17. Appendix E
Hydraulic Technical Note

17E   Hydraulic Technical Note

Project	A9 Dualling: Kincraig to Dalraddy
Subject	Detailed Analysis of Hydraulic Models
Date	18th October 2013

1.   Introduction

1.1. Background

An Environmental Statement (ES) for the proposed A9 Dualling: Kincraig to Dalraddy has been prepared by Atkins and published in November 2013. SEPA highlighted during consultation on the ES that the earthworks at the Allt an Fhearna and Dunachton Burn would potentially encroach onto the Indicative Flood Outlines and recommended a Flood Risk Assessment (FRA) was undertaken to assess any risk to the area. In August 2013 there was an amendment to the scheme design following continuing discussion with statutory consultees. The revised design includes a cycleway running parallel to the road. A revised FRA has been produced to reflect the changes due to the addition of a cycleway. This technical note will provide detail of the hydraulic modelling undertaken to assess the risk of fluvial flooding to the proposed design.

1.2. Proposed Development

The proposed development crosses six watercourses:

- Unnamed Watercourse at Meadowside (Chainage 0000 metres)
- Dunachton Underpass/Watercourse (Chainage 1660 metres)
- Leault Burn Watercourse (Chainage 3090 metres)
- Baldow Smiddy Underpass/Watercourse (Chainage 3540 metres)
- Unnamed Watercourse at Dalraddy (Chainage 7025)
- Allt an Fhearna Underpass/Watercourse (Chainage 7050 metres).

The proposed structures are detailed in the FRA. During consultation (dated 19.12.12), SEPA expressed concern that the proposed embankments for the A9 Dualling at the Allt an Fhearna were encroaching onto the functional flood plain. The SEPA Indicative Flood Risk Map also showed flooding at the Dunachton Burn crossing. Historical flood records showed reports of flooding at a property adjacent to the unnamed watercourse at Meadowside.

Hydraulic models were built for all six watercourses. Details of the hydraulic models and their results are provided in this technical note.

2. Review of Data

2.1. Topographical Survey

A topographical survey was undertaken by Loy Surveys Ltd in March 2013 and additional survey was carried out in August 2013 in accordance with a survey specification and brief to survey open channel crosssections for each of the watercourses. The cross-sections included a survey of the river channel and extended to a distance of 10m beyond each bank top. It also included a survey of the structures crossing the watercourses.

Loy Surveys Ltd provided the following deliverables:

- A longitudinal section in dwg format
- Cross-section in dwg format
- Cross-section in xyz format
- Photographs of cross-sections

2.2. LiDAR

The first version of the FRA submitted in June 2013 used NextMap DTM to generate a groundmodel. This provided ground surface elevation points every five metres and has a vertical accuracy of +/- 0.6m. This revised FRA has used LiDAR (accuracy of +/- 0.05m) data provided by Transport Scotland. Both the NextMap DTM and the LiDAR were compared and verified against the the topographical survey. The LiDAR provided the closest accuracy to the topographical survey and therefore an improvement in accuracy for the hydraulic models was achieved compared to the first version of the FRA.

2.3. Site Visits

Two site visits were carried out. The first was undertaken in November 2012 and used to visually inspect the watercourses and identify any drainage channels and flow routes for the hydrological analysis. The second was carried out in August 2013 as the revision of the cycleway resulted in an additional watercourse being modelled. During the second site visit a visual inspection of the unnamed watercourse at Meadowside was undertaken.

3. Hydraulic Modelling

3.1. Model Build

The hydraulic models were built using either ISIS or InfoWorks RS software. The Allt an Fhearna model included 2D modelling to simulate the storage within the low lying ground at Loch Alvie and Loch Beag as well as storage within the lochs themselves. The models were built using the cross-sections surveyed by Loy Surveys Ltd. The cross-sections were renamed using the chainages corresponding to the survey location. This was relative to the distance from the downstream extent of each watercourse. Each crosssection has a unique label, in which the initial three letters of each node relates to the watercourse name and the last four digits refer to the cross-section chainage. Manning's n values have been used as roughness co-efficients for the models. The n values were based on a visual inspection during the site visit, and photographs of each cross-section provided by the surveyors. The values were defined in accordance with values depicted in 'Open Channel Hydraulics' (Chow, 1959).

