,000, at approximately 310mAOD.

2.2 The majority of this upland area is rough pasture, broken by the developed land at Dalwhinnie and Cuaich, and a narrow strip of trees (approximately 50m wide) alongside the first two kilometres of the road. The River Spey Special Area of Conservation (SAC) includes the adjacent River Truim. The Drumochter Hills area is also a designated SAC, Special Protection Area (SPA) and Site of Special Scientific Interest (SSSI).

2.3 The Highland Mainline (HML) railway is on the opposite slope of the narrow Truim valley at the southern end of Project 8, leaving its parallel course to round the western edge of Dalwhinnie, before crossing the River Truim north of Dalwhinnie to run between the A9 and the river through the northern half of Project 8, passing in close proximity to the road at Presmuchrach (ch. 27,000) and again at Crubenmore (ch. 31,000).

2.4 The A9 has a junction with the A889 after the latter crosses the River Truim (ch. 23,300). At the northern end of Project 8 the adjacent River Truim channel is again crossed by a local road, at Crubenmore Bridge, that joins the A9 north of Project 8. A length of the Beauly to Denny Power Line (BDL) and associated track is upslope of the A9 in the southern half of Project 8.

Watercourses

2.5 Watercourses are classified as 'Major' where they are shown on 1:50k Ordnance Survey (OS) mapping; all other watercourses (identified via OS 1:10K mapping, topographical survey, site visits and review of Transport Scotland records) are classified as 'Minor'. Watercourse labels and crossing IDs are marked on the 'Water Features Survey' figures provided in **Annex C**. In this report, 'tributaries' is used to describe watercourses crossing the A9, as described below, whereas 'land drains' is used to describe smaller features that do not have an associated crossing under the A9.

2.6 The River Truim is in close proximity to the A9: the distance from the road to the main river channel varies from 10 to 600m within the Project 8 extents. Accordingly, the A9 crosses many tributaries to the River Truim. Sixty tributaries are crossed within the length of Project 8. The overall catchment draining to the River Truim grows from approximately 30km^2 at the southern end of Project 8, to 120km^2 at the northern end of the Project as it is joined by the tributary catchments on the valley slopes. The catchment draining to the Truim at the northern end of the Project can be considered as a series of nested sub-catchments.

2.7 The majority (50) of the tributaries of the River Truim are estimated to have catchments smaller than 50ha draining to them where they are crossed by the road. Of the others the Allt Cuaich is a clear outlier with a catchment of approximately 37km^2. Descriptions of these watercourses are provided in **Annex A**. Catchment boundaries are shown on figures provided in **Annex C**. Nested sub-catchments of the River Truim and tributary catchments are discussed further in **Section 6**.

Other Water Features

2.8 There are a number of bodies of impounded water within the Truim catchment: Loch Cuaich, Loch Ericht and a smaller dam in Glen Truim adjacent to the road at chainage' (ch.) 21,900. The first two are on the Controlled Reservoirs Register under the Reservoirs (Scotland) Act 2011; the smaller does not have the potential to impound a large enough volume to be included in the register. Both are managed by Scottish and Southern Energy (SSE) Generation Limited and form part of the Tummel Valley hydro scheme, along with the aqueduct that links the two, and the smaller Glen Truim dam.

2.9 An SSE Aqueduct is crossed by the A9 near Dalwhinnie. SSE operates the Tummel Valley hydro scheme utilising waters abstracted and transferred from the Spey catchment to the Tay. Part of the hydro scheme includes the aqueduct which carries water from Loch Cuaich and the wider catchment of Allt Cuaich, located on the hillside east of the A9, to Loch Ericht, south-west of Dalwhinnie. The A9 runs parallel to the aqueduct in Project 8 for approximately 3.4km, crossing it at crossing ID88 (ch. 23,400).

2.10 The effects of any hydro abstraction within the Project 8 study area have not been accounted for in the Stage 3 modelling, to maintain a precautionary approach to the assessment.

Survey Information

2.11 In addition to 1:10k scale and 1:25k scale OS mapping used under licence, a number of ground surveys have been used to inform this assessment:

- High precision 1:500 topographic mapping of the carriageway envelope, based on Light Detection and Ranging (LiDAR) remote sensing and ground survey, produced by Blom for the project in 2014
- Photogrammetry and accompanying aerial photographs undertaken by Blom for the project in 2014

<u>River survey campaigns October 2015 and June 2016</u>

2.12 To support the DMRB Stage 3 H&HM study a topographical survey was specified to gather information on channel shapes along the River Spey, Truim and Allt Dubhaig/Garry. The survey was targeted at locations identified as important in terms of potential flood risk impact, on the basis of information from earlier stages of the DMRB process.

2.13 The river survey includes cross-sections of the river bed and includes details of potentially influential structures on watercourses (e.g. HML crossings). It was carried out in two stages due to access restrictions associated with the fish spawning season.

<u>Other survey and geographical information</u>

2.14 Other survey and geographical information includes:

- Peat survey (incl. probing, coring and other ground investigation) information predominantly gathered in 2016, but dating back to 2011 and currently ongoing
- As-built information for the A9 received from THC
- National Vegetation Classification (NVC) as a Geographic Information System (GIS) shapefile from SNH
- Walkover surveys conducted in 2016 to support the DMRB Stage 3 assessment, including information gathered to clarify crossing connectivity and size

SNH environmental information

2.15 Processed environmental survey information is publically available on the SNH website. A number of these GIS shapefiles were used to inform placement of mitigation areas as part of the ongoing design and wider environmental assessment. This information includes:

- Ancient Woodland Inventory
- Geological Conservation Review Sites
- Sites of Special Scientific Interest (SSSI)
- Special Areas of Conservation (SAC)
  - The River Spey SAC boundary itself has not been used, as a review of the design against Blom topographical survey and aerial photography revealed that the River Truim had migrated outside the defined SAC boundary, in cases closer to the existing A9, and SNH has confirmed that it is the watercourse, banks and supporting habitats that are protected, not a fixed area in a static shapefile. An appropriate offset has been taken from the river itself based on up-to-date survey information.
- Special Protection Areas (SPA)
- UNESCO World Heritage Sites [none within Project 8 extents]
- Wetlands of International Importance (Ramsar Convention) [none within Project 8 extents]

3 Flood Risk Information

SEPA Flood Maps

3.1 SEPA Flood Maps provide guidance on the possible extent, depth and velocity for different likelihoods (‘High, Medium and Low’) of three different sources of flooding (River, Coastal and Surface Water), alongside other associated information. Caveats to the mapping note that *“…they are indicative and of a strategic nature… It is inappropriate for these Flood Maps to be used to assess flood risk to an individual property”.*

3.2 The river flood map is based on a two dimensional flood modelling method applied across Scotland to all catchments greater than $3km^2$, and includes hydraulic structures ‘where appropriate information was available’; thus many of the tributaries are not considered and the mapping may be particularly unrepresentative of flood extents at watercourse crossings.

3.3 SEPA have advised that the SEPA Flood Maps are not suitable for DMRB [stage 2] assessment in their current form, noting that *“In a few areas, namely on main river channels where the floodplain is very wide and flat, and flood depths are expected to be relatively shallow, the flood extent appears to be sometimes under predicted”* (25th June 2015).

3.4 Whilst the SEPA Flood Maps can be a useful tool for initially considering whether a site may be at risk of flooding, more detailed analysis is required to assess flood risk around the A9 corridor.

A9 Strategic Flood Risk Assessment

3.5 The A9 Strategic Flood Risk Assessment (SFRA), published in 2013, takes into account the entire 177km of the A9 between Perth and Inverness and breaks the road into sections. It focusses on potential flooding from rivers and surface water.

3.6 The SFRA notes that through preliminary consultation with SEPA it was agreed that A9 dualling will be designed in consideration of the 1 in 200 year return period flood event. The SEPA indicative flood maps (superseded by the SEPA Flood Maps) are analysed for a 1 in 200 year fluvial event. The floodplain is noted as a possible constraint alongside Project 8.

3.7 Data was collated from THC’s biennial flood report, SEPA, THC, and TS Operating Company. Historic Scotland, Scottish Water and Cairngorms National Park Authority were also contacted, but had no additional information. Most occurred around residential properties away from A9 route corridor. There is no history of flooding recorded within Project 8.

3.8 Review of the incident reports provided by TS Operating Company indicated some flooding due to surface water runoff (36 incidents over 17 locations, where maintenance was required between 2009 and 2013). Three reports concern the A9 at the northern end of Project 8 (approximately ch. 30,000). It is noted that the area surrounding the A9 is largely rural and many historical flooding incidents may not have been reported.

3.9 Using available Digital Terrain Model (DTM) information, the locations where road flooding is frequently reported were noted to be along the stretches within cuts adjacent to steep hill sides. The descriptions within the TS Operating Company reports suggest a typical hillside runoff flood mechanism where flooding is caused by issues related to roadside drainage in collection and draining of the surface water runoff from the fields or hillside during heavy rain or snowmelt. Some of the surface water runoff was noted to carry sediment resulting in blockages of drainage.

3.10 There is a Potentially Vulnerable Area (PVA) within Project 8 at Dalwhinnie, with known sources of flooding split 57:43 between fluvial and surface water. SEPA have no flood events reported.

3.11 The SFRA recommends as a strategic principle that the route alignment avoids functional floodplain where possible, otherwise it remains operational and safe for users in times of flood, results in no loss of floodplain storage, does not impede water flows and does not increase flood risk elsewhere.

Findhorn, Nairn and Speyside Local Flood Risk Management Plan (2016)

3.12 The first Local Flood Risk Management Plan for Findhorn, Nairn and Speyside was published by Moray Council in June 2016 in agreement with THC, Scottish Water, SEPA, Forestry Commission Scotland and CNPA. It follows the Draft FRM Plan produced by SEPA in 2014.

3.13 Dalwhinnie, adjacent to Project 8, is identified within a Potentially Vulnerable Area (PVA) factsheet for an area of approximately 63km^2 including the town and surrounding rural area, large parts of which are within the CNP. The River Truim is the main river in this PVA and there are many small burns draining off the steep hillsides. There are approximately twenty residential and fewer than ten non-residential properties at risk of flooding. The Annual Average Damages are approximately £170,000, all caused by river flooding. Three lengths of the A9, 330m in total, are noted as being at risk from flooding.

Other Studies

3.14 A review of other studies in the area was carried out at an earlier stage of the road design. Envirocentre carried out an FRA for a site at Dalwhinnie in 2003. The site is remote from the Proposed Scheme and the study does not reflect current conditions. No studies relevant to Project 8 were identified.

Previous Stages of the Proposed Scheme Flood Risk Assessment

3.15 This Stage 3 Flood Risk Assessment follows on from the (2013) A9 Dualling Strategic Flood Risk Assessment (SFRA), prepared in support of the DMRB Stage 1 Strategic Environmental Assessment (SEA)) and Chapter 10 of the CFJV (2015) DMRB Stage 2 Environmental Assessment: Road Drainage and the Water Environment, which is a comparative assessment of the potential environmental impacts, including flood risk, of the proposed road alignment options. This report takes the SFRA into account; the Stage 3 work builds on and hence supersedes the Stage 2 flood risk findings, and follows the approach laid out in the DMRB Stage 3 Hydrology & Hydraulic Modelling Approach report (2016), reiterated in **Section 6**.

SEPA and THC Information

3.16 SEPA and THC have provided datasets indicating locations of previous flood events that occurred in the recent past. None are located within or adjacent to Project 8.

3.17 SEPA’s initial pre-planning response (27 March 2012) notes the potential need to consider the cumulative impact of multiple areas of flood risk along each ‘route’.

3.18 SEPA have provided information on their flow gauge at Invertruim and provided feedback on the hydrological and hydraulic modelling approach taken at previous stages of the Proposed Scheme. The latest SEPA advice note, based on the Stage 3 H&HM Approach report, advises that the hydrology approach (adoption of Stage 2 flows and the tributary approach) is suitable and reasonable, and welcomes the use of a full-length model to further investigate floodplain capacity. Gauge information is provided in **Annex A**. Hydrology is discussed in more detail in **Section 6**.

4 Proposed Scheme Design

4.1 The Proposed Mainline is to follow the same line as the Existing Road. The wider Proposed Scheme includes measures that change the way the road interacts with the water environment, such as widening the road surface for the dual carriageway itself; the provision of access roads, drainage and watercourse crossings and diversion channels that meet modern design standards; and the introduction of mitigation to alleviate adverse environmental impacts.

Design Freeze

4.2 Throughout the DMRB Stage 3 iterative design process, a number of environmentally-led workshops considered each aspect of the developing design and made recommendations for certain features to be included in the next design iteration.

4.3 The main body of this assessment, particularly the hydraulic modelling study, is based on proposals included in the '4th Iteration' Design Freeze, completed in autumn 2016. Several design iterations have been required to avoid and minimize potential clashes with environmental or physical constraints and further develop the preferred option to better meet stakeholder needs (e.g. refinement of track location to maintain access and avoid deep peat).

4.4 The findings of this assessment have been fed back to design teams and mitigation options have been developed where necessary as part of the evolving design. Changes to the design since the 4th Iteration are accounted for in **Section 9 –** flood risk mitigation is recommended as part of the Assessment Design (completed in October 2017) along with an assessment of residual risk.

Key Design Features

4.5 A number of features of the Proposed Scheme intrinsically affect flood risk to the Scheme itself, as well as the potential impacts of the Proposed Scheme on flood risk elsewhere, notably:

- Upsizing **watercourse crossings** to have capacity for the 200yr design event, with a climate change and freeboard allowance (culverts below 1200mm in height are to allow for 300mm freeboard between 200yr water level and soffit, those larger have a freeboard one quarter of their height, whilst all culverts are to allow for 600mm freeboard allowance between road level and 200yr+20% flow water level), and setting a minimum 900mm diameter crossing size (s*ee crossing design note at the end of this section for more details)*
- Raising **road levels** to accommodate for increased watercourse crossing heights, as well as a minimum of 2m above culvert crowns for road build up, drainage and services, and 600mm freeboard to the functional floodplain, with climate change allowance
- Providing **Sustainable Drainage Systems** (SuDS) to manage surface runoff and water quality
- Providing and upgrading **tracks** and other operational assets for local users or maintenance access, as, depending on end-user requirements and other planning constraints, on a case by case basis the defined standard for the Proposed Mainline may not apply and 200yr floodwaters may be affected
- Providing **compensatory storage** to mitigate for loss of floodplain volume

4.6 In order to maintain a precautionary approach to the assessment, and with the exception of **Section 9**, this FRA considers the Proposed Scheme without compensatory storage.

Other Pertinent Changes

4.7 The Proposed Scheme will inherently change the road infrastructure within Project 8 extents. Changes likely to impact on the water environment include:

- The **earthworks footprint** of the Proposed Mainline versus the Existing Road. Though it is to remain online, the dualling process will increase the road footprint, with potential implications on local watercourse floodplains, channels and drainage requiring consideration
- **Channel diversions**. The new road footprint and profile may necessitate the diversion of some watercourse channels, either to relocate outwith the footprint as noted above, or to upgrade channels to meet Proposed Scheme design standards. Diversion channels are sized to accommodate 200yr design flows
- Changes to **road drainage**. The Proposed Scheme will affect the characteristics of the road surface drainage. The Existing Road drainage will be replaced by a new drainage system and all areas catered for by Existing Road drainage will be catered for in the Proposed Scheme

4.8 The implications of these changes are assessed in **Section 7** and **Section 8**.

Context for Culvert Design Approach

4.9 Within the study area for this project the existing A9 mainline crosses more than 40 'minor' watercourses, ranging in size from small open channels, such as field drains, to much larger watercourses. To support the dualling of the A9, the Proposed Scheme will include the extension or replacement of the culverts which convey these flows.

4.10 The design process for the watercourse crossings takes account of a range of design criteria and constraints to develop the most appropriate crossing for each watercourse. The primary technical standards driving the design of culverts are DMRB HA107/04 Design of Outfall and Culvert Details (2004) and the CIRIA Culvert design and operation guide C689 (2010). In addition to these technical standards, other drivers that influence the culvert design include:

- Flood risk - in the event that a culvert is either extended (based on current geometry) or replaced, the impact on flood sensitive receptors may change by either retaining more water on the upstream side of the A9 or by passing more water through the culvert
- Maintenance requirements - maintenance of culverts to meet DMRB standards (as defined by HA107/04) requires consideration of a minimum culvert size - increasing the culvert size for maintenance access may have an impact on flood sensitive receptors downstream
- Ecological considerations - when designing new culverts, consideration is given to the provision of adequate integrated mammal passage, which if required will influence culvert size. In addition, consideration is given to maintaining a natural bed level within the culvert barrel by burying the culvert invert such that the culvert is sized to carry both flood flow and river bed sediment

- Geomorphological considerations - when increasing (or decreasing) the size of a culvert there is the potential to influence sediment transport (erosion or deposition) locally
- Road drainage design - the culvert design, in terms of both gradient and cross-section, needs to be considered to avoid conflicts with the proposed scheme i.e. the proposed road structure and drainage system

4.11 These factors have been considered on a case-by-case basis to develop the most appropriate culvert design for each crossing. This design process is iterative, such that the final design meets the fundamental design standard, which is that the Proposed Scheme remains free from flooding in the 0.5% AEP (200 year) design flood event plus an allowance for climate change (increase in flow of 20%), and freeboard (typically 600mm). In this context freeboard is defined as the difference between the proposed road level and the peak water level during the 0.5% AEP (200 year) plus climate change event.

4.12 The design approach for the watercourse crossings, which takes account of the culvert design guidance, allows for a degree of flexibility and engineering judgement to be applied to the culvert design, to account for the various influencing factors outlined above. Watercourse crossings are designed to comply with this guidance, with a focus on design considerations set out in CIRIA C689 and DMRB HA107/04.

5 Potential Sources of Flood Risk

5.1 The following have been identified as potential sources of flood risk over the length of Project 8:

- **Fluvial flows**: Extreme fluvial flood events have the potential to cause rapid inundation of land whilst posing a threat to the welfare of occupants and potentially preventing emergency access to properties and essential infrastructure. The site may be at risk of direct fluvial flooding from the River Truim and its tributaries. In addition, any change on the hydrological environment brought about by the Proposed Scheme may change the hydrological or hydraulic behaviour of local watercourses, potentially increasing flood risk to parts of the Proposed Scheme or elsewhere. The effect of the Proposed Scheme on flood risk at local and wider scales requires consideration.
- **Infrastructure failure**: Flooding due to the failure of man-made water infrastructure. The failure or blockage of conveyance infrastructure such as culverts or bridges could increase the risk of flooding at the site. Local drainage infrastructure is also a potential source of flood risk, including any locations where SuDS are to impound water. In addition, where there are bodies of water impounded in the wider Truim catchment, such as at Loch Cuaich, there may be a risk associated with the failure of these structures. An aqueduct carries water above the road in the Loch Cuaich catchment and the potential flood risk from this source also requires to be considered.
- **Overland flow**: Overland flow occurs when the infiltration capacity of the ground is exceeded in a storm event. This could result in water travelling as sheet flow overland or excess water being conveyed from one location to another by local road networks. Overland flow from the hillside to the east is a potential source of flood risk.
- **Groundwater**: Groundwater flooding could occur at low points on any given site, particularly if that site is next to a water feature or below local land features. Groundwater is likely to be a flooding mechanism that contributes to other flooding. It has the potential to extend the duration or extent of flooding in low-lying areas, and may be important to consider in flood mitigation strategies.
- **Sewer flooding**: If the capacity of surface, combined or foul sewers is exceeded in an extreme event, or a blockage occurs, surcharging of the network can result in surface flooding.

5.2 One other potential source has been discounted:

- **Coastal flooding**: the site is not at risk from tidal inundation or coastal waves due to its elevation – over 250m above sea level.

6 Hydraulic Modelling Study

Overview

6.1 It is recognised that the Proposed Scheme may impact on flood risk elsewhere, and that both the Existing Road and Proposed Mainline could be at risk of fluvial flooding. A Hydrological and Hydraulic Modelling (H&HM) study has been undertaken to aid the assessment of both aspects of fluvial flood risk.

6.2 The DMRB Stage 3 H&HM approach has been developed with the aid of SEPA consultations and feedback on previous iterations of the modelling study undertaken and consulted at earlier DMRB stages and early in the DMRB Stage 3 assessment itself. The hydrological analysis has been reviewed following consultation with SEPA and hydraulic models have been refined; in particular targeted ground survey data has been used to refine the model surface at key locations, and 2D models have been 'enhanced' with the addition of 1D elements where watercourses are crossed by smaller structures.

6.3 'Stage 3' models have been developed to consider both the existing situation and the proposed post-development situation along a reach of the River Truim extending from Drumochter Pass to Crubenmore Bridge. The design information from the autumn 2016 (4th Iteration) Design Freeze, including the Proposed Mainline, tracks, SuDS basins and watercourse diversions, has been used to create post-development versions of each model reach in order to analyse the effect of the Proposed Scheme. The findings have been fed back into the ongoing design process, as they were at earlier DMRB stages.

<u>Full-length Model</u>

6.4 As the River Truim model is split into several reaches (described in *Approach* below), a separate model of the River Truim has been constructed in addition to the main modelling study, to assess cumulative impact of the changes throughout Project 8 and thus inform the assessment of the potential impact of the Proposed Scheme on flood risk downstream. The 'full-length' model is reported separately at the end of this section.

<u>Further modelling – Assessment Design</u>

6.5 At three locations DMRB Stage 3 models have been locally amended or refined to investigate particular aspects of ongoing design: amendments to crossing ID76 (ch. 21,350) to assess impacts in the adjacent River Truim channel of an underpass introduced in the 5th Iteration Design ; the arrangement at ID81 (ch. 22,150) to inform the constriction of the crossing and sizing of compensatory storage; and at Cuaich to better understand the hydraulic regime, inform the design of the new underpass, and assess the effectiveness of further minimising encroachment and providing compensatory storage. In addition, a separate 1D model was created to inform the Dalwhinnie Junction crossing design and sensitivity test hydraulic model parameters.

Scope

6.6 The modelling output is intended to provide the assessor with information on predicted changes in flood level, depth and velocity, as well as define the functional floodplain of key watercourses. These outputs allow for the potential impact of the Proposed Scheme to be assessed at receptors, and are supplied to other disciplines for input to the wider EIA (e.g. hydromorphology assessment).

6.7 The H&HM study considers design proposals as they were in the autumn 2016 4th Iteration Design Freeze. Given the complexity involved and uncertainty with representing compensatory storage using hydraulic models, compensatory storage areas (CSAs) are not included in the scope of the H&HM study, in order to maintain a precautionary approach to the assessment.

6.8 Changes made since autumn 2016 are considered in **Section 9**, where measures to alleviate flood risk are recommended. Where these measures include compensatory storage, storage areas have been sized following SEPA's preferred method of like-for-like replacement.

Approach

6.9 Due to the length and complexity of the River Truim catchment, the river and its floodplain has been considered as seven separate reaches alongside Project 8 for the Stage 3 modelling study (numbered 'M07' to 'M15' within the model files). Similarly, the length of the River Truim upstream has been split into six further reaches as part of the EIA work undertaken for Project 7, and the tie-in to the River Spey adjacent to Project 9 is covered by a further reach. The seven Project 8 reaches generally extend from the confluence of one significant tributary to immediately upstream of the confluence with the next significant tributary. This has the benefit of allowing the critical duration event to be assessed for each modelled reach, providing a worst-case 200 year return period flood extent for each, as opposed to the whole extent only. Each model overlaps with its neighbours, sharing water level to provide a smooth transition from one modelled reach to the next (initial conditions for each are provided by the water level predicted for the neighbouring model downstream). The split-reach approach also eases the computational demands and allows simulations for each reach to be run in parallel, significantly reducing overall model run times. **Figure 1** to **Figure 3** below show the location of Stage 3 model reaches.

6.10 A variety of standard techniques have been used to represent channel bridging structures in the models, including applying head loss and creating cuts in the Digital Terrain Model (DTM). These representations have been tested and a precautionary approach applied. Compared with blockage and other factors considered in the sensitivity analysis, model results are relatively insensitive to variation in bridge details.

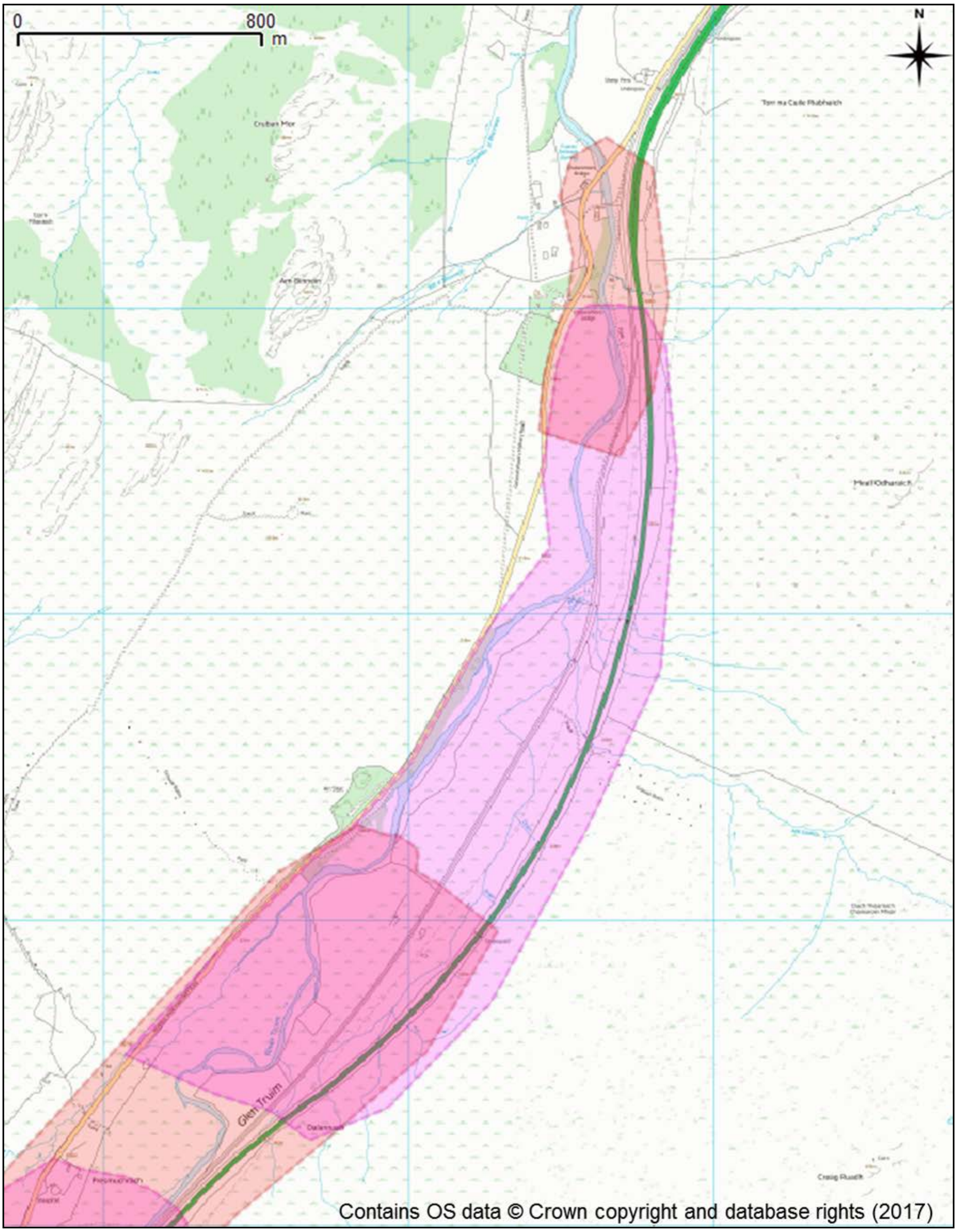


Figure 1: Project 8 Stage 3 model reaches (1)

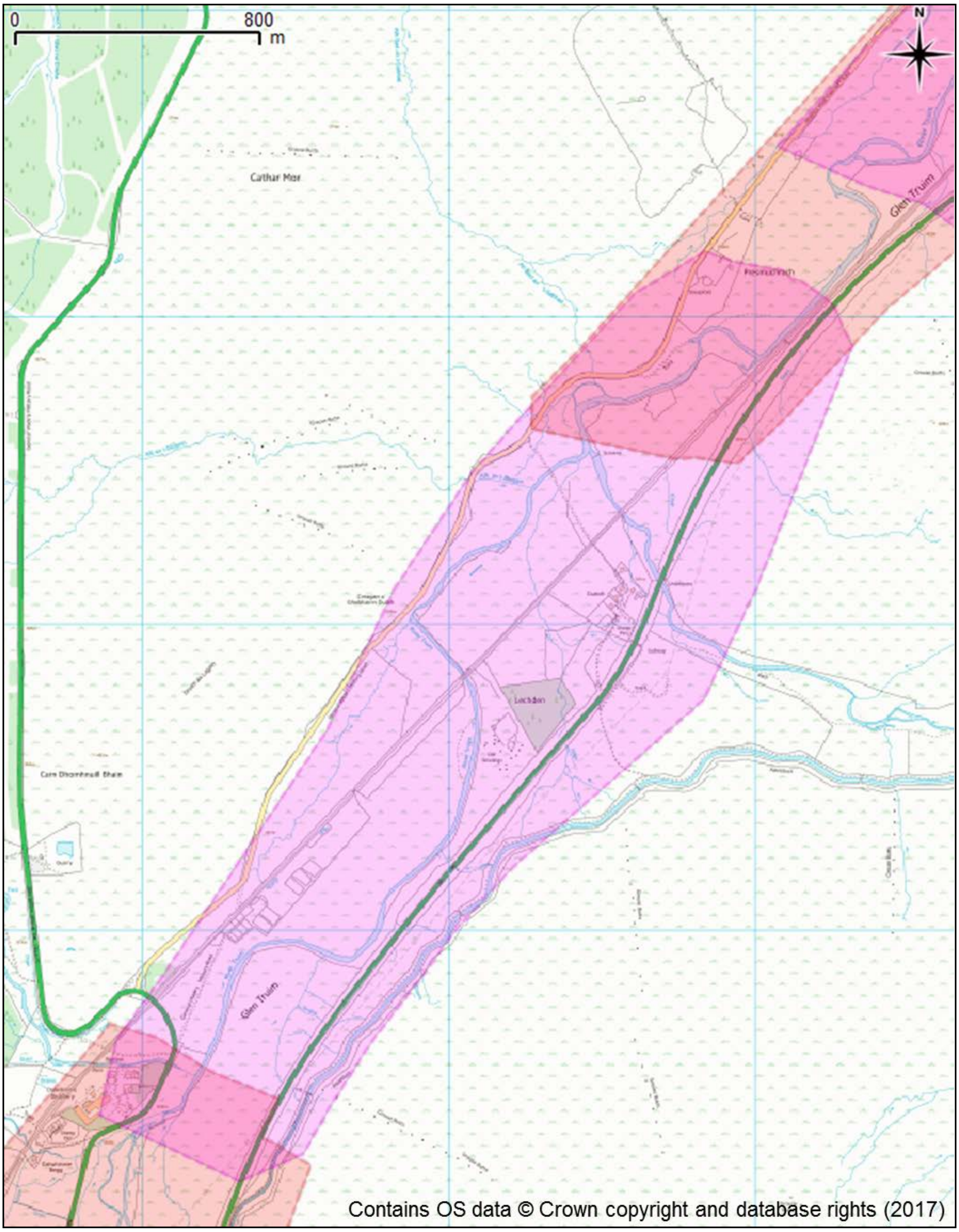


Figure 2: Project 8 Stage 3 model reaches (2)

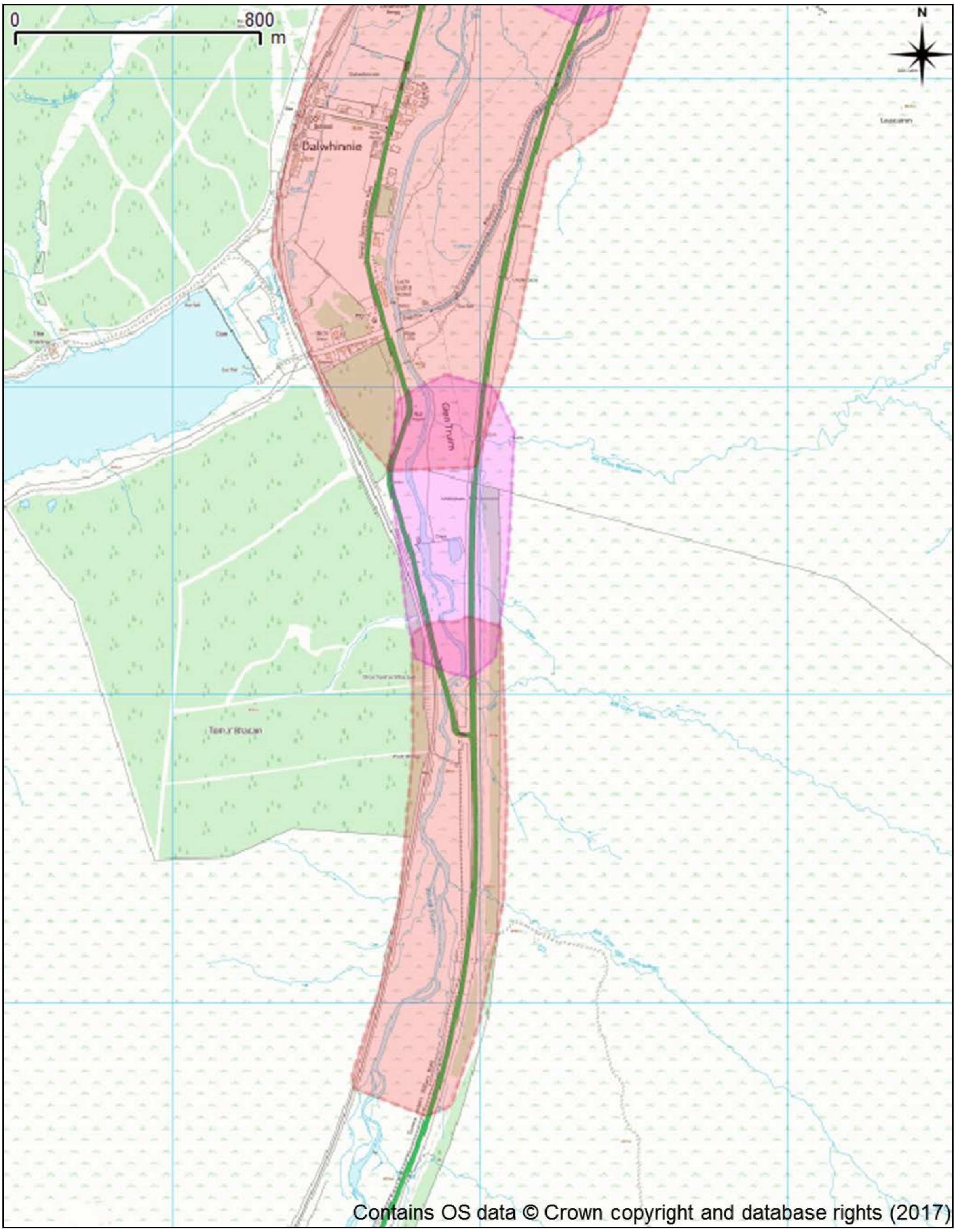


Figure 3: Project 8 Stage 3 model reaches (3)

Hydrological Assessment

River Truim

6.11 Design flows are required for all the watercourses modelled. Precautionary design flows adopted for the H&HM work undertaken at DMRB Stage 2 have been checked against those derived from an updated hydrological assessment of the catchment, considering the revised Annual Maximum (AMAX) record, which accounts for the updated rating at Invertruim. Gauge information received from SEPA, including the AMAX calculated using this revised rating, is included in the appendices of this report.

6.12 Flows for 16 nested sub-catchments of the River Truim catchment have been derived using a series of hydrological techniques. These include Flood Estimation Handbook (FEH, 1999) methods (single site and enhanced single site at Gauge 8007, pooling group for the River Truim), applying growth curves to index-flood (QMED) transferred from the gauge record at Invertruim. Flows for these sub-catchments have also been calculated using the FEH rainfall-runoff method (FEH RR) and revitalised rainfall-runoff model version 2.2 (ReFH2) methods.

6.13 200yr flows produced by the FEH statistical methods are between 43% and 66% of those produced using FEH RR with Standard Percentage Runoff (SPR) adjusted. ReFH2 produces 200yr estimates between 55% and 79% of the FEH RR values (this range is 61% to 91% if considering a summer storm profile). Catchment descriptors and other details of the hydrological data and methods used for the DMRB Stage 3 analysis are provided in **Annex A**.

6.14 There is uncertainty over how representative flows recorded at the Invertruim gauge are of the mechanisms in the Truim catchment. The gauge is located on the Spey just downstream of the confluence with the Truim. The Truim catchment makes up approximately a third of the area draining to the gauge. Although the descriptors for these two major catchments just upstream of the gauge are similar in terms of values typically checked for the suitability of QMED donation, such as FARL (0.974 & 0.932), FPEXT (0.046 & 0.058) and URBEXT (0 & 0.0001), there is no data available on the River Truim itself to verify the approach.

6.15 During DMRB Stage 2 a ratio between 200yr flow estimates at the Invertruim gauge on the Spey (just downstream of the confluence with the Truim) produced by single site analysis and the FEH RR model was established and accordingly a factor of 0.86 was used to scale the FEH RR hydrographs used to define design flow in the Truim. Storm durations for each nested sub-catchment have been selected to provide the critical duration as defined in the FEH units, as earlier model runs show that these (peak flow) hydrographs produce the highest flood level predictions in this reach of the Truim.

6.16 Given the inherent uncertainty in hydrological methods for estimation of design flood flows on ungauged catchments, the flows derived at DMRB Stage 2 have been adopted as a precautionary approach for the Stage 3 Assessment. As part of this precautionary approach, the SPR used in the FEH RR calculation has been adjusted to 57.37 where it would otherwise be lower, based on the low range marked for the Truim on the Base Flow Index (BFI) map of Scotland (Gustard et al, 1986).

Catchments at tributary crossings

6.17 A review of the hydrological assessment carried out at DMRB Stage 2 for the tributaries crossed by the A9 considered has been undertaken. ‘Other’ watercourses (i.e. not shown on OS 1:50,000 or OS 1:10,000 scale mapping) were scoped out of the DMRB Stage 2 assessment and a simplified equal distribution of flows had been applied to groups of ‘Other’ crossings. In contrast, all watercourses crossed by the A9 were initially considered at DMRB Stage 3.

6.18 Design flows for tributaries with catchments greater than $0.5km^2$ have been derived using the FEH RR method, with SPR raised to match the SPR applied to the River Truim catchments, where necessary. Institute of Hydrology (IH) Report No.124 (IH124, 1994) methodology has been adopted for catchments below $0.5km^2$. Flows have been derived using the ReFH2 method for comparison purposes alongside flows derived using variations of the adopted methods. The sensitivity of flow estimates to these changes was found to be within the bounds of the sensitivity tests applied to the hydraulic model results (+/-20%).

6.19 Catchment areas draining to these watercourses at the point they are crossed by the A9 were estimated using 1:25,000 scale OS mapping, survey information on the watercourse channel adjacent to the road and, where catchment boundaries are unclear from OS contour lines, aerial photography and site observations. A figure showing the catchments adopted for the study is provided in **Annex C**.

6.20 For the proposed modelling, catchment areas were determined in cognisance of the 4th Iteration Design Freeze diversions and crossings, with capacity assumptions as noted in **Section 4**. Post-development, design flows are predicted to be larger at three crossings (ID 3, ID21 and ID64) where the sizes of the catchments draining to these crossings are judged to be materially increased by the Proposed Scheme due to watercourse diversions.

6.21 FEH CD-ROMv3 catchment descriptors have been used to inform the parameters within the hydrological methods. Values are donated from the nearest appropriate FEH catchment. A new online tool for catchment descriptors (FEH Web Service) became available during the study and, as for other variations in estimation techniques noted above, the sensitivity of flow estimates to the newer descriptors and (FEH13 depth duration frequency rainfall model) rainfall profiles was found to be within the bounds of typical sensitivity tests.

6.22 As many of the smaller catchments are located lower on the hillside than the centroids of the FEH catchments, the donated 1961-90 standard-period average annual rainfall (SAAR) value is likely to be precautionary. Where a flow is estimated using the FEH RR method and the difference between estimated area and catchment descriptor area is significant, other key descriptors such as Drainage Path Length (DPL) have been checked against the estimated area (in the case of DPL, using the alternative FEH calculation) and adjusted to be precautionary.

Model Surface

6.23 Ground levels in the computational grid are informed by ground models consisting of the:

- DTM generated using the combined LiDAR and ground survey dataset within the 200m corridor of the A9
- DTM generated from photogrammetry based on 10cm ortho-photographs within the 1km corridor of the road
- additional survey information collected along the River Truim in June 2016

6.24 The addition of the targeted (June 2016) survey information at DMRB Stage 3 improves the channel definition where greater resolution is beneficial (i.e. in the vicinity of receptors, including the road). Improved representation is also possible for remote structures and at the location of the proposed link road from Dalwhinnie junction to the A889, which crosses the River Truim.

6.25 A 2m computational grid has been adopted for the assessment. This grid size provides a reasonable representation of the Truim channel within the 200m road corridor, where findings are most relevant (the accuracy of the model output is limited by the DTM resolution available beyond the 200m corridor) whilst allowing for reasonable computational run time.

6.26 The 4th Iteration Design Freeze is represented in the proposed models by amending the DTM used by the existing models with the proposed earthworks footprint. Access road levels and watercourse diversion channels have also been imposed on the DTM for the proposed runs.

Tributary crossings

6.27 A screening exercise was undertaken on the tributary crossings to consider whether they have the potential to impact on flood risk. All crossings with 200yr flow greater than 1.1m3/s have been implemented in the Stage 3 models. 1.1m3/s represents the full bore capacity of a 900mm diameter circular culvert, the minimum culvert size in the proposed conditions. Where the 200yr flows are less than 1.1m3/s, the capacity of the existing crossing is compared to the proposed to establish if the 900mm diameter culverts of the Proposed Scheme will remove an existing flow constraint. If so, the crossing has been implemented in the existing and proposed models to assess the impact of its removal. Remaining crossings are screened out of the H&HM study.

6.28 Crossing geometry has been updated to reflect the findings of the detailed surveys. Crossings themselves are represented as nested 1D elements in the Stage 3 model. A list of the crossings included in the H&HM study is included with dimensions and assumptions in **Annex B**.

Model Boundaries

6.29 Modelled reaches are run in sequence from downstream to upstream. The downstream boundary of each reach is informed by the flood levels predicted within the reach further downstream. The downstream boundary of the lowest reach is informed by the flood level predicted at Invertruim by the Spey model developed as part of the Project 9 (Crubenmore to Kincraig) H&HM exercise.

6.30 The main channel inflows for each River Truim model reach are obtained by applying the scaled FEH RR approach (described above) to the corresponding contributing catchment for each reach. The inflows are ramped up to the peak value and remain constant – giving steady-state-type conditions within the modelled reach, before the addition of tributary inflows.

6.31 Tributaries inflows are represented using simplified hydrographs and input to the model upstream of each crossing. Localised patches of high Manning's roughness have been used to stabilise model boundaries where necessary (typically on steep channels).

Limitations

6.32 Models have been developed to assess existing flood risk within a realistic timeframe, budget and with an eye to the limits of the topographic information, hydrological information, hydraulic modelling methods and computational power available, as appropriate and suitable for a DMRB Stage 3 assessment of flood risk.

6.33 It is important to understand the limitations of any modelling study before interpreting the results of simulations, whether they are presented graphically or otherwise. Where a modelling assumption has a clear bearing on assessment of flood risk it is highlighted in the relevant section of this FRA.

6.34 The model grid resolution does not allow for small channels to be represented within the model. The DTM has been checked for potential issues with grid sampling (e.g. false blockages) and is considered to represent the wider River Truim floodplain and potential overland flood routes suitably for the relatively large 200yr return period flows being considered. Where channels have been enforced on the DTM, because they are deemed large enough to carry 200yr flow, the model potentially overestimates channel capacity. This is necessary to maintain a precautionary approach to assessment of potential impacts downstream, but limits the accuracy with which the model can predict the capacity of the proposed diversion channels. Where this may impact on the assessment findings it is noted in the relevant section.

6.35 There are uncertainties in relation to the design flow. The return period approach represents the industry standard approach for planning and design; however, the hydrology of a catchment the size of the Truim, with its many sub-catchments, is complex. In the absence of local gauging and fully representative rainfall records a conservative approach has been adopted for the peak flow estimation. An idealised triangular hydrograph shape has been adopted for the tributary crossings. This may not provide 'worst case' results where flows are predicted to back up from crossings; however, this potential difference is allowed for in the freeboard. River Truim flows are run at a steady maximum flow as part of the precautionary approach to flood risk analysis.