3.2. Structures

All surveyed structures were included in the model. The structures were represented in the model using an Arch Bridge unit or a conduit unit. Details of the modelled structures are in Table 1. Default parameters were used unless otherwise stated.

Table 1. Schedule of Hydraulic Structures

Structure Label	Grid Reference	Label on Dwg file (from Loy Surveyors Ltd)	Hydraulic Model Unit	Additional Information
MEA06_0095U	281147, 803754	MEA06	**Existing** – Circular Conduit **Proposed** – rectangular conduit	A9 road crossing
MEA03_0017U	281178, 803694	281178, 803694	Circular Conduit	B9150 road crossing
DUN_0543A	282275, 805040	DUN Track Road Crossing U	Arch Bridge	Access track
DUN_0360A	282337, 804942	DUN06_0349	Arch Bridge	A9 road crossing
DUN_0281A	282353, 804803	DUN B9152 Road Crossing U	Arch Bridge	B9150 road crossing
LEA_0215	282908, 805997	LEA A9 Road Crossing U	Circular Conduit	A9 road crossing
BAL_03U	283269, 806491	BAL A9 Road Crossing U	**Existing** - Circular conduit **Proposed** - Arch bridge	A9 road crossing
UNN_4	285200, 808889	UNN04_0253	Circular Conduit	A9 road crossing
ALL_0530A	285332, 809145	ALL A9 Road Crossing U	Arch Bridge	A9 road crossing

3.3. Modelling Out-of-Bank Flow

Out-of-bank flow can be modelled either as extended cross-sections or as floodplain storage areas. Extended sections can be used where the floodplains are adjacent to the river bank area, allowing unrestricted transfer of water between the channel and the floodplain. Floodplain storage is used in areas where significant pooling of flood waters occurs, or where the floodplain flows are separated from the main channel by walls or embankments. Floodplains are connected to the main channel by later spills over the banks allowing different flood levels in the channel and floodplains to be modelled. Out-of-bank flow pathways can be modelled by connecting a series of storage areas together using floodplain sections or spills.

In the majority of areas, out-of-bank flow was modelled using extended cross-sections. The exception to this is the Allt an Fhearna which flows into Loch Alvie and there is an extensive flood plain area between the A9 road crossing and the loch. This was modelled using a 2D simulation polygon. All cross-sections were extended using LiDAR groundmodel data. The 2D simulation polygon was also created using LiDAR data.

3.4. Boundary Conditions

Upstream boundary conditions were defined using the FEHBDY option in InfoWorks/ISIS which is based on the rainfall runoff methodology of the Flood Estimation Handbook (FEH). This generates a hydrograph for the modelled inflows. The statistical peak flow was applied to these hydrographs by using the 'fit to peak' function in the boundary conditions. Hydrological estimates and methodology are described in Appendix B of the A9 Dualling: Kincraig to Dalraddy Flood Risk Assessment.

All downstream boundaries were defined using a stage/flow boundary. This is generated using the crosssection data for the cross-section at the downstream extent of the model and the Conveyance Estimation System rating automatically generated for each cross-section within InfoWorks.

3.5. Model Calibration and Verification

The hydraulic models were not calibrated as there is no gauged data available for any of the modelled watercourses. Verification was provided on the unnamed watercourse at Meadowside based on details of historical flooding in this area. The flood outlines for the Allt an Fhearna and Dunachton were compared to the SEPA Indicative Flood Map. It was found that both flood outlines predicted out-of-bank flow in the same locations. The SEPA flood outlines were found to be of a greater extent. It should be noted that the SEPA Indicative Flood Map outlines could be over-predicting or under-predicting the actual flood risk. This could be due to the more generalised application of the FEH methodology, the use of Nextmap DTM data to represent both the river channel and the flood plain and the absence of hydraulic structures from the SEPA Indicative models (SEPA, 2008).

4. Sensitivity Analysis

4.1. Introduction

A sensitivity analysis was carried out to ascertain the impact of variations in critical design parameters to modelled peak flood levels at the area of interest. The variables selected for the sensitivity tests were channel and floodplain roughness co-efficients, downstream boundary conditions and flow. A further sensitivity analysis was carried out on the Allt an Fhearna model to assess the sensitivity of the model results to the loch level. The unnamed watercourse at Meadowside was analysed for sensitivity to Manning's n only.

4.2. Channel and Floodplain Roughness Co-efficients

Channel and floodplain roughness was represented using a Manning's n co-efficient. Sensitivity to this parameter was tested by increasing and decreasing the value by 20%. The water levels at the A9 crossings were assessed.

The change in stage for each watercourse due to adjustments in Manning's n values are listed in the table below.

Table 2. Sensitivity to Manning's n values

Watercourse	Maximum variation in Water level due to changes in Manning's n (m)
Unnamed at Meadowside	+/- 0.02
Dunachton Burn	+/- 0.01
Leault Burn	+/- 0.02
Baldow Smiddy	+/- 0.0
Unnamed at Dalraddy	0
Allt an Fhearna	+/- 0.1

The analysis found that the models have a low sensitivity to changes in Manning's n values as there were only very slight changes in water level.

4.3. Downstream Boundary

Sensitivity to the downstream boundary was undertaken by decreasing the bed level of the downstream cross-section by 1m. The downstream boundary was then recalculated and the models re-run using the 0.5% AEP (with 20% increase as allowance for climate change). The water levels at the A9 crossings were assessed.

The change in stage for each watercourse due to adjustments in the downstream boundary are listed in the table below.

Table 3. Sensitivity to Downstream Boundary

Watercourse	Maximum Variation in Water level due to changes in Downstream Boundary (m)
Unnamed at Meadowside	NA
Dunachton Burn	0
Leault Burn	0.02
Baldow Smiddy	0
Unnamed at Dalraddy	0.0
Allt an Fhearna	0

The analysis found that the models have a low sensitivity to changes in the downstream boundary.

4.4. Flow

The hydrological analysis estimated the rainfall runoff peak for the 0.5% AEP (with 20% increase as allowance for climate change) and this was applied to the hydraulic models to assess the sensitivity to flow. For all models it increased the water levels at the upstream face of the structures. The table below shows the water level upstream of the structure and the soffit level of the proposed structure.

Table 4. Sensitivity due to changes in Flow

Watercourse	Water level upstream of the structures (m AOD)	Soffit level (m AOD)
Unnamed at Meadowside	NA	NA
Dunachton Burn	228.7	232.5
Leault Burn	**240.5**	241.5
Baldow Smiddy	234.6	239.5
Unnamed at Dalraddy	220.3	220.8
Allt an Fhearna	219.4	222.7

The analysis found that the structures were able to convey the rainfall runoff flow without surcharging.

4.5. Allt an Fhearna Sensitivity to Loch Level

A sensitivity analysis for the level of Loch Alvie was undertaken. The loch level was increased and decreased by 1m and the water level of the upstream face of the structure was assessed. The analysis found that there was no increase in water level at the A9 crossing due to changes in the loch level. The bed level from the A9 crossing is 7.3 m above the modelled level of the loch.

5. Results

This section details the results for the hydraulic models. For most watercourses two options were assessed and a preferred option was identified. The preferred options are the only options that have been reported in the FRA. The location of the cross-section for each model are in Figures 1-6.

5.1. Unnamed Watercourse at Meadowside

Two options were simulated for the unnamed watercourse at Meadowside. The preferred option (Option1) of placing a spanned structure over the watercourse and an alternative option (Option 2) of extending the 0.8m pipe 13m upstream.

The results for the preferred option (Option 1) are shown in the tables below. The results for the location of the upstream section of the proposed culvert are highlighted.