6.36 With the exception of the Truim, each watercourse has been modelled within the road corridor only. There is a risk that flood waters in catchments upstream may approach the road in an unpredicted manner. Similarly, the characteristics of watercourse channels upstream of the road may change over time. Where desk study review within the corridor suggests that out of bank upstream may occur this has been modelled. This risk is considered appropriate for the assessment and, as with other modelling assumptions, is highlighted where it may be of particular note.

Model Results

6.37 2D results (depth varying output) have been produced and interrogated to inform the FRA. This interrogation of results is recorded in the tables provided in **Annex B2**, particularly Table 8 (describing the sifting exercise used to interpret clashes with the floodplain extent) and **Annex B3** (recording the impacts predicted by the Stage 3 models). Flood extent figures showing 200yr flood depths predicted for both the pre- and post-development case are included in **Annex C**. Predicted flood depth, level, velocity, stream power and bed shear stress have been exported as TIF files and fed to other disciplines as part of the wider EIA process at DMRB Stage 3.

6.38 The flood extents identified during DMRB Stage 2 have been are superseded by those of this DMRB Stage 3 Assessment. Of particular note are the A889 crossing and Crubenmore Bridge areas, where refinements to the DTMs and inclusion of surveyed bridge information result in predicted flood extents overtopping the local roads, and at Dalwhinnie where changes to flood extents reflect revised DTM information. Model results are discussed in **Section 7** and **Section 8**.

Sensitivity Analysis

6.39 In the absence of local gauged flow records to calibrate the models, proving techniques have been adopted to assess the influence of three key model parameters – Manning's 'n' roughness coefficient (+20%), design flow (+20%) and bridge coefficients.

6.40 The results of the flow test give flood levels approximately 200mm higher than the base case at most locations in the main floodplain; flood levels at the key crossings under the A9 are predicted to increase by approximately 300mm in this scenario. The largest differences in level are at the crossings of the River Truim that are predicted to constrict the capacity of the floodplain. Where flood waters are predicted to back up from structures in the base case, predicted flood levels vary by as much as one metre from the base case results. Several of the tributaries spill over the A9 as a result of undersized crossings. At these locations it is noted that in the increased flow scenario the maximum depths on the road increase by around 50mm. The results of the roughness parameter test are similar to those of the flow test, but less pronounced.

6.41 Overall the model behaves as expected to changes in key parameters.

6.42 Flood levels where flood waters are predicted to pond at the end of the overland flood route through Dalwhinnie are more sensitive to changes in flow and roughness than might otherwise be expected, as the drain crossing next to the school is not represented in the Stage 3 model (it is not required in the base case model) and flood waters back up locally. Flood waters at this location are not predicted to reach nearby receptors for either sensitivity scenario (though a residential development immediately downstream, outwith 200yr flood extent, is predicted to be within the 200+climate change flood extent).

Dalwhinnie junction crossing

6.43 An independent 1D model of the pipe bridge crossing the River Truim upstream of Loch Ericht Hotel, undertaken to inform design water level for the Dalwhinnie junction design, found predictions of peak flood level may fluctuate by approximately 50mm depending on the representation of structures in the Truim.

Blockage

6.44 The sensitivity of 200yr water levels upstream of the A9 to a 50% blockage of the tributary crossing structures was checked at locations where floodwaters would find relief across the A9 if water were to back up behind the road. In each location the road level is over 600mm above 200yr water level with 50% tributary crossing blockage and +20% flow climate change allowance.

Full-length Model

6.45 A new TUFLOW 2D model has been built of the full length of the River Truim as it passes Project 8, to support the assessment of the cumulative impact of the Proposed Scheme on flood risk downstream. The model takes its information from each reach of the Stage 3 model (DTM, Domain, 1D elements etc.).

6.46 The hydrological assessment is expanded to include discrete inflows for the contributing catchments from the west of the Truim valley. All inflows to the full-length model are derived using the FEH RR method, with otherwise the same parameters and scaling adopted for the main study. Breaking the nested sub-catchments on the River Truim into their constituent sub-catchments generally results in higher peak flows than those used for the Stage 3 reach models, resulting in an approximately 20% higher peak flow estimate at the downstream reach of Project 8.

6.47 The full-length model has been run for 5hr, 10hr and 15hr duration events. Existing and proposed conditions (4th Iteration Design Freeze, without mitigation) have been compared for each run and a predicted change of less than +3mm is noted at the downstream end of the model.

7 Flood Risk to Existing Road and Proposed Scheme

7.1 Sources of flood risk identified in **Section 5** (Fluvial, Infrastructure Failure, Overland Flow, Groundwater and Sewer/Drainage Network) are assessed in this section, considering the Existing A9 Trunk Road and the Proposed Scheme (4th Iteration Design Freeze) without specific flood risk mitigation measures such as compensatory storage.

7.2 Potential impacts on flood risk receptors other than the Proposed Scheme are assessed in **Section 8**.

7.3 **Section 9** considers revisions made to the Proposed Scheme between autumn 2016 and October 2017 and describes the mitigation options included (embedded) in the Assessment Design.

Fluvial

<u>River Truim</u>

7.4 Fluvial flood risk from the River Truim and its larger tributaries has been assessed with the aid of the H&HM study. Figures showing the outline of the Proposed Scheme (4th Iteration) versus predicted extents and depths of the 200yr return period flood, both pre- and post-development, are provided in **Annex C**.

7.5 The 200yr floodplain of the River Truim is predicted to reach the foot of the Existing Road and Proposed Scheme Mainline embankment (Proposed Mainline) at three locations within Project 8: ch. 20,300–20,550, ch. 21,450–21,850, ch. 24,400–24,850. At these locations both the Existing Road and the Proposed Mainline are over 4m above the 200yr flood levels estimated in the adjacent River Truim channel. The closest relative levels throughout Project 8 are at ch. 27,300, where the Existing Road is separated by 2m of elevation and the HML railway from the adjacent River Truim floodplain. These differences in elevation allow for uncertainties in the hydraulic modelling process, as well as predicted sensitivity of flood levels to future climate change.

7.6 Though the A889 is predicted to be overtopped by floodwaters in the River Truim in a 200yr event, there is dry access to Project 8 to the north and south at the tie-ins with adjacent A9 Dualling Programme Projects. Both the Existing Road and the Proposed Mainline have a low risk of flooding from the River Truim.

7.7 Other aspects of the Proposed Scheme – SuDS/ landowner access tracks in three locations (ch. 22,550, ch. 27,650, and ch. 30,700-950) – are at risk of flooding from the River Truim in a 200yr event.

<u>Dalwhinnie Junction crossing</u>

7.8 The proposed crossing over the River Truim, part of the proposed junction to the south of Dalwhinnie, is to be set above design 200yr water level, with climate change allowance, allowing for a freeboard to accommodate for uncertainties in the modelling process.

7.9 An independent 1D model of the pipe bridge crossing the River Truim upstream of Loch Ericht Hotel, undertaken to inform design water level for Dalwhinnie junction design, found predictions of peak flood level may fluctuate by approximately 50mm depending on the representation of structures in the Truim.

7.10 The Proposed Scheme is at low risk of flooding from the River Truim at Dalwhinnie junction.

Modelled Tributaries

7.11 The underpass above Cuaich (ch. 25,850) is to be realigned as part of the Proposed Scheme. The 4th Iteration Design Freeze underpass is predicted to be at risk of flooding in a 200yr event from floodwaters of the Allt Cuaich upstream of the road, raised locally by the Proposed Mainline footprint. This flood risk is discussed within **Section 8**.

7.12 200yr flood waters in watercourse W8.38 are predicted to back up from crossing ID67 to overtop the Existing Road at ch. 20,350, to spill across the road surface at depths of up to 100mm. The model predicts floodwater would flow north inside the western kerb, escaping into other watercourse crossings up to the Allt Coire nan Cisteachan (MW8.5, crossing ID72) 400m to the north of the original overtopping.

7.13 200yr flood waters in many of the other modelled tributaries of the River Truim are predicted to back up from existing crossings, with little difference between predicted 200yr flood level and road level. The Existing Road is at risk of flooding from these watercourses in a 200yr event.

7.14 As part of the Proposed Scheme watercourse crossings are to be sized to allow for a 300mm freeboard from culvert soffit to 200yr water level. The Proposed Mainline is set still further above this. The Proposed Mainline is at low risk of flooding from modelled watercourses.

7.15 Other aspects of the 4th Iteration Design Freeze Proposed Scheme – SuDS at Cuaich and SuDS/landowner access tracks in two locations (ch. 25,850 and ch. 27,250-600) – are at risk of flooding from modelled tributaries in a 200yr event.

Hydromorphology – lateral migration

7.16 There is a risk that the relatively large channels of the River Truim and the Allt Cuaich may change position to increase flood risk to the A9 in the future. As noted above, the 200yr floodplain of the River Truim is predicted to reach the foot of the Proposed Mainline embankment at three locations within Project 8. The Allt Cuaich meanders on a steep local floodplain, crossed by the A9 on an embankment between ch. 25,750 and ch. 26,050. Peak flows in the Allt Cuaich are likely to be attenuated by the artificial storage upstream at Loch Cuaich (discounted in the H&HM study in order to maintain a precautionary approach for design flood extents).

7.17 It is assumed that any gradual impingement on the road embankments by these watercourses will be picked up by monitoring and can be mitigated as necessary by bank reinforcement or other suitable targeted mitigation as and when required. Flood risk to the Existing Road and Proposed Scheme is therefore not likely to be exacerbated by channel migration.

Minor watercourses (not modelled)

7.18 In the south of Project 8 a number of smaller watercourses are located on the hillside above the A9 where the Proposed Mainline is to be in cut. The cut slope is vulnerable to out-of-bank flow from upslope watercourses. In addition, where the road is in cut, there is little or no attenuation volume upstream and the road is the next viable flood relief route. Flood risk from natural catchment runoff is considered within *Overland Flow* below. The Existing Road is at risk of flooding should flows exceed the capacity of minor watercourse channels upslope of the A9, or the culverts carrying these watercourses underneath the A9.

7.19 Extreme flow predictions for small steep catchments carry more uncertainty than those for larger watercourses, though the ceiling for extreme flows is also limited by their small catchment area. Proposed earthworks drainage has been designed to have capacity for 75yr events (plus climate change allowance). Proposed Watercourse Diversion channels are sized for 200yr design flows. The Proposed Scheme may be at low risk of flooding from the minor watercourses sifted from the modelling study in extreme flood events, with much of the residual risk in a 200yr event alleviated by responsible drainage design.

7.20 The BDL is located on the hillside above the A9. Initial assessment indicates that watercourse crossings under the BDL access track will not convey 200yr flows without overtopping, potentially causing floodwaters to flow overland towards the A9. It is recommended that BDL track crossings are upgraded to convey 200yr flows or other suitable mitigation provided, where required, to protect the A9 mainline.

Climate change

7.21 Prediction of the possible impact of climate change on extreme weather events is problematic, in part because the processes causing extremes (such as floods and droughts) are complex and their representation is at the limit of the current capability of climate models. SEPA generally recommend a climate change allowance of +20% be applied to the 200yr design flow (SEPA 2015) in order to assess the impact of climate change on fluvial flood risk. This value was confirmed during Design Guide consultation with SEPA hydrologists (A9 Dualling Programme Environmental Design Guide CH2M, 2015). The potential impacts of climate change on fluvial flood risk to the Proposed Scheme are assessed in this report using the results of the +20% flow model run undertaken as part of the hydraulic modelling study sensitivity analysis.

7.22 The results given by the +20% flow model suggest that a 20% increase in design flow in the River Truim and its modelled tributaries would increase 200yr flood levels in the River Truim channel by approximately 200mm at most locations. The largest differences in level are where flood waters are predicted to back up from structures crossing the River Truim; flood levels at these crossings vary by as much as one metre. The Existing Road is raised 2m or higher above adjacent structures crossing the River Truim.

7.23 200yr + CC flood levels at modelled watercourse crossings are predicted to be approximately 300mm higher on the upstream side of the road than those predicted for the 200yr event. All proposed watercourse crossings have been checked for free discharge against respective 200yr +20% flows. This allows for over 600mm freeboard to the Proposed Mainline road surface. Proposed watercourse diversions have a designed 200yr capacity, estimated using the precautionary hydrology noted in **Section 6**.

7.24 Flooding at minor watercourses not included in the modelling study is also likely to be exacerbated by climate change. Calculations using Haested Methods CulvertMaster software indicate that the flood level for a 900mm diameter crossing (the smallest diameter crossing proposed) could increase by 0.06m with +20% change in the largest design flow for which this size of crossing is proposed. A minimum 0.3m freeboard between soffit level and 200yr flood level is allowed for in the sizing of proposed crossings.

7.25 The Proposed Mainline is at low risk of fluvial flooding when considering future climate change. Where other aspects of the Proposed Scheme are at risk of fluvial flooding they are at increased risk when considering climate change. Other aspects of the Proposed Scheme – SuDS/landowner access tracks in three locations (ch. 22,550, ch. 27,650, and ch. 30,700-950) – are at risk of flooding from the River Truim in a 200yr event.

Summary of fluvial flood risk to the Existing Road and Proposed Scheme

7.26 At a number of discrete locations, the Proposed Scheme access roads and SuDS are at risk of flooding in a 200yr event. As noted in **Section 4**, the design standards applicable to these features may differ from those applied to the A9 Mainline.

7.27 The underpass at Cuaich, realigned as part of the Proposed Scheme, is at risk of flooding post-development.

7.28 BDL track crossings should be upgraded or other suitable mitigation provided to protect the A9 Mainline downstream.

Infrastructure Failure

7.29 The Existing Road is at risk of flooding from infrastructure failure as existing fluvial flood risk will be exacerbated by any blockage or otherwise failure of conveyance infrastructure on the River Truim or its tributaries.

Conveyance Infrastructure in the adjacent River Truim floodplain

7.30 The Proposed Mainline is over 2m higher than the levels at which flood waters may find relief spilling across adjacent structures. If the two structures closest to road level were to block – the A889 bridge (ch. 21,350) and the new road crossing watercourse MW8.5 (crossing ID73, ch. 20,760) – there are alternative, preferable flow routes available: at the A889 crossing floodwaters can spread out over a 100m width of the A889 below the adjacent Proposed Mainline, and floodwaters backing up behind crossing ID73 would find relief to the north before reaching the level of the Proposed Mainline.

Crossings under the Proposed Mainline

7.31 Proposed Scheme watercourse crossings are typically designed to convey the 200yr flow with a 300mm freeboard to structure/culvert soffit, and the 200yr +20% flow (climate change) with a freeboard of more 600mm to the proposed road surface. Minimum culvert barrel size is 900mm diameter and crossings are expected to be regularly checked and responsibly cleared of debris as part of future maintenance activities. The risk of a full blockage of any of the crossings is low. Any departures from this proposed culvert capacity, such as a designed restriction of capacity as part of mitigation measures (**Section 9**) will maintain the 900mm minimum culvert size requirement, allow for 600mm freeboard to the road surface and be checked for flood risk in case of partial blockage.

7.32 There are 33 locations where floodwaters would find relief across the Proposed Mainline, if water were to back up from tributary crossings to a high enough level upstream of the road. The sensitivity of 200yr water levels upstream of the A9 to a 50% blockage of the Proposed Scheme tributary crossing structures has been checked using Haestad Methods' Culvertmaster and Flowmaster software. At each location the proposed road level is found to be over 600mm above 200yr water level when considering 50% blockage and (+20%) climate change allowance.

7.33 Significant blockage is generally considered unlikely, with appropriate maintenance, due to the size of the crossings relative to catchment size and the lack of vegetation or other source of debris upstream. The Proposed Scheme earthworks drainage and road drainage would help to mitigate flooding and disperse floodwaters should floodwaters back up from a blockage to overtop onto the road surface.

Local Drainage Infrastructure

7.34 The BDL is located on the otherwise undeveloped hillside above the Proposed Scheme. Flood waters arising from a blockage of field drains will be limited and likely to be caught by earthworks drainage and diversions put in place to alleviate flooding from the hillside above the Proposed Scheme; however, any blockage of watercourse crossings under the BDL track could potentially divert floodwaters overland towards the A9.

7.35 It is recommended that upgraded BDL track crossings are maintained with a view to minimising the residual risk from these structures. Where the BDL track above the A9 is not part of the Proposed Scheme, this risk should be mitigated by other suitable targeted mitigation where required – this flood risk should be considered further at the detailed design stage.

7.36 A data request has been made to BEAR Scotland regarding records of 'special inspections'. These records are compiled in order to inform whether to implement some form of remedial work at crossing structures, (removal of debris, replacement of scour protection or repair of structural damage etc.) and would highlight those structures at risk, or previously impacted by, flood events.

Impoundments

7.37 There are a number of bodies of impounded water within the Truim catchment: Loch Cuaich, Loch Ericht and a dam at ch. 21,900, south of Dalwhinnie and approximately 400m downstream of the A889 crossing. The first two are large enough to be registered as controlled reservoirs under the Reservoirs (Scotland) Act 2011. Both are managed by SSE Generation Limited and form part of the Tummel Valley hydro scheme, along with the dam and the aqueduct that links the two (crossed by the A9 near Dalwhinnie at crossing ID88). The dam at Dalwhinnie poses little risk to the Existing Road or Proposed Mainline due to its location in the base of the valley below the Existing Road and its small size.

7.38 As they are all parts of the arrangement feeding Loch Ericht, these features are maintained by SSE and have a very low probability of failure.

Summary of risk from Infrastructure Failure

7.39 There is a low risk of flooding to the Proposed Mainline from infrastructure failure.

Overland Flow

Direct rainfall - road surface drainage

7.40 SEPA flood maps identify pluvial flooding within Project 8. Discrete areas of the existing A9 are marked as potentially at risk in a 200yr event. These are low points in the road surface where water will gather during intense rainfall events. Areas within Project 8 marked with a likelihood of pluvial flooding on SEPA Flood Maps are noted in **Annex B4**. The SFRA notes three incident reports provided by TS Operating Company at the northern end of Project 8 (approximately ch. 30,000) indicating some flooding due to surface water runoff.

7.41 The drainage design for the Proposed Scheme will comprise a number of new and independent gravity drainage networks designed to collect and convey surface water runoff from impermeable surfaces, in accordance with DMRB standards. The system is designed to shed any excess floodwater safely from the road surface. Performance in exceedance events should be considered at the detailed design stage to confirm that flood risk is not increased elsewhere.

Natural Catchment Runoff

7.42 In the event that rainfall exceeds the infiltration capacity of the natural ground, excess water will flow overland. This may present a flood risk to the Existing Road where ground levels fall towards the road. The SFRA found "*Using available Digital Terrain Model information, the locations where road flooding is frequently reported were noted to be along the stretches within cuts adjacent to steep hill sides*".

7.43 The majority of the land to the east of Project 8 is steep mountainous topography with numerous 'flashy' watercourses flowing off the hillside. Much of any overland flow in these areas will be collected by local watercourses before reaching the A9; however, the Existing Road may be at risk of flooding from natural catchment runoff approaching the road overland, particularly where the road is in cut.

7.44 The Proposed Scheme will be afforded some protection from new earthworks drainage (designed to 75yr standard plus climate change allowance and freeboard) intercepting overland flow and diverting it safely to the nearest watercourse. The storm events critical for the road drainage network will be shorter and more intense than those producing the peak flows in the natural catchments. If any flow were to overtop onto the Proposed Mainline the severity of surface flooding will be eased by the proposed drainage network.

Summary of flood risk from overland flow

7.45 The Proposed Scheme will be designed to DMRB standards catering for surface water runoff (natural catchment flows) from higher ground.

Groundwater

7.46 SEPA flood maps provide a guide to where groundwater could influence the duration and extent of flooding from other sources (as distinct to where groundwater alone could cause flooding). There are no such areas identified within the Project 8 corridor. **Chapter 10** of the EIA 'Geology, Soils and Groundwater' provides a detailed review and assessment of the existing geology and hydrogeology of the area.

Groundwater flow

7.47 Approximately 5.85km of the Proposed Mainline is to be cut into the hillside. The road is raised above the valley floor; however, there is a risk that ground water flow may emerge from the cut embankment, resulting in flooding of the carriageway if not collected by road drainage.

7.48 Groundwater flow within superficial deposits is likely to follow the fall of surface topography, towards local watercourses; however, shallow flows are also likely to be locally complex – possibly influenced by the presence of peat, local lower permeability deposits, shallow rock and the presence of culverts – and overland flows may also be locally significant.

7.49 Any flooding from this source is likely to be limited and, if present at all, provide a minor contribution to the risk of flooding from overland flow considered above. Flood risk to the Proposed Scheme will be alleviated by the proposed earthworks and drainage systems.

Groundwater table

7.50 Any risk of groundwater flooding would be exacerbated by a high water table. Development at Cuaich and on the opposite bank of the River Truim at Dalwhinnie is at a lower level than the adjacent A9. Initial Ground Investigation (Raeburn 2015) recorded groundwater in a number of boreholes and trial pits, with water strikes at depths between 0.50m Below Ground Level (BGL) (at TP8-056) and 8.00m BGL (BH8-025) in the superficial deposits, and between 1.10m (TP8-048) and 8.90m BGL (BH8-029) in the bedrock.

7.51 Groundwater level data was collected on a monthly basis through 2016 at twenty-two boreholes with monitoring installations. The depths of groundwater recorded range from 0.05m (BH8-031) to 10.85m BGL (BH8-012), varying across Project 8, with many levels in the 3-4m BGL range.

Groundwater Summary

7.52 With appropriate measures included catering for any groundwater flows encountered, groundwater should not considered as a significant flood risk to the Proposed Mainline.

Sewer Flooding and the Road Drainage Network

7.53 The A9 within Project 8 passes through a rural landscape. Dalwhinnie is on the opposite bank of the River Truim from the Proposed Scheme and lower than the level of the Proposed Mainline. The risk to the Existing Road from sewer flooding is low.

7.54 The drainage design for the Proposed Scheme will comprise a number of new and independent gravity drainage networks designed to collect and convey surface water runoff from impermeable surfaces, in accordance with DMRB standards. The system is designed to shed any excess floodwater safely from the road surface. Drainage network design has been checked against the 200yr flood event and the filter media is predicted to accommodate excess flood volume. It is recommended that the performance of the proposed drainage system in exceedance events is considered at the detailed design stage.

7.55 There is no risk of flooding to the Proposed Scheme from local sewer networks and only a very low risk of flooding from the road drainage network.

8 Impact of the Proposed Scheme (on other receptors)

8.1 In accordance with the requirements of the DMRB, Volume 11, Environmental Assessment, the potential impacts of the Proposed Scheme on flood risk elsewhere are identified in this section. To support decision making, this process identifies receptors outwith the Proposed Scheme itself that may be at increased risk due to the impact on the water environment.

8.2 As noted in **Section 4**, the Proposed Scheme is considered here as it was in the autumn 2016 4^{th} Iteration Design Freeze, without specific flood risk mitigation measures such as compensatory storage areas. Further design development, including mitigation and assessment of residual impacts, is discussed in **Section 9**.

Receptors

8.3 Potential flood risk receptors outwith the boundary of the Proposed Scheme have been identified using SEPA's Flood Risk Appraisal Baseline Receptor Datasets (GIS shapefile) reviewed and augmented by information from OS OpenData (District Vectors). Receptors that may be affected by the Proposed Scheme include residential and non-residential properties, roads, rail, utilities, environmental designated sites, cultural heritage and agricultural land. Land classifications have been downloaded from The James Hutton Institute website.

8.4 Receptors identified as being at risk of flooding pre-development include properties at Dalwhinnie and Crubenmore, a length of the HML railway opposite Cuaich, and local infrastructure including the A889 bridge and Crubenmore Bridge. Figures showing receptors alongside predicted 200yr flood extents are included in **Annex C.** Environmental designated sites alongside Project 8 are predominantly the Drumochter Hills SSSI and others fundamentally part of the water environment; these sites and agricultural land designations are excluded from the receptor figures for clarity.

Fluvial Flood Risk

8.5 The impacts of the Proposed Scheme on the 200yr flood extents of the River Truim and its major tributaries outside the boundary of the Proposed Scheme have been assessed by comparing pre- and post-development results from the H&HM Study. Potential impacts on fluvial flood risk are assessed by comparing model results at and adjacent to receptors.

8.6 Aspects of the Proposed Scheme represented in the post-development hydraulic model include embankments and cuts to reflect the Proposed Mainline, channel diversions, new access roads and junctions. Post-development, design flows are predicted to be larger at three crossings (ID79, ID82 and ID110) where the sizes of the catchments draining to these crossings are judged to be materially increased by the Proposed Scheme due to watercourse diversions.

8.7 The Proposed Scheme is likely to have an impact on fluvial flood risk in the following cases:

- **Encroachments**: where the footprint of the Proposed Mainline embankment encroaches into the 200yr floodplain, floodplain volume is lost and design flood levels may increase locally as less attenuation is available for flood flows. The characteristics peculiar to each watercourse will determine how far downstream flood levels and flows are impacted

- **Access tracks and SuDS basins:** although access tracks are to be designed to retain existing ground levels as far as possible, in some locations they currently encroach on the 200yr floodplain. The effect of access track and SuDS basin encroachments is classified separately to Proposed Mainline encroachments as it is more likely there is scope to reposition these features

- **Crossings**: larger flows may be passed downstream in an extreme flood event where proposed crossings provide greater capacity than crossings under the Existing Road. As for encroachments into the floodplain, there may be an impact on flood levels and flows downstream where floodplain volume upstream of the Existing Road is lost due to the Proposed Scheme design. In addition, where the positions of crossing inlets and outlets have changed there are local impacts on the floodplain

- **Diversions**: downstream of the tributary crossings, flood flow may be impacted by the diversion of watercourses, or otherwise the inclusion of designed channels with larger capacity than existing channels adjacent to the road. As well as having a local impact on the floodplain, diversions have the potential to route water more quickly to the receiving watercourse and impact on downstream flood risk, depending on local flow characteristics. This may also be the case where catchments draining to crossings are larger and/ or a greater amount of flow is caught by earthworks drainage and improved channel diversion upstream of a crossing

8.8 Predicted impacts of the Proposed Scheme (4th Iteration Design Freeze, without mitigation) on fluvial flood risk are summarised in **Table 1**, below. Specific findings are noted alongside comment on floodplain predictions in **Annex B3.** Comments on the Assessment Design have been included for clarity; for more on the assessment of the Assessment Design see **Section 9**.

Table 1: Predicted impacts summary (fluvial flood risk) by receptor type.

**'locations' refer to potential flood risk receptors presented in Annex Table 10*

Receptor	Impact*	Comment
Residential property	1nr location where flooding introduced to 3nr properties and freeboard to 200yr flood level reduced to 1nr property 3nr locations with 'no measurable change'	Flood waters up to **70mm** in depth introduced to properties at Cuaich ('D-022' to 'D-026' on **Figure PFR5**), as a result of the proposed underpass acting as a flow path (4th Iteration) *Assessment Design comment: flow path removed, less than **3mm** rise in 200yr flood level adjacent to one property*
Non-residential property	1nr location where flooding introduced to 2nr properties and freeboard to 200yr flood level reduced to 1nr property 4nr locations with 'no measurable change'	Flood waters up to **100mm** in depth introduced to properties at Cuaich ('NRes-015' to 'NRes-017' on **Figure PFR5**), as a result of the proposed underpass acting as a flow path (4th Iteration) *Assessment Design comment: flow path removed*
Utilities	1nr location with 'no measurable change'	-

Receptor	Impact*	Comment
Roads	4nr locations with 'no measurable change' [A9 trunk road removed (raised) from 200yr floodplain]	Fluvial flood risk unaffected where adjacent roads are predicted to be overtopped by 200yr flood waters in existing 'baseline' conditions [As noted in **Section 7**, where the existing A9 is within the 200yr floodplain (one length, totalling approximately 420m, 'A9-001' on **Figure PFR-2**), the Proposed Mainline is raised above the floodplain and predicted to be free of flood risk in a 200yr event]
Area of Cultural Heritage	1nr location with 'no measurable change'	-
HML railway	<u>Where HML railway is within the 200yr floodplain</u> 2nr locations with 'no measurable change'	-
	<u>Where 200yr floodwaters are adjacent to the HML</u> 2nr locations where freeboard to 200yr flood level is marginally reduced	Between **90mm** and **600mm** predicted rise in 200yr flood level at 2nr adjacent locations. At these locations the railway is 2m or more above the raised 200yr flood level *Assessment Design comment: encroachments and impacts removed*
Agricultural land	Approximately 3.3ha rough grazing land (LCA6.1, LCA6.3) introduced to 200yr 'functional' floodplain Approximately 2.5ha rough grazing land (LCA6.2) removed from 200yr 'functional' floodplain	The new overland flow route at Cuaich is the primary reason for the increase in area of LCA Code 6.1 and 6.3 flooded in the existing case Changes in the extent of LCA code 6.2 land predicted to be inundated in the design event are due to a number of channel realignments and removal of the A9 from the functional floodplain (all reducing flood extent) at crossing ID67 *Assessment Design comment: flow path removed at Cuaich; net removal of rough grazing land from 200yr floodplain*
	Negligible change in flood extent across land capable of use as improved grassland	[90m^2 of agricultural land with Macaulay Land Capability for Agriculture (LCA) classification code 5.2 ('Land capable of use as improved grassland') introduced to 200yr floodplain, due to negligible differences in overland flow predicted to cross the A889 south of Dalwhinnie – this is brought about by hydraulic model solvers and can be ignored]
	Flood depth increased at 11nr locations within the functional floodplain	200yr flood depths increased at 11nr locations within the 200yr floodplain, extending functional floodplain (totalling less than 0.1ha). Approximately **500mm** increase on the Allt Cuaich upstream of Cuaich (comment below)

8.9 The majority of potential adverse impacts are due to the predicted effects of the Proposed Scheme (4th Iteration) on the fluvial floodplain at Cuaich. In this location, the floodplain of the Allt Cuaich upstream of the A9 is encroached on by Proposed Mainline embankment as well as proposed SuDS and access track. The approach of the Allt Cuaich upstream of the Allt Cuaich crossing (ID104) is narrowed by these encroachments and proposed lengthening of the crossing itself. As a result, 200yr floodwaters upstream of the A9 crossing are predicted to be approximately 500mm deeper, and find relief through the adjacent underpass, realigned as part of the Proposed Scheme; introducing a flood risk to properties at Cuaich. The Proposed Scheme has been developed further to address this impact – these measures and an assessment of flood risk at neighbouring development in relation to the Assessment Design are discussed in **Section 9** of this appendix.

8.10 In two locations the model results appear to indicate that diversion channels are detrimental to flood risk. Care is needed in interpreting the model results in these locations; detailed analysis of the model results alongside the revised design in these locations reveals that:

- at ch. 27,600 access track encroachments into the floodplain are driving the changes in flood extent in the location of the diversion channel (these tracks have been removed as part of the ongoing design)
- at ch. 29,400 the hydraulic model does not represent the proposed channel capacity; as the channel in this location will have capacity for design flood waters, flood extent here is predicted to be confined within the proposed diversion, reducing overall flood risk

Flood Risk Downstream

8.11 The potential impact on fluvial flood risk downstream of Project 8 has been assessed by analysing the results of the Stage 3 models, in particular changes in 200yr water level in the River Truim channel downstream of areas the Proposed Scheme may influence the water environment, and the results from the ‘full-length’ model, developed specifically to assess the potential cumulative impact of the Proposed Scheme on flood risk further downstream the River Truim.

8.12 The Stage 3 model results indicate that the impacts the Proposed Scheme does have on water levels stay relatively local to the source; where changes in flood levels are passed downstream the effect is predicted to fade to nothing over the reach length.

8.13 The full-length model predicts that impacts throughout Project 8 culminate in an increase of up to 3mm in flood levels in the River Truim at the northern end of the Project. Neither the Stage 3 models, nor the full-length model, consider mitigation options. Residual impacts are discussed at the close of **Section 9** of this appendix.

Road Drainage Network

<u>Discharges from the Road Drainage Network</u>

8.14 The construction of the Proposed Scheme will increase the proportion of impermeable surfaces in the catchment. This will increase the volume and rate of surface runoff via the road drainage network. The uncontrolled discharge of surface runoff from the road drainage network to existing watercourses during storm events would have the potential to cause localised flooding and increase the risk of flooding downstream, although consequential damage and disturbance to residential and commercial properties and natural features is likely to be marginal.

8.15 The Proposed Scheme employs SuDS to alleviate the potential impacts of increased surface runoff rates and reduce flood risk in the receiving watercourse. Site controls such as extended detention basins – attenuation and treatment of surface runoff prior to discharge – are to be included in the drainage design, and attenuation basins are to be designed to attenuate a 200yr storm to 2yr greenfield runoff rates. Where drainage networks cross catchment watersheds the allowable discharge is based on the greenfield runoff from the receiving catchment. Attenuation (greenfield) calculations consider the road as greenfield land and therefore provide betterment downstream.

Overland Flow Routes from SuDS Basins

8.16 Proposed SuDS basin locations (4th Iteration Design Freeze) are shown on the flood extents figures provided in **Annex C**. In the event of design capacity exceedance, blockage of the outfall, or otherwise failure of the basins, flood waters would spill onto the surrounding land. SuDS should be designed with emergency spillways to direct excess flood water safely away from nearby receptors to the receiving watercourse, via overland flow routes or overflow pipes.

8.17 All SuDS basins are located next to receiving watercourses, thus overland flow routes will not impact on property or infrastructure.

Exceedance of Road Drainage Capacity

8.18 Road drainage is designed to DMRB standards and represents an improvement on the existing arrangement. The system is designed to shed any excess floodwater safely from the road surface. Drainage network design has been checked against the 200yr flood event and the filter media is predicted to accommodate excess flood volume. Flood risk elsewhere is not increased by the road drainage proposals.

Infrastructure Failure

8.19 With one exception – the Allt Cuaich (crossing ID104) – the Proposed Scheme reduces the likelihood of a blockage of watercourse crossings under the road in an extreme event, as the design standard has at the least a neutral effect, but at most of them an increase in capacity of watercourse crossings. Associated flood risk downstream will also be reduced by the proposed earthworks and road drainage reducing the risk of uncontrolled flows downstream from crossing blockages.

8.20 If crossing ID104 were blocked or otherwise restricted in an extreme event, floodwaters would back-up, raising floodwater level at the underpass above Cuaich and increasing the flood risk to Cuaich from this pathway. Mitigation of this adverse impact of the Proposed Scheme (4th Iteration Design Freeze) is discussed in **Section 9**.

8.21 The proposed link road from Dalwhinnie Junction to the A889, which crosses the River Truim, is to be set above design 200yr water level, with climate change allowance, and clearly span the watercourse. The adjacent road is approximately 1m above 200yr water level upstream of the crossing. There are otherwise no adjacent receptors upstream of the crossing. The crossing is not predicted to impact on flood risk.

Overland Flow

8.22 The earthworks drainage and watercourse diversion channels upslope of the Proposed Scheme are designed to modern standards, and will better manage design flows with less chance of exceedance and failure. The Proposed Scheme will provide betterment to overland flood risk downstream.

8.23 There is a marked reduction in flood risk downstream of ch. 20,350 to ch. 20,750, where the risk of floodwaters overtopping the road (crossing ID67) in the 200yr event is removed by the Proposed Scheme.

8.24 The Proposed Scheme has a positive impact on overland flood risk to receptors downstream.

Groundwater

8.25 Development at Cuaich and on the opposite bank of the River Truim at Dalwhinnie is at a lower level than the adjacent A9. Where the Proposed Scheme is raised above existing levels it is unlikely to have any material impact on the effect that groundwater may have on flood risk elsewhere, and may present a betterment if intercepting floodwaters from groundwater springs or similar. There are no soakaways proposed as part of the roads drainage. The Proposed Scheme will not have an adverse impact on this source of flood risk.

9 Mitigation (and Residual Impacts)

9.1 One major adverse impact of the Proposed Scheme (4th Iteration Design Freeze) on flood risk to receptors outwith the site has been identified:

- potential mobilisation of a flow route through the underpass above Cuaich, putting residential and non-residential receptors at risk

9.2 Otherwise, without mitigation, the Proposed Scheme (4th Iteration Design Freeze) is predicted to have only limited adverse impacts adjacent to receptors outwith the site:

- increases in 200yr flood level adjacent to the HML railway
- minor local increases in flood level and changes in flood extent
- possible increase in cumulative flood risk downstream (full-length model results)

9.3 Measures to mitigate these impacts (including compensatory storage to replace lost floodplain volume) are outlined in this section. One location (Cuaich) warranted further study; this is discussed before residual impacts are summarised with recommendations, at the close of this section.

Approach

9.4 As the design has progressed from the 4th Iteration Design Freeze (autumn 2016) to the Assessment Design (October 2017), many of the potential impacts noted above have been designed out, with a preference for removal of floodplain encroachments – a flood risk alleviation hierarchy of avoidance, then reduction, and finally mitigation has been followed, as described below. No additional mitigation is proposed to specifically target local impacts from diversion channels.

9.5 When the 4th Iteration Design Freeze was assessed, compensatory storage areas (CSAs) were recommended to replace lost floodplain volume, using the approach detailed overleaf. CSAs were refined alongside the design as encroachments were removed and minimised, and the areas were considered holistically alongside other environmental disciplines. The CSAs proposed as part of the Assessment Design are assessed in the *Recommended Mitigation* sub-section of this section.

Encroachments

9.6 Encroachments into the functional floodplain have been avoided where possible. Many encroachments have been removed from the floodplain as the design has been refined. Locations where the Proposed Scheme (4th Iteration) was found to encroach on the existing 200yr floodplain are noted in **Annex B2**, with an indicative encroachment volume and note on measures taken to minimise or reduce the encroachment for the Assessment Design. **Annex B2** also records the sifting exercise undertaken to identify encroachments from areas where the Proposed Scheme overlays the 200yr floodplain in plan, but other aspects of the Proposed Scheme – notably upsized diversion channels – act to compensate for lost volume at the same like-for-like levels, or the proposed crossing size and headwall detailing will remove the footprint from the floodplain. In these cases there is no net loss of storage and no further mitigation is proposed.

Crossings

9.7 Upsizing watercourse crossings to meet Proposed Scheme design standards may result in loss of floodplain storage upstream. Reducing flood levels upstream also increases the area required for effective compensatory storage measures upstream of a crossing.

9.8 A number of non-flood-risk considerations may impact on crossing capacity, such as provision of mammal passage and geomorphological issues.

9.9 Where it is recommended that the potential for limiting capacity of crossings is further investigated it is noted in **Table 2**, within the *Proposed Mitigation* sub-section below.

Compensatory Storage Areas

9.10 It is recommended that compensatory storage areas are provided to replace floodplain lost to encroachments. The potential to provide compensatory storage to replace lost volume has been investigated, within the wider constraints on the Proposed Scheme such as land classification, location of receptors and how they tie-in with local hydrology post-development.

9.11 CSAs have been initially sized assuming that the encroachment into the 200yr floodplain gives a reasonable guide to the volume of floodplain required to be compensated between each design flood return period level. This assumption has been verified against cross-sections through the land at the encroachments. The initial plan area has been sized to account for likely differences between return period water depths at the encroachment and potential CSA locations, measured from the profile of the 200yr flood level in cross-section. The plan areas also account for 1:3 side slopes to the lowest level from surrounding land.

9.12 During detailed design, CSAs should be sized using a volume-balance approach, on a 'return period slices' basis. 200, 100, 50, 30 and 10 year return period flood levels will be available from the DMRB Stage 3 H&HM study. The recommended mitigation for the Assessment Design has been developed ahead of this information being available, using the method outlined in the preceding paragraph, with the exception of one location – Cuaich – discussed separately following **Table 2** below.

9.13 The volume-balance approach provides compensation for floodplain loss on both a volume-for-volume and a level-for-level basis. Level-for-level storage can be provided where CSAs are adjacent to the lost floodplain. Otherwise, where storage is remote to the source of floodplain loss, the return period slices approach enables elevation to be considered relative to the water surface profile of the river and not Ordnance Datum, so that storage effects the flood hydrograph in the same manner pre- and post-development.

9.14 The areas of compensatory storage proposed minimise the impact on the environment and flood risk. They are local to storage losses and will be accessible for maintenance. Where there is an encroachment into the floodplain upstream of a watercourse crossing, like-for-like replacement of lost floodplain storage is more comparable if the crossing is not upsized. At appropriate locations it is recommended in Table 2 and Table 3 below to maintain the existing capacity of watercourse crossings in order to preserve the depth between return periods upstream, and hence maximise the effective use of land upstream of the crossings. At some locations it is not possible to provide fully effective storage to replace lost floodplain volume; and at others direct mitigation is precluded due to spatial constraints imposed by the tree belt. Tree belt has been prioritised over compensatory storage for operational reasons as part of the wider environmental assessment.

Proposed Mitigation

9.15 CSAs have been proposed alongside other measures to mitigate the potential impacts of the Proposed Scheme on local and downstream flood risk. Details are provided in **Table 2**, below. Plans of CSAs alongside respective encroachments are shown on figures provided in **Annex C**.

Table 2: CSAs and associated mitigation to replace lost floodplain volume in the Assessment Design

CSA location (P08 ch. and OS ref.)	Floodplain loss	Assessment Design comment
CSA201 ch. 20,150 [u/s of ID65] E263890 N781740 **Figure CS-1**	ch. 20,150 Mainline encroachment on floodplain of W8.1, where flood waters back-up periphery channel upstream of crossing ID65	Direct replacement* of lost volume – additional storage built into diversion channel upstream of crossing Crossing capacity conserved as existing ** Direct replacement = on the watercourse from which it is lost*
CSA206 ch. 20,550 – ch. 20,600 [west of A9] E263920 N782180 **Figure CS-2**	ch. 20,700 – ch. 20,750 Access track encroachment on floodplain of R. Truim	Direct replacement of lost volume, upstream of encroachment More local replacement precluded by spatial constraint (Proposed Scheme – adjacent land) and access (HML railway - opposite bank)
CSA213 ch. 21,300 ch. 21,350 [u/s of ID76] E264020 N782920 **Figure CS-3**	ch. 21,350 – ch. 21,400 Mainline encroachment into floodplain of W8.4, upstream of crossing ID76 NB Pre-development, flood waters are predicted to build up behind the crossing before finding relief overland to the north, joining MW8.6 upstream of crossing ID77. An underpass has been introduced along this flood route as part of ongoing design	**Partial direct replacement** of lost volume – additional storage built into diversion channel upstream of crossing **Full replacement precluded** by spatial (tree belt) and topographic restraints (northern flood route). Not possible to mitigate changes to flood risk downstream –and, due to the local topography, the upstream diversion channel is not predicted to have capacity in a design flood event NB No recommendation to restrict crossing size below 200yr capacity in this location – a restriction would increase uncontrolled flood risk to neighbouring underpass (proposed)
CSA217 ch. 21,650 – ch. 21,800 [u/s of ID79] E264010 N783330 **Figure CS-4**	ch. 21,650 – ch. 22,000 Mainline encroachment into floodplain of W8.58, upstream of crossing ID79	Direct replacement of lost volume Due to spatial constraints (tree belt), it is necessary to **restrict proposed crossing size** to maintain existing crossing capacity in order to provide direct replacement of volume loss. Retaining existing capacity maximises the efficiency of area available
CSA220 ch. 22,000 – ch. 22,100 [d/s of ID81] E236930 N783640 **Figure CS-5**	ch. 22,000 – ch. 22,150 Mainline encroachment into floodplain of W8.7, upstream of crossing ID81 Potential for additional volume loss upstream of encroachment due to crossing upsizing NB Pre-development, flood waters are predicted find relief overland to the south, through the adjacent underpass (crossing ID80, to be removed as part of the Proposed Scheme)	Direct replacement of volume lost to encroachment, downstream of encroachment and receptor (Proposed Mainline) Replacement upstream of receptor precluded by spatial constraints (tree belt) Partial replacement of volume lost due to crossing upsizing (lower return periods) – necessary to **restrict proposed crossing size** to mobilise natural floodplain upstream, potentially resulting in a slight increase in flood extent outwith the Proposed Scheme boundary
CSA254 ch. 25,400 [u/s of ID100] E265390 N786590 **Figure CS-6**	ch. 25,400 Mainline encroachment into floodplain of MW8.13, upstream of crossing ID100	Direct replacement of lost volume – additional storage to be built into diversion channel upstream of crossing Crossing capacity conserved as existing

CSA location (P08 ch. and OS ref.)	Floodplain loss	Assessment Design comment
CSA279 ch. 27,950 [u/s of ID114] E266900 N788550 **Figure CS-7**	ch. 27,950 Mainline encroachment into floodplain of MW8.19, upstream of crossing ID114	Direct replacement of lost volume – additional storage to be built into diversion channel upstream of crossing Crossing capacity conserved as existing
CSA284 ch. 28,400 – ch. 28,450 [west of A9] E267160 N788940 **Figure CS-8**	ch. 28,300 – ch. 28,450 Access track encroachments into combined floodplain of watercourses between MW8.18 and W8.153 inclusive (crossing IDs 112-117)	Direct replacement of lost volume
CSA289 ch. 28,900 – ch. 28,950 [west of A9] E267400 N789390 **Figure CS-9**	ch. 28,900 – ch. 29,000 Access track encroachment into combined floodplain of watercourses between MW8.18 and W8.26 inclusive (crossing IDs 112-119)	Direct replacement of lost volume
CSA306 ch. 30,500 – ch. 30,550 [RHB of R.Truim] E267700 N790900 **Figure CS-10**	ch. 30,550 – ch. 30,950 Access track and SuDS encroachments into River Truim and MW8.22 floodplain	Direct replacement of lost volume, upstream on R. Truim

Cuaich

Encroachments and flood risk

9.16 The Proposed Scheme design as it was in autumn 2016 (4th Iteration Design Freeze) increased flood levels in the Allt Cuaich upstream of the crossing and introduced a risk of flooding to properties at Cuaich, as described in **Section 8**, with the mobilisation of a new overland flow route through the relocated underpass. The Assessment Design includes refinements to minimise encroachments into the floodplain and remove this potential overland flow route: the mainline embankment has been steepened, the underpass and SuDS have been moved approximately 20m southwards and the underpass and access track have been raised and are protected further with the addition of a bund.

9.17 A hydraulic model has been constructed to represent the Assessment Design. 200yr flood levels are predicted to rise by up to 320mm immediately upstream of the watercourse crossing post-development, whilst flows in the channel downstream are marginally reduced due in part to the proposed removal of the sheep creep on the northern bank of the Allt Cuaich. In this case, adjacent to the point where flood waters meet the footprint of the access track at the southern underpass opening, the track is predicted to be approximately 20mm above the 200yr+climate change flood level, with the bund providing a further 600mm freeboard , whilst the Proposed Mainline is approximately 4m above the 200yr flood level.

9.18 Crossing ID103, which currently comprises two 900mm diameter culverts, will be replaced by a 1200mm diameter pipe culvert in the Proposed Scheme. With the increased head upstream, flows from this crossing are predicted to combine with flood water downstream of crossing ID104 to marginally increase water level (approximately 2mm) adjacent to a residential property (identified as receptor D-026 on **Figure PFR-006** provided in **Annex C**). Modelling results show that the Proposed Scheme has no measurable effect on flood levels further downstream.

Potential for compensatory storage

9.19 The hydraulic model has been run to consider compensatory storage – a CSA that was developed at an earlier design stage (shown on **Figure CS-11** in **Annex C**) was included in the model ; representing it as a depression in the model terrain. The CSA was found to be ineffective, with the predicted impacts unchanged from those noted above. Although the storage area was sized to provide like-for-like replacement of volume lost (in line with 'best practice' guidelines), the floodplain upstream is formed by a wide, steep flow route, which does not store water in extreme events. Provision of storage immediately adjacent to the encroachment is precluded by the steep topography on the right-hand bank, and is constrained by the Scheme on the left-hand bank.

Flood levels upstream of the crossing and impacts on flood risk downstream are driven by the hydraulic behaviour of the channel and crossing (including the sheep pass and, in an extreme event, crossing ID103) rather than by loss of floodplain storage due to the encroachment.

Alternative mitigation options

9.20 Alternative mitigation options have been investigated to minimise flood risk impacts, noting that a local increase in flooding upstream of the crossing would have no material effect on flood risk to the Proposed Mainline and there are no other potential flood risk receptors upstream on the Allt Cuaich.

9.21 The Assessment Design model has been run to consider the effect of reducing the pipe culvert diameter at crossing ID103, to reduce flows passing downstream. This lowers flood levels adjacent to the affected residential property (flood risk receptor D-026) and raises flood water level adjacent to the underpass by approximately 20mm (in 200yr flood event). The recommended measures to address the residual flood risk at this location – restricting the capacity of crossing ID103 – are noted in **Table 3** in the post-mitigation sub-section below.

Post-mitigation (Residual Impacts)

9.22 Potential impacts on flood risk are identified in **Section 8** and impacts are quantified in **Annex Table 9**. Compensatory Storage Areas have been provided to replace lost floodplain volume. In some locations it has not been possible to achieve fully effective compensatory storage. These locations are noted in **Table 3** below, alongside other residual impacts, with final mitigation recommendations.

Table 3: Residual Impacts (Assessment Design) and recommendations

Approx. location (P08 ch. and OS ref.)	Residual impacts of the Assessment Design	Recommendations
ch. 21,350 ch. 21,400 E264000 N782900 *watercourse W8.4* *crossing ID76*	**Minor loss of floodplain volume** CSA213 provides partial replacement of volume lost to Mainline encroachment into floodplain of W8.4, upstream of crossing ID76 (Minor changes to local flood level and extent)	None. Constraints preclude further mitigation. No increase in flood levels at adjacent receptors
ch. 21,750 E264000 N783360 *watercourse W8.58* *crossing ID79*	**Loss of floodplain volume** CSA217 provides partial replacement of volume lost to Mainline encroachment into floodplain of W8.58, upstream of crossing ID79	**Minimise** loss by restricting proposed crossing size to 900mm diameter or equivalent in order to maximise effectiveness of mitigation
ch. 22,150 E264000 N783730 *watercourse W8.7* *crossing ID81*	**Loss of floodplain volume** CSA220 provides partial replacement of volume lost to Mainline encroachment into floodplain of W8.7, upstream of crossing ID81	**Mitigate impact** by restricting proposed crossing size to 900mm diameter or equivalent in order that CSA220 can fully mitigate for loss of floodplain volume Mobilising natural floodplain upstream raises 200yr flood level by approximately 0.23m, extending the floodplain 2 to 5m from the Scheme Assessment Boundary across an area of approximately 240m^2 previously outwith the floodplain
ch. 25,850 ch. 26,100 E265800 N786900 *watercourse MW8.14* *crossing ID103* *crossing ID104*	**Flood levels raised adjacent to A9, upstream of crossing ID104** (see below)	None. Compensatory storage not viable and downstream receptors preclude further mitigation No adjacent receptors upstream and Mainline road surface >5m above 200yr floodplain
	2mm increase in flood levels at receptor downstream (D-026) Encroachments have been minimised and the underpass and track have been moved and raised above 200yr+CC flood event, with a bund provided to secure 600mm freeboard, in order to avoid introducing flood risk to Cuaich. The changes to crossing ID103, crossing ID104, and the sheep pass (removed), have some residual impact.	**Mitigate impact** at receptor by restricting capacity of crossing ID103 (reduce to 900mm diameter) to reduce flows passing downstream, thereby mitigating flood risk to properties downstream The bund affords 600mm freeboard for the underpass to 200yr+CC flood levels when considering this reduced culvert size. It is recommended that this bund is designed as a formal flood defence, and maintained accordingly

9.23 With appropriate mitigation, including the proposed compensatory storage and design revisions included in the Assessment Design, the potential local impacts of the Proposed Scheme will have no material cumulative impact to flood risk on the River Truim downstream.

10 Conclusion

10.1 Sources of flood risk to the Existing Road and the Proposed Scheme have been assessed. The potential impacts of the Proposed Scheme on fluvial flood risk have been assessed with the aid of a Hydrological and Hydraulic Modelling study, developed with the aid of stakeholder consultations at earlier stages in the DMRB process. The design information from the autumn 2016 4th Iteration Design Freeze has been used to create post-development models, and the findings have been fed back into the ongoing design process.

10.2 The Existing Road is predicted to be at risk of fluvial flooding. There is a low risk of fluvial flooding to the Proposed Mainline. In one location an access track (Proposed Scheme) is at risk of flooding in an extreme event. Flood extents figures showing 200yr flood depths predicted for both pre- and post- development (4th Iteration Design Freeze) are included in **Annex C**.

10.3 The proposed crossing over the River Truim, part of the proposed Dalwhinnie junction to the south of Dalwhinnie, is to be set above design 200yr flood level with climate change allowance, and spans the River Truim floodplain. The crossing is not predicted to impact on flood risk.

10.4 It is recommended that the BDL access track crossings are upgraded and maintained with a view to minimising the residual risk from these structures. The Proposed Scheme is at low risk of flooding from overland flow during events exceeding the design capacity of the road drainage.

10.5 Flood risk assessment findings have been fed back into the ongoing design, and mitigation options have been developed accounting for changes made since the autumn 2016 design iteration. Further modelling has informed ongoing design and flood risk analysis. Mitigation measures have been recommended to alleviate flood risk, in particular compensatory storage areas to offset floodplain storage lost to encroachments. CSAs proposed as part of the Assessment Design are evaluated in **Table 2** of **Section 9** and shown on the CSA figures in **Annex C**. There are two locations where CSAs cannot be provided to replace lost storage and two where it is recommended that crossing size is restricted to fully replace lost storage.

10.6 The Proposed Scheme reduces the floodplain extents locally and has a positive impact on flood risk to adjacent receptors, other than at Cuaich, where there is a residual risk to a property. Measures to mitigate residual risks have been investigated. Residual impacts and flood risk recommendations are noted in **Table 3** within **Section 9**.

10.7 The Proposed Scheme represents an overall reduction in flood risk. With appropriate mitigation, including the proposed compensatory storage and design revisions included in the Assessment Design, the potential local impacts of the Proposed Scheme will have no material cumulative impact to flood risk on the River Truim downstream.

Annex A - Hydrology

A.1 Watercourse Descriptions

Major Watercourses (shown on 1:50,000 scale OS maps)

[Summarised from the DMRB Stage 3 Environmental Impact Assessment Chapter 11: Road Drainage and the Water Environment report for Project 8]

<u>River Truim (MW 8.1)</u>

The River Truim is the dominant watercourse throughout the Project 8 extent, with a catchment area of approximately 125km^2 draining the western edges of the Cairngorms Mountains. It is a major tributary of the River Spey.

The headwaters of the River Truim are situated in the Pass of Drumochter, approximately 8km south of Dalwhinnie. It has a WFD classification of 'Good ecological potential' – from source to Allt Cuaich confluence (2015), and 'Moderate ecological potential' – lower catchment (2015). It is designated as part of the River Spey Special Area of Conservation (SAC) for its populations of Atlantic salmon (Salmo salar) (the Truim is noted as important for its salmonid smolt production) and otter (Lutra lutra). (Sea lamprey (Petromyzon marinus) and freshwater pearl mussel (Margaritifera margaritifera) are also qualifying features of the River Spey SAC; no evidence has been determined in the River Truim Project 8 extents, however their presence has been assumed for assessment purposes.) It is situated in the Cairngorms National Park and its source is also within the Drumochter Hills Site of Special Scientific Interest (SSSI)/ SAC. British Geological Survey (BGS) data indicates that the waterbody is predominantly within a high groundwater vulnerability classification zone (Class 4).

The gentler gradients of the wider valley floors result in lower energy flows and subsequent deposition of this coarse material; this has been noted by channel narrowing at confluences with the River Spey. The watercourses within the catchment retain gravel-bed channels due to continued lateral migration; working into the glacial deposits, transporting and depositing materials exhibited by sinuous meandering and braided planforms and varied morphological features.

<u>Allt Coire nan Cisteachan (MW8.5 / crossing ID72 & 73)</u>

Allt Coire nan Cisteachan is a tributary of the River Truim with a catchment size of approximately 1.6km^2 and a length of approximately 2.4km flowing in a north-westerly direction from its source in the Cairngorm Mountains. The watercourse is situated within the Drumochter Hills Mixed SSSI boundary (designated for Geomorphology: Fluvial geomorphology of Scotland, as well as biodiversity features). It has been assumed that larger tributaries of the Truim may support salmon species. British Geological Survey (BGS) data indicates that the waterbody is within a medium groundwater vulnerability classification zone (Class 3).

There is evidence of the watercourse incising into bedrock and/ or superficial deposits with very large (cobble-small boulder) sediment deposited immediately upstream of the crossing. This indicates that some large sediment will eventually be transmitted to the crossing.

<u>Allt Coire Uilleim (MW 8.6 / crossing ID 77)</u>

Allt Coire Uilleim is a tributary of the River Truim. It has a catchment size of approximately 1.7km^2, a length of approximately 3.4km and flows in a north-westerly direction from its source in the Cairngorm Mountains. The watercourse is located within the Drumochter Hills Mixed SSSI boundary. It has been assumed that larger tributaries of the Truim may support salmon species and so a conservative estimation of their water quality/ biodiversity sensitivity has been adopted. BGS data indicates that the waterbody is within a medium groundwater vulnerability classification zone (Class 4).

Peat is present in the upper catchment with gullying, peat slides, hillslope slides, and vertical incision noted, resulting in a high potential for sediment supply in upper catchment.

Allt Coire Bhathaich (MW 8.8 / crossing ID 82)

Allt Coire Bhathaich is a tributary of the River Truim with a catchment size of approximately 4.5km^2, and a length of approximately 5.5km. It flows firstly in a north-westerly direction from its source at Coire Bhathaich before shifting almost 90 degrees at Ruighe Coire Bhathaich (ch. 22,570) with a sinuous planform for much of its length discharging to the River Truim at ch. 22,330. BGS data indicates that the waterbody is within a very high groundwater vulnerability classification zone (Class 5).

The watercourse has been heavily modified by the construction of the A9 bridge crossing and a dam approximately 100m upstream from the bridge, with noted sediment accumulation behind the dam which also may impact pollutant dilution/ dispersal capacity.

Unnamed (MW 8.9 / crossing ID 89)

This watercourse is a narrow unnamed tributary of the River Truim which is currently piped under the SSE aqueduct. It has a catchment size of approximately 0.6km^2 and length of approximately 1km, flowing north parallel to the existing A9. From source it drops from approximately 375mAOD to 370mAOD at the A9, with a further drop to approximately 350mAOD where it joins the River Truim at ch. 23,750. The channel was originally natural but has had a small weir installed upstream of the aqueduct directing water flow under the A9, inhibiting natural geomorphic processes.

The inlet from the dam on the watercourse upstream (part of the SSE scheme) may affect the natural catchment hydrology. The watercourse contributes to the hydro scheme.

Unnamed Tributary of the River Truim (MW8.12 / crossing ID 100)

This unnamed watercourse is a tributary of the River Truim with a catchment size of approximately 0.5km^2, and a length of 1.25km. BGS data indicates that the water feature is within a medium groundwater vulnerability classification zone (Class 3).

This watercourse has a source elevation of 370mAOD with a drop to 330mAOD at its confluence with the River Truim. It has a straightened stone protected channel, which flows predominantly through heather grassland upstream of the pipe crossing the A9, and a more sinuous pebble and gravel-bedded channel downstream flowing through coniferous woodland (Lechden) and rough grassland floodplain.

Allt Cuaich (MW 8.14 / crossing ID 104)

Allt Cuaich is a tributary of the River Truim with a catchment area of approximately 36km^2. It flows in a south-west then westerly direction from Loch Cuaich for approximately 4.1km. From source at Loch Cuaich, the river has a fall from approximately 410mAOD to 340mAOD at the A9, down to 335mAOD at its confluence with the River Truim (ch. 26,300), flowing under the A9 and HML railway.

It has a WFD classification of 'Bad ecological potential' (2015). Pressures identified for the watercourse not meeting good ecological status are 'abstraction for production of renewable electricity thus changing natural flow conditions' – it is a major contributor to the SSE Tummel

Hydropower Scheme and a large volume of its water is abstracted and diverted to Loch Ericht via the aqueduct. Habitat surveys concluded that salmon are present in the Allt Cuaich.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). There is geomorphic evidence of bar development and bank erosion as well as engineered preventative measures using stone gabions highlighting erosion risk upstream and downstream of the A9 crossing.

Unnamed watercourse (MW 8.16 / crossing ID 107)

This watercourse has a catchment size of approximately 0.4km^2 with a length of approximately 1.1km. It flows west then north-west from its source to the A9 stone culvert with a fall from 390mAOD to 334mAOD.

Dalannach (MW 8.18 / crossing ID 112)

This watercourse is an unnamed tributary of the River Truim. It has a catchment size of approximately 0.2km^2, and is approximately 2.6 km in length, flowing north to the pipe crossing the A9 then north-east, joining several other watercourses also culverted under A9 passing under the HML railway at ch. 29,100. Although classed as a Major watercourse, based on its poor connectivity to the River Truim, it is considered unlikely to support any designated fresh-water species.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). Downstream, bed cover is predominantly gravels and pebbles, and upstream there are larger boulder and cobble-sized materials. Upstream of the A9 pipe the channel is straightened and bound by stone bank protection.

Unnamed watercourse (MW 8.19 / crossing ID 114)

This watercourse is a narrow unnamed tributary of MW8.18 (confluence of the two at ch. 28,050) flowing beneath the A9 via a box culvert. It has a catchment size of approximately 0.5km^2 and a length of approximately 0.5km. Although classed as a Major watercourse, based on its poor connectivity to the River Truim, it is considered unlikely to support any designated fresh-water species.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). It appears to be a natural channel, which has been realigned to a drain with evidence of deposition at the confluence with MW8.18 and the outlet of the culvert. There is some degree of vegetation establishment indicating a level of channel stability. Bed materials are largely gravels, pebbles and cobbles with evidence of deposition at the confluence with MW8.18 and at the outlet of the culvert.

Allt Garbh (MW 8.20 / crossing ID 121)

Allt Garbh is a tributary of the River Truim with a catchment size of approximately 2.4km^2, and flows in a westerly direction from its source at Coire Thearlaich for a distance of 2.5km. At its source height of 530mAOD the watercourse flows over gently sloping acid grassland and bog within the corrie; it reaches a steeper gradient and fall from 470m to 330mAOD over a distance of approximately 850m down a straight channel. It has been assumed that larger tributaries of the Truim may support salmon species.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). Incision is evident at the crossing (this has been reduced by the presence of a reno mattress); however, the materials have been reworked indicating excess energy. There is high sediment source potential from upper catchment debris flows, shallow slides and valley side erosion in till and alluvial fan deposits, as well as unvegetated bars.

Unnamed watercourse (MW 8.21 / crossing ID 129)

The unnamed watercourse is a tributary of the River Truim with a catchment size of approximately 0.2km^2. It has a source height of 370mAOD and a fall to 300mAOD at the confluence with the River Truim at ch. 30,500. The watercourse is constrained, passing under the A9, the HML railway and discharging to the Truim within a distance of approximately 80m. Although classed as a Major watercourse, based on its poor connectivity to the River Truim, it is considered unlikely to support any designated fresh-water species.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). There appears to be a limited sediment supply in the catchment as it is well vegetated throughout, although there are numerous boulders located around the catchment, indicating a possible ready supply of coarse material below the vegetation.

Allt na Ceardaich (MW8.22 / crossing ID 130)

Allt na Ceardaich is a tributary of the River Truim, with a catchment area of approximately 3.81km^2, which flows in a westerly direction from its source (405mAOD) for approximately 1.6km to the Truim confluence (300mAOD) at ch. 30,750. Although classed as a Major watercourse, based on its poor connectivity to the River Truim, it is considered unlikely to support any designated fresh-water species.

BGS data indicates that the water feature is within a high groundwater vulnerability classification zone (Class 4). The channel has a sinuous planform in the upper catchment but is heavily engineered at the road bridge, where it has been straightened and the streambed laid with cobble bricks. Little to no natural geomorphic variation is evident.

Minor Watercourses & Ditches

There are numerous other watercourses, and other land and road earthwork drainage ditches, along the route of the existing A9 within Project 8. The majority of the minor watercourses in Project 8 have relatively short longitudinal profiles, ranging from a few hundred metres to approximately 1km, with largely straight channel planforms with confluence elevations ranging from 400mAOD at Dalwhinnie to approximately 310mAOD at Crubenmore.

Many of the minor watercourse channels are narrow (i.e. between 0.5 and 1.5 m wide), with few exhibiting significant evidence of geomorphic diversity. The terrain is dominated by heather, grassland and bog; on gentler gradients in close proximity to the A9, watercourses flow through established channels, both engineered and following the natural gradient over vegetation, where there is some deposition of small-grained materials, i.e. sands and silts.

To the east of the River Truim, minor watercourses drain the lower slopes of the Cairngorms and exhibit steeper gradients. These higher energy channels are more incised into the fluvio-glacial deposits, supplying larger sediment materials available for transport downstream. Some geomorphic diversity and fluvial processes are evident such as bank erosion and the development of small lateral gravel bars and deposition of gravel, pebble and cobble-sized materials. Several of the minor watercourses have engineering work in the form of gabion walls and mattresses, cascades and drops. These works are located where the watercourse is crossed by the existing A9.

A.2 River Truim Catchments

Catchment Descriptors

Annex Table 1: River Truim and watercourses at Invertruim

LABEL	Truim-01	Truim-02	Truim-03	Truim-04	Truim-05	Truim-06	Truim-07	Truim-08	Truim-09	Truim-10	Truim-11	Truim-12	Truim-13	Truim-14	Truim-15	Truim-16	Truim-17	8007	*Spey*
Easting	262650	262800	262750	263100	263600	263850	263900	263850	264000	264150	265250	265400	267500	267650	267650	268350	268700	268650	*268600*
Northing	777300	779100	779700	780700	781450	782350	783000	783850	785300	785450	787400	787550	265460	791050	791450	792800	796150	796200	*796150*
AREA	2.73	7.79	15.93	21.79	27.19	30.05	33.6	36.55	42.59	45.81	58.16	62.6	105.68	112.59	116.84	119.99	124.8	401.59	*276.78*
ALTBAR	603	597	639	635	644	638	633	630	619	604	584	571	566	559	556	551	541	518	*507*
ASPBAR	228	73	78	51	22	8	352	343	331	335	351	0	344	338	337	339	340	311	*179*
ASPVAR	0.27	0.15	0.24	0.16	0.15	0.16	0.18	0.2	0.25	0.22	0.2	0.19	0.18	0.2	0.21	0.2	0.2	0.03	*0.06*
BFIHOST	0.407	0.384	0.409	0.408	0.413	0.41	0.408	0.407	0.405	0.411	0.417	0.41	0.401	0.4	0.4	0.404	0.413	0.411	*0.411*
DPLBAR	1.57	3.06	3.56	4.29	4.9	5.55	5.86	6.47	7.6	7.39	9.43	9.14	11.88	12.42	12.52	14.27	17.64	21.54	*23.2*
DPSBAR	265.4	262.6	258.4	251.1	250.2	245.5	238.5	233.9	222.5	213.3	205.1	196	195.6	194.2	192.4	192.8	189.1	181.3	*177.7*
FARL	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	0.97	0.97	0.97	0.97	0.97	0.95	*0.93*
FPEXT	0.03	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.04	0.05	0.05	0.05	0.04	0.04	0.05	0.05	*0.06*
FPDBAR	0.323	0.417	0.333	0.349	0.374	0.39	0.384	0.4	0.466	0.502	0.596	0.607	0.605	0.607	0.594	0.588	0.615	0.807	*0.893*
FPLOC	0.799	0.622	0.622	0.661	0.649	0.674	0.718	0.729	0.694	0.638	0.647	0.64	0.697	0.718	0.738	0.781	0.813	0.803	*0.786*
LDP	3.71	5.88	6.58	7.87	8.93	9.97	10.72	11.68	13.34	13.58	16.46	16.7	20.88	22.05	22.5	24.58	28.6	41.13	*41.06*
PROPWET	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.75	*0.77*
RMED-1H	11	10.9	10.8	10.8	10.8	10.7	10.7	10.7	10.6	10.6	10.4	10.4	10.2	10.1	10.1	10.1	10	10	*10*
RMED-1D	47.4	46.6	44.5	44.6	44.3	44.1	43.9	43.6	43.1	42.8	41.4	41.1	39.3	38.9	38.7	38.5	38.2	39.5	*40.1*
RMED-2D	70.6	69.1	65.1	65.2	64.6	64.2	63.8	63.3	62.3	61.9	59.5	58.8	56	55.5	55.1	54.8	54.4	55.6	*56.1*
SAAR	1764	1762	1786	1753	1740	1723	1704	1691	1659	1632	1563	1538	1476	1456	1444	1435	1417	1431	*1437*
SAAR4170	1761	1757	1752	1741	1744	1733	1716	1703	1666	1636	1579	1551	1465	1439	1424	1413	1396	1445	*1468*
SPRHOST	55.8	54.18	55.55	55.52	55.84	55.72	55.6	55.56	55.13	54.18	52.4	52.4	53.05	52.88	52.7	52.36	51.58	51.15	*50.96*
URBEXT90	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.0001	*0.0001*
URBEXT00	0	0	0	0	0	0	0	0	0	0.0003	0.0002	0.0002	0.0001	0.0001	0.0001	0.0001	0.0001	0	*0*
Qmed cds	4.1	10.5	18.3	23.4	27.7	30.1	32.9	35.1	39.3	40.5	46.4	49.3	67.6	70.8	72.3	72.9	72.7	180.4	*126.0*
Qmed s,adj	3.4	8.6	15.0	19.3	22.8	24.7	27.0	28.8	32.2	33.1	37.7	40.0	54.8	57.4	58.5	59.0	58.8	-	*96.3*

8007 Gauge Data

New rating received June 2015 from SEPA, along with reworked AMAX backdated through entire period of record. The 2016 water year AMAX was added to this record using the rating equation provided, after a 0.05m stage adjustment based on the drawdown reported in SEPA advice.

Annex Table 2: Current AMAX values alongside historic for 8007@Invertruim.

Hiflows WINFAPv3 (historic)		AMAX received 2014 (historic)		AMAX received 2015 plus 2016 value (current)	
DATE	FLOW	DATE	FLOW	DATE	FLOW
02-Sep-53	56.601	02-Sep-53	67.070	02-Sep-53	57.798
07-Nov-53	74.849	07-Nov-53	84.050	07-Nov-53	73.636
04-Dec-54	109.050	04-Dec-54	111.500	04-Dec-54	99.389
28-Dec-55	114.66	28-Dec-55	118.000	28-Dec-55	103.249
15-Dec-56	101.861	15-Dec-56	107.000	15-Dec-56	94.310
20-Dec-57	74.849	20-Dec-57	84.620	20-Dec-57	73.636
19-Jan-59	43.566	19-Jan-59	53.490	19-Jan-59	41.167
17-Oct-59	72.030	17-Oct-59	66.790	17-Oct-59	71.305
28-Sep-61	83.748	28-Sep-61	91.410	28-Sep-61	80.760
11-Feb-62	232.586	11-Feb-62	198.200	11-Feb-62	170.486
15-Dec-62	73.431	15-Dec-62	82.920	15-Dec-62	72.467
21-Oct-63	36.542	21-Oct-63	37.640	21-Oct-63	38.918
11-Jan-65	74.849	11-Jan-65	79.520	11-Jan-65	73.636
01-Nov-65	56.601	01-Nov-65	60.280	01-Nov-65	57.798
17-Dec-66	274.680	17-Dec-66	259.500	18-Dec-66	190.317
27-Mar-68	126.455	27-Mar-68	131.900	27-Mar-68	111.098
30-Oct-68	59.001	30-Oct-68	63.210	31-Oct-68	59.990
17-Mar-70	86.866	02-Nov-69	91.080	17-Mar-70	83.177
09-Jan-71	91.687	09-Jan-71	89.070	09-Jan-71	86.842
22-Oct-71	90.060	22-Oct-71	88.330	22-Oct-71	85.615
13-Dec-72	54.268	13-Dec-72	53.990	13-Dec-72	55.630
18-Jan-74	166.191	18-Jan-74	153.700	18-Jan-74	135.351
20-Dec-74	113.901	20-Dec-74	120.600	20-Dec-74	102.732
07-Jan-76	78.034	07-Jan-76	81.720	07-Jan-76	76.225
27-Nov-76	51.222	27-Nov-76	52.170	27-Nov-76	52.742
30-Oct-77	70.511	30-Oct-77	72.660	30-Oct-77	70.032
02-Mar-79	245.673	02-Mar-79	274.500	02-Mar-79	176.822
27-Jul-80	80.857	04-Dec-79	75.250	27-Jul-80	78.483
20-Sep-81	128.086	20-Sep-81	108.000	20-Sep-81	112.158
20-Nov-81	86.551	03-Mar-82	82.650	20-Nov-81	82.934
05-Jan-83	123.833	05-Jan-83	133.200	05-Jan-83	109.383
31-Dec-83	237.204	31-Dec-83	254.000	31-Dec-83	172.741
27-Nov-84	119.871	27-Nov-84	122.100	27-Nov-84	106.760
22-Mar-86	130.976	22-Mar-86	128.700	22-Mar-86	114.019
07-Dec-86	116.380	07-Dec-86	114.800	07-Dec-86	104.416
19-Apr-88	62.221	19-Apr-88	62.222	18-Apr-88	62.876

Hiflows WINFAPv3 (historic)		AMAX received 2014 (historic)		AMAX received 2015 plus 2016 value (current)	
DATE	**FLOW**	**DATE**	**FLOW**	**DATE**	**FLOW**
15-Jan-89	267.896	15-Jan-89	267.901	15-Jan-89	188.769
05-Feb-90	272.633	05-Feb-90	272.638	04-Feb-90	191.869
02-Jan-91	94.163	02-Jan-91	94.165	01-Jan-91	88.692
02-Jan-92	228.330	02-Jan-92	228.334	02-Jan-92	168.389
17-Jan-93	270.935	17-Jan-93	270.940	16-Jan-93	188.614
08-Mar-94	165.703	08-Mar-94	165.706	08-Mar-94	135.070
11-Dec-94	146.979	11-Dec-94	146.982	10-Dec-94	124.003
24-Oct-95	114.660	24-Oct-95	114.662	24-Oct-95	103.249
02-Mar-97	204.449	02-Mar-97	204.453	01-Mar-97	156.263
18-Nov-97	112.018	18-Nov-97	112.020	18-Nov-97	101.442
27-Dec-98	49.906	27-Dec-98	51.641	27-Dec-98	51.473
30-Nov-99	100.811	30-Nov-99	100.813	30-Nov-99	93.555
20-Dec-00	50.123	20-Dec-00	52.056	20-Dec-00	51.684
06-Mar-02	133.066	06-Mar-02	133.069	06-Mar-02	115.353
22-Nov-02	45.173	22-Nov-02	47.249	21-Nov-02	46.798
08-Jan-04	97.534	08-Jan-04	97.536	08-Jan-04	91.177
10-Jan-05	181.012	10-Jan-05	181.015	09-Jan-05	143.694
12-Nov-05	118.505	12-Nov-05	118.507	11-Nov-05	105.847
[END]		14-Dec-06	209.544	13-Dec-06	158.902
Median	**101.336**	26-Jan-08	220.484	26-Jan-08	171.988
		11-Jan-09	127.363	11-Jan-09	120.061
		26-Nov-09	119.235	26-Nov-09	114.685
		16-Jan-11	126.740	16-Jan-11	119.655
		27-Nov-11	163.663	27-Nov-11	142.128
		12-Dec-12	135.231	12-Oct-12	125.097
		23-Feb-14	114.542	23-Feb-14	111.495
		[END]		08-Mar-15	202.678
		Median	**113.281**	05-Dec-15	203.468
				[END]	
				Median	**103.249**

Statistical Methods

PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	1 of 3		
TITLE	River Truim at Crubenmore Bridge [T15] Pooling Group	DATE	11/11/2016	Checked by	LG

Pooling group generated using WINFAP-FEH v4.1 dataset

Pooling Group Details

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
47020 (Inny @ Bealsmill)	0.279	32	34.422	0.226	0.079	1.304
47004 (Lynher @ Pillaton Mill)	0.284	53	43.741	0.218	0.283	0.53
46008 (Avon @ Loddiswell)	0.297	34	63.421	0.174	0.06	1.409
60006 (Gwili @ Glangwili)	0.353	46	78.452	0.164	0.168	0.397
72015 (Lune @ Lunes Bridge)	0.39	35	201.71	0.128	0.028	0.32
203033 (Upper Bann @ Bannfield)	0.397	39	67.053	0.122	-0.014	0.412
47005 (Ottery @ Werrington Park)	0.399	50	64.369	0.148	0.105	0.055
79004 (Scar Water @ Capenoch)	0.425	43	132.92	0.087	0.07	0.678
47024 (Tavy @ Tavistock Abbey Bridge)	0.45	5	130	0.339	0.422	2.886
203039 (Clogh @ Tullynewey)	0.464	33	38.1	0.054	-0.06	1.258
67005 (Ceiriog @ Brynkinalt Weir)	0.471	56	29.78	0.199	0.213	0.465
79003 (Nith @ Hall Bridge)	0.476	47	70.779	0.193	0.427	2.341
45009 (Exe @ Pixton)	0.483	49	47.153	0.224	0.148	0.946
Total		522				
Weighted means				0.169	0.136	

Station	Distance	AREA	SAAR	FPEXT	FARL	URBEXT 2000
47020 (Inny @ Bealsmill)	0.279	102.05	1429	0.036	1	0.004
47004 (Lynher @ Pillaton Mill)	0.284	135.29	1423	0.034	0.996	0.008
46008 (Avon @ Loddiswell)	0.297	102.37	1549	0.03	0.986	0.006
60006 (Gwili @ Glangwili)	0.353	131.05	1603	0.029	0.999	0.004
72015 (Lune @ Lunes Bridge)	0.39	140.83	1630	0.055	0.993	0.002
203033 (Upper Bann @ Bannfield)	0.397	101.64	1261	0.062	0.951	0.001
47005 (Ottery @ Werrington Park)	0.399	121.64	1199	0.047	0.999	0.005
79004 (Scar Water @ Capenoch)	0.425	142.76	1627	0.032	0.999	0.001
47024 (Tavy @ Tavistock Abbey Bridge)	0.45	95.63	1666	0.032	0.998	0.004
203039 (Clogh @ Tullynewey)	0.464	98.37	1296	0.074	0.986	0.001
67005 (Ceiriog @ Brynkinalt Weir)	0.471	111.76	1198	0.023	1	0.001
79003 (Nith @ Hall Bridge)	0.476	155.76	1512	0.066	0.973	0.003
45009 (Exe @ Pixton)	0.483	147.85	1375	0.017	0.95	0.001

PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	2 of 3		
TITLE	River Truim at Crubenmore Bridge [T15]	DATE	11/11/2016	Checked by	LG
	Pooling Group				

Heterogeneity Test

H2= 3.3782
H1= 7.8506
Heterogeneous and review undertaken; none removed

Distributions	Goodness-of-fit
	Z value
Generalised Logistic (GL)	0.2880
Generalised Extreme Value (GEV)	-1.9547

Growth Curve Fitting

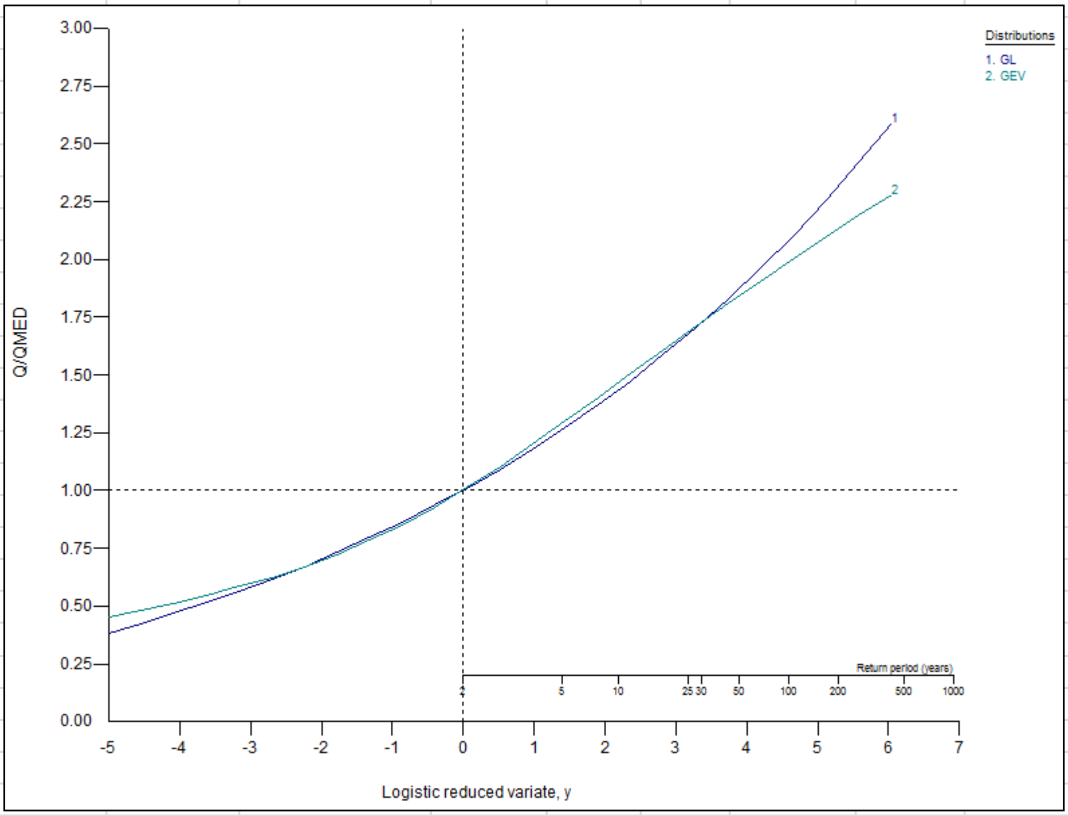
Return Period	GL	GEV
2	1	1
5	1.26	1.288
10	1.436	1.469
25	1.677	1.688
30	1.728	1.729
50	1.874	1.843
100	2.087	1.991
200	2.32	2.133
500	2.662	2.312
1000	2.95	2.442

Fitting for FFC Qmed= 72.282 m^3/s (catchment descriptors)

Return Period	GL	GEV
2	72.3	72.3
5	91.1	93.1
10	103.8	106.2
25	121.2	122.0
30	124.9	125.0
50	135.5	133.2
100	150.9	143.9
200	167.7	154.2
500	192.4	167.1
1000	213.2	176.5

PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	3 of 3		
TITLE	River Truim at Crubenmore Bridge [T15]	DATE	11/11/2016	Checked by	LG
	Pooling Group				

Growth Curves



PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	1 of 3		
TITLE	River Spey at Invertruim - 8007	DATE	11/11/2016	Checked by	LG
	Enhanced Single Site & Single Site Analysis				

Pooling group generated using WINFAP-FEH v4.1 dataset
and updated 8007 (Spey@Invertruim) record (June 2015 rating curve with 2016 value added).

Pooling Group Details

Station	Distance	Years of data	QMED AM	L-CV	L-SKEW	Discordancy
8007 (Spey @ Invertruim)	0	64	103.249	0.231	0.139	1.141
27043 (Wharfe @ Addingham)	0.306	41	262.267	0.167	0.062	0.87
79006 (Nith @ Drumlanrig)	0.393	39	336.556	0.133	0.132	0.449
21007 (Ettrick Water @ Lindean)	0.412	45	241.075	0.195	0.036	1.77
7001 (Findhorn @ Shenachie)	0.424	47	248.084	0.198	0.162	0.628
202001 (Roe @ Ardnargle)	0.424	39	149.642	0.088	0.017	1.366
45002 (Exe @ Stoodleigh)	0.436	54	140.766	0.18	0.286	2.295
81002 (Cree @ Newton Stewart)	0.456	43	226.806	0.148	0.038	0.365
27034 (Ure @ Kilgram Bridge)	0.469	47	243.408	0.129	0.084	0.917
77002 (Esk @ Canonbie)	0.476	44	354.566	0.13	0.16	0.534
25008 (Tees @ Barnard Castle)	0.481	47	261.3	0.175	0.156	0.664
Total		510				
Weighted means				0.216	0.123	

Station	Distance	AREA	SAAR	FPEXT	FARL	URBEXT 2000
8007 (Spey @ Invertruim)	0	401.59	1431	0.054	0.945	0
27043 (Wharfe @ Addingham)	0.306	429.98	1385	0.035	0.975	0.004
79006 (Nith @ Drumlanrig)	0.393	468.87	1485	0.041	0.99	0.002
21007 (Ettrick Water @ Lindean)	0.412	502.73	1306	0.039	0.928	0.002
7001 (Findhorn @ Shenachie)	0.424	415.59	1217	0.039	0.982	0
202001 (Roe @ Ardnargle)	0.424	365.69	1250	0.059	0.993	0.006
45002 (Exe @ Stoodleigh)	0.436	420.71	1361	0.022	0.979	0.002
81002 (Cree @ Newton Stewart)	0.456	366.25	1757	0.07	0.932	0.002
27034 (Ure @ Kilgram Bridge)	0.469	510.9	1338	0.045	0.99	0.004
77002 (Esk @ Canonbie)	0.476	495.37	1423	0.035	0.994	0.001
25008 (Tees @ Barnard Castle)	0.481	510.17	1310	0.035	0.912	0.00

Note: Superseded 8007 (Spey@Invertruim) in WINFAP-FEH v4.1 dataset marked "not suitable for Pooling".

PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	2 of 3		
TITLE	River Spey at Invertruim - 8007 Enhanced Single Site & Single Site Analysis	DATE	11/11/2016	Checked by	LG

Heterogeneity Test

H2= 2.3767
H1= 8.1217

Heterogeneous and review undertaken; none removed

Distributions

	Goodness-of-fit
	Z value
Generalised Logistic (GL)	5.5893
Generalised Extreme Value (GEV)	2.2607

Growth Curve Fitting - Enhanced Single Site

Return Period	GL	GEV
2	1	1
5	1.332	1.369
10	1.555	1.596
25	1.855	1.866
30	1.917	1.917
50	2.097	2.055
100	2.358	2.232
200	2.64	2.4
500	3.05	2.609
1000	3.392	2.757

Growth Curve Fitting - Single Site

Return Period	GL	GEV
2	1	1
5	1.361	1.4
10	1.607	1.654
25	1.944	1.961
30	2.014	2.019
50	2.22	2.18
100	2.52	2.39
200	2.848	2.592
500	3.332	2.849
1000	3.74	3.035

Fitting for FFC

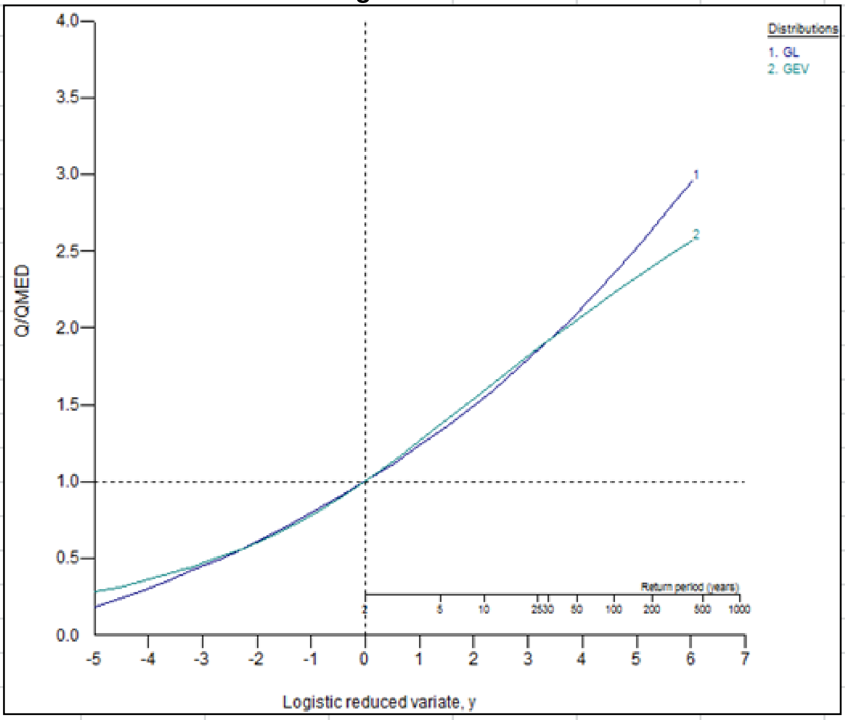
Qmed= 103.249 m^3/s (from 8007 AMAX)

Return Period	GL	GEV
2	103.2	103.2
5	137.5	141.3
10	160.6	164.8
25	191.5	192.7
30	197.9	197.9
50	216.5	212.2
100	243.5	230.5
200	272.6	247.8
500	314.9	269.4
1000	350.2	284.7

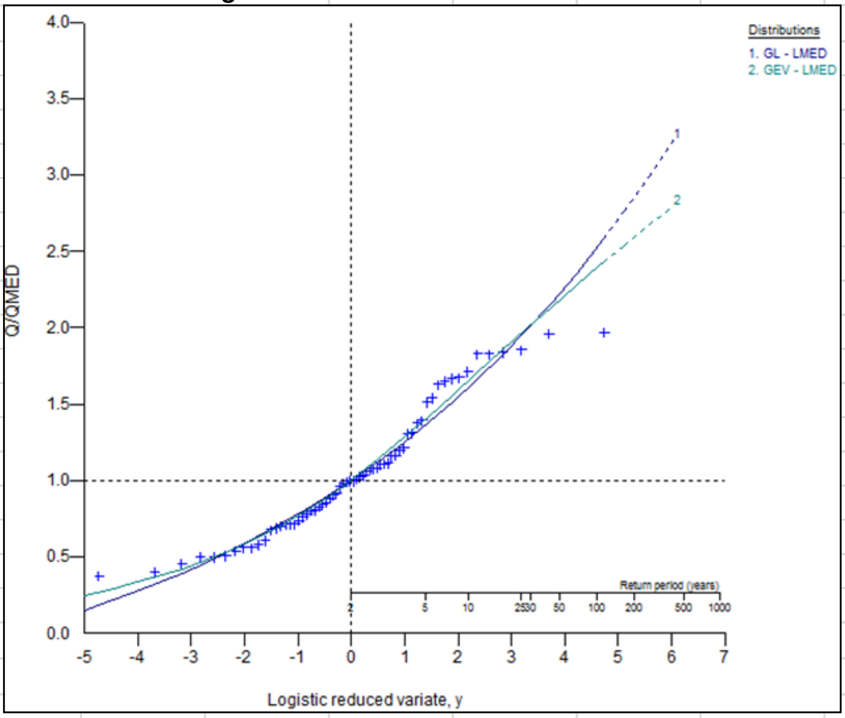
Return Period	GL	GEV
2	103.2	103.2
5	140.5	144.5
10	165.9	170.8
25	200.7	202.5
30	207.9	208.5
50	229.2	225.1
100	260.2	246.8
200	294.1	267.6
500	344.0	294.2
1000	386.2	313.4

PROJECT	A9 Dualling	JOB No	97318	Calculated by	JMcN
		PAGE	3 of 3		
TITLE	River Spey at Invertruim - 8007 Enhanced Single Site & Single Site Analysis	DATE	11/11/2016	Checked by	LG

Growth Curves - Enhanced Single Site



Growth Curves - Single Site



Rainfall Runoff Methods

Example – Spey at Invertruim (8007)

FEH RR – 200yr using FEHcds with SPR adjusted to 37.420 (gauge BFI 0.52) and winter profile

Unit hydrograph time to peak	:	4.617 hours
Instantaneous UH time to peak	:	4.567 hours
Data interval	:	0.100 hours
Design storm duration	:	11.300 hours
Critical storm duration	:	11.224 hours
Return period for design flood	:	200.000 years
Requires rain return period	:	246.667 years
ARF	:	0.889
Design storm depth	:	87.445 mm
CWI	:	124.937
Standard Percentage Runoff	:	37.420 %
Percentage runoff	:	44.113 %
Snowmelt rate	:	0.000 mm/day
Unit hydrograph peak	:	19.135 (m3/s/mm)
Quick response hydrograph peak	:	521.364 m3/s
Baseflow	:	17.254 m3/s
Baseflow adjustment	:	0.000 m3/s
Hydrograph peak	:	538.618 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 v

ReFH2 – 200yr using FEHcds and winter profile

Site details

Checksum: 5DAB-D54D

Site name: 8007

Easting: 268650

Northing: 796200

Country: Scotland

Catchment Area (km²): 401.59

Using plot scale calculations: No

Site description: None

Model run: 200 year

Summary of results

Rainfall - FEH 1999 (mm):	74.83	Total runoff (ML):	9877.37
Total Rainfall (mm):	54.39	Total flow (ML):	21027.23
		Peak flow (m³/s):	655.48
Peak Rainfall (mm):	12.36		

Parameters

Where the user has overriden a system-generated value, this original value is shown in square brackets after the value used.