Table 5. Option 1 (preferred): Spanned structure over watercourse – Flow (m³/s)

Cross-section	Flow for existing scenario (m³/s)	Flow for proposed scenario (m³/s)	Difference
MEA01_0000U	1.62	1.64	0.02
MEA02_0006D	1.62	1.64	0.02
MEA03_0017U	1.62	1.64	0.02
MEA04_0039	1.62	1.64	0.02
MEA05_0054D	1.62	1.64	0.02
MEA06_0054B	1.62	1.64	0.02
MEA06_0075	1.62	1.64	0.02
MEA06_0095J	1.62	1.64	0.02
MEA07_0108	1.62	1.64	0.02
MEA07_0167	1.63	1.64	0.01
MEA08_0254	1.63	1.64	0.00
MEA09_0324	1.64	1.64	0.00

The results show a negligible change in flow due to the proposed structures.

Table 6 shows the changes in stage due to the changes for option 1.

Table 6: Option 1 (preferred): Spanned structure over watercourse – Stage (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
MEA01_0000U	220.89	0.53	220.89	0.53	0.00
MEA02_0006D	221.07	0.68	221.08	0.69	0.00
MEA03_0017U	222.24	1.68	222.24	1.68	0.00
MEA04_0039	222.35	0.73	222.36	0.73	0.00
MEA05_0054D	222.93	0.67	222.93	0.67	0.00
MEA06_0054B	223.05	0.79	223.07	0.81	0.01
MEA06_0075	223.69	0.48	223.70	0.49	0.01
MEA06_0095J	226.46	2.26	226.06	1.86	-0.40
MEA07_0108	226.46	1.52	226.06	1.32	-0.20
MEA07_0167	229.04	0.41	229.03	0.40	-0.01
MEA08_0254	234.88	0.55	234.89	0.56	0.01
MEA09_0324	242.95	0.44	242.95	0.44	0.00

The results show that there was a reduction in water levels as a result of the proposed design. Tables 7 and 8 show the results for the second option which was to extend the 800mm pipe by 13m.

Table 7. Option 2: Extending the pipe - Flow (m3/s)

Cross-section	Flow for Existing Scenario	Flow for proposed Scenario	Difference
MEA01_0000U	1.62	1.64	0.0
MEA02_0006D	1.62	1.64	0.0
MEA03_0017U	1.62	1.64	0.0
MEA04_0039	1.62	1.64	0.0
MEA05_0054	1.62	1.64	0.0
MEA06_0054B	1.62	1.64	0.0
MEA06_0075	1.62	1.64	0.0
MEA06_0095J	1.62	1.64	0.0
MEA07_0108	1.63	1.64	0.0
MEA07_0167	1.64	1.64	0.0
MEA08_0254	1.64	1.64	0.0
MEA09_0324	1.64	1.64	0.0

Table 8. Option 2: Extending the pipe - Water level (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
MEA01_0000U	220.89	0.53	220.89	0.53	0.0
MEA02_0006D	221.07	0.68	221.08	0.69	0.0
MEA03_0017U	222.24	1.68	222.24	1.68	0.0
MEA04_0039	222.35	0.73	222.36	0.73	0.0
MEA05_0054D	222.93	0.67	222.93	0.67	0.0
MEA06_0054B	223.05	0.79	223.07	0.81	0.0
MEA06_0075	223.69	0.48	223.70	0.49	0.0
MEA06_0095J	226.46	2.26	226.00	1.80	-0.4
MEA07_0108	226.46	1.52	226.00	1.26	-0.2
MEA07_0167	229.04	0.41	229.03	0.40	0.0
MEA08_0254	234.88	0.55	234.89	0.56	0.0
MEA09_0324	242.95	0.44	242.95	0.44	0.0

The results showed that there was no change in flow as a result of the proposed option and a decrease in stage.

Option 1 was chosen as the preferred option as this option would be a simpler solution to construct. The span would be built over the watercourse and the existing pipe will remain undisturbed. This would result in minimul disruption to the watercourse. The first option has a negligible effect on the flow and stage of the watercourse. Therefore there was no increase in flood risk as a result of this option.