** Indicates that the user locked the duration/timestep*

Rainfall parameters (Rainfall - FEH 1999 model)

Name	Value	User-defined?
Duration (hh:mm:ss)	05:30:00	No
Timestep (hh:mm:ss)	00:30:00	No
SCF (Seasonal correction factor)	0.85	No
ARF (Areal reduction factor)	0.85	No
Seasonality	Winter	n/a

Loss model parameters

Name	Value	User-defined?
Cini (mm)	133.52	No
Cmax (mm)	355.41	No
Use alpha correction factor	No	No
Alpha correction factor	n/a	No

Routing model parameters

Name	Value	User-defined?
Tp (hr)	2.12	No
Up	0.65	No
Uk	0.8	No

Baseflow model parameters

Name	Value	User-defined?
BF0 (m^3/s)	25.01	No
BL (hr)	30.47	No
BR	1.13	No

Method Analysis

Annex Table 3: 200yr flow estimates (m^3/s) for River Truim catchments produced by a range of methods

LABEL	Truim-01	Truim-02	Truim-03	Truim-04	Truim-05	Truim-06	Truim-07	Truim-08	Truim-09	Truim-10	Truim-11	Truim-12	Truim-13	Truim-14	Truim-15	Truim-16	Truim-17	8007	Spey for comparison
Easting	262650	262800	262750	263100	263600	263850	263900	263850	264000	264150	265250	265400	267500	267650	267650	268350	268700	268650	268600
Northing	777300	779100	779700	780700	781450	782350	783000	783850	785300	785450	787400	787550	265460	791050	791450	792800	796150	796200	796150
AREA	2.73	7.79	15.93	21.79	27.19	30.05	33.6	36.55	42.59	45.81	58.16	62.6	105.68	112.59	116.84	119.99	124.8	401.59	276.78
$Qmed_{cds}$	4.1	10.5	18.3	23.4	27.7	30.1	32.9	35.1	39.3	40.5	46.4	49.3	67.6	70.8	72.3	72.9	72.7	180.4	126.0
$Qmed_{s,adj}$	3.4	8.6	15.0	19.3	22.8	24.7	27.0	28.8	32.2	33.1	37.7	40.0	54.8	57.4	58.5	59.0	58.8	-	96.3
FEH RR	16.3	36.1	69.0	88.0	104.7	110.2	119.2	124.3	133.6	140.4	153.7	163.7	242.6	250.9	256.4	249.7	235.5	700.9	485.3
FEH RR SPR(BFI)	16.7	38.0	71.0	90.6	107.3	113.0	122.5	127.9	138.4	147.7	166.5	177.3	259.9	269.6	276.3	270.5	258.5	538.6	374.5
REFH2	9.2	26.3	48.2	64.1	75.9	81.1	88.6	95.7	104.5	109.7	127.0	135.6	205.6	213.8	218.8	220.3	206.2	655.5	461.7
Single Site (GL)	9.6	24.6	42.9	54.9	64.9	70.4	76.8	82.0	91.7	94.2	107.4	114.0	156.1	163.4	166.7	168.0	167.5	294.1	274.2
Enhanced SS (GL)	8.9	22.8	39.7	50.9	60.2	65.3	71.2	76.0	85.0	87.3	99.6	105.6	144.7	151.4	154.6	155.7	155.3	272.6	254.2
Pooling (at T15)	7.8	20.0	34.9	44.8	52.9	57.4	62.6	66.8	74.7	76.7	87.5	92.8	127.2	133.1	135.8	136.9	136.4	239.5	223.4

$Qmed_{cds}$ = Qmed calculated from descriptors; $Qmed_{s,adj}$ = Qmed transferred from 8007 [$Qmed_{obs}$ 103.249] (Kjeldsen et al, 2008).

A.3 Catchments at A9 crossings

Catchment Descriptors

Annex Table 4: Donor FEH catchment descriptors for catchments at A9 crossings

LABEL	NN63758145	NN63958235	NN63958385	NN64008305	NN64258490	NN65358695	NN65708710	NN66958870	NN67608960	NN67709110
Easting	263750	263950	263950	264000	264250	265350	265700	266950	267600	267700
Northing	781450	782350	783850	783050	784900	786950	787100	788700	789600	791100
AREA	1.26	1.77	5.08	1.61	0.59	0.56	36.23	1.05	2.26	3.43
ALTBAR	744	713	581	746	432	396	593	432	539	472
ASPBAR	299	304	307	301	276	342	323	296	300	321
ASPVAR	0.56	0.8	0.6	0.64	0.89	0.88	0.27	0.72	0.53	0.55
BFIHOST	0.434	0.43	0.373	0.432	0.364	0.387	0.387	0.373	0.34	0.391
DPLBAR	2.05	2.14	3.12	2.78	0.73	0.88	6.23	0.99	1.89	2.58
DPSBAR	276.1	232.3	173.4	255.1	138.1	96.2	214.5	189	150.2	124.9
FARL	1	1	1	1	1	1	0.915	1	1	1
LDP	3.28	3.42	5.86	4.04	1.56	1.79	11.09	2.71	3.41	4.43
PROPWET	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72	0.72
RMED-1H	10.7	10.6	10.3	10.6	9.9	9.8	10.1	9.6	9.6	9.2
RMED-1D	41.6	40.7	39.6	39.9	39.4	37	37.2	34.8	33.5	31.7
RMED-2D	59.3	58	56.2	56.6	56.1	52.1	52.9	48.2	46.8	45
SAAR	1717	1669	1496	1706	1285	1170	1441	1163	1215	1147
SAAR4170	1785	1721	1481	1722	1229	1165	1394	1089	1080	1015
SPRHOST	57.87	57.47	54.94	57.82	48.29	48.61	54.85	51.7	53.4	48.74
URBEXT1990	0	0	0	0	0	0	0	0	0	0
URBEXT2000	0	0	0	0	0	0	0	0	0	0

Flow Estimates

Annex Table 5: Design flow estimates at crossings – Baseline

Crossing ID	Watercourse Category	Donor catchment	FEH area (km^2)	Estimated area	5yr (m^3/s)	10yr (m^3/s)	30yr (m^3/s)	50yr (m^3/s)	200yr (m^3/s)	1000yr (m^3/s)
65	Minor	NN63758145	-	0.38	0.7	0.9	1.2	1.3	1.7	2.2
66	Minor	NN63758145	-	0.03	0.1	0.1	0.1	0.1	0.2	0.2
67	Minor	NN63758145	-	0.25	0.5	0.6	0.8	0.9	1.2	1.5
68	Minor	NN63958235	-	0.01	0.0	0.0	0.1	0.1	0.1	0.1
69	Minor	NN63958235	-	0.09	0.2	0.2	0.3	0.3	0.5	0.6
70	Minor	NN63958235	-	0.20	0.4	0.5	0.6	0.7	1.0	1.2
71	Minor	NN63958235	-	0.02	0.0	0.1	0.1	0.1	0.1	0.1
72	Major	NN63958235	1.77	1.65	3.4	4.1	5.5	6.3	8.4	12.1
74	Minor	NN63958235	-	0.02	0.0	0.1	0.1	0.1	0.1	0.1
75	Minor	NN63958235	-	0.02	0.1	0.1	0.1	0.1	0.1	0.2
77	Minor	NN63958235	1.77	1.11	2.9	3.5	4.6	5.3	7.2	10.5
78	Major	NN64008305	1.61	1.73	3.4	4.0	5.4	6.1	8.2	11.8
79	Minor	NN63958385	-	0.04	0.1	0.1	0.1	0.1	0.2	0.2
81	Minor	NN63958385	-	0.42	0.7	0.8	1.1	1.2	1.6	2.1
82	Minor	NN63958385	-	0.43	0.7	0.9	1.1	1.3	1.7	2.1
83	Major	NN63958385	5.08	4.54	7.6	9.1	12.2	13.8	18.4	26.5
84	-	NN64258490	-	0.09	0.1	0.2	0.2	0.3	0.3	0.4
85	-	NN64258490	-	0.23	0.3	0.4	0.5	0.6	0.8	1.0
86	Minor	NN64258490	-	0.02	0.0	0.0	0.1	0.1	0.1	0.1
87	Minor	NN64258490	-	0.05	0.1	0.1	0.1	0.1	0.2	0.2
89	Minor	NN64258490	-	0.03	0.1	0.1	0.1	0.1	0.1	0.2
90	Major	NN64258490	0.59	0.57	1.4	1.7	2.3	2.6	3.6	5.4
91	Minor	NN64258490	-	0.08	0.1	0.2	0.2	0.2	0.3	0.4
92	-	NN64258490	-	0.06	0.1	0.1	0.2	0.2	0.2	0.3
93	-	NN64258490	-	0.09	0.1	0.2	0.2	0.2	0.3	0.4
94	Minor	NN64258490	-	0.13	0.2	0.2	0.3	0.4	0.5	0.6
95	Minor	NN65358695	-	0.12	0.2	0.2	0.3	0.3	0.4	0.5
96	Minor	NN65358695	-	0.12	0.2	0.2	0.3	0.3	0.4	0.5
97	Minor	NN65358695	-	0.13	0.2	0.2	0.3	0.3	0.4	0.5
98	Minor	NN65358695	-	0.14	0.2	0.2	0.3	0.4	0.5	0.6
99	Minor	NN65358695	-	0.12	0.2	0.2	0.3	0.3	0.4	0.5
100	Minor	NN65358695	-	0.24	0.3	0.4	0.5	0.6	0.7	1.0
101	Major	NN65358695	0.56	0.38	0.5	0.6	0.7	0.8	1.1	1.4
102	Minor	NN65358695	-	0.02	0.0	0.0	0.0	0.1	0.1	0.1
103	Minor	NN65358695	-	0.19	0.3	0.3	0.4	0.5	0.6	0.8
104	Minor	NN65358695	-	0.01	0.0	0.0	0.0	0.0	0.0	0.1
106	Major	NN65708710	36.23	36.54	47.7	56.7	75.2	84.9	112.5	160.6
107	Minor	NN66958870	-	0.12	0.2	0.2	0.3	0.3	0.4	0.5
109	Major	NN66958870	-	0.34	0.4	0.5	0.7	0.8	1.0	1.3
110	Minor	NN66958870	-	0.07	0.1	0.1	0.2	0.2	0.3	0.3

Crossing ID	Watercourse Category	Donor catchment	FEH area (km^2)	Estimated area	5yr (m^3/s)	10yr (m^3/s)	30yr (m^3/s)	50yr (m^3/s)	200yr (m^3/s)	1000yr (m^3/s)
111	Minor	NN66958870	-	0.14	0.2	0.2	0.3	0.3	0.5	0.6
112	Minor	NN66958870	-	0.22	0.3	0.3	0.4	0.5	0.7	0.9
114	Major	NN66958870	-	0.27	0.3	0.4	0.5	0.6	0.8	1.1
115	Major	NN66958870	1.05	0.50	0.6	0.7	0.9	1.1	1.4	1.8
116	Minor	NN66958870	-	0.36	0.4	0.5	0.7	0.8	1.0	1.3
117	Minor	NN66958870	-	0.13	0.2	0.2	0.3	0.3	0.4	0.5
118	Minor	NN66958870	-	0.05	0.1	0.1	0.1	0.1	0.2	0.2
119	Minor	NN66958870	-	0.17	0.2	0.3	0.4	0.4	0.5	0.7
120	Minor	NN66958870	-	0.28	0.4	0.4	0.6	0.6	0.8	1.1
121	Minor	NN66958870	-	0.04	0.1	0.1	0.1	0.1	0.2	0.2
122	Major	NN67608960	2.26	2.43	4.2	5.0	6.6	7.5	10.2	14.9
123	Minor	NN66958870	-	0.11	0.2	0.2	0.2	0.3	0.4	0.5
124	Minor	NN67608960	-	0.14	0.2	0.2	0.3	0.4	0.5	0.6
125	Minor	NN67608960	-	0.19	0.3	0.3	0.4	0.5	0.6	0.8
126	Minor	NN67608960	-	0.18	0.3	0.3	0.4	0.5	0.6	0.8
127	Minor	NN67608960	-	0.23	0.3	0.4	0.5	0.6	0.7	1.0
128	Minor	NN67608960	-	0.21	0.3	0.3	0.5	0.5	0.7	0.9
129	Minor	NN67608960	-	0.15	0.2	0.3	0.3	0.4	0.5	0.7
130	Major	NN67608960	-	0.18	0.3	0.3	0.4	0.5	0.6	0.8
132	Major	NN67709110	3.43	3.82	5.4	6.5	8.4	9.6	13.0	18.8

IH124 parameters: SOIL 0.5.

FEH RR parameters: DPL for ID76 calculated from estimated area using FEH, otherwise DPL values from donor catchments. SPR adjusted to 57.37 where otherwise lower.

Annex Table 6: 200yr flow estimates at crossings – Stage 3 4th Iteration Design Freeze

Crossing ID	Watercourse Category	FEH donor catchment	FEH area (km²)	Estimated area	5yr (m³/s)	10yr (m³/s)	30yr (m³/s)	50yr (m³/s)	200yr (m³/s)	1000yr (m³/s)
65	Minor	NN63758145		0.38	0.7	0.9	1.2	1.3	1.7	2.2
66	Minor	NN63758145		0.03	0.1	0.1	0.1	0.1	0.2	0.2
67	Minor	NN63758145		0.25	0.5	0.6	0.8	0.9	1.2	1.5
68	Minor	NN63958235		0.01	0.0	0.0	0.1	0.1	0.1	0.1
69	Minor	NN63958235		0.09	0.2	0.2	0.3	0.3	0.5	0.6
70	Minor	NN63958235		0.20	0.4	0.5	0.6	0.7	1.0	1.2
71	Minor	NN63958235		0.02	0.0	0.1	0.1	0.1	0.1	0.1
72	Major	NN63958235	1.77	1.65	3.4	4.1	5.5	6.3	8.4	12.1
74	Minor	NN63958235		0.02	0.0	0.1	0.1	0.1	0.1	0.1
75	Minor	NN63958235		0.02	0.1	0.1	0.1	0.1	0.1	0.2
76	Minor	NN63958235	1.77	1.11	2.9	3.5	4.6	5.3	7.2	10.5
77	Major	NN64008305	1.61	1.73	3.4	4.0	5.4	6.1	8.2	11.8
78	Minor	NN63958385		0.03	0.1	0.1	0.1	0.1	0.1	0.2
79	Minor	NN63958385		0.43	0.7	0.8	1.1	1.2	1.6	2.1
81	Minor	NN63958385		0.43	0.7	0.9	1.1	1.3	1.7	2.1
82	Major	NN63958385	5.08	4.66	7.8	9.4	12.5	14.1	18.9	27.2
85	Minor	NN64258490		0.23	0.3	0.4	0.5	0.6	0.8	1.0
86	Minor	NN64258490		0.04	0.1	0.1	0.1	0.1	0.2	0.2
87	Minor	NN64258490		0.03	0.1	0.1	0.1	0.1	0.1	0.2
89	Major	NN64258490	0.59	0.57	1.4	1.7	2.3	2.6	3.6	5.4
90	Minor	NN64258490		0.14	0.2	0.3	0.3	0.4	0.5	0.7
93	Minor	NN64258490		0.21	0.3	0.4	0.5	0.6	0.7	1.0
94	Minor	NN65358695		0.12	0.2	0.2	0.3	0.3	0.4	0.5
95	Minor	NN65358695		0.12	0.2	0.2	0.3	0.3	0.4	0.5
96	Minor	NN65358695		0.13	0.2	0.2	0.3	0.3	0.4	0.5
97	Minor	NN65358695		0.14	0.2	0.2	0.3	0.4	0.5	0.6
98	Minor	NN65358695		0.12	0.2	0.2	0.3	0.3	0.4	0.5
99	Minor	NN65358695		0.24	0.3	0.4	0.5	0.6	0.7	1.0
100	Major	NN65358695	0.56	0.38	0.5	0.6	0.7	0.8	1.1	1.4
101	Minor	NN65358695		0.02	0.0	0.0	0.0	0.1	0.1	0.1
102	Minor	NN65358695		0.19	0.3	0.3	0.4	0.5	0.6	0.8
103	Minor	NN65358695		0.01	0.0	0.0	0.0	0.0	0.0	0.1
104	Major	NN65708710	36.23	36.54	47.7	56.7	75.2	84.9	112.5	160.6
106	Minor	NN66958870		0.08	0.1	0.1	0.2	0.2	0.3	0.4
107	Major	NN66958870		0.37	0.5	0.6	0.7	0.8	1.1	1.4
109	Minor	NN66958870		0.07	0.1	0.1	0.2	0.2	0.3	0.3
110	Minor	NN66958870		0.12	0.2	0.2	0.3	0.3	0.4	0.5
111	Minor	NN66958870		0.24	0.3	0.4	0.5	0.5	0.7	0.9
112	Major	NN66958870		0.27	0.3	0.4	0.5	0.6	0.8	1.1
114	Major	NN66958870	1.05	0.50	0.6	0.7	0.9	1.1	1.4	1.8
115	Minor	NN66958870		0.36	0.4	0.5	0.7	0.8	1.0	1.3
116	Minor	NN66958870		0.13	0.2	0.2	0.3	0.3	0.4	0.5

Crossing ID	Watercourse Category	FEH donor catchment	FEH area (km^2)	Estimated area	5yr (m^3/s)	10yr (m^3/s)	30yr (m^3/s)	50yr (m^3/s)	200yr (m^3/s)	1000yr (m^3/s)
117	Minor	NN66958870		0.05	0.1	0.1	0.1	0.1	0.2	0.2
118	Minor	NN66958870		0.17	0.2	0.3	0.4	0.4	0.5	0.7
119	Minor	NN66958870		0.28	0.4	0.4	0.6	0.6	0.8	1.1
120	Minor	NN66958870		0.04	0.1	0.1	0.1	0.1	0.2	0.2
121	Major	NN67608960	2.26	2.43	4.2	5.0	6.6	7.5	10.2	14.9
122	Minor	NN66958870		0.11	0.2	0.2	0.2	0.3	0.4	0.5
123	Minor	NN67608960		0.14	0.2	0.2	0.3	0.4	0.5	0.6
124	Minor	NN67608960		0.19	0.3	0.3	0.4	0.5	0.6	0.8
125	Minor	NN67608960		0.18	0.3	0.3	0.4	0.5	0.6	0.8
126	Minor	NN67608960		0.23	0.3	0.4	0.5	0.6	0.7	1.0
127	Minor	NN67608960		0.21	0.3	0.3	0.5	0.5	0.7	0.9
128	Minor	NN67608960		0.15	0.2	0.3	0.3	0.4	0.5	0.7
129	Major	NN67608960		0.18	0.3	0.3	0.4	0.5	0.6	0.8
130	Major	NN67709110	3.43	3.82	5.4	6.5	8.4	9.6	13.0	18.8
132	Minor	NN67608960		0.18	0.3	0.3	0.4	0.4	0.6	0.8

IH124 parameters: SOIL 0.5.

FEH RR parameters: DPL for ID76 calculated from estimated area using FEH, otherwise DPL values from donor catchments. SPR adjusted to 57.37 where otherwise lower.

Annex B - Hydraulic Modelling

[For flood extents figures see Annex C]

B.1 Modelling notes

Annex Table 7: Mainline crossing modelling properties

Crossing ID	Existing Model Crossing Dimensions (m)	Existing Model Crossing Description	Proposed Model Crossing Dimensions (m)	Proposed Model Crossing Description
65	D = 1.4	1d Culvert	N/A	Outfall
67	D = 0.6	1d Culvert	N/A	Outfall
69	D = 0.6	1d Culvert	N/A	Outfall
72	W = 4.9	Cut	W = 5.2	Cut
76	D = 1.3	1d Culvert	W = 3.0, H = 1.8	1d Culvert
77	W = 5.0	Cut	W = 4.8	Cut
79	D = 0.8	1d Culvert	N/A	Outfall
80	D = 1.4	1d Culvert	N/A	Removed
81	D = 0.6	1d Culvert	W = 2.7, H = 1.0	1d Culvert
82	W = 5.1	Cut	N/A	Outfall
89	D = 0.45	1d Culvert	D = 0.45	1d Culvert
100	D = 1.0	1d Culvert	N/A	Outfall
104	W = 19.5	Cut	W = 13.0	Cut
110	D = 0.6	1d Culvert	N/A	Outfall
114	W = 1.8, H = 0.6	1d Culvert	N/A	Outfall
121	W = 5.0	Cut	N/A	Outfall
123	D = 0.65	1d Culvert	N/A	Outfall
130	W = 5.4	Cut	W = 4.5	Cut

<u>Key</u>

D	Diameter of the circular culvert.
W	Width of the box culvert or cut in topography.
H	Height of the box culvert.
1d Culvert	Modelled using a 1d culvert ESTRY unit in TUFLOW.
Cut	DTM cut either while producing the DTM or using a ZSH shape file in TUFLOW.
Outfall	Inflow boundary condition located downstream of mainline (crossing sized to pass 1 in 200 year flow).

B.2 Sifting Exercise – Identifying Encroachments

Sifting exercise carried out on 4th Iteration Design Freeze, with Assessment Design comment.

This table identifies real encroachments from those erroneously created by processing tools and summarises decisions to sift out encroachments. The final column has been updated in the current version of the FRA to address any changes to these encroachments in the Assessment Design.

Annex Table 8: Sifting exercise – encroachments from clashes.

* Conservative estimates: 'encr' = floodplain displaced by encroachment, 'cap' = floodplain lost due to removal of flow constriction.
NB estimates are indicative only, and do not account for 3D shape or channel flow volume (therefore may significantly over-estimate volume).

** 'Ruled out' = area overlain in plan by Proposed Scheme footprint (4th Iteration) rejected as a tangible encroachment.
'Encroachment' = area of floodplain volume loss identified, see FRA **Section 8** and **Section 9**.

Chainage	Associated feature	*Indicative vol. lost (200yr, m^3)	Characteristics of overlain floodplain	**Sifting decision *{comment on Assessment Design}*
ch. 20,150	W8.1	10 (encr)	Mainline footprint across floodwaters backing up from crossing ID65, including a periphery channel	Encroachment (periphery channel storage). Main channel ruled out as proposed crossing will have similar capacity and conveyance *{Encroachment unchanged in Assessment Design}*
ch. 20,350 to ch. 20,750	W8.38 [W8.41] [MW8.5]	N/A	Flood waters from crossing ID67 spilling across Existing Road and flowing north along road to crossings ID70 and 72	Ruled out: overland flow path (precluded by crossing upsizing and replaced by watercourse diversion). Potential impact of removal assessed separately
ch. 20,450	W8.40	N/A	Small area of out-of-bank flow upstream of crossing ID69	Ruled out: proposed crossing will have similar capacity and conveyance
ch. 20,700	MW8.1	100 (encr)	SuDS footprint in River Truim floodplain	Encroachment *{Encroachment minimised in Assessment Design}*
ch. 20,750	MW8.5	N/A	Mainline and track footprint across floodwaters in channel through crossing ID72 and ID73 NB crossing ID72 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Ruled out: proposed crossings will have similar capacity and conveyance
ch. 21,350 to ch. 21,450	W8.2 [MW8.6]	500 (encr) 250 (cap)	Mainline footprint across both the flood extent from flood waters backing up from crossing ID76, and the floodwaters spilling northwards to join MW8.6 NB crossing ID77 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Encroachment. Part ruled out as overland flow path precluded by crossing upsizing and watercourse diversion. Potential impact of removal assessed separately *{Encroachment into water backing up unchanged in Assessment Design}*
ch. 21,400	W8.2	N/A	Track footprint across channel	Ruled out: proposed crossing will have similar capacity and conveyance

Chainage	Associated feature	*Indicative vol. lost (200yr, m^3)	Characteristics of overlain floodplain	**Sifting decision *{comment on Assessment Design}*
ch. 21,450	MW8.6	N/A	Mainline footprint across crossing ID77. (see ch. 21,350 above for floodwater upstream of crossing) NB crossing ID77 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Ruled out: proposed crossing will have similar capacity and conveyance
ch. 21,650 to ch. 22,000	W8.58 [W8.7] MW8.1	250 (encr) 50 (cap)	[Upstream] Mainline footprint across out-of-bank flow upstream of crossing ID79 joining flood waters backing up from crossing, spreading south and minimal flow spilling north to join flood extent adjacent to underpass south of crossing ID81 [Downstream] Mainline footprint across combined floodplain	[Upstream] Encroachment. Part ruled out as overland flow path precluded by crossing upsizing and watercourse diversion. Potential impact of removal assessed separately *{Encroachment unchanged in the Assessment Design}* [Downstream] Ruled out: proposed diversion channel will have similar capacity
ch. 22,000 to ch. 22,150	W8.7	2500 (encr) 600 (cap)	[Upstream] Mainline footprint across floodwaters backing up from crossing ID81, spreading to pass through adjacent underpass [Downstream] Mainline footprint across watercourse channel and underpass route	[Upstream] Encroachment *{Encroachment reduced in Assessment Design}* [Downstream] Ruled out: proposed crossing will have similar capacity and conveyance
ch. 22,250	MW8.8	N/A	Mainline footprint across crossing ID82 NB crossing ID82 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Ruled out: proposed crossing will have similar capacity and conveyance
ch. 22,500	MW8.1	N/A	Junction footprint across River Truim	Ruled out: proposed crossing will span floodplain
ch. 22,550	MW8.1	150 (encr)	SuDS and track footprint into the River Truim	Encroachment *{Encroachment REMOVED in Assessment Design}*
ch. 23,350 to ch. 23,400	MW8.9	N/A	Floodwaters backing up from crossing ID89, mostly spanned by structure – small encroachment into floodwaters backed up the channel NB crossing ID88 represented in the model using cut in the DTM: flood waters from MW8.9 are not predicted to overtop A9	Ruled out: storage offset *{Storage lost in Assessment Design due to revised watercourse diversion sizing – impact downstream assessed separately}*
ch. 23,350 to ch. 23,400	A8.1	N/A	Mainline across aqueduct channel adjacent to road, upstream of A9 crossing ID88 NB crossing ID88 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Ruled out: proposed crossing will span aqueduct channel

Chainage	Associated feature	*Indicative vol. lost (200yr, m^3)	Characteristics of overlain floodplain	**Sifting decision *{comment on Assessment Design}*
ch. 25,400 to ch. 25,450	MW8.12	10 (encr)	[Upstream] Mainline footprint across floodwaters backing up from ID100 crossing, including a periphery channel [Downstream] Mainline footprint and track on floodwaters spreading from crossing ID100	[Upstream] Encroachment (periphery channel storage). Main channel ruled out as proposed crossing will have similar capacity and conveyance *{Encroachment unchanged in Assessment Design}* [Downstream] Ruled out: overland flow path precluded by watercourse diversion (incl. track crossing). Potential impact of removal assessed separately
ch. 25,500	W8.103	N/A	Track footprint in floodplain downstream of crossing ID101	Ruled out: overland flow path from MW8.12 precluded by watercourse diversion (incl. track crossing). Potential impact of removal assessed separately. Track crossing to have capacity for W8.103
ch. 25,850 to ch. 26,000	MW8.14	2600 (encr)	Mainline footprint, SuDS and track on floodplain upstream of ID104 crossing. Crossing capacity maintained NB crossing ID104 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Encroachment NB Cuaich area analysed in more detail in FRA body *{Encroachments reduced in Assessment Design}*
ch. 26,100	MW8.14	50 (encr)	Mainline footprint across floodwaters downstream of crossing ID104 NB crossing ID104 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Encroachment NB Cuaich area analysed in more detail in FRA body
ch. 27,250 to ch. 27,650	W8.19a W8.22	300 (encr)	Track, and Mainline footprint adjacent to layby, in floodplain between A9 and HML railway	Encroachment *{Encroachments REMOVED in Assessment Design}*
ch. 27,950 to ch. 28,000	MW8.19	10 (encr)	[Upstream] Mainline footprint in floodwaters backing up from ID114 crossing [Downstream] Mainline footprint and track on floodwaters spreading from crossing ID114	[Upstream] Encroachment. Channel further upstream ruled out as proposed crossing will have similar capacity and conveyance *{Encroachment unchanged in Assessment Design}* [Downstream] Ruled out: overland flow path precluded by watercourse diversion (incl. track crossing). Potential impact of removal assessed separately
ch. 28,300 to ch. 28,350	W8.24 MW8.18	30 (encr)	Track on floodplain, downstream of crossing ID116	Encroachment, part ruled out due to proposed crossing capacity and new watercourse diversion *{Encroachment unchanged in Assessment Design}*
ch. 28,450	W8.153 MW8.18	10 (encr)	Track on floodplain, downstream of crossing ID117	Encroachment, part ruled out due to proposed crossing capacity *{Encroachment unchanged in Assessment Design}*
ch. 28,550	W8.154 MW8.18	N/A	Track on floodplain, downstream of crossing ID118	Ruled out: proposed crossing will have similar capacity

Chainage	Associated feature	*Indicative vol. lost (200yr, m^3)	Characteristics of overlain floodplain	**Sifting decision *{comment on Assessment Design}*
ch. 28,650 to ch. 700	MW8.18	15 (encr)	Track / SuDS on floodplain	Encroachment *{Encroachment REMOVED in Assessment Design}*
ch. 28,900 to ch. 29,000	W8.160 MW8.18	40 (encr)	Track / Mainline footprint on floodplain (backing up watercourse)	Encroachment *{Encroachment increased in Assessment Design}*
ch. 29,050	W8.166	N/A	Track on floodplain downstream of crossing ID120 (also backing up watercourse)	Ruled out: proposed crossing will have similar capacity and conveyance
ch. 29,300 to ch. 29,350	MW8.20	100 (encr)	Track on floodplain and watercourse channel downstream of crossing ID121 NB crossing ID121 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Encroachment *{Encroachment REMOVED in Assessment Design}*
ch. 29,450	W8.27	N/A	Mainline footprint on channel downstream of ID123 crossing	Ruled out: proposed crossing will have similar capacity and conveyance
ch. 29,500	W8.28	N/A	Mainline footprint on channel upstream and downstream of crossing ID124	Ruled out: proposed crossing will have similar capacity and conveyance
ch.30,600 to ch. 30,700	MW8.1 MW8.22	800 (encr)	SuDS footprint in River Truim floodplain and floodplain downstream of crossing ID130 NB crossing ID130 represented in the model using cut in the DTM: flood waters are not predicted to overtop A9	Encroachment *{Encroachment REMOVED in Assessment Design}*
ch. 30+700 to ch. 30,950	MW8.1 MW8.22	900 (encr)	Track footprint in River Truim floodplain and floodplain downstream of crossing ID130	Encroachment *{Encroachment reduced in Assessment Design}*

B.3 Analysis: Impacts on 200yr floodplain

Comparison of Stage 3 model results (post-development versus existing case)

Impacts estimated using H&HM model results (4th Iteration Design Freeze, without mitigation).

This table records the results of the flood modelling exercise at locations where the Proposed Scheme affects the functional floodplain, and notes the potential effects on flood risk including impacts at adjacent receptors. The final column has been updated in the current version of the FRA to address any changes to these impacts in the Assessment Design.

Annex Table 9: Comparison of Stage 3 model results (post-development versus existing case)

*Elements of the Proposed Scheme categorized as: 'Mainline', 'SuDS' or 'Track' (encroachments), 'Crossing' (watercourse crossing structure/culvert changed) and 'Diversion' (watercourse channel moved and or significantly enlarged).

Changes described as the post-development results relative to the baseline model results. The predicted impact of crossing upsizing is conservative where the watercourse upstream of a crossing has not been modelled in the proposed case – see FRA **Section 6 for more on the precautionary assessment approach.

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 20,150 to ch. 20,300	W 8.1	Encroachment Crossing ID65 Diversion	Locally: flood extents are confined to the line of the diversion channel for approximately 130m where before floodplain in the existing case is otherwise up to 50m wide. Downstream floodplain: flood depths are comparable approximately 25m beyond the end of the diversion to the west. To the north, the difference in depth is insignificant compared to the influence of changes at ch. 20,350, noted below. Adjacent Truim channel: depths are the same	Overall reduction in flood risk A9: flood risk reduced upstream, no material difference downstream	No change

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 20,350 to ch. 20,750	W 8.38	Encroachment Crossing ID67	Locally: the crossing has capacity in the post-development case and accordingly the proposed case flood extent is not predicted to spill across the road from an overtopping upstream in the proposed case, unlike the existing case. Proposed outfall location is 21m south of the existing outfall. Proposed flood extent adjacent to the new outfall location is then approximately 5m wider over a 25m length, with approximately 40mm depth increase locally. Downstream floodplain: flood depths are comparable approximately 60m to the west of the road at crossing ID67, and by ID68 150m north of ID67. Proposed flood extent does not run north to crossing ID72. Floodplain at crossing ID72 is then 9m narrower. Adjacent Truim channel: depths are the same	Overall reduction in flood risk A9: flood risk reduced upstream, local increase in levels downstream has no material effect as the road is elevated approximately 5m above the floodplain	No change
ch. 20,450	W 8.40	Crossing ID69	New culvert covers existing channel. Locally: depths are the same. Wider combined floodplain: depths are the same. Adjacent Truim channel: depths are the same	No impact on flood risk	No change
ch. 20,650 to ch. 20,750	MW 8.5	Track	Locally: 200yr WL in the channel increased by up to 0.1m. Truim downstream: depths immediately downstream of adjacent W8.2 inflow are the same in existing and proposed cases	Local increase in flood risk [No key receptors]	Encroachment reduced – impact on flood risk reduced
ch. 21,350 to ch. 21,400	W 8.2	Encroachment Crossing ID76 Diversion	Locally: depth upstream of the crossing is approximately 170mm higher in the proposed case, extending 3 to 5m further up the hillside as a result. Flows overland to ID77, as in the existing case. Due in part to lack of capacity in 4th Iteration diversion channel. Downstream floodplain: depth in the downstream channel is increased by as much as a metre as flood extent is confined to the diversion channel. Adjacent Truim channel: depths upstream of the bridge and 70m downstream are the same pre- and post-development	Localised increase in flood risk. See A9 note below A889, NRP (NRes-001): no effect on water level A9: minor increase in flood risk, due to erroneous channel size. Flood risk reduced if assuming design capacity	Watercourse channel upsized and crossing has capacity. Reduction of flood risk

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 21,650 to ch. 22,000	W 8.58	Encroachment Crossing ID79	Locally: due to changes in the contributing catchment upstream, 200yr design flow is increased by 2%. The crossing outfall is to be relocated approximately 6m south of its current position. The 4th Iteration diversion channel as represented in the 2D model does not have capacity and proposed flood extent is thus approximately 5m wider to the south of the crossing than in the existing case; however, this is predicted to be contained within the channel in reality. Marked reduction in flood risk upstream. Downstream floodplain: beyond the short diversion channel the model predicts that 200yr WL may be raised by approximately 2mm. Adjacent Truim channel: depths pre-- and post-development are the same downstream of the dam (ch. 21,900)	Overall reduction in flood risk A9: Overall reduction of flood risk, with no material increase in water level downstream – the A9 is over 4m above the floodplain	No change
ch. 22,000 to ch. 22,150	W 8.7	Encroachment Crossing ID81 Diversion	Locally: Local increase in 200yr WL of up to 100mm around the mouth of the diversion channel. Flood extents removed south of the channel. Although floodwaters are predicted by the model to spill from the diversion 20m downstream of the crossing, the diversion channel is smaller than model resolution and expected to have capacity for a further 60m before it re-joins the channel. Downstream floodplain: the floodplain 100m downstream of the crossing is predicted between 10 and 20mm deeper in the proposed case than the existing. Adjacent Truim channel: water levels are approximately 10mm higher in the proposed case	Local increase in flood risk downstream A9: Reduction of flood risk	Encroachment reduced – impact on flood risk reduced
ch. 22,250 to ch. 22,300	MW 8.8	Crossing ID82	Locally: Negligible change in channel downstream of crossing. Due to changes in the contributing catchment upstream, 200yr design flow is increased by 4%. Combined floodplain: watercourse merges with the Truim floodplain approximately 130m downstream of the crossing. Up to 5mm difference in predicted flood depths throughout. Adjacent Truim channel: difference in depths negligible	No impact on flood risk	No change
ch. 22,550	MW 8.1	SuDS Track	Locally: negligible change in flood level adjacent to encroachment. Adjacent Truim channel: depths are the same	No impact on flood risk	Encroachment removed – no impact on flood risk

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 22,600 to ch. 23,550	A 8.1	Diversion	Locally: Increase in flood level in the aqueduct <0.02m. Adjacent Truim channel: Approximately 2mm increase in predicted 200yr WL at confluence. Post-development model (4th Iteration) predicts water spills into the aqueduct from MW8.9, as for the existing case. See below	Localised increase in flood risk A9: increase in flood risk negligible – road >5m above water level RP & NRP (NRes-003/004; D-001): negligible changes, just upstream (<0.002m)	Water not predicted to spill into the aqueduct from MW8.9 – flood risk negligible
ch. 23,350 to ch. 23,350	MW 8.9	Encroachment Crossing ID89 Diversion	Locally: the encroachment and relocation of crossing ID89 move the floodplain higher on the hillslope. Floodwaters on this hillside are predicted to be approximately 0.75m deeper post-development (4th Iteration). Downstream floodplain: Negligible difference in downstream channel, other than relocation. Adjacent Truim channel: depths are the same	Localised increase in flood risk A9: increase in flood risk negligible – road 5m above water level	Water not predicted to spill into the aqueduct from MW8.9, proposed crossing and diversion channels predicted to have capacity for 200yr event – overall reduction in flood risk
ch. 25,400 to ch. 25,450	W 8.13	Encroachment Diversion Crossing ID100	Locally: the channel diversion is to have capacity for the design flow, thus in the proposed case out-of-bank flooding is only predicted from the point the diversion re-joins the channel, approximately 60m downstream of the crossing. Downstream floodplain: downstream of the point the diversion joins the channel, flood depth on the floodplain is approximately 10mm higher in the proposed case. Adjacent Truim channel: depths are the same	Overall reduction in flood risk HML: negligible changes in 200yr flood level (<0.002m)	Diversion channel more sympathetic to track layout – impact removed
ch. 25,850 to ch. 26,100	MW 8.14	Encroachment Underpass SuDS Track Crossing ID103 Crossing ID104 Sheep Pass	Locally: 200yr WL upstream of the crossing is predicted to be approximately 0.5m higher in the proposed case. Downstream floodplain: as a result of the underpass being inundated, a floodplain across Cuaich – approximately 0.1m deep in places – is predicted to be mobilised. Adjacent Truim channel: negligible difference in depths (<0.002m)	**Increase in flood risk** A9: no material increase in flood risk – road surface >5m above 200yr floodplain RPs and NRPs: flood risk introduced – 200yr depths predicted to reach 0.1m in places. See main body of FRA for analysis HML: negligible changes in 200yr flood level (<0.002m)	Encroachments reduced and underpass raised – lowering flood risk to Cuaich See 'Cuaich' sub-section of FRA **Section 9**

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 27,250 to ch. 27,650	MW 8.1 W8.19	Track Encroachment	Locally: 200yr WL differ by up to 0.4m. Due to changes in the contributing catchment upstream, 200yr flow predicted to be 4% higher for the proposed case. Downstream floodplain: there is no difference between existing and proposed flood depth prediction downstream, west of the HML railway crossing at ch. 27,650. Adjacent Truim channel: depths are the same	**Increase in flood risk locally** A9: increase of up to 0.4m in adjacent flood level. Road approximately 4m above 200yr WL here HML: increase of up to 0.4m in adjacent flood level. Railway approximately 2m above 200yr WL	Encroachments removed – impact on flood risk removed
ch. 27,950 to ch. 28,150	MW 8.19	Encroachment Crossing ID114 Diversion	Locally: due to changed crossing location (35m to the south-west) and diversion channel downstream having capacity for the 200yr flow, floodplain downstream is reduced by approximately 0.7ha. Downstream floodplain: at the mouth of the diversion channel water levels are up to 0.15m higher, falling to 3mm 25m from the channel. Further downstream: 250m downstream of the new crossing there is no difference in 200yr flood levels	Overall reduction in flood risk A9: no material increase in flood risk - road level approximately 4.5m above 200yr WL	No change
ch. 28,300	MW 8.19	Track	Locally: 200yr WL is locally increased by up to 0.04m. Downstream floodplain: 50m downstream of the crossing difference in 200yr WL is <0.002m	Localised increase in flood risk A9: no material increase in flood risk - road level approximately 5m above 200yr WL	No change
ch. 28,450	MW 8.19	Track	Locally and wider floodplain: difference in 200yr WL is <0.002m, possibly passed on by larger encroachment upstream (see above)	Negligible increase in flood risk A9 over 5m above 200yr WL	No change
ch. 28,650 to ch. 28,700	MW 8.19	Track	Locally: difference in 200yr WL of up to 0.02m immediately upstream of the encroachment, with negligible difference (<0.002m) adjacent (west) of the encroachment. Downstream floodplain: depths are the same	Localised increase in flood risk [No key receptors]	Encroachment removed – impact on flood risk removed
ch. 28,900 to ch. 28 950	MW 8.1	Track	Locally: Floodplain slightly reduced; depths are the same	No impact on flood risk	Encroachment increased, no material increase in flood risk predicted at receptors

Chainage	Feature	*Changes affecting the floodplain	**Comparison of indicative 200yr floodplains	Overall impact and effect on flood risk Incl. impact at receptors	Assessment Design comment
ch. 29,300 to ch. 29,350	MW 8.20	Track	Locally: floodplain introduced by flood waters spilling from LHB of watercourse adjacent to encroachment. 200yr water level in channel approximately 0.1m higher. Water level in new floodplain predicted to pond to depths of 0.6m. Adjacent Truim channel: Up to 0.02m increase in peak water level locally	**Increase in flood risk** HML: flood level adjacent to HML increased by up to 0.6m. Rail level approximately 2m above 200yr WL	Encroachment removed – impact on flood risk removed
ch. 29,400 to ch. 29,450	W 8.27	Crossing ID123 Diversion	Locally: the location of the outfall has changed. No significant change in flood risk. Flood levels are approximately 0.01m shallower in the watercourse channel and 0.01m deeper to the west, in part due to the influence of the change at crossing ID121, noted above. NB The diversion channel is too small for its capacity to be accurately represented and accordingly the model results display an erroneous out-of-bank extent for the proposed case. Adjacent Truim channel: Up to 0.02m increase in peak water level locally	**Increase in flood risk** – may be due to impacts to south (see above) HML: flood level increased by less than 0.1m. Rail level approximately 2.5m above 200yr WL	Encroachment removed- – impact on flood risk removed
ch. 30,600 to ch. 30,750	MW 8.22 MW 8.1	SuDS Track	Adjacent Truim channel: encroachment likely to increase local flood level	**Increase in flood risk** – local flood levels and levels downstream RP (D-027): No measurable impact OS Road: No measurable impact	Encroachments reduced – flood risk removed

Annex C - Figures

Water Features

Figure WFP1 – A9P08-CFJ-EWE-J_ML200_ZZ-DR-EN-0001 (sheet 2) revision C02

Figure WFP2 – A9P08-CFJ-EWE-J_ML214_ZZ-DR-EN-0001 revision C02

Figure WFP3 – A9P08-CFJ-EWE-J_ML230_ZZ-DR-EN-0001 revision C02

Figure WFP4 – A9P08-CFJ-EWE-J_ML246_ZZ-DR-EN-0001 revision C02

Figure WFP5 – A9P08-CFJ-EWE-J_ML260_ZZ-DR-EN-0001 revision C02

Figure WFP6 – A9P08-CFJ-EWE-J_ML276_ZZ-DR-EN-0001 revision C02

Figure WFP7 – A9P08-CFJ-EWE-J_ML290_ZZ-DR-EN-0001 (sheet 8) revision C02

Figure WFP8 – A9P08-CFJ-EWE-J_ML290_ZZ-DR-EN-0001 (sheet 9) revision C02

Catchments

Figure CTP1– A9P08-CFJ-EWE-J_ZZZZZ_ZZ-DR-EN-0001 version C02

Flood Extents

Pre-development showing 4th Iteration Design Freeze (as modelled)

Figures FEX1 to FEX9

Post-development showing 4th Iteration Design Freeze (as modelled)

Figures FPO1 to FPO9

Potential Flood Risk Receptors

Figures PFR-1 to PFR-9

Compensatory Storage Areas

Figures CS-1 to CS-10

Figure CS-11 – interim design

Water Features

Figure WFP1

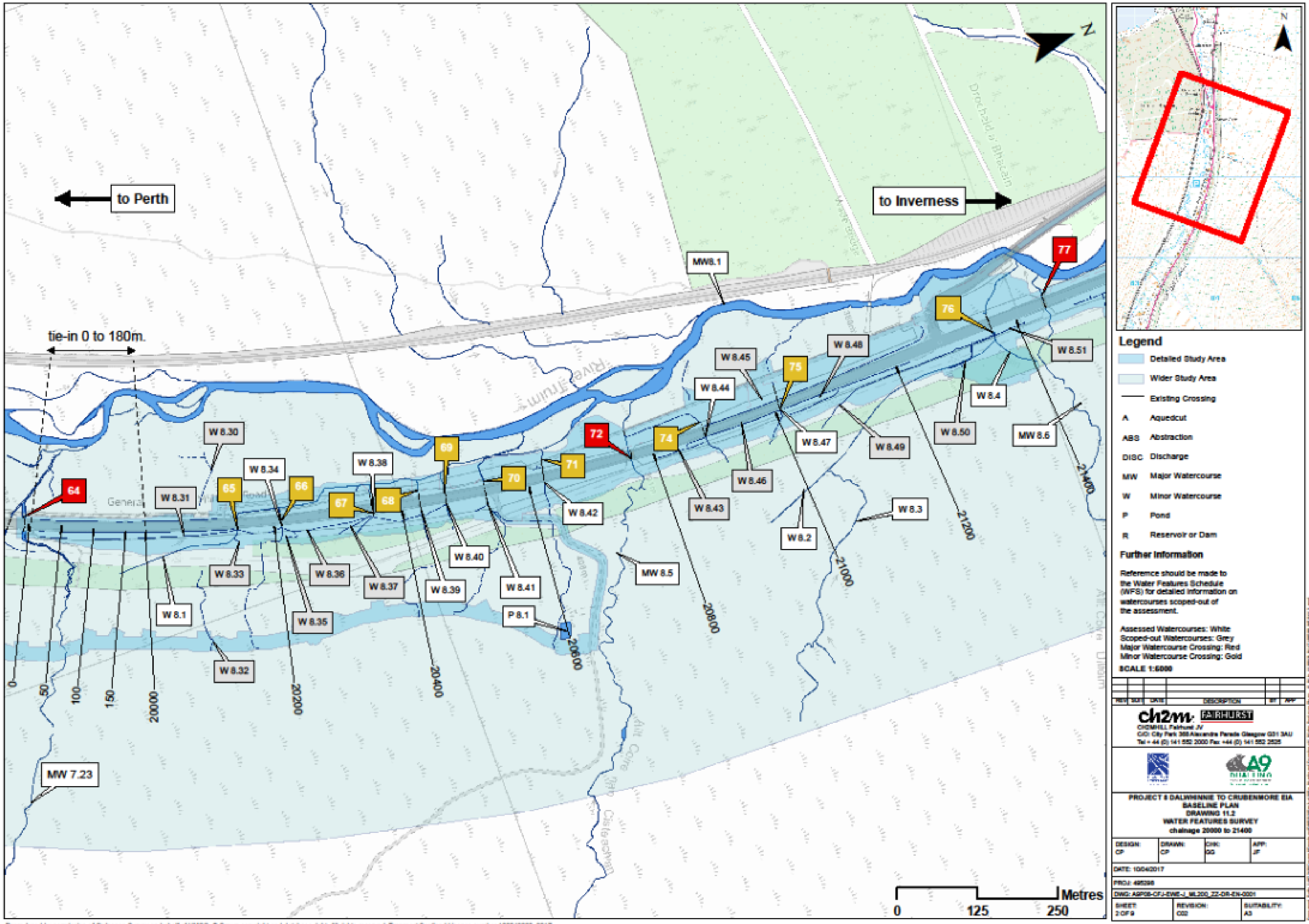
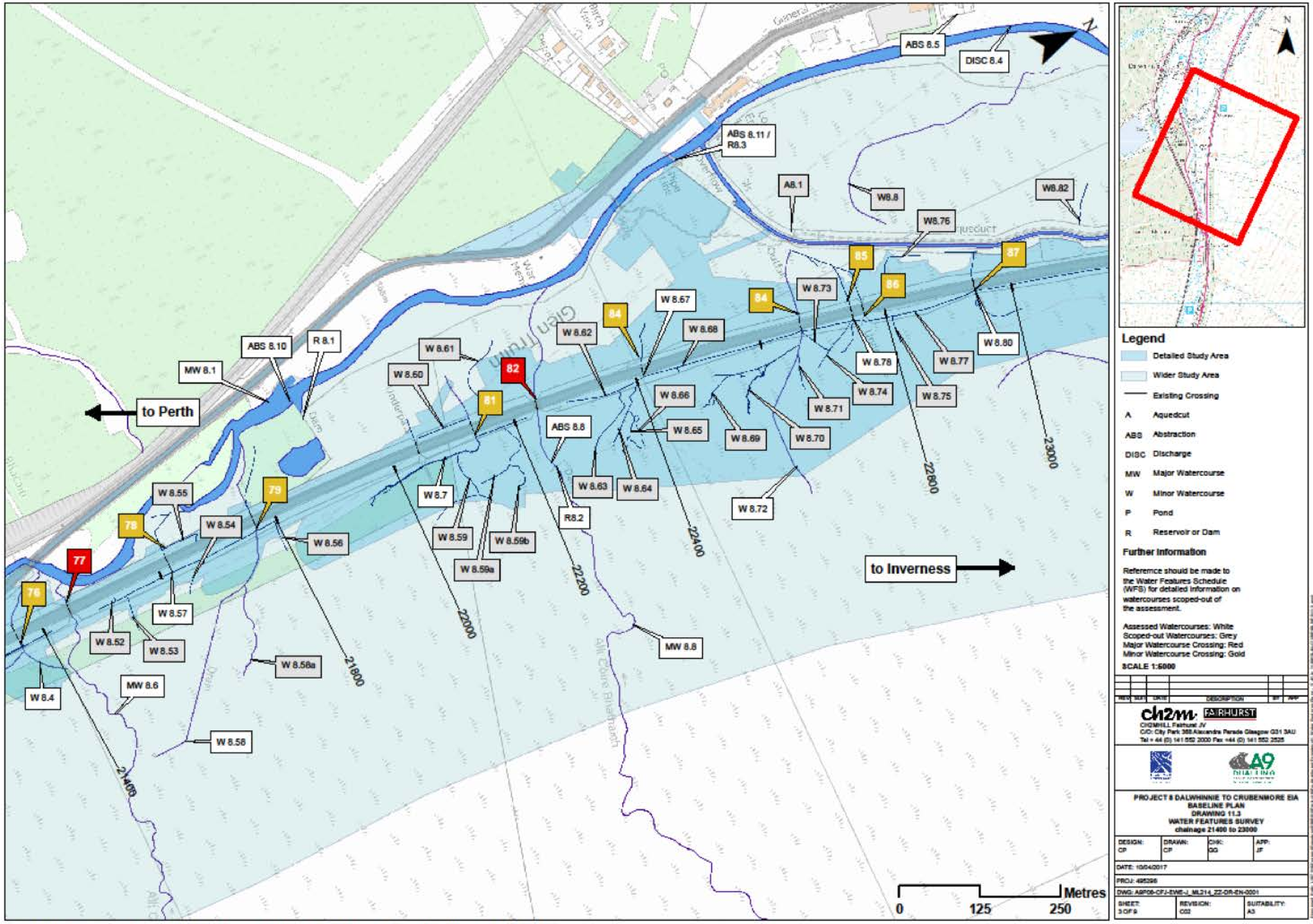


Figure WFP2


to Perth
to Inverness
ABS 8.5
DISC 8.4
ABS 8.11 / R8.3
A8.1
W8.8
W8.82
W8.76
ABS 8.10
R 8.1
MW 8.1
W 8.61
W 8.60
W 8.62
W 8.67
W 8.68
W 8.73
W 8.78
W 8.77
W 8.80
W 8.74
W 8.75
W 8.71
W 8.66
W 8.65
W 8.69
W 8.70
ABS 8.8
W 8.63
W 8.64
R8.2
W 8.72
W 8.55
W 8.54
W 8.56
W 8.7
W 8.59
W 8.59b
W 8.59a
W 8.57
W 8.52
W 8.53
W 8.58a
MW 8.6
W 8.4
W 8.58
MW 8.8
76
77
78
79
81
82
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86
87
21400
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22000
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22400
22800
23000
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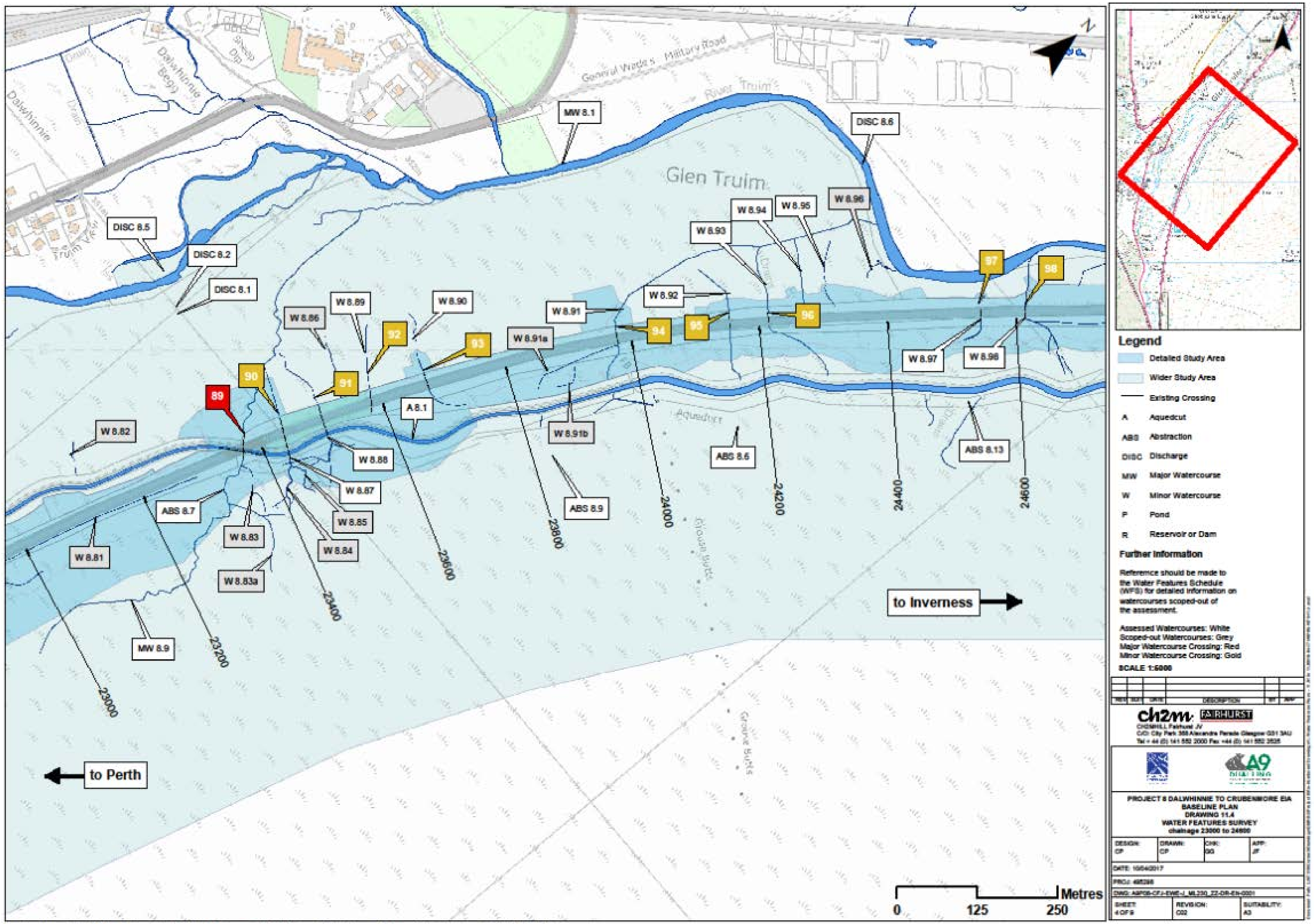
250
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
Reference should be made to the Water Features Schedule (WFS) for detailed information on watercourses scoped-out of the assessment.
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:5000
ch2m FAIRHURST
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.3
WATER FEATURES SURVEY
chainage 21400 to 23000

Figure WFP3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River Truim
General Wade's Military Road
Aqueduct
MW 8.1
DISC 8.6
DISC 8.5
DISC 8.2
DISC 8.1
W 8.96
W 8.95
W 8.94
W 8.93
W 8.92
W 8.91
W 8.91a
W 8.91b
W 8.90
W 8.89
W 8.86
W 8.82
W 8.88
W 8.87
W 8.85
W 8.84
W 8.83
W 8.83a
W 8.81
W 8.97
W 8.98
A 8.1
ABS 8.6
ABS 8.13
ABS 8.9
ABS 8.7
MW 8.9
89
90
91
92
93
94
95
96
97
98
23000
23200
23400
23600
23800
24000
24200
24400
24600
to Inverness
to Perth
0
125
250
Metres
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aquedcut
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
Reference should be made to the Water Features Schedule (WFS) for detailed information on watercourses scoped-out of the assessment.
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:6000
ch2m FAIRHURST
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.4
WATER FEATURES SURVEY
chainage 23000 to 24600
DESIGN: CP
DRAWN: CP
CHK: GG
APP: JF
SHEET: 4 OF 8
REVISION: C02
SUITABILITY: A3

Figure WFP4

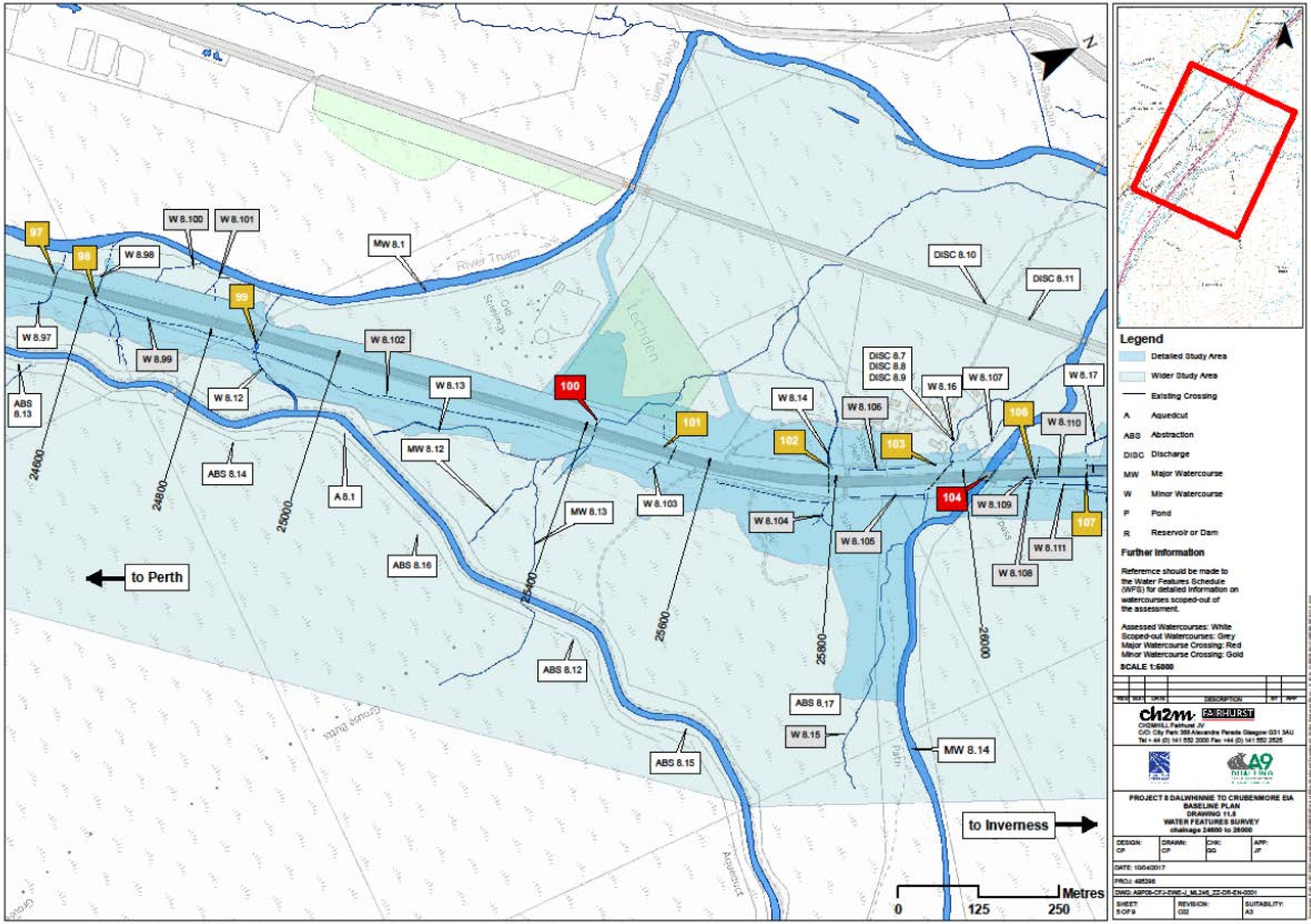
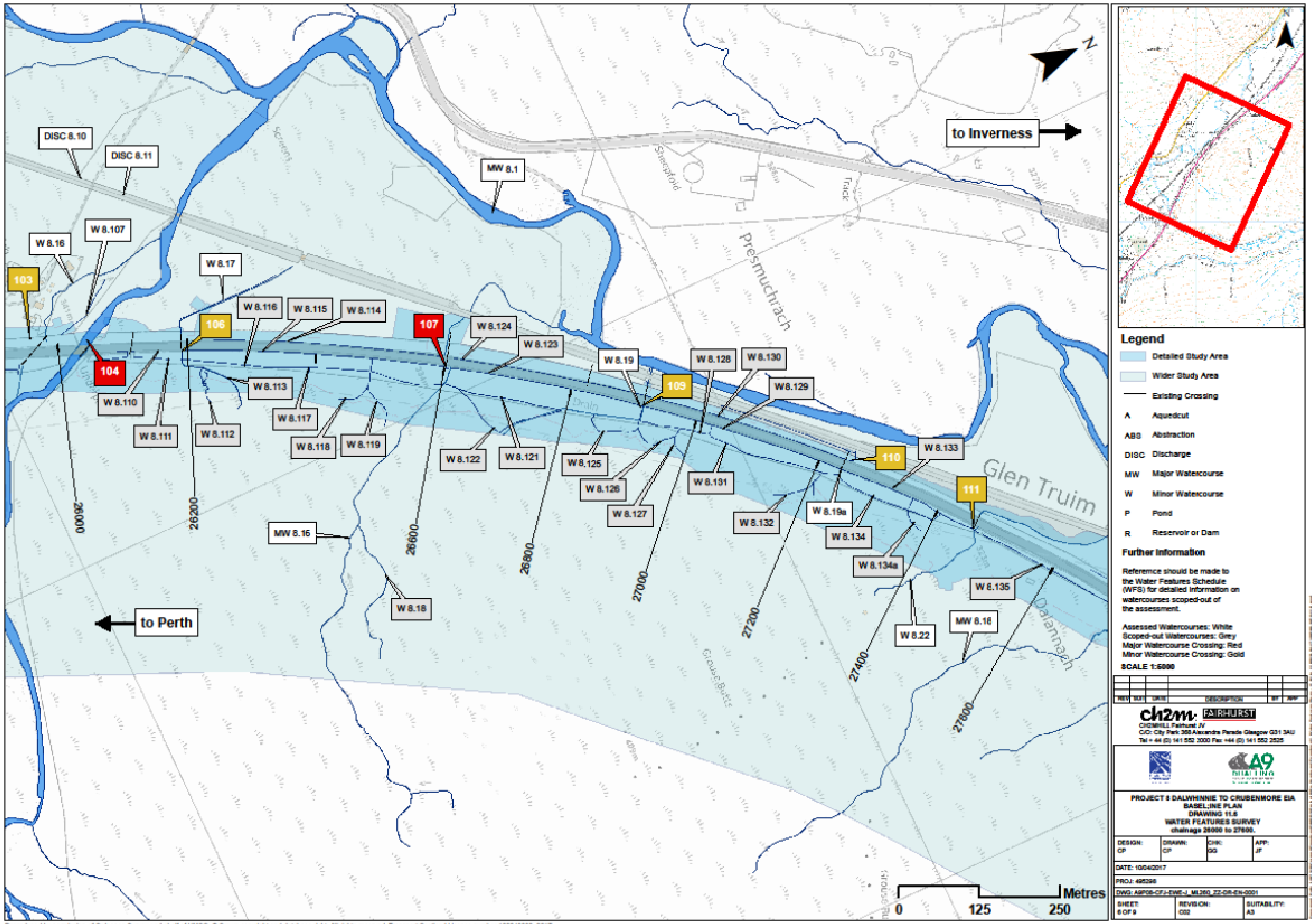

W 8.100
W 8.101
MW 8.1
W 8.98
W 8.97
W 8.99
ABS 8.13
W 8.12
ABS 8.14
W 8.102
A 8.1
W 8.13
MW 8.12
MW 8.13
W 8.103
ABS 8.16
ABS 8.12
ABS 8.15
W 8.14
W 8.104
W 8.105
W 8.106
DISC 8.7
DISC 8.8
DISC 8.9
W 8.16
W 8.107
W 8.17
W 8.110
W 8.109
W 8.111
W 8.108
DISC 8.10
DISC 8.11
ABS 8.17
W 8.15
MW 8.14
97
98
99
100
101
102
103
104
106
107
24600
24800
25000
25400
25600
25800
26000
River Truim
to Perth
to Inverness
0
125
250
Metres
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
Reference should be made to the Water Features Schedule (WFS) for detailed information on watercourses scoped-out of the assessment.
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:6000
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.5
WATER FEATURES SURVEY
chainage 24600 to 26000

Figure WFP5



to Inverness
to Perth
Glen Truim
Presmuchrach
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
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Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:5000
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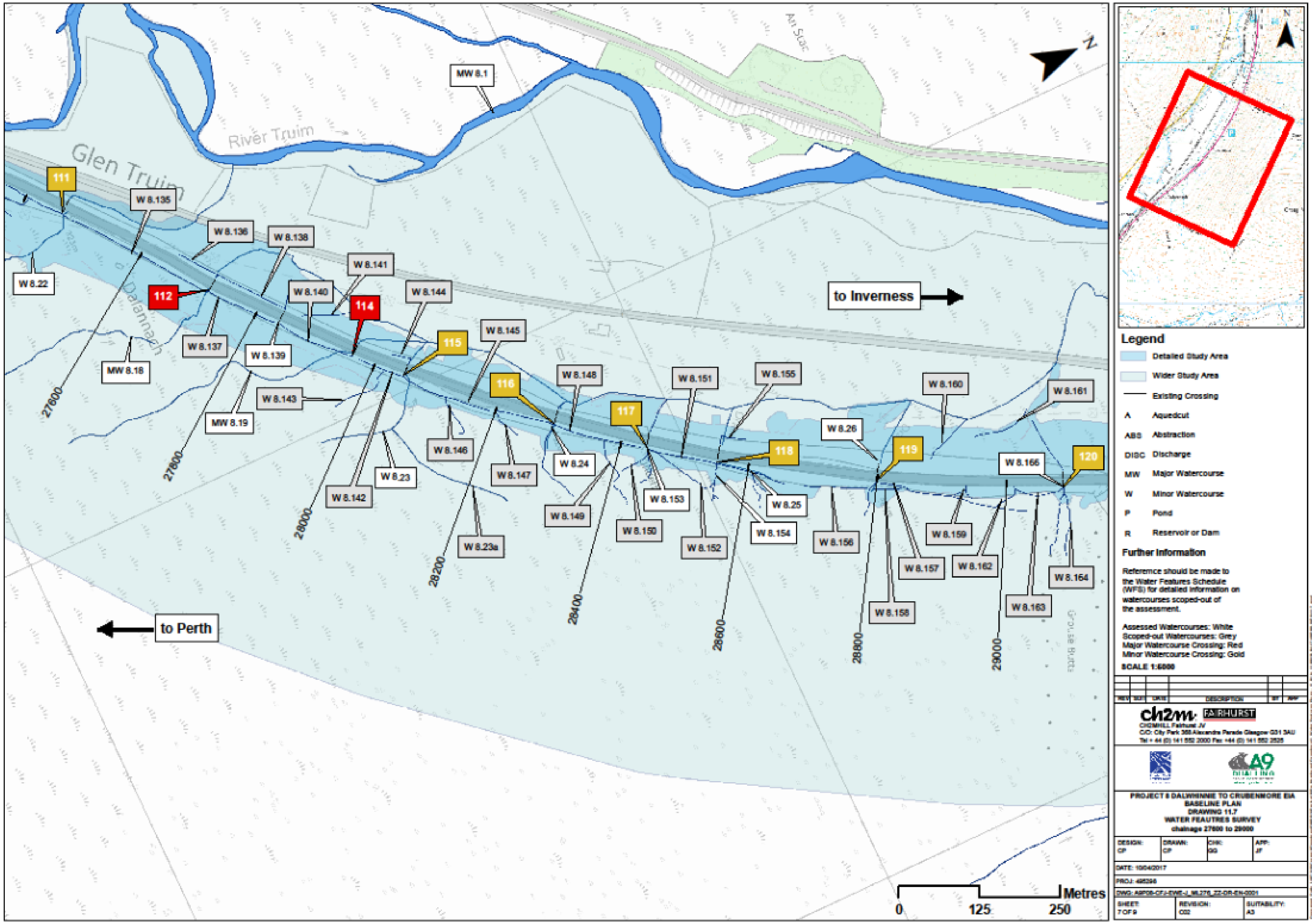
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.6
WATER FEATURES SURVEY

Figure WFP6


MW 8.1
River Truim
Glen Truim
111
W 8.135
W 8.136
W 8.138
W 8.141
W 8.22
112
W 8.140
114
W 8.144
Dalannach
W 8.137
W 8.139
115
W 8.145
MW 8.18
W 8.143
MW 8.19
116
W 8.148
W 8.151
W 8.155
to Inverness
W 8.160
W 8.161
117
W 8.26
118
119
120
W 8.166
W 8.146
W 8.23
W 8.147
W 8.24
W 8.142
W 8.149
W 8.153
W 8.25
W 8.150
W 8.152
W 8.154
W 8.156
W 8.159
W 8.157
W 8.162
W 8.164
W 8.163
W 8.158
W 8.23a
27600
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28200
28400
28600
28800
29000
to Perth
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Metres
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
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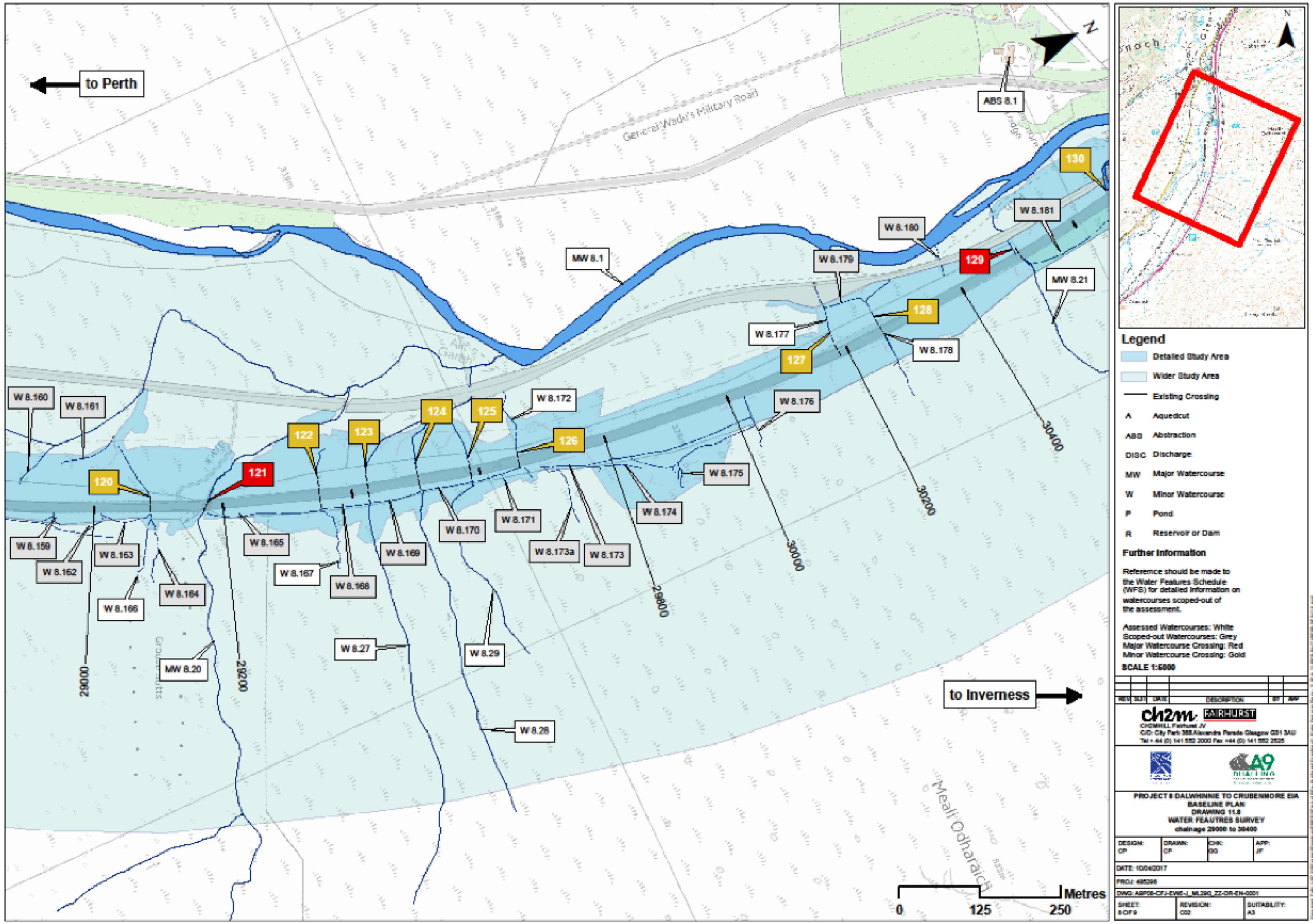
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:5000
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.7
WATER FEAUTRES SURVEY
chainage 27600 to 29000
DATE: 10/04/2017
SHEET 7 OF 9

Figure WFP7


to Perth
to Inverness
General Wade's Military Road
ABS 8.1
MW 8.1
MW 8.20
MW 8.21
W 8.27
W 8.28
W 8.29
W 8.159
W 8.160
W 8.161
W 8.162
W 8.163
W 8.164
W 8.165
W 8.166
W 8.167
W 8.168
W 8.169
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W 8.171
W 8.172
W 8.173
W 8.173a
W 8.174
W 8.175
W 8.176
W 8.177
W 8.178
W 8.179
W 8.180
W 8.181
120
121
122
123
124
125
126
127
128
129
130
29000
29200
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30000
30200
30400
Meall Odharaich
Metres
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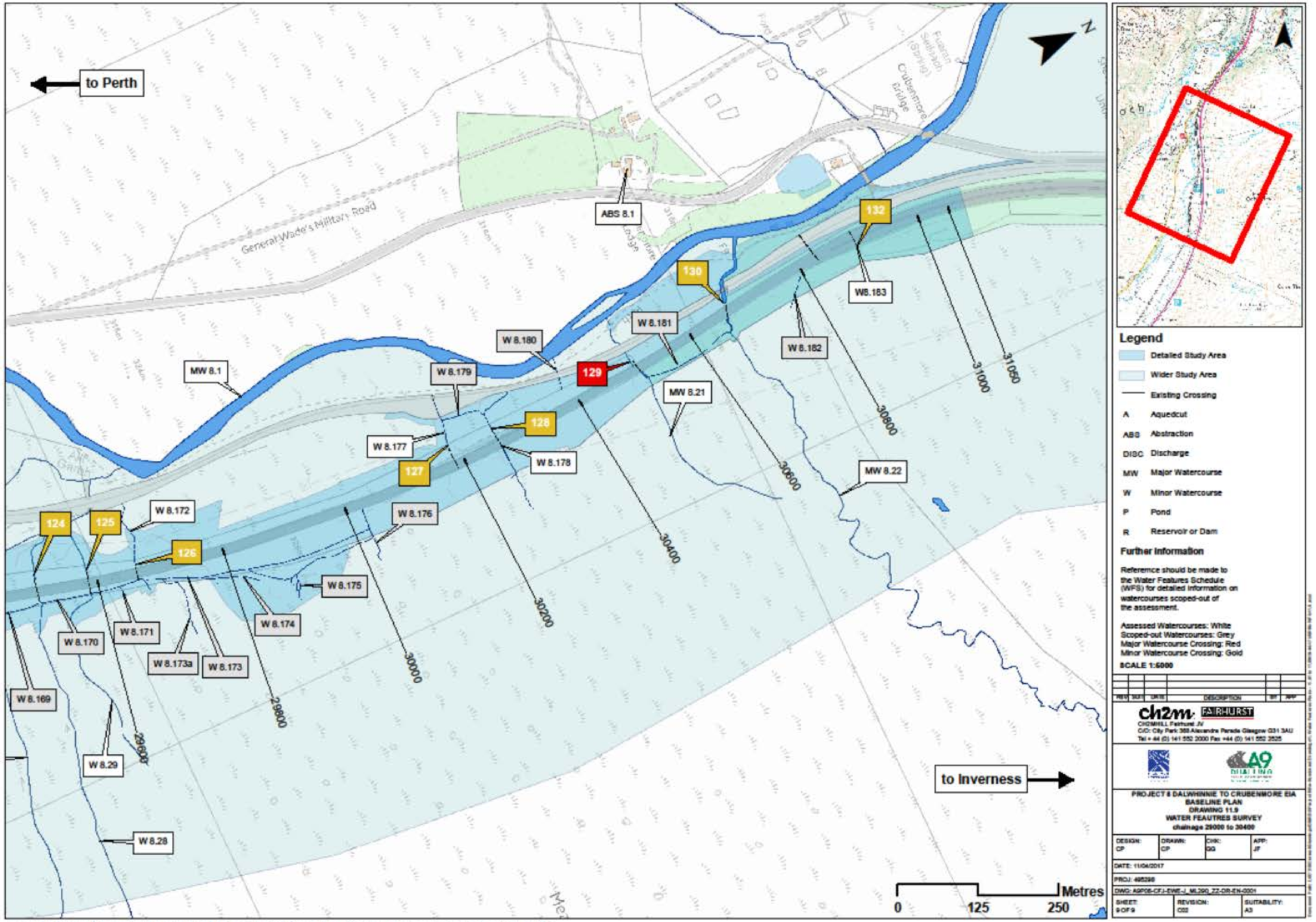
250
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
Reference should be made to the Water Features Schedule (WFS) for detailed information on watercourses scoped-out of the assessment.
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:5000
CH2MHILL Fairhurst JV
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.8
WATER FEAUTRES SURVEY
chainage 29000 to 30400
DESIGN: CP
DRAWN: CP
CHK: GG
APP: JF
DATE: 10/04/2017
SHEET: 8 OF 8
REVISION: C02
SUITABILITY: A3

Figure WFP8


to Perth
General Wade's Military Road
ABS 8.1
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W 8.179
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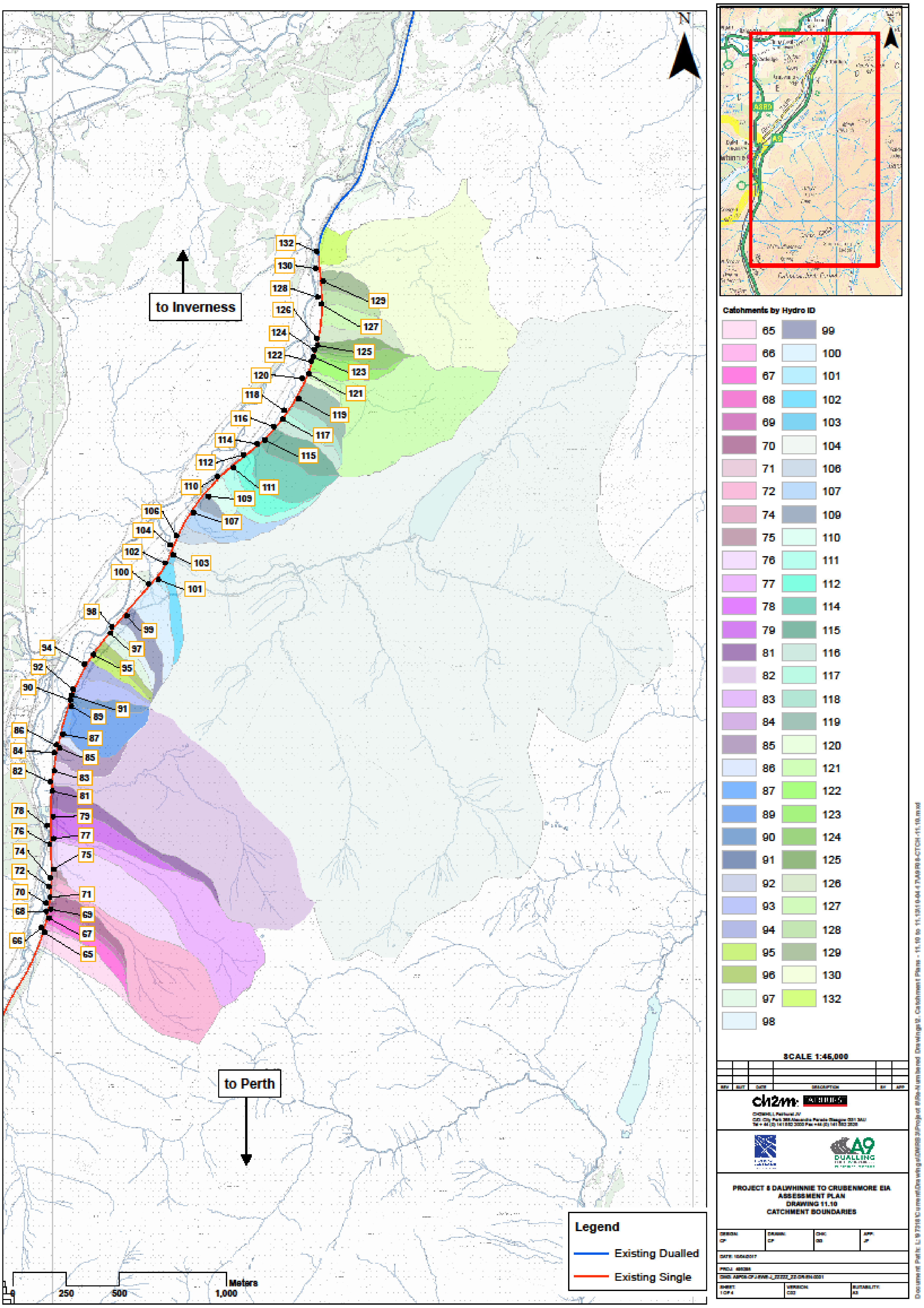
W 8.181
130
132
W8.183
W 8.182
MW 8.21
128
W 8.177
W 8.178
127
MW 8.22
W 8.172
124
125
126
W 8.176
W 8.175
W 8.174
W 8.170
W 8.171
W 8.173a
W 8.173
W 8.169
W 8.29
W 8.28
29800
29900
30000
30200
30400
30600
30800
31000
31050
to Inverness
0
125
250
Metres
Legend
Detailed Study Area
Wider Study Area
Existing Crossing
A Aqueduct
ABS Abstraction
DISC Discharge
MW Major Watercourse
W Minor Watercourse
P Pond
R Reservoir or Dam
Further Information
Reference should be made to the Water Features Schedule (WFS) for detailed information on watercourses scoped-out of the assessment.
Assessed Watercourses: White
Scoped-out Watercourses: Grey
Major Watercourse Crossing: Red
Minor Watercourse Crossing: Gold
SCALE 1:5000
DESCRIPTION
PROJECT 8 DALWHINNIE TO CRUBENMORE EIA
BASELINE PLAN
DRAWING 11.9
WATER FEAUTRES SURVEY
DESIGN: CP
DRAWN: CP
APP: JF
DATE: 11/04/2017
SUITABILITY: A3

Catchments

Figure CTP1



Flood Extents Pre-development showing 4th Iteration Design Freeze (as modelled)