5.2. Dunachton Burn

Two options were modelled for the Dunachton Burn. Option 1, which is the preferred option is a structure with a span of 9.45m The second option is to reduce the span to 6.65m. Results for Option 1 are in Tables 9 and 10.

Table 9. Option 1 - Replace structure, 9.45m span – Flow (m3/s)

Cross-section	Flow for Existing Scenario	Flow for proposed Scenario	Difference
DUN_0000	21.8	21.8	0
DUN_0098	21.8	21.8	0
DUN_0255	21.8	21.8	0
DUN_0280	21.8	21.8	0
DUN_0280A	21.8	21.8	0
DUN_0280B	21.8	21.8	0
DUN_0334	21.8	21.8	0
DUN_0361_int	21.8	21.8	0
DUN_0361A	21.8	21.8	0
DUN_0361B	21.8	21.8	0
DUN_0361B!	21.8	21.8	0
DUN_0522	21.8	21.8	0
DUN_0543B	21.8	21.8	0
DUN_0550	21.8	21.8	0
DUN_0550A	21.8	21.8	0
DUN_0712	21.8	21.8	0
DUN_1031	21.8	21.8	0

Table 10. Option 1 – Replace Structure 9.45m Span - Water Level (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
DUN_0000	222.61	1.91	222.61	1.91	0.00
DUN_0098	222.95	1.05	222.95	1.05	0.00
DUN_0255	224.79	1.02	224.79	1.02	0.00
DUN_0280	225.57	1.61	225.57	1.61	0.00
DUN_0280A	225.47	1.52	225.47	1.52	0.00
DUN_0280B	224.91	0.95	224.91	0.95	0.00
DUN_0334	225.96	1.43	225.96	1.43	0.00
DUN_0361	227.75	2.55	228.43	2.48	-0.07
DUN_0361A	227.59	2.39	228.19	2.36	-0.03
DUN_0361B	227.59	2.39	228.19	2.36	-0.03
DUN_0361B!	227.54	2.34	228.13	2.31	-0.03
DUN_0522	228.98	1.00	228.98	1.00	0.00
DUN_0543B	230.38	1.66	230.37	1.64	-0.01
DUN_0550	230.50	1.70	230.50	1.69	-0.01
DUN_0550A	230.42	1.61	230.40	1.59	-0.01
DUN_0712	231.68	1.40	231.68	1.40	0.00
DUN_1031	235.85	1.12	235.85	1.13	0.01

The results show that there is no change in flow and a slight decrease in water level as a result of the proposed changes. The decrease in water level occurs at the proposed crossing as the span has increased, resulting in the flow that is out-of-bank at the 0.5% AEP (with 20% allowance for climate change) being conveyed over a larger cross-sectional area.

A second option was simulated to assess the effects of reducing the span of the structure. This would provide a more cost-effective solution. The second option reduced the span to 6.65m. The results for Option 2, decreasing the span to 6.65m are in Tables 11 and 12.

Table 11. Option 2 - Structure Span 10m - Flow (m₃/s)

Cross-section	Flow for Existing Scenario	Flow for proposed Scenario	Difference
DUN_0000	21.8	21.8	0
DUN_0098	21.8	21.8	0
DUN_0255	21.8	21.8	0
DUN_0280	21.8	21.8	0
DUN_0280A	21.8	21.8	0
DUN_0280B	21.8	21.8	0
DUN_0334	21.8	21.8	0
DUN_0361_int	21.8	21.8	0
DUN_0361A	21.8	21.8	0
DUN_0361B	21.8	21.8	0
DUN_0361B!	21.8	21.8	0
DUN_0522	21.8	21.8	0
DUN_0543B	21.8	21.8	0
DUN_0550	21.8	21.8	0
DUN_0550A	21.8	21.8	0
DUN_0712	21.8	21.8	0
DUN_1031	21.8	21.8	0