Figure FEX1

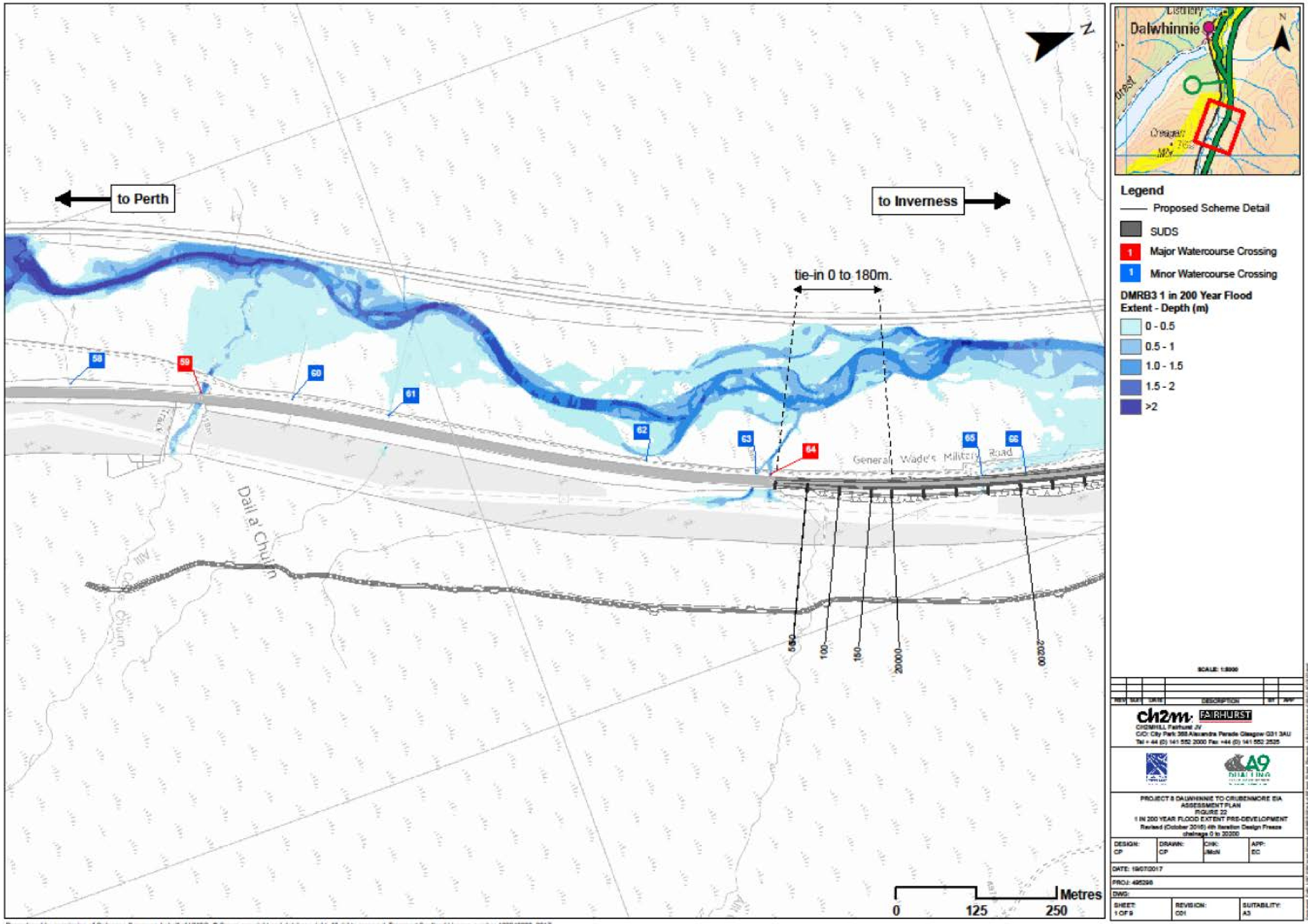


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Figure FEX2

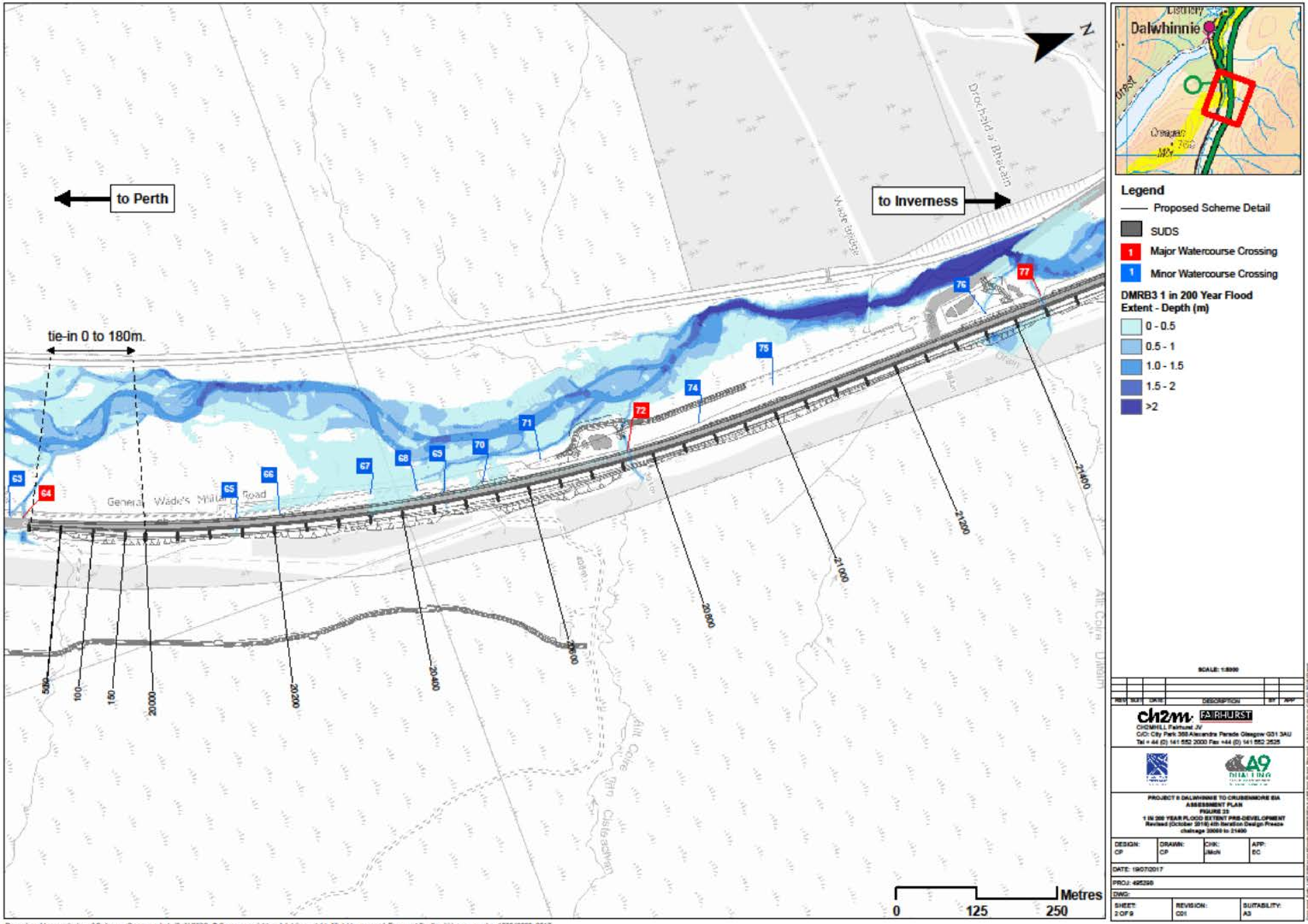
to Perth
to Inverness
tie-in 0 to 180m.
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
Metres
0
125
250

Figure FEX3

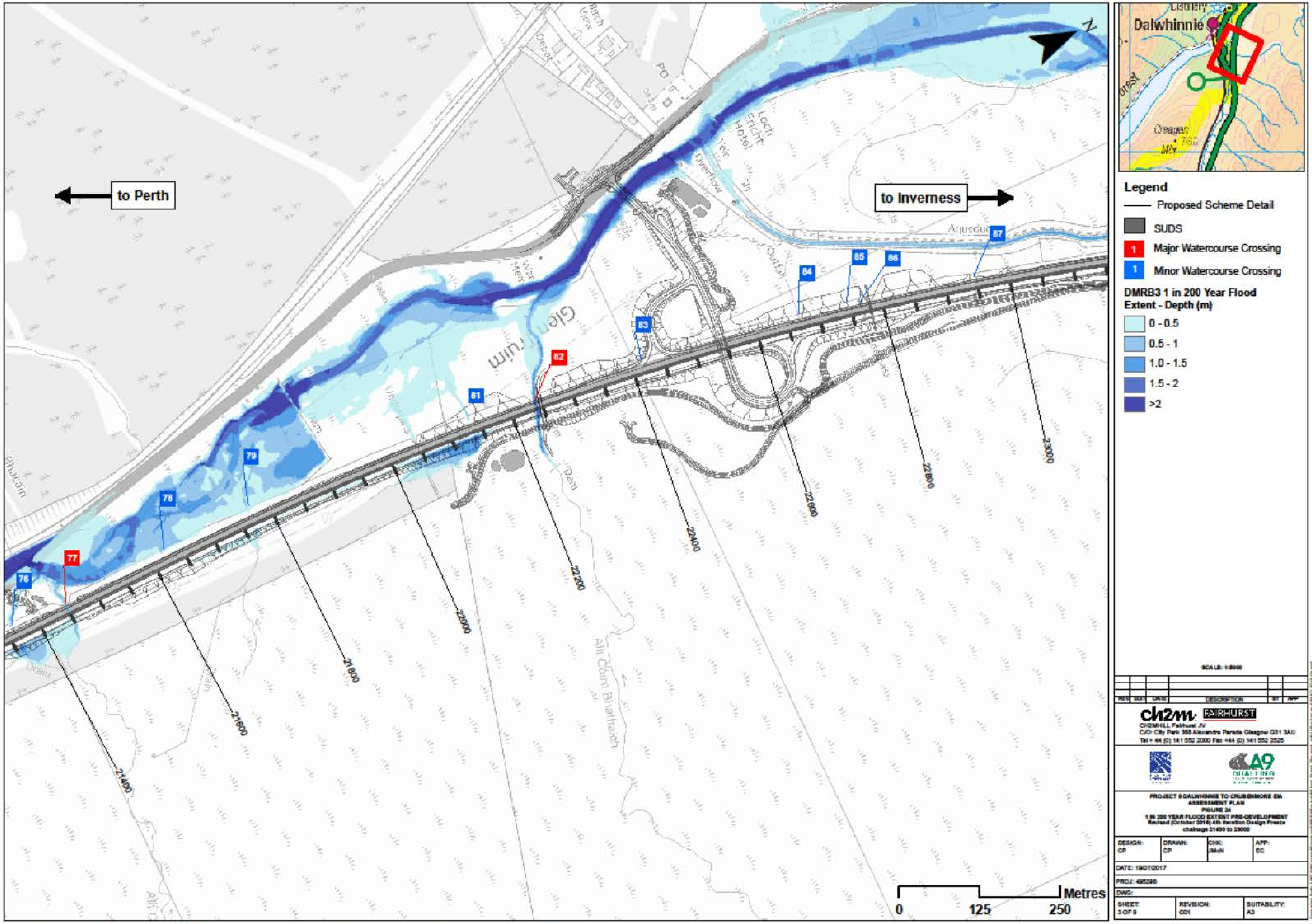
to Perth
to Inverness
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
0
125
250
Metres
21400
21600
21800
22000
22200
22400
22600
22800
23000
76
77
78
79
81
82
83
84
85
86
87

Figure FEX4

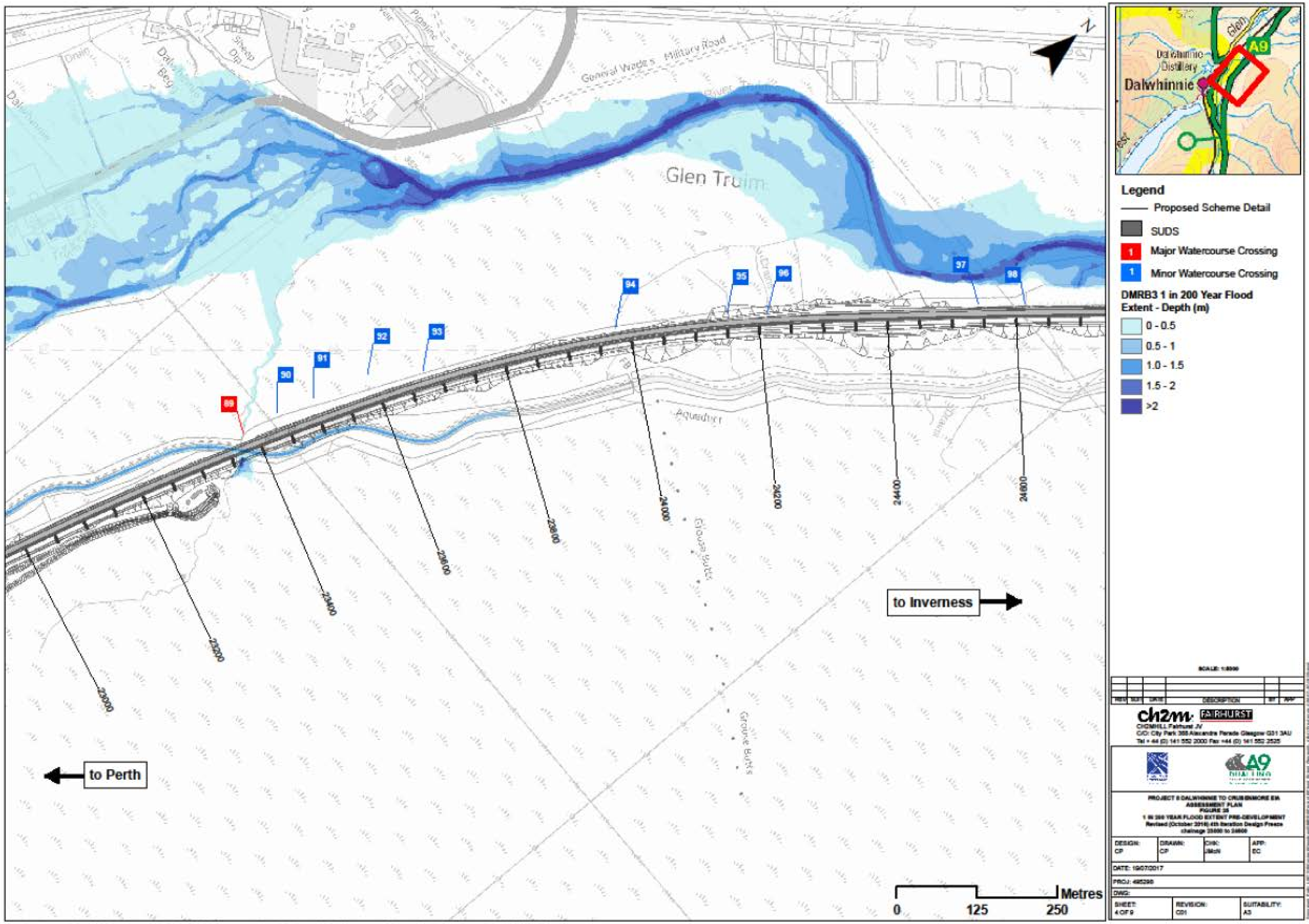
Glen Truim
to Inverness
to Perth
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
Metres
0
125
250

Figure FEX5


Dalwhinnie
A9
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
97
98
99
100
101
102
103_1
103_2
104
106
24600
24800
25000
25200
25400
25600
25800
26000
26200
to Perth
to Inverness
0
125
250
Metres
DESIGN: CP
DRAWN: CP
DATE: 19/07/2017
SHEET: 5 OF 9
REVISION: C01
SUITABILITY: A3

Figure FEX6

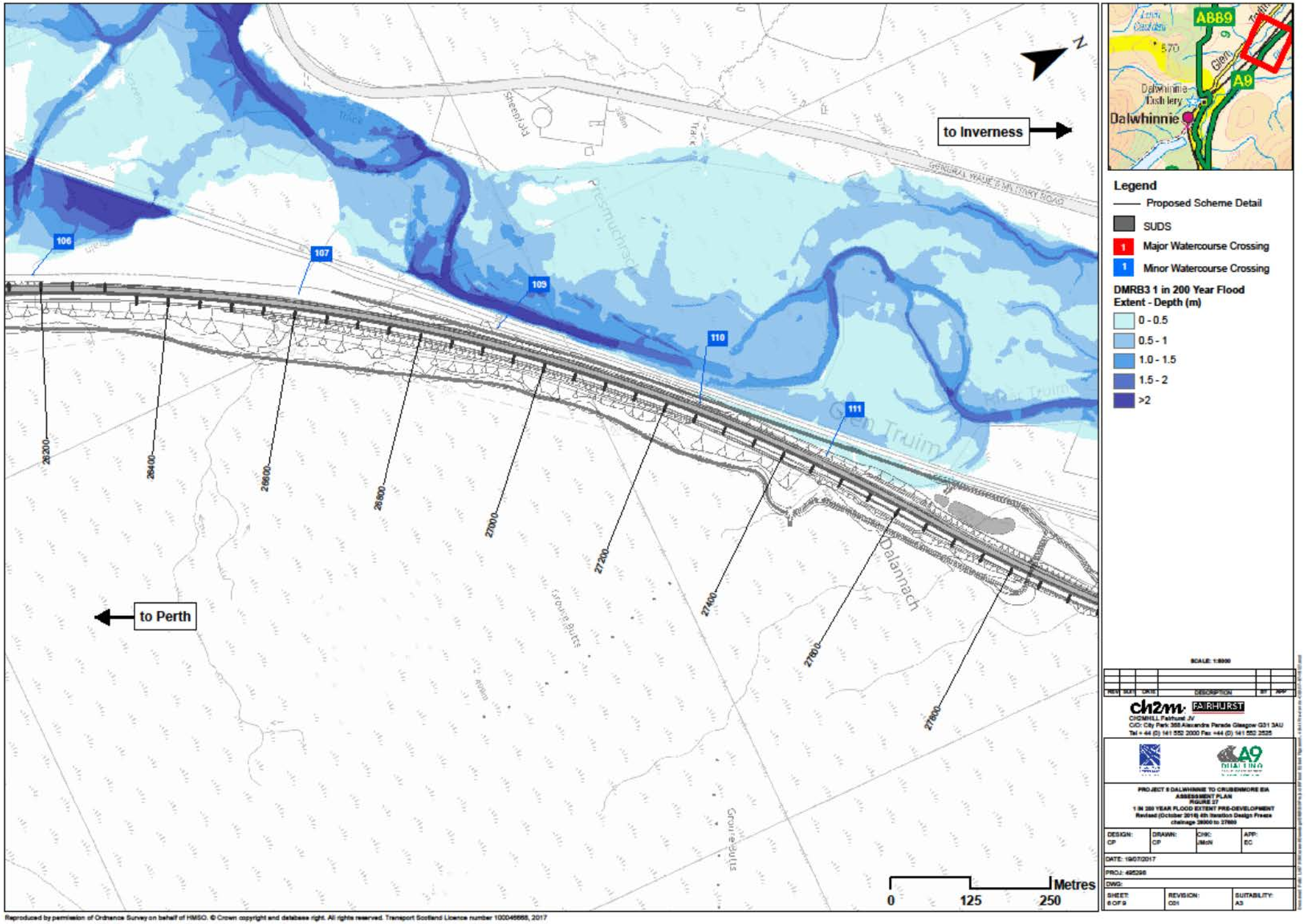
to Inverness
to Perth
106
107
109
110
111
26200
26400
26600
26800
27000
27200
27400
27600
27800
Glen Truim
Dalannach
A889
A9
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
0
125
250
Metres
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Figure FEX7

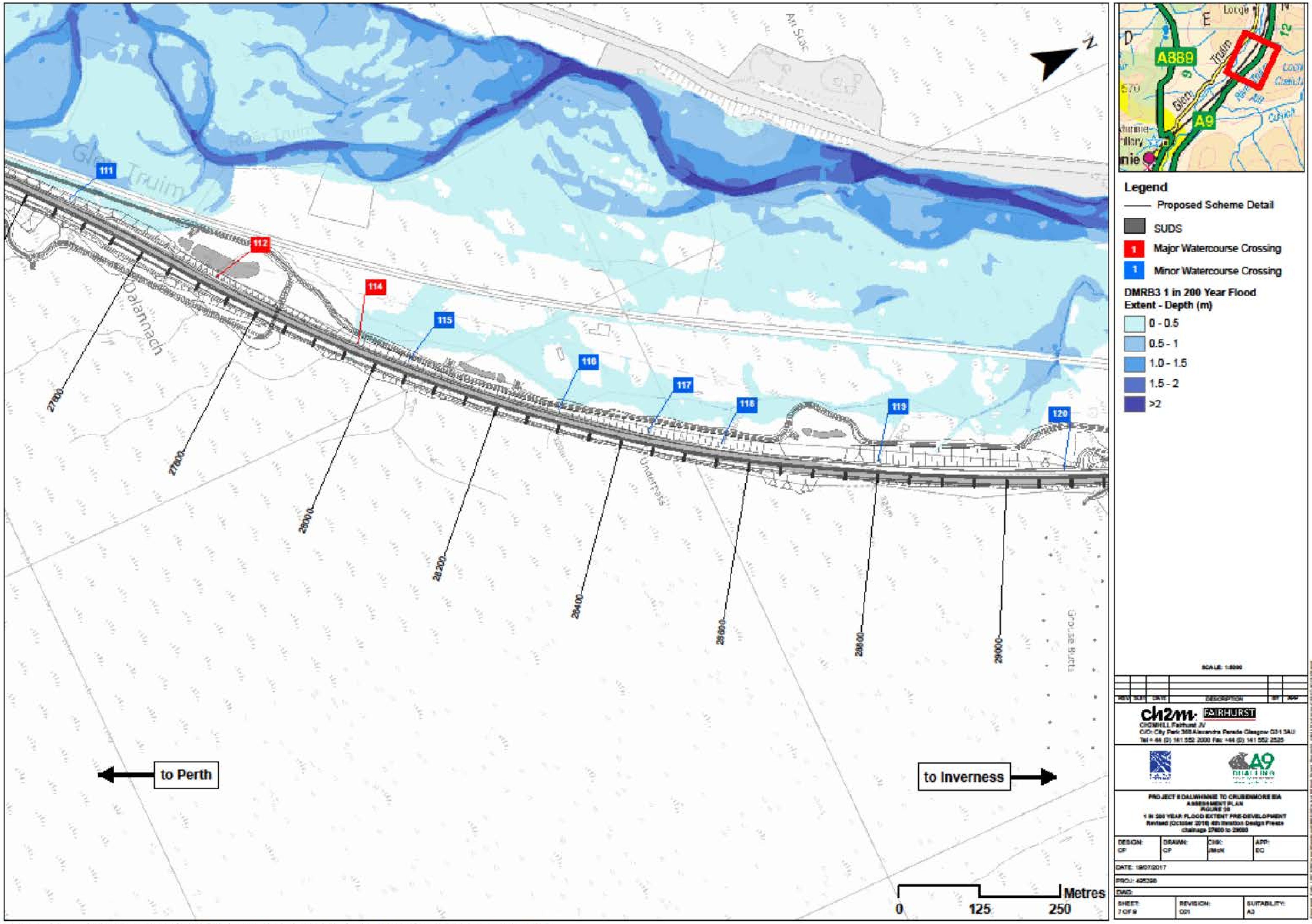

Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
to Perth
to Inverness
Metres
0
125
250
111
112
114
115
116
117
118
119
120
27600
27800
28000
28200
28400
28600
28800
29000

Figure FEX8

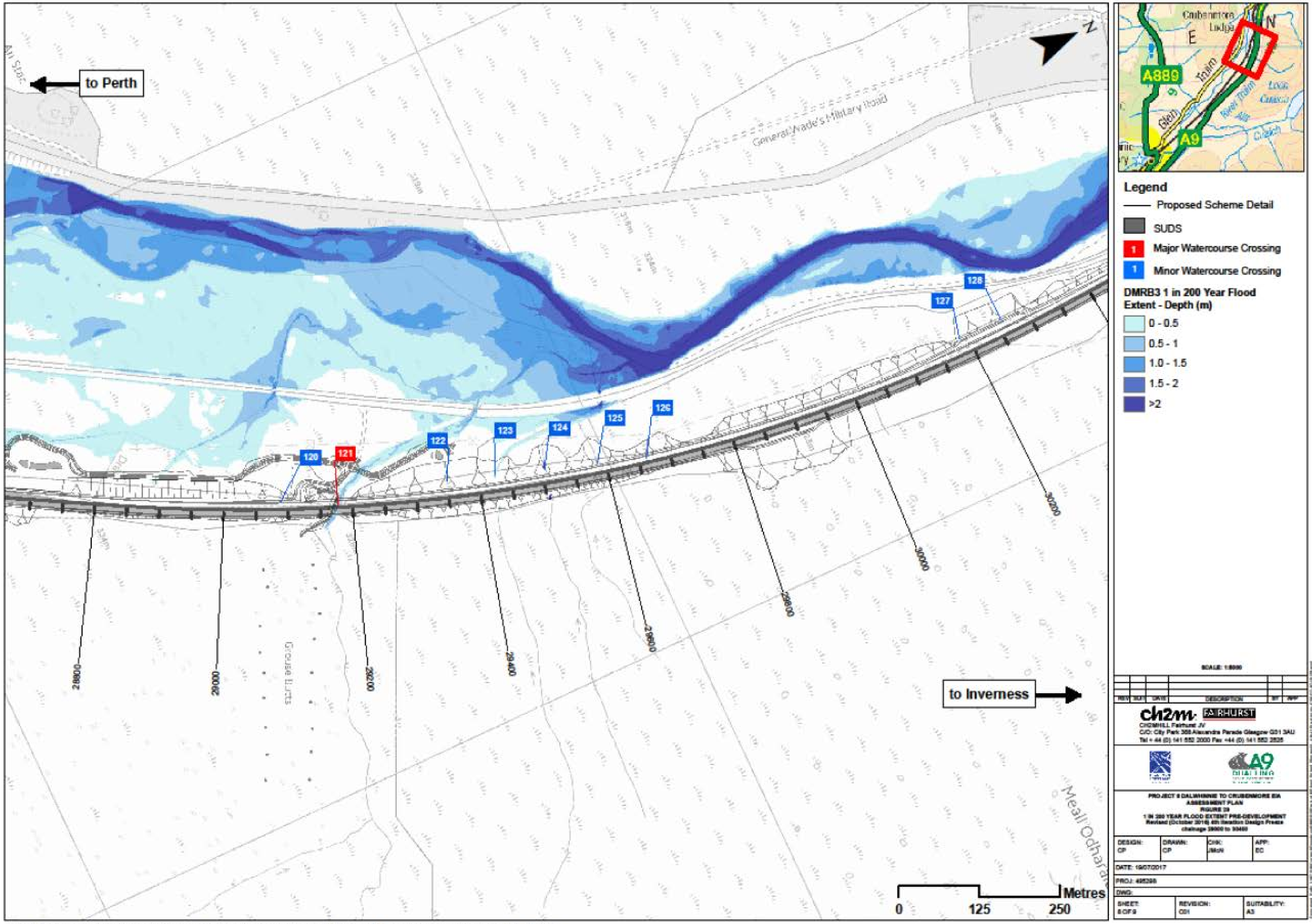
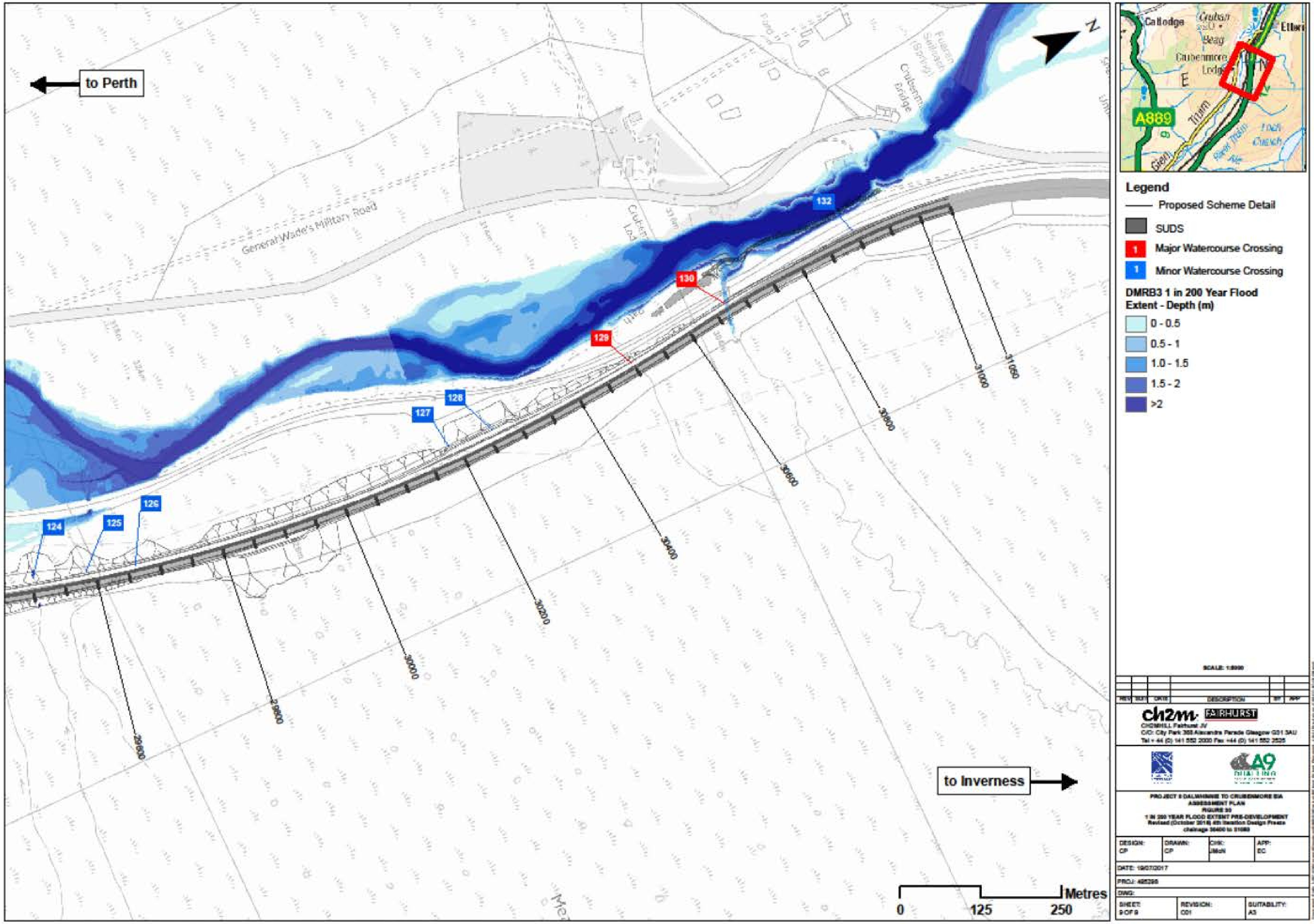

to Perth
to Inverness
General Wade's Military Road
Grouse Butts
Meall Odhar
120
121
122
123
124
125
126
127
128
28800
29000
29200
29400
29600
29800
30000
30200
0
125
250
Metres
Crubenmore Lodge
A889
A9
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
SCALE: 1:5000
CH2MHILL Fairhurst JV
DESIGN: CP
DRAWN: CP
DATE: 19/07/2017
SHEET: 8 OF 8
SUITABILITY: A3

Figure FEX9


to Perth
to Inverness
General Wade's Military Road
124
125
126
127
128
129
130
132
29800
29900
30000
30200
30400
30600
30800
31000
31050
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
Catlodge
A889
0
125
250
Metres
DATE: 19/07/2017
SHEET: 9 OF 9
REVISION: C01
SUITABILITY: A3

Flood Extents   Post-development showing 4th Iteration Design Freeze (as modelled)

Figure FPO1

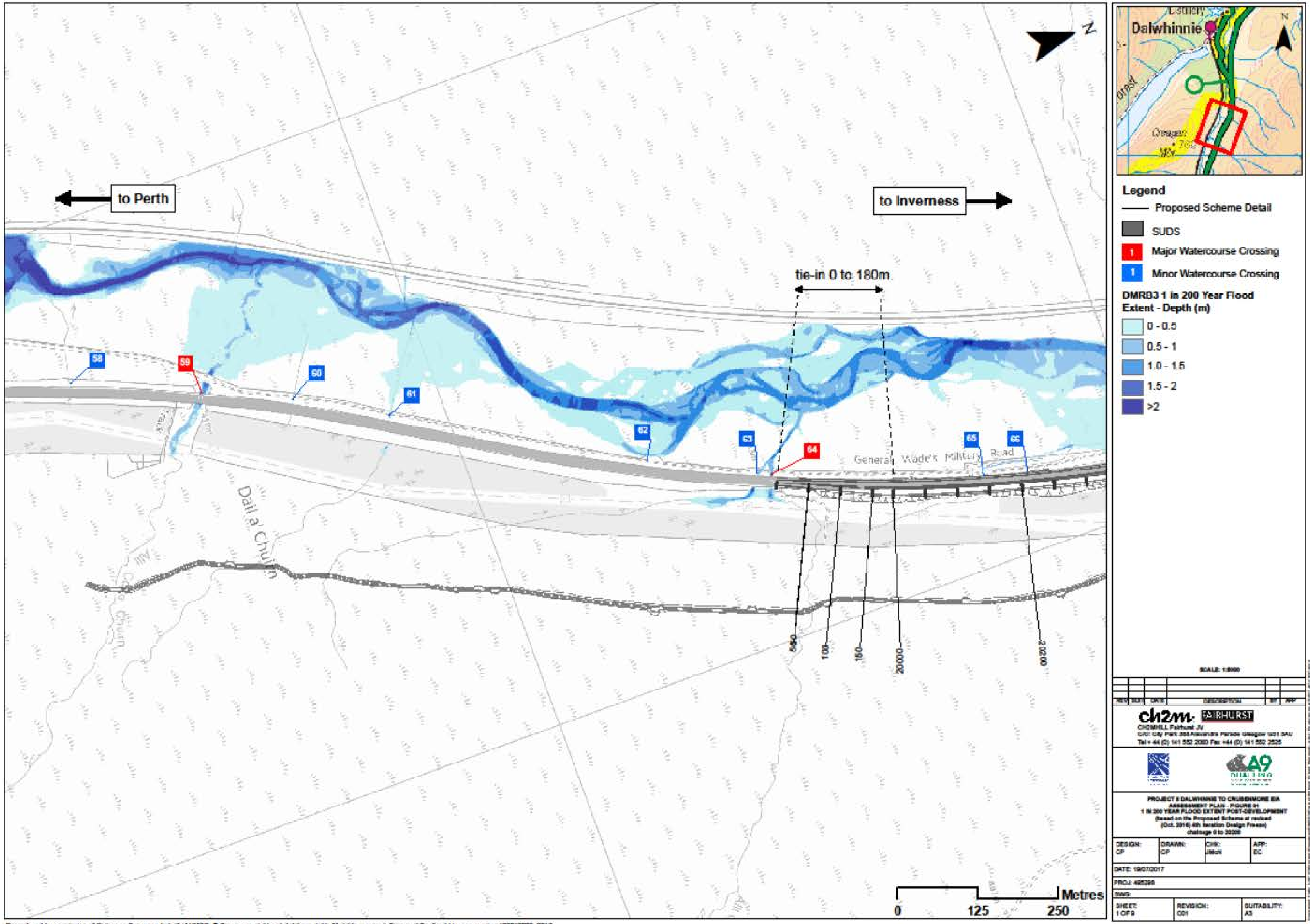


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Figure FPO2

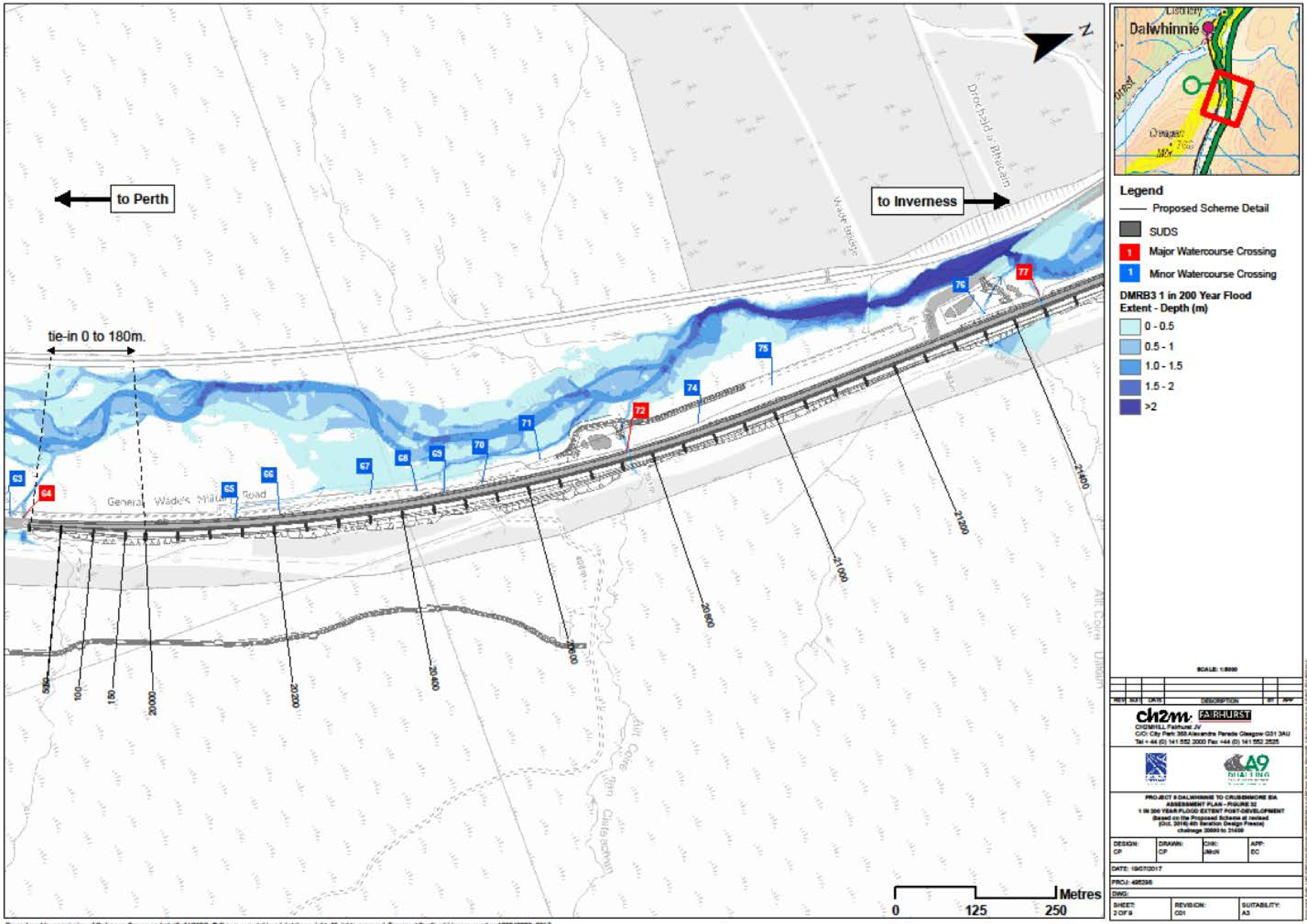
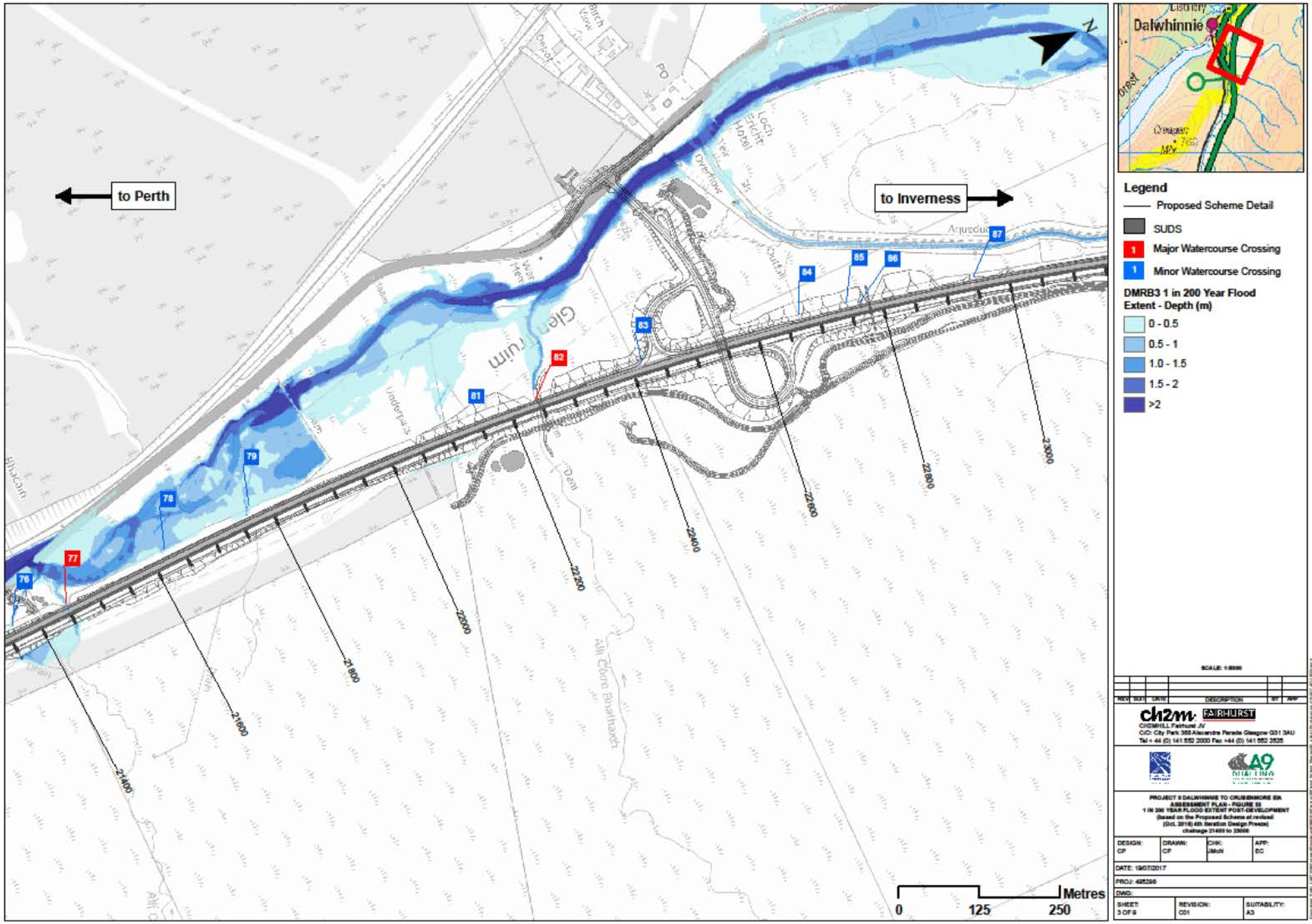

to Perth
to Inverness
tie-in 0 to 180m.
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
Metres
0
125
250

Figure FPO3



to Perth
to Inverness
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
76
77
78
79
81
82
83
84
85
86
87
21400
21600
21800
22000
22200
22400
22600
22800
23000
0
125
250
Metres
SCALE: 1:5000
DESCRIPTION
CH2MHILL Fairhurst JV
DATE: 19/07/2017
SHEET: 3 OF 9
REVISION: C01
SUITABILITY: A3

Figure FPO4

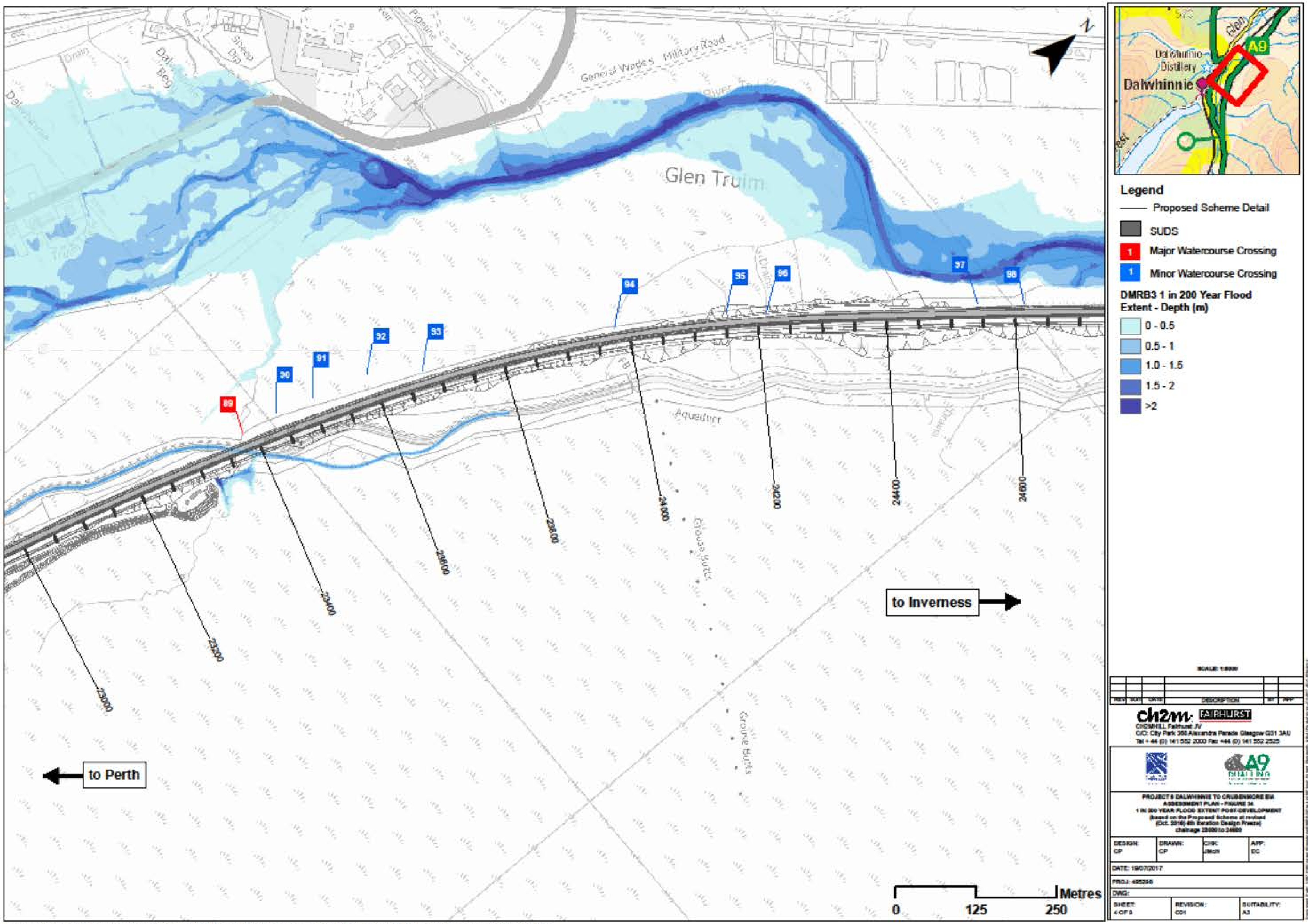


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Figure FPO5


N
Dalwhinnie
A9
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
97
98
99
100
101
102
103_1
103_2
104
106
24600
24800
25000
25200
25400
25600
25800
26000
26200
Lechden
to Perth
to Inverness
0
125
250
Metres
SCALE: 1:5000
DESCRIPTION
CH2MHILL Fairhurst JV
DESIGN:
CP
DRAWN:
CP
CHK:
APP:
DATE: 19/07/2017
DWG:
SHEET:
5 OF 9
REVISION:
C01
SUITABILITY:
A3

Figure FPO6

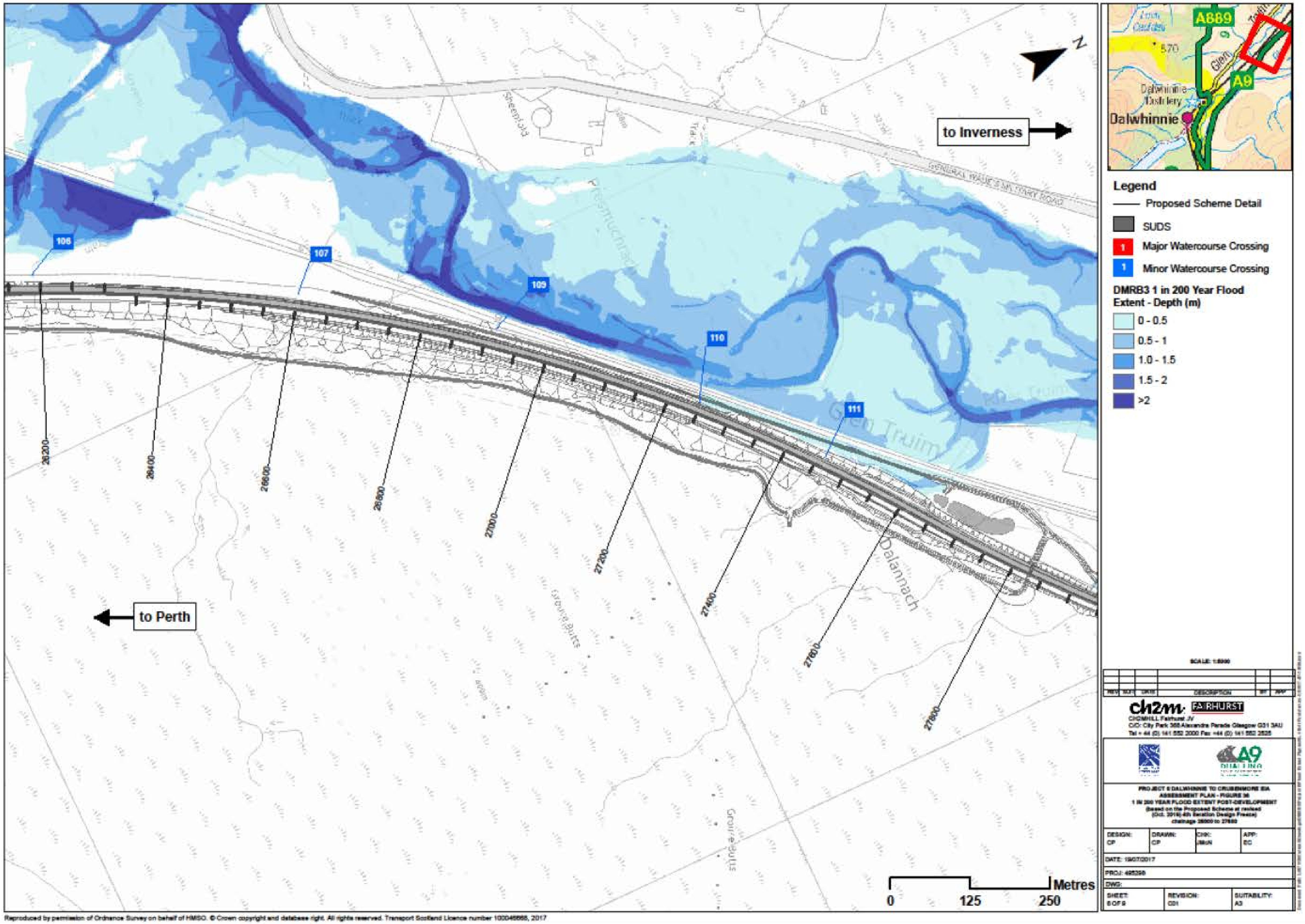
to Inverness
to Perth
N
A889
A9
Dalwhinnie
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
106
107
109
110
111
26200
26400
26600
26800
27000
27200
27400
27600
27800
Metres
0
125
250
Glen Truim
Dalannach
ch2m FAIRHURST
DESIGN: CP
DRAWN: CP
SHEET: 8 OF 9
REVISION: C01
SUITABILITY: A3
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Figure FPO7

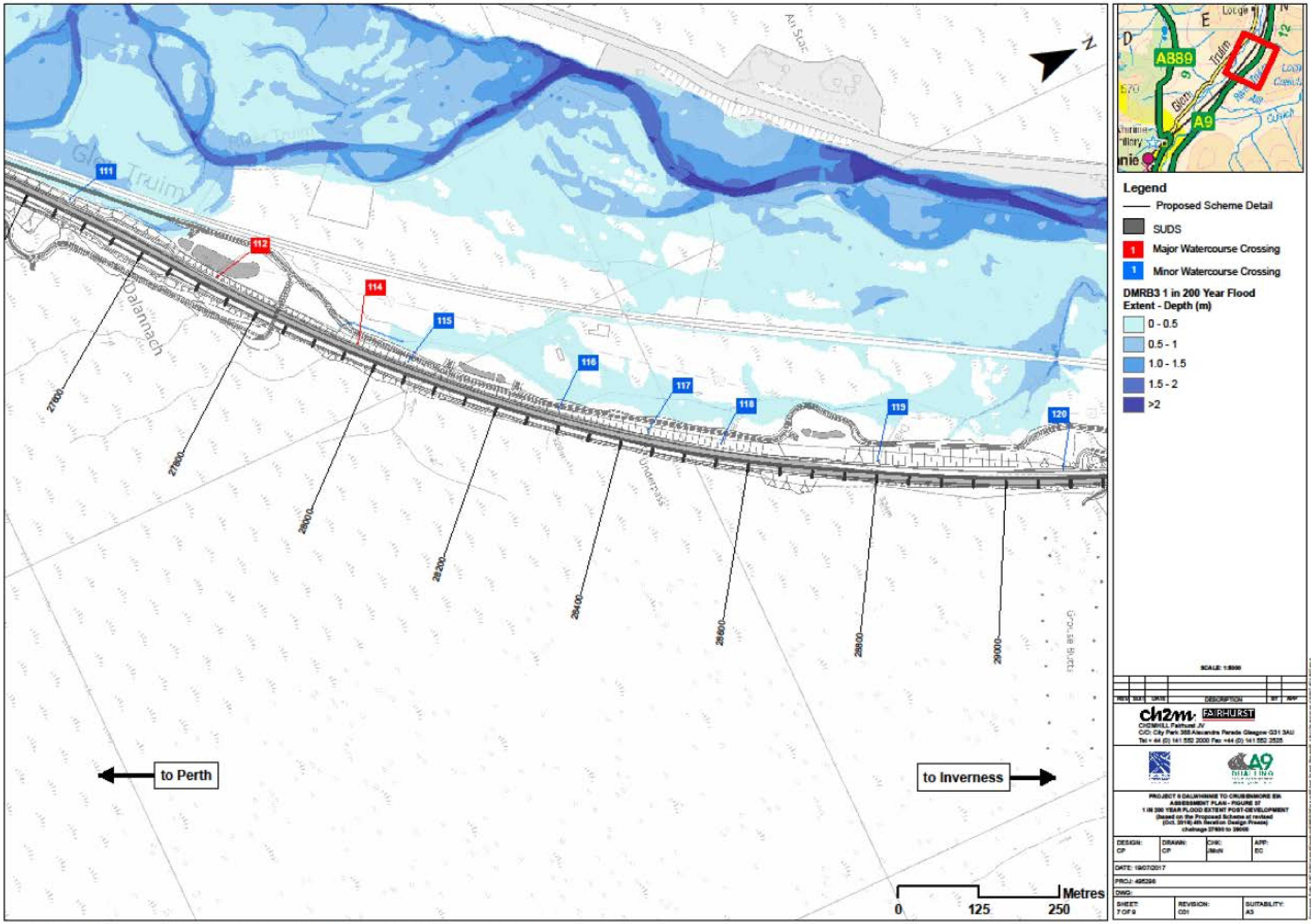

Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
A889
A9
111
112
114
115
116
117
118
119
120
27600
27800
28000
28200
28400
28600
28800
29000
Dalannach
Underpass
Grouse Butts
to Perth
to Inverness
0
125
250
Metres
ch2m. FAIRHURST
A9 DUALLING

Figure FPO8

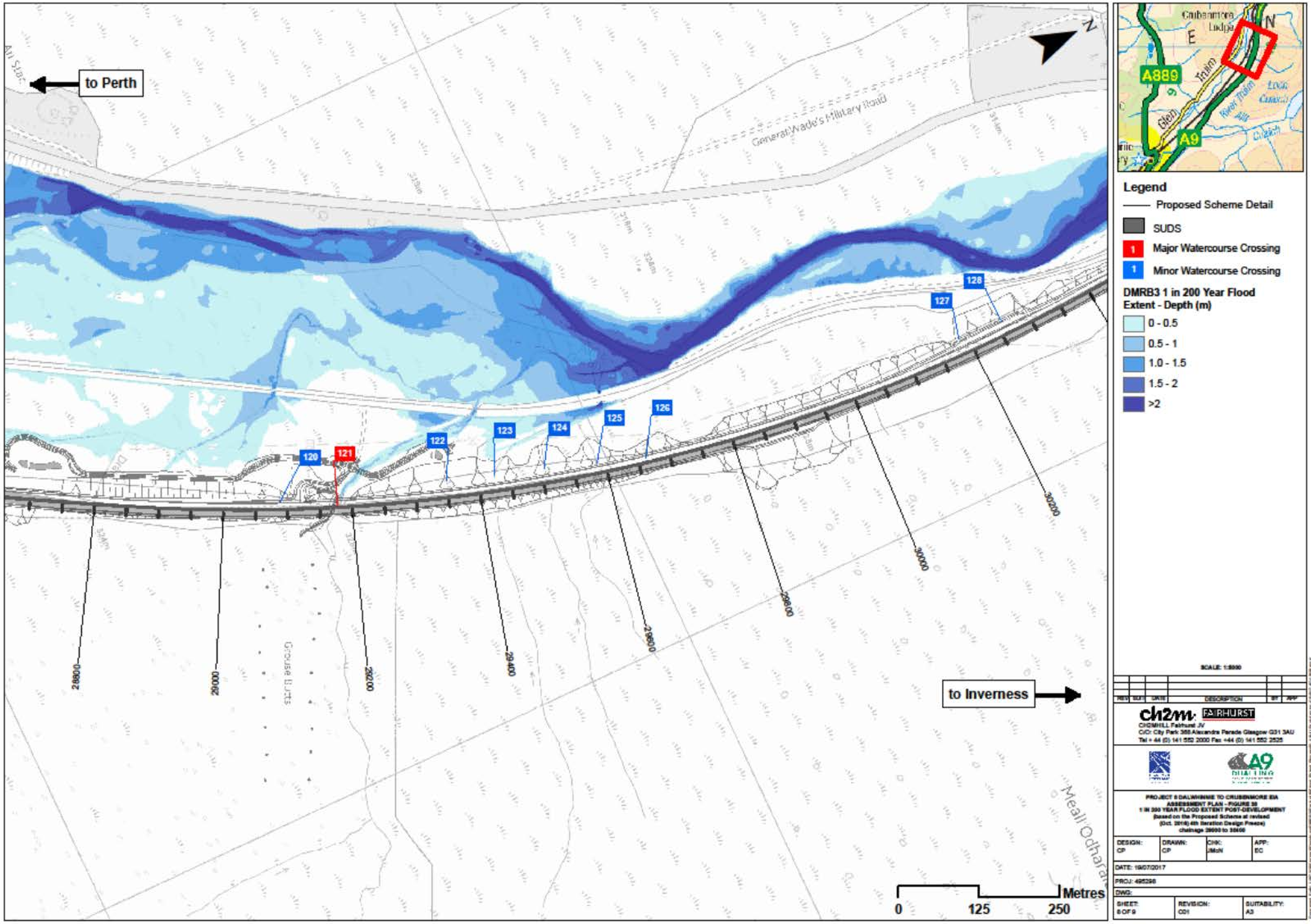
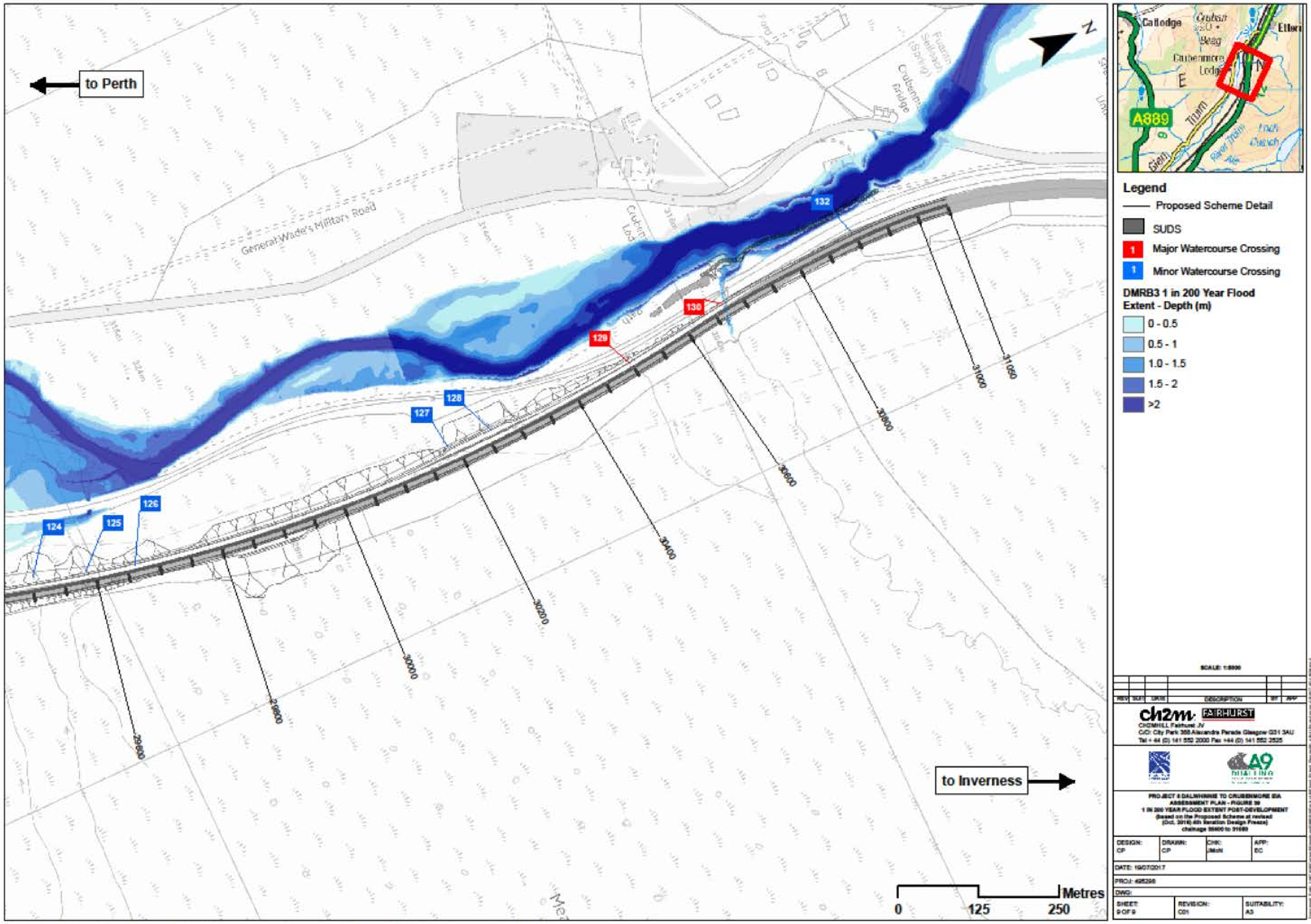

to Perth
to Inverness
General Wade's Military Road
Grouse Butts
Meall Odhar
120
121
122
123
124
125
126
127
128
28800
29000
29200
29400
29600
29800
30000
30200
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
0
125
250
Metres
A889
A9
N

Figure FPO9


to Perth
to Inverness
General Wade's Military Road
124
125
126
127
128
129
130
132
29800
29900
30000
30200
30400
30600
30800
31000
31050
Metres
0
125
250
Cattlodge
A889
Legend
Proposed Scheme Detail
SUDS
Major Watercourse Crossing
Minor Watercourse Crossing
DMRB3 1 in 200 Year Flood Extent - Depth (m)
0 - 0.5
0.5 - 1
1.0 - 1.5
1.5 - 2
>2
DESIGN: CP
DRAWN: CP
APP: EC
SHEET: 9 OF 9
REVISION: C01
SUITABILITY: A3

Potential Flood Risk Receptors

Annex Table 10: Location of potential flood risk receptors identified on Figures PFR-1 to PFR-9

LABEL	TYPE	DESCRIPTION
D-001	Residential Properties	Marked as 'Loch Ericht Hotel' on OS mapping; Proposed Scheme ch. 22,600
D-002 to D-021	Residential Properties	Properties in central Dalwhinnie; Proposed Scheme ch. 23,050 – ch. 23,300
D-022 to D-026	Residential Properties	Properties at Cuaich; Proposed Scheme ch. 25,900 – ch. 26,050
D-027	Residential Properties	Proposed Scheme ch. 30,900
NRes-001	Non-Residential Properties	Proposed Scheme ch. 21,500
NRes-003/004	Non-Residential Properties	Proposed Scheme ch. 22,600
NRes-005	Non-Residential Properties	Proposed Scheme ch. 22,850
NRes-006 to NRes-014	Non-Residential Properties	Properties in central Dalwhinnie; Proposed Scheme ch. 23,050 – ch. 23,300
NRes-015 to NRes-017	Non-Residential Properties	Properties at Cuaich; Proposed Scheme ch. 25,950 – ch. 26,000
HML-001	HML railway	Proposed Scheme ch. 25,650 – ch. 26,000
HML-002	HML railway	Proposed Scheme ch. 26,300 – ch. 26,450
A9-001	OS Roads [A9]	A9 mainline; Proposed Scheme ch. 20,350 – ch. 20,750
A889-001	OS Roads [A889]	A889; Proposed Scheme ch. 21,400 – ch. 21,600
A889-002	OS Roads [A889]	A889 south of Dalwhinnie centre; Proposed Scheme ch. 22,650 – ch. 22,850
A889-003	OS Roads [A889]	A889 through Dalwhinnie; Proposed Scheme ch. 22,950 – ch. 23,550
GWMR-001	OS Roads [local]	Crubenmore Bridge; Proposed Scheme ch. 31,000 – ch. 31,100
Util-001	Utilities	Proposed Scheme ch. 23,000
ACH-001	Area of Cultural Heritage	Wade Bridge; Proposed Scheme ch. 21,200

Figure PFR-1

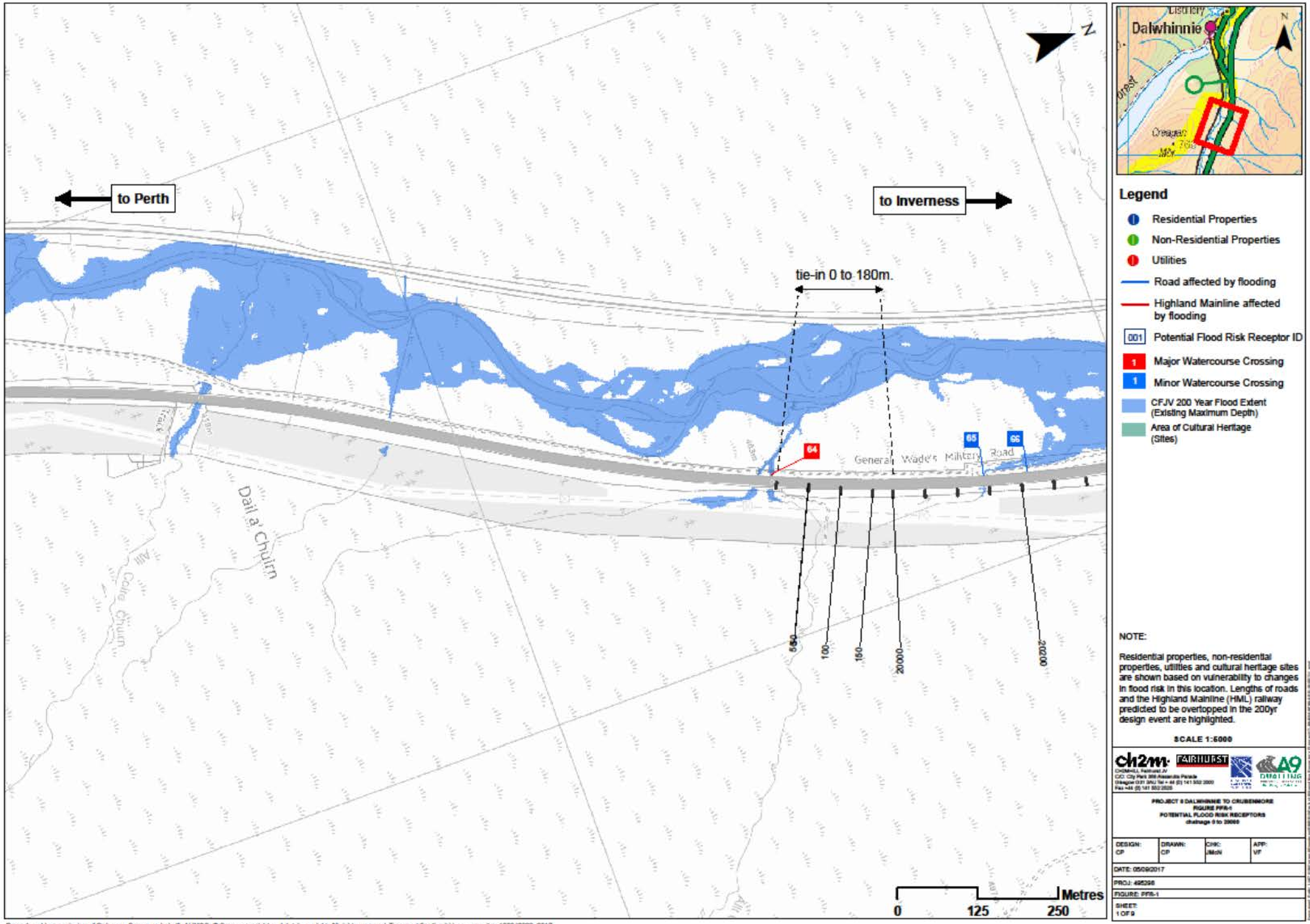

to Perth
to Inverness
tie-in 0 to 180m.
Dalwhinnie
General Wade's Military Road
Dail a' Chuirn
Coire Chuirn
64
65
66
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
001 Potential Flood Risk Receptor ID
1 Major Watercourse Crossing
1 Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:5000
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: VF
DATE: 05/09/2017
FIGURE: PFR-1
SHEET: 1 OF 9
0
125
250
Metres

Figure PFR-2

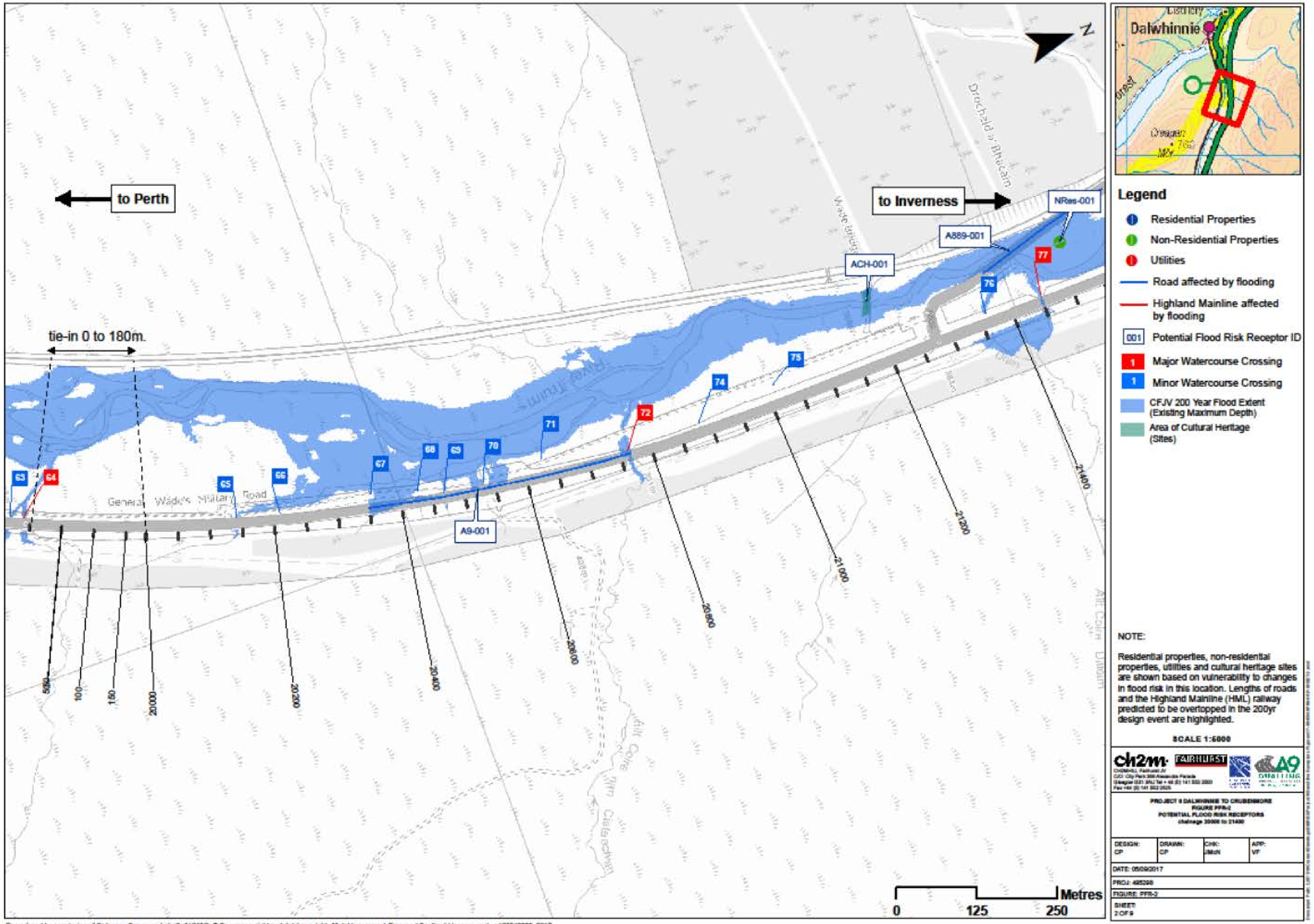

Dalwhinnie
to Perth
to Inverness
tie-in 0 to 180m.
General Wade's Military Road
River Truim
NRes-001
A889-001
ACH-001
A9-001
63
64
65
66
67
68
69
70
71
72
74
75
76
77
50
100
150
20000
20200
20400
20600
20800
21000
21200
21400
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:6000
0
125
250
Metres

Figure PFR-3

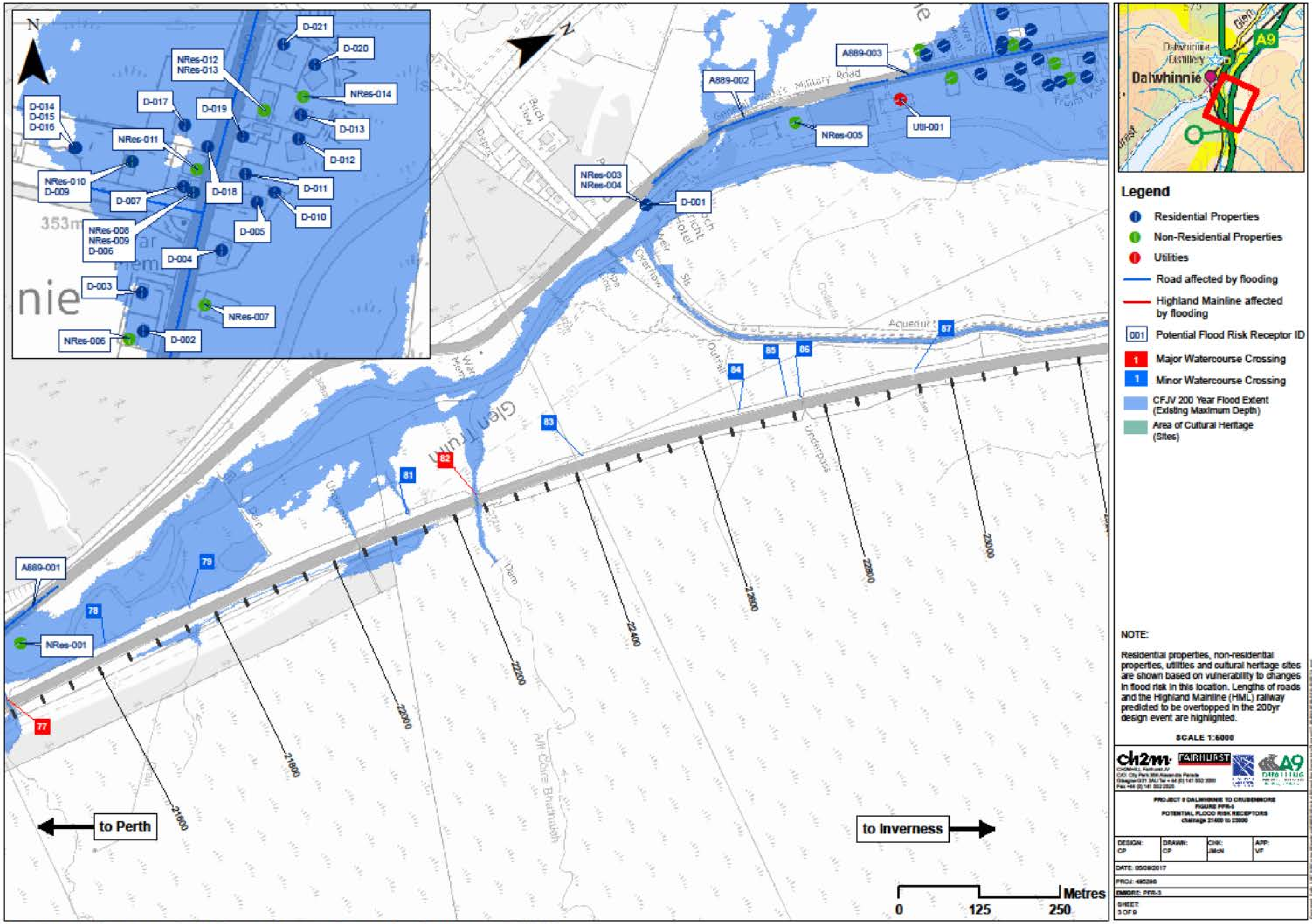

D-021
D-020
NRes-012
NRes-013
NRes-014
D-017
D-019
D-013
D-014
D-015
D-016
NRes-011
D-012
NRes-010
D-009
D-007
D-018
D-011
D-010
D-005
NRes-008
NRes-009
D-006
D-004
D-003
NRes-007
NRes-006
D-002
A889-003
A889-002
Util-001
NRes-005
NRes-003
NRes-004
D-001
A889-001
NRes-001
77
78
79
81
82
83
84
85
86
87
21600
21800
22000
22200
22400
22600
22800
23000
to Perth
to Inverness
0
125
250
Metres
Dalwhinnie
A9
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:6000
DESIGN: CP
DRAWN: CP
APP: VF
DATE: 05/09/2017
SHEET 3 OF 9

Figure PFR-4

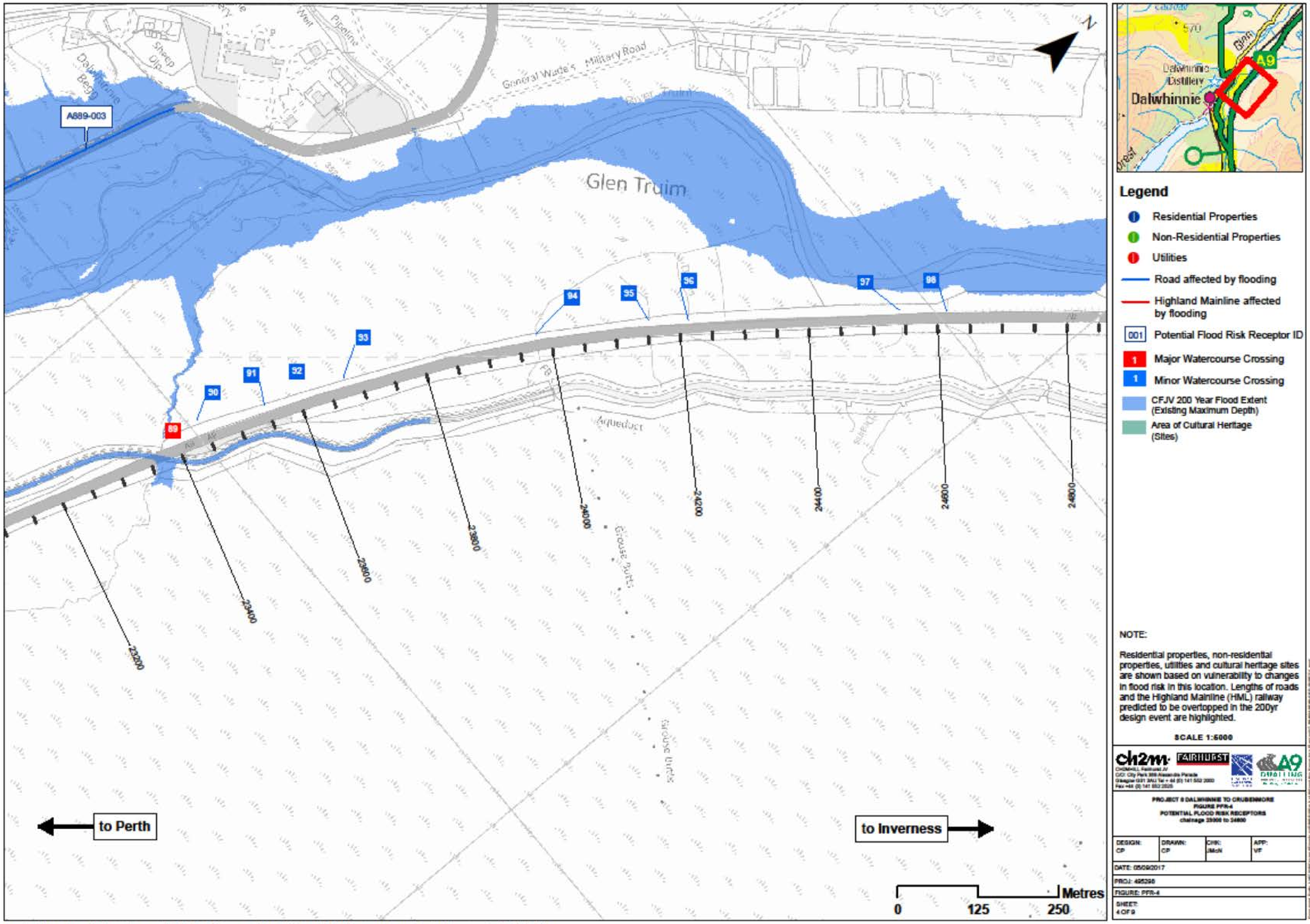

Glen Truim
General Wade's Military Road
River Truim
Aqueduct
Grouse Butts
A889-003
89
90
91
92
93
94
95
96
97
98
23200
23400
23600
23800
24000
24200
24400
24600
24800
to Perth
to Inverness
0
125
250
Metres
N
Dalwhinnie
Dalwhinnie Distillery
A9
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
001 Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:6000
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: VF
DATE: 05/09/2017
FIGURE: PFR-4
SHEET: 4 OF 9

Figure PFR-5

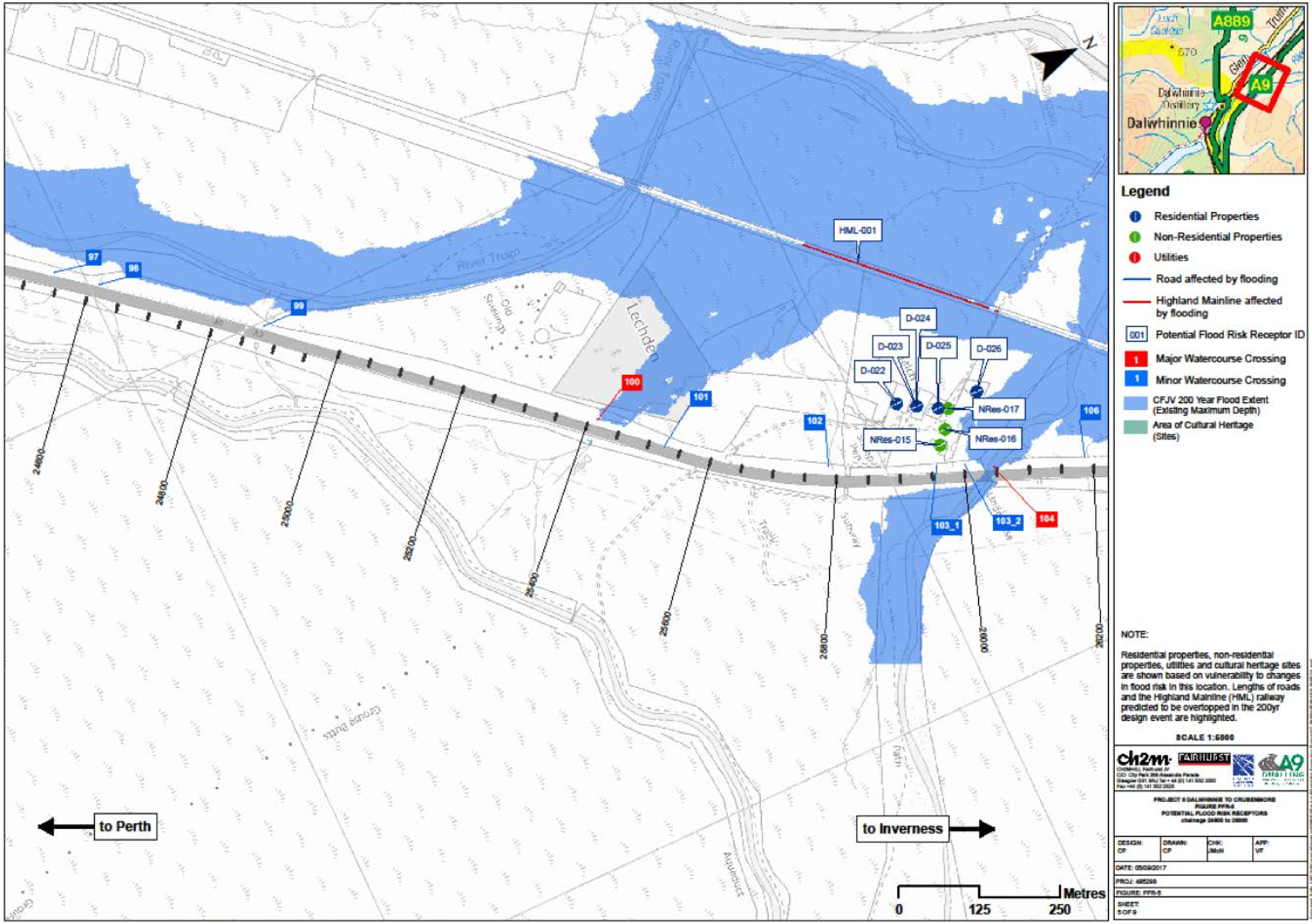

A889
A9
Dalwhinnie
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
001 Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
HML-001
D-022
D-023
D-024
D-025
D-026
NRes-015
NRes-016
NRes-017
97
98
99
100
101
102
103_1
103_2
104
106
River Truim
24600
24800
25000
25200
25400
25600
25800
26000
26200
to Perth
to Inverness
0
125
250
Metres
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:6000
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: VF
SHEET 5 OF 9

Figure PFR-6

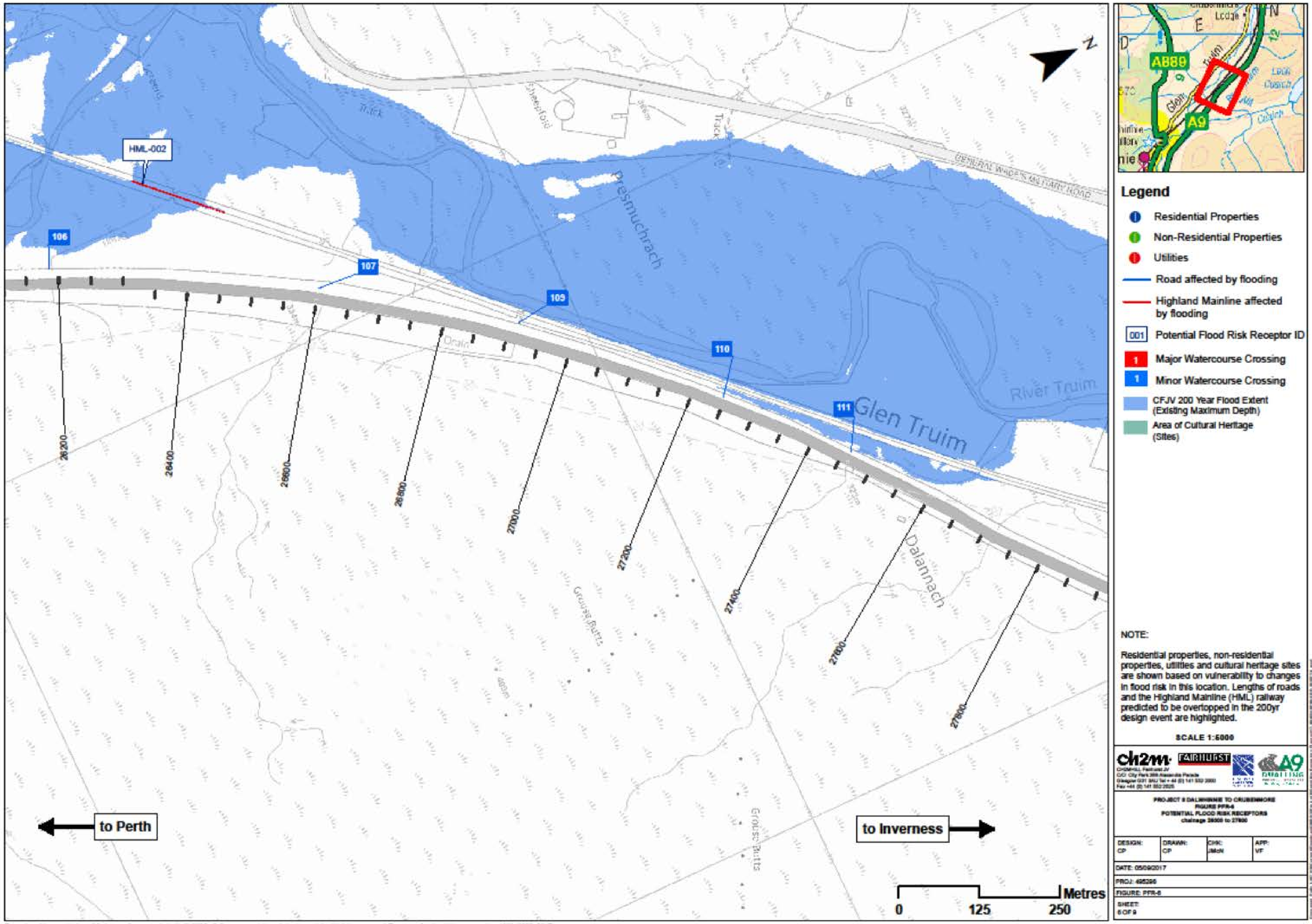

HML-002
106
107
109
110
111
26200
26400
26600
26800
27000
27200
27400
27600
27800
Presmuchrach
Glen Truim
River Truim
Dalannach
Grouse Butts
General Wade's Military Road
Track
to Perth
to Inverness
0
125
250
Metres
N
A889
A9
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:6000
ch2m
FAIRHURST
A9
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: VF
DATE: 05/09/2017
SHEET: 6 OF 9