Table 12. Option 2 – Replace Structure 6.65m Span - Water Level (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
DUN_0000	222.61	1.91	222.61	1.91	0.00
DUN_0098	222.95	1.05	222.95	1.05	0.00
DUN_0255	224.79	1.02	224.79	1.02	0.00
DUN_0280	225.57	1.61	225.57	1.61	0.00
DUN_0280A	225.47	1.52	225.47	1.52	0.00
DUN_0280B	224.91	0.95	224.91	0.95	0.00
DUN_0334	225.96	1.43	225.96	1.43	0.00
DUN_0361	227.75	2.55	228.71	2.76	0.21
DUN_0361A	227.59	2.39	228.42	2.59	0.20
DUN_0361B	227.59	2.39	228.42	2.59	0.20
DUN_0361B!	227.54	2.34	228.36	2.53	0.19
DUN_0522	228.98	1.00	229.01	1.03	0.03
DUN_0543B	230.38	1.66	230.37	1.64	-0.01
DUN_0550	230.50	1.70	230.50	1.69	-0.01
DUN_0550A	230.42	1.61	230.40	1.59	-0.01
DUN_0712	231.68	1.40	231.73	1.45	0.05
DUN_1031	235.85	1.12	235.85	1.13	0.01

The results show that there is an increase in water level when the span is reduced to 6.65m. A span wider than 9.45m was not assessed as the span of 9.45m decreased water level and reduced flood risk.

5.3. Leault Burn

The proposed structure for the Leault Burn was modelled and the changes in water level and flow are shown in Table 13 and 14.

Table 13: Proposed Option for Leault Burn - Flow (m3/s)

Cross-section	Flow for existing scenario	Flow for proposed scenario	Difference
LEA_0000	3.99	3.99	0.00
LEA_0087	3.99	3.99	0.00
LEA_0182	3.99	3.99	0.00
LEA_0215	3.99	3.99	0.00
LEA_0495	4.00	3.99	-0.01
LEA_0713	3.99	3.99	0.00

Table 14: Proposed Option for Leault Burn - Stage (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
LEA_0000	235.58	1.08	235.52	1.02	-0.06
LEA_0087	236.96	0.85	236.95	0.85	0.00
LEA_0182	238.62	1.16	238.38	0.92	-0.24
LEA_0215	239.62	1.20	239.09	0.68	-0.51
LEA_0495	243.33	0.76	243.35	0.40	-0.36
LEA_0713	247.18	0.70	247.17	0.32	-0.38

The results show that there is a decrease in water level as a result of the proposed option. There is a negligible decrease in flow which may simply be a result of model variance and convergence

A second option which reduced the span was modelled. This reduced the overall span from 4.8m to 3.55m. This option provided no additional benefit to option 1.

5.4. Baldow Smiddy

The results for the proposed option for Baldow Smiddy are in Tables 15 and 16 below. Option 1 was for a structure with an overall span of 10m.

Table 15: Option 1 for Baldow Smiddy - flow (m$_3$/s)

Cross-section	Flow for existing scenario	Flow for proposed scenario	Difference
Bal_01	2.68	2.68	0.0
Bal_02	2.68	2.68	0.0
Bal_03U	2.68	2.68	0.0
Bal_03	0.89	0.85	0.0
Bal_04	0.85	0.85	0.0
Bal_05	0.85	0.85	0.0

Table 16: Option 1 for Baldow Smiddy - Stage (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
Bal_01	233.13	1.3	233.13	1.3	0.0
Bal_02	233.6	0.7	233.64	0.7	0.0
Bal_03U	234.40	1.1	234.3	0.8	-0.4
Bal_03	234.90	1.0	234.93	1.0	0.0
Bal_04	246.15	0.2	246.14	0.2	0.0
Bal_05	251.696	0.4	251.69	0.4	0.0

The results show that there is no increase in flow or stage as a result of the proposed design. There was a decrease in water level at the upstream face of the proposed culvert.

A second option was modelled to assess the affect of reducing the span to minimum of 9.55m There was also no change in flow or water level associated with this scenario.