Figure PFR-7

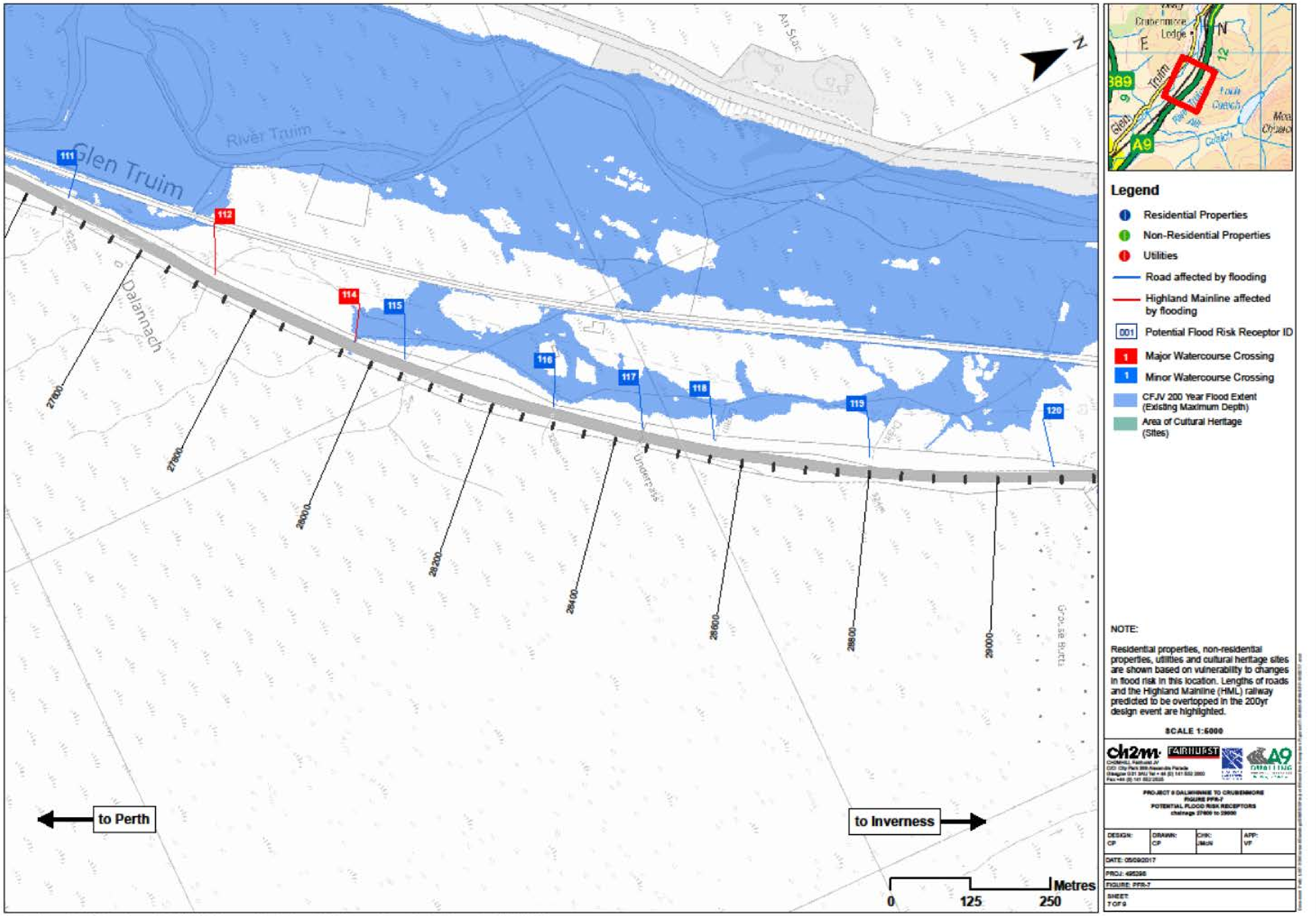

River Truim
Glen Truim
Dalannach
111
112
114
115
116
117
118
119
120
27600
27800
28000
28200
28400
28600
28800
29000
to Perth
to Inverness
0
125
250
Metres
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:5000
DESIGN: CP
DRAWN: CP
APP: VF
DATE: 05/09/2017
FIGURE: PFR-7

Figure PFR-8

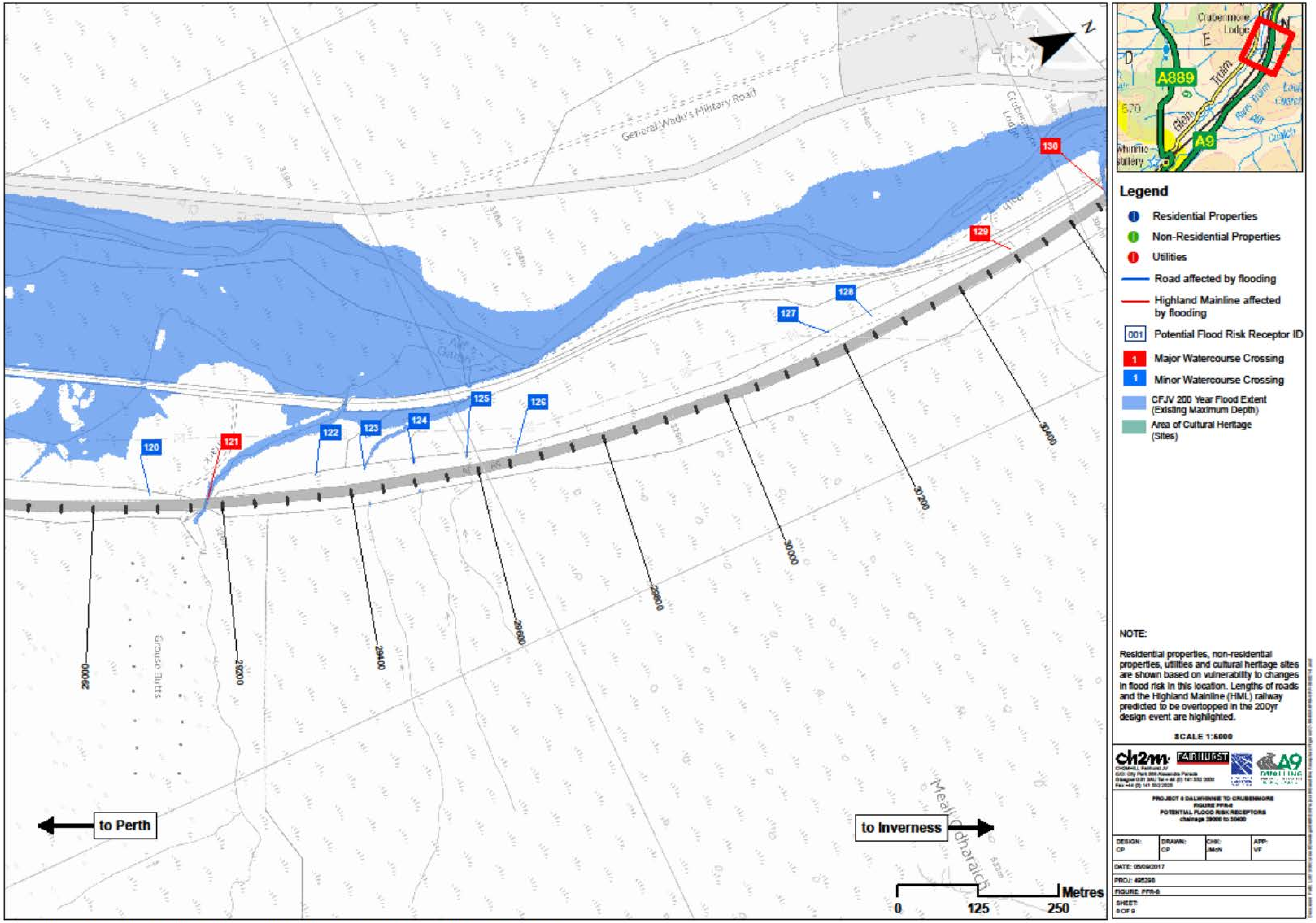
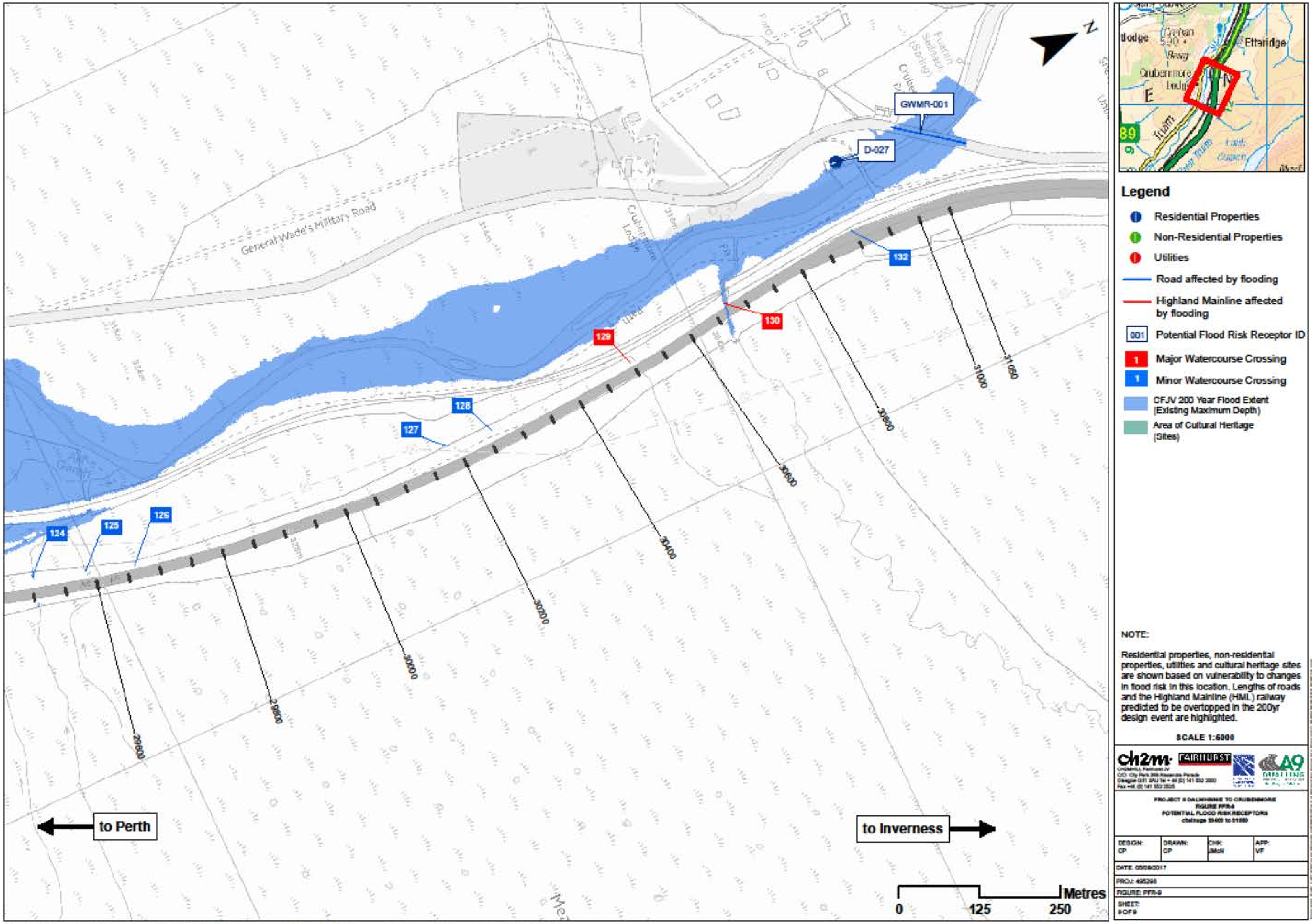

General Wade's Military Road
Grouse Butts
to Perth
to Inverness
120
121
122
123
124
125
126
127
128
129
130
29000
29200
29400
29600
29800
30000
30200
30400
0
125
250
Metres
A889
A9
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:5000
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: VF
DATE: 05/09/2017
SHEET 8 OF 9

Figure PFR-9


GWMR-001
D-027
General Wade's Military Road
132
130
129
128
127
126
125
124
29800
29900
30000
30200
30400
30600
30800
31000
31050
to Perth
to Inverness
0
125
250
Metres
Legend
Residential Properties
Non-Residential Properties
Utilities
Road affected by flooding
Highland Mainline affected by flooding
001 Potential Flood Risk Receptor ID
Major Watercourse Crossing
Minor Watercourse Crossing
CFJV 200 Year Flood Extent (Existing Maximum Depth)
Area of Cultural Heritage (Sites)
NOTE:
Residential properties, non-residential properties, utilities and cultural heritage sites are shown based on vulnerability to changes in flood risk in this location. Lengths of roads and the Highland Mainline (HML) railway predicted to be overtopped in the 200yr design event are highlighted.
SCALE 1:5000

Compensatory Storage Areas

Figure CS-1

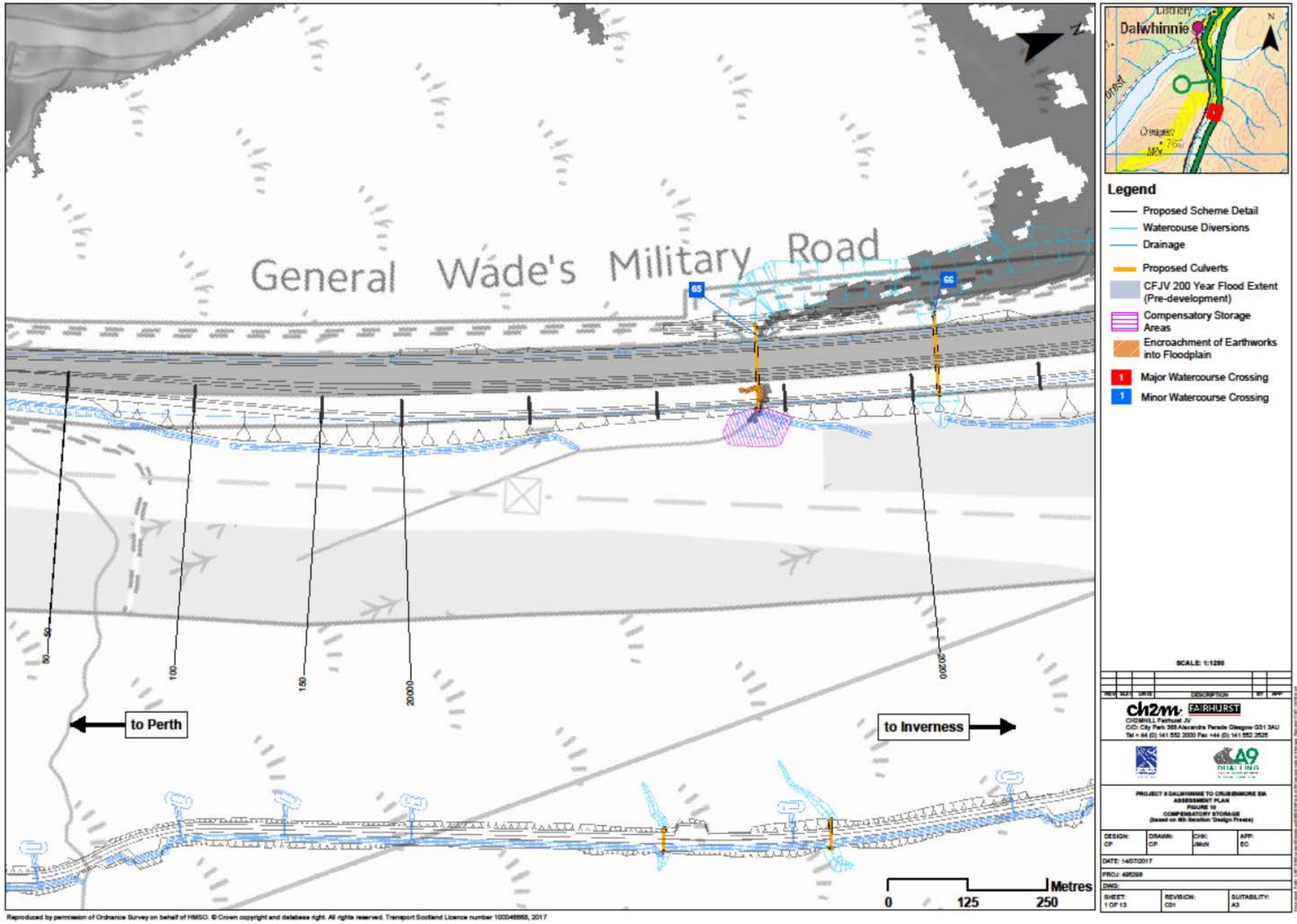


Figure CS-2


River Truim
391m
408m
to Perth
to Inverness
Metres
0
125
250
Dalwhinnie
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
ch2m FAIRHURST
A9

Figure CS-3

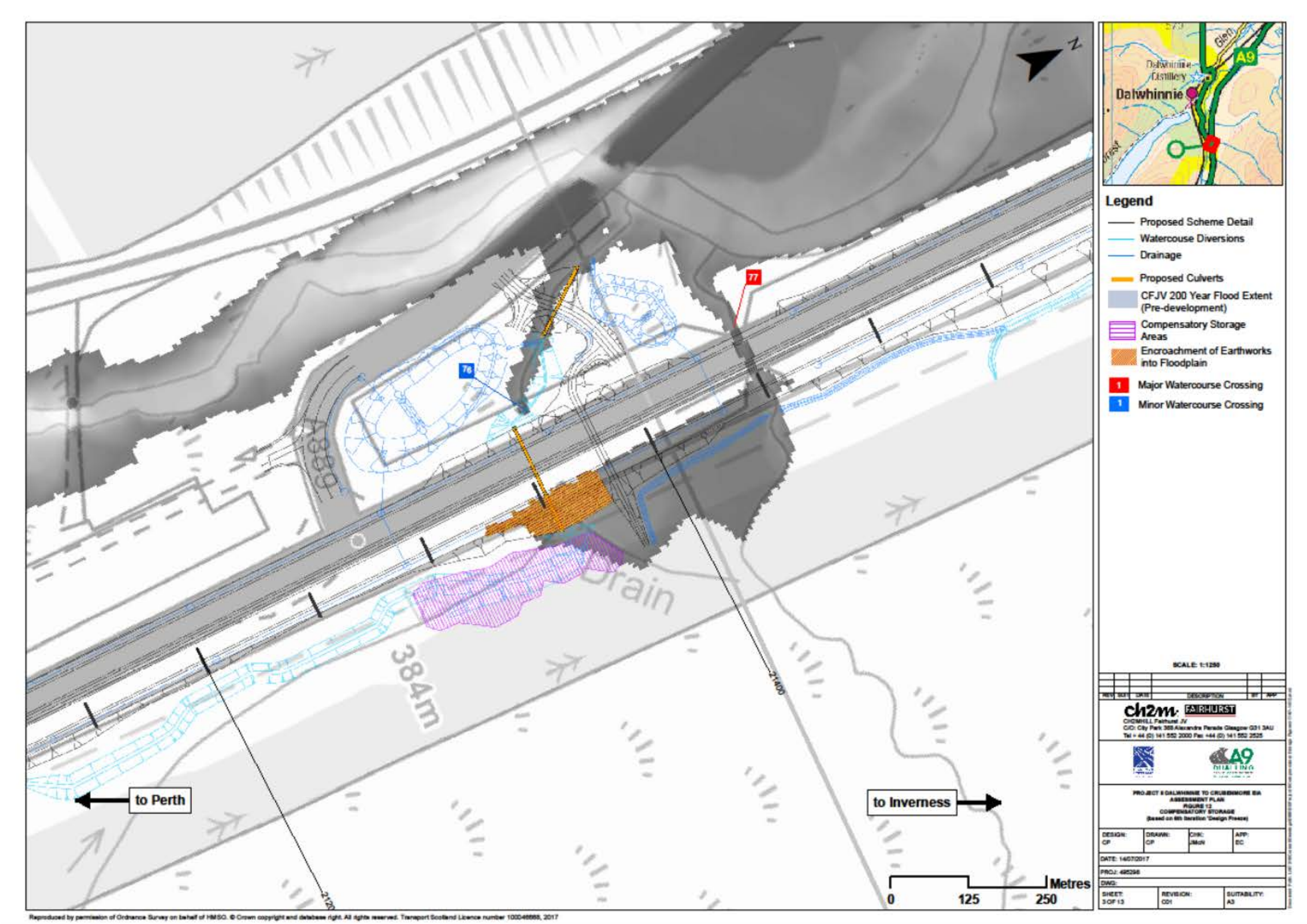

Dalwhinnie
A9
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
76
77
Drain
384m
to Perth
to Inverness
0
125
250
Metres
SCALE: 1:1250
DESIGN: CP
DRAWN: CP
APP: EC
DATE: 14/07/2017
SHEET: 3 OF 13
REVISION: C01
SUITABILITY: A3

Figure CS-4


Dalwhinnie
A9
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
79
78
to Perth
to Inverness
Metres
0
30
60
SCALE: 1:1250
CH2MHILL Fairhurst JV
FIGURE 13
COMPENSATORY STORAGE
DESIGN: CP
DRAWN: CP
CHK: JMcN
APP: EC
DATE: 14/07/2017
SHEET: 4 OF 13
REVISION: C01
SUITABILITY: A3

Figure CS-5

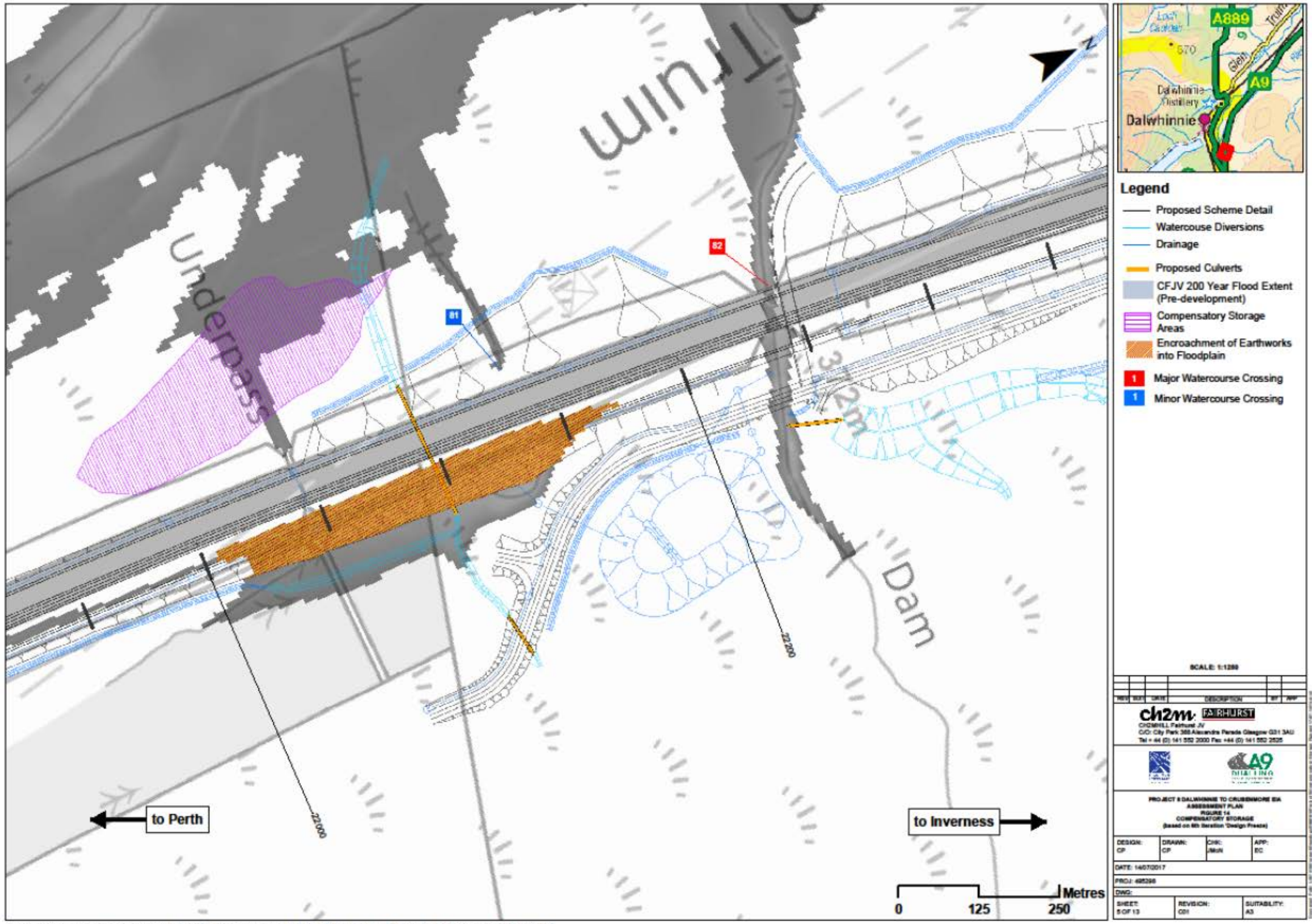

Truim
Underpass
Dam
to Perth
to Inverness
0
125
250
Metres
Dalwhinnie
A889
A9
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing

Figure CS-6

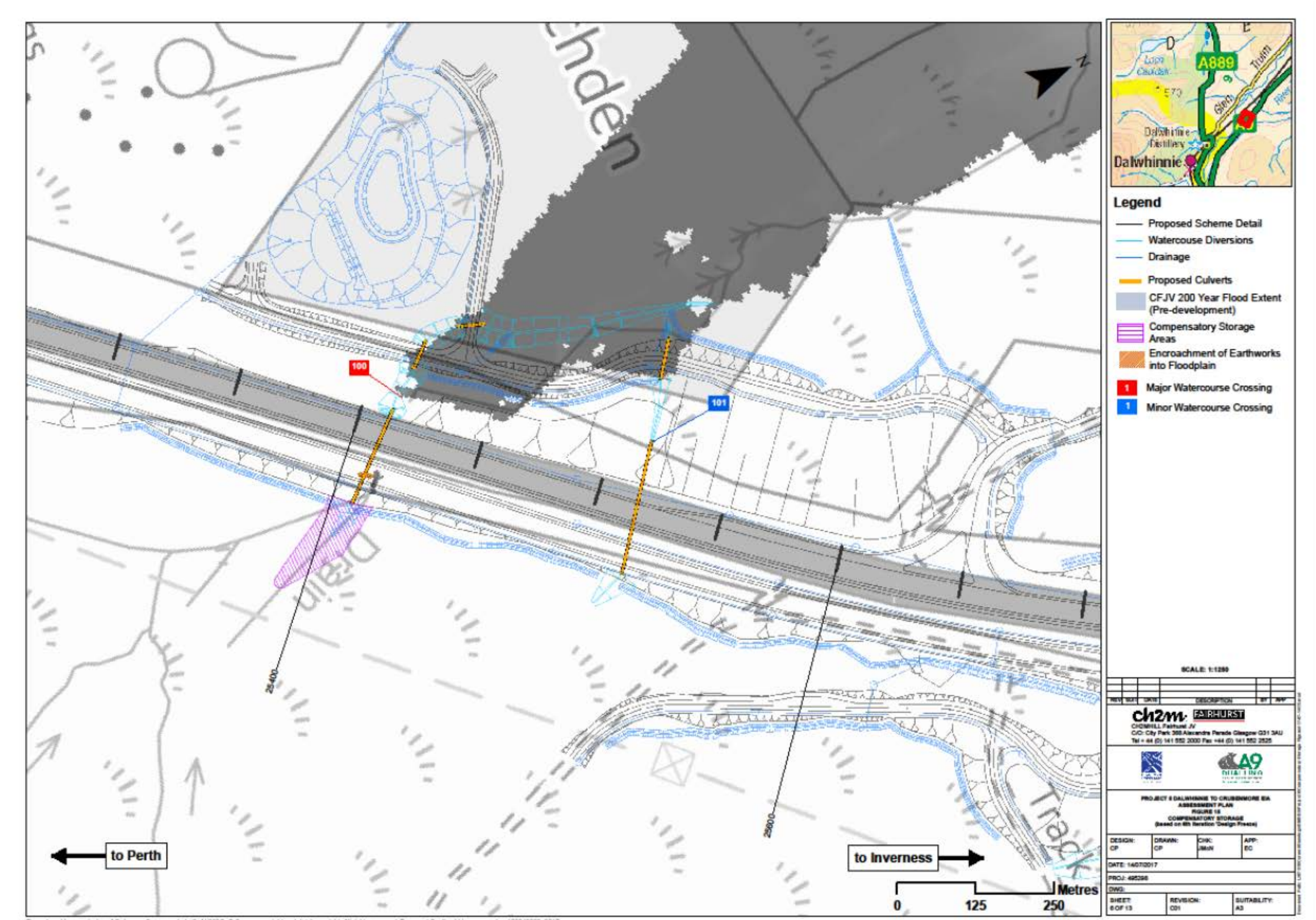

A889
Dalwhinnie
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
100
101
Drain
Track
to Perth
to Inverness
0
125
250
Metres
SCALE: 1:1250
REV
DESCRIPTION
BY
APP
CH2MHILL Fairhurst JV
C/O: City Park 368 Alexandra Parade Glasgow G31 3AU
DESIGN: CP
DRAWN: CP
APP: EC
DATE: 14/07/2017
DWG:
SHEET: 6 OF 13
REVISION: C01
SUITABILITY: A3

Figure CS-7

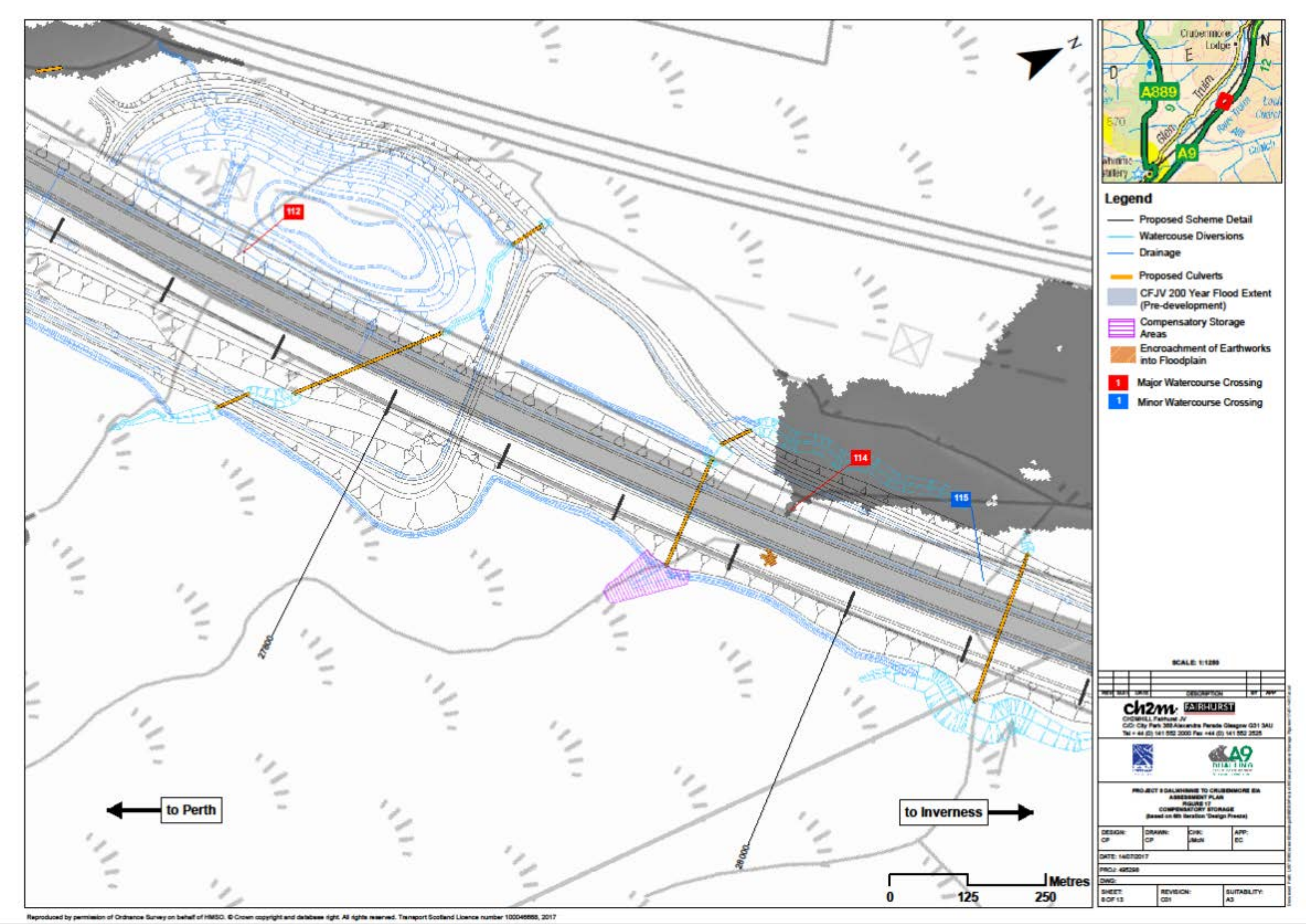

to Perth
to Inverness
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
0
125
250
Metres

Figure CS-8

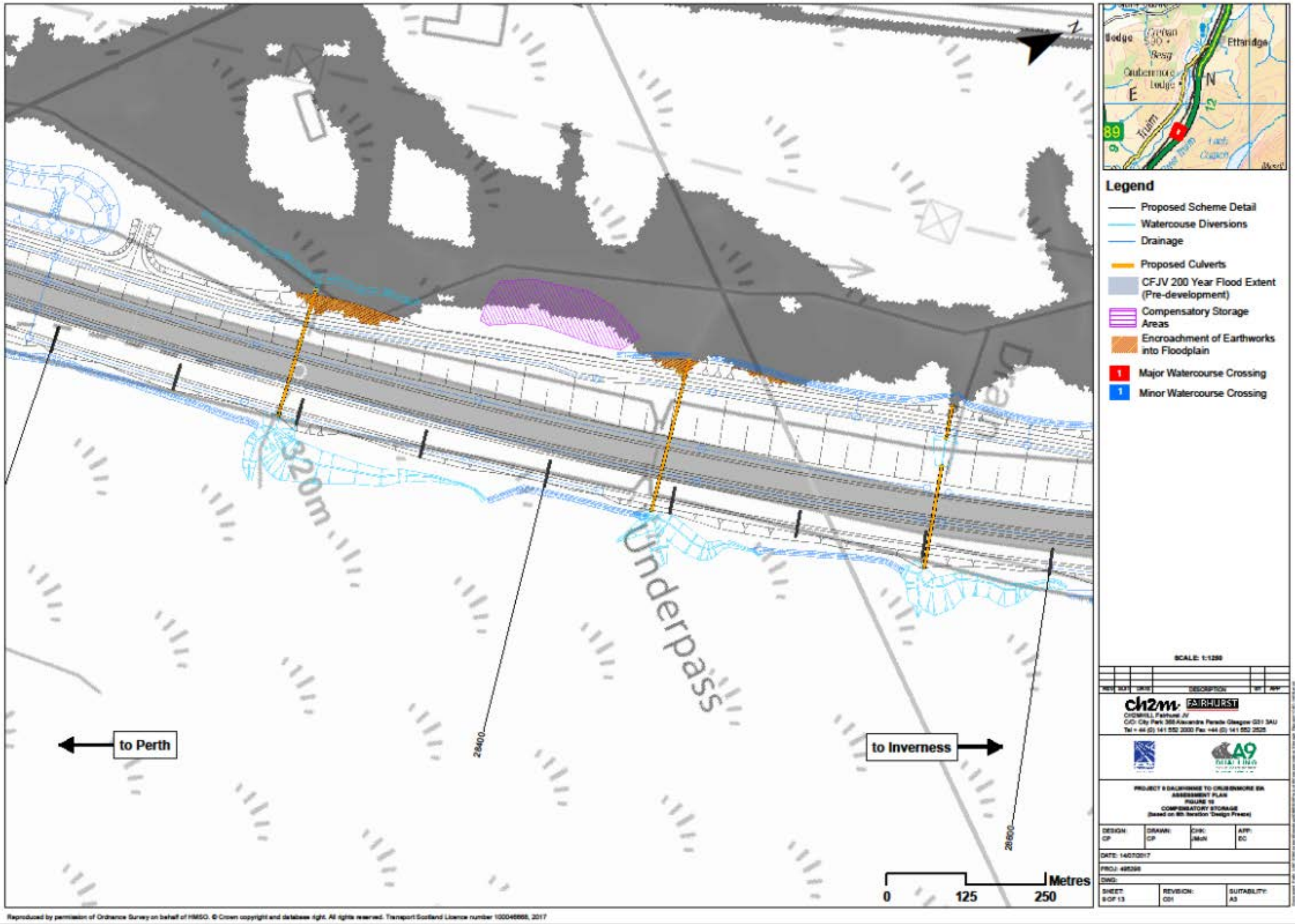

Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
Underpass
to Perth
to Inverness
Metres
0
125
250

Figure CS-9

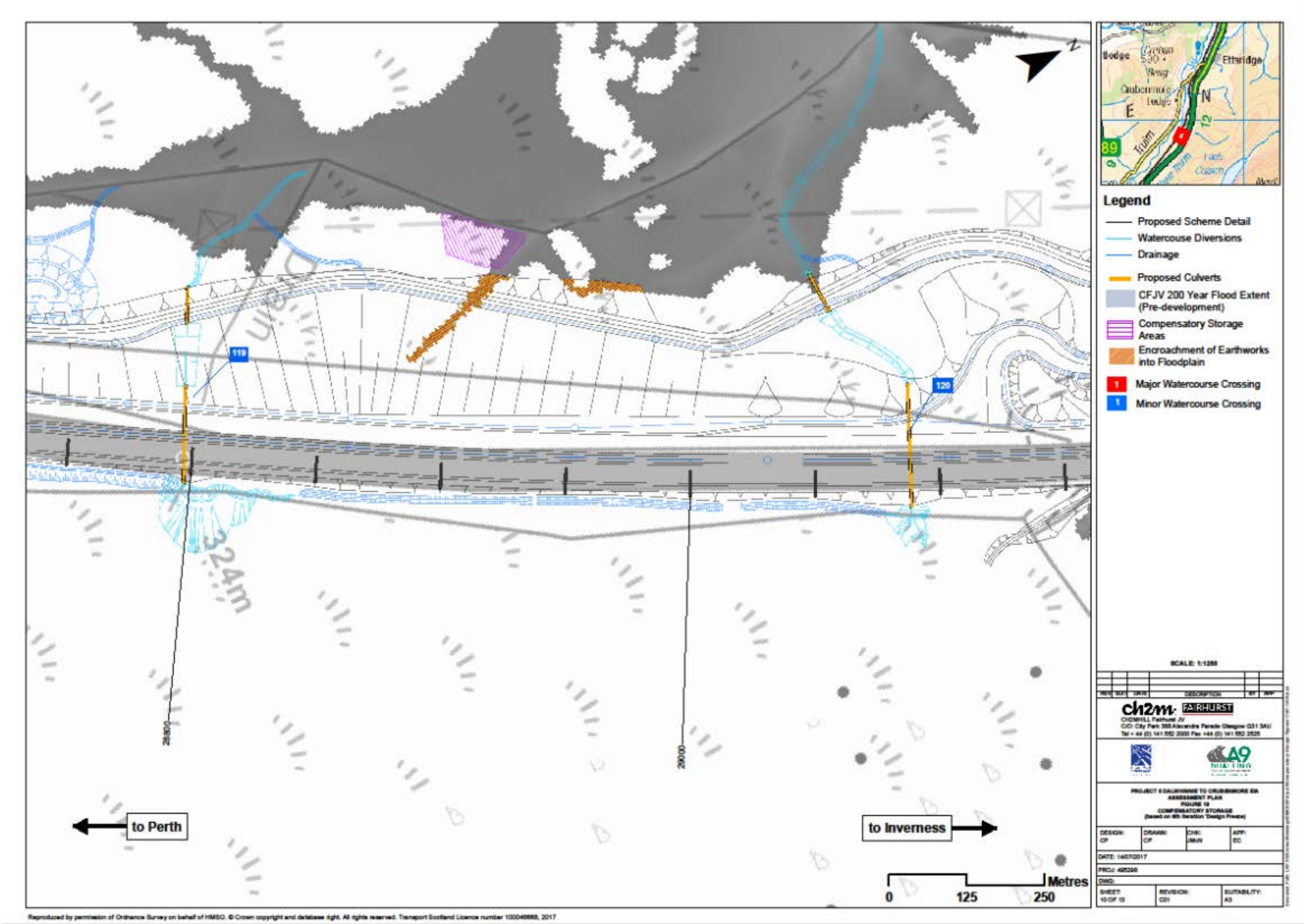

119
120
to Perth
to Inverness
0
125
250
Metres
Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
ch2m FAIRHURST

Figure CS-10

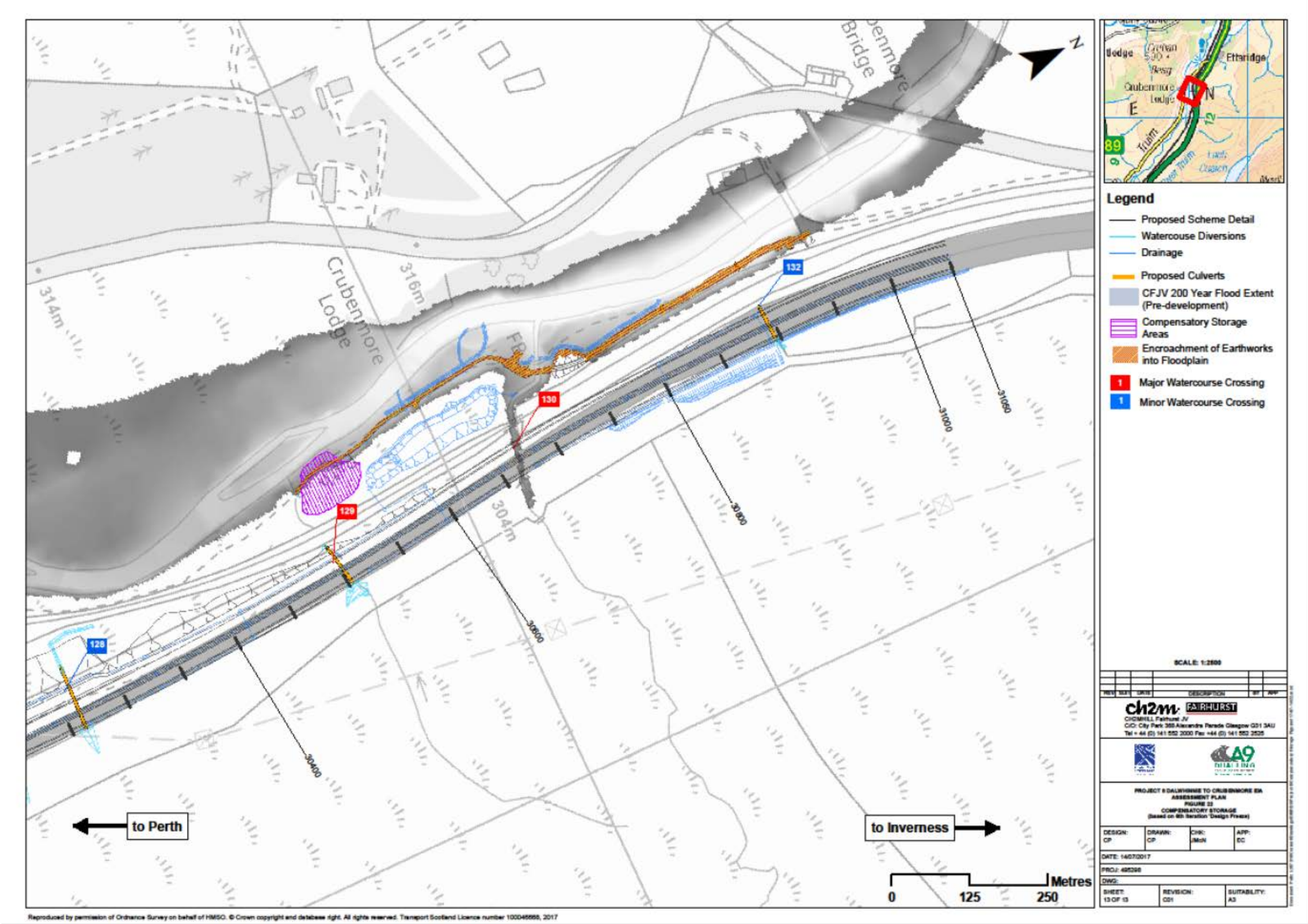

Legend
Proposed Scheme Detail
Watercouse Diversions
Drainage
Proposed Culverts
CFJV 200 Year Flood Extent (Pre-development)
Compensatory Storage Areas
Encroachment of Earthworks into Floodplain
Major Watercourse Crossing
Minor Watercourse Crossing
to Perth
to Inverness
Metres
0
125
250
Crubenmore Lodge
Crubenmore Bridge
128
129
130
132

Figure CS-11 – interim design – see 'Cuaich' sub-section of FRA **Section 9**