5.5. Allt an Fhearna

The proposed structure was assessed using the hydraulic model. The flow and water levels for the existing and proposed models are presented in Tables 17 and 18.

Table 17: Allt an Fhearna - Flow (m$_3$/s)

Cross-section	Flow for existing scenario	Flow for proposed scenario	Difference
Allt_0000	12.28	10.77	-1.50
Allt_0258	12.24	10.75	-1.49
Allt_0492	24.30	20.30	-4.00
ALL_0530A	38.93	38.75	-0.18
Allt_0542	39.75	38.75	-0.99
Allt_0793	39.11	38.91	-0.20
Allt_0929	38.89	38.87	-0.02
Allt_1152	38.89	38.91	0.02
Allt_1306	38.87	38.87	0.00

Table 18. Allt an Fhearna - Stage (m)

Cross-section	Water level for Existing Scenario (m AOD)	Water Depth (m)	Water level for Proposed Scenario (m AOD)	Water Depth (m)	Difference in Water Depth (m)
Allt_0000	212.90	1.49	212.88	1.47	-0.01
Allt_0258	215.54	0.70	215.45	0.61	-0.09
Allt_0492	217.87	1.51	217.81	1.44	-0.07
ALL_0530A	219.78	2.66	219.11	1.85	-0.81
Allt_0542	220.10	2.69	219.28	1.86	-0.82
Allt_0793	221.51	1.29	221.41	1.19	-0.10
Allt_0929	223.35	1.21	223.40	1.26	0.05
Allt_1152	226.96	1.25	226.92	1.21	-0.04
Allt_1306	229.14	1.63	229.17	1.66	0.03

The results show that there is a drop in downstream flow and stage in the watercourse as a result of the proposed option. The proposed design decreases the water level as the width of the access track is increasing from approximately 3m to 6.6m. The out-of-bank flow spills onto the access track, as the access track is wider it reduces the water level. There is no increase in water level as a result of the proposed embankments. It was found that the out-of-bank flow spills to the flood plain through low lying ground downstream of the culvert outlet cross-section. The levels of this spill are unaffected by the proposed earthworks embankments. The flow from the Allt an Fhearna is therefore still able to flow into the floodplain and this results in no increase in flow or water level downstream of the proposed design.

The floodplain storage is modelled using a 2D mesh. Volume and levels of each triangle within the mesh vary, however a check was carried out of the flood levels for two locations in the mesh. A location near the A9 crossing and a location at the loch was picked. This analysis found that there was negligible difference in water level at each location (+/- 0.05m) between the existing and proposed scenarios. Its important to note that it is difficult to do a direct comparison as the triangles making up the 2D mesh are repositioned between the existing and the proposed model, however checks on several points at various locations provided the most accurate check for increases in water level.

Although flood waters will have been displaced due to the proposed embankments there has been no increase in water level in the channels and a negligible difference to floodplain water levels. Compensatory storage has not been optioned as the model has shown that there is no increase in flood risk associated with the proposed works. With no increase in water level in the channel or the floodplain due to the proposed design, construction of compensatory storage cannot be demonstrated to provide any benefit to the water environment.

No options were assessed for the Allt an Fhearna. Increasing the span would require a deeper deck crosssection which would reduce the headroom required for vehicle passage through the access track within the structure. The trunk road vertical profile has been raised through this section to achieve required headrooms and it would be difficult to raise this profile further within the confines of road design standards. Furthermore, raising the profile would result in an increase of the earthworks embankments. Reducing the span was not considered as it would result in further encroachment of the embankments onto the flood plain area.

6. Conclusions

The key conclusions to this study are as follows

- Hydraulic models were used to assess the changes to flow and water levels for all watercourses crossed by the proposed A9 Dualling: Kincraig to Dalraddy.
- Where possible two options for each crossing were assessed,
- The models found that there was no increase to flow or water level as a result of the proposed design.
- For the Dunachton Burn and Allt an Fhearna crossings, the models show an improvement to flood risk at the structures.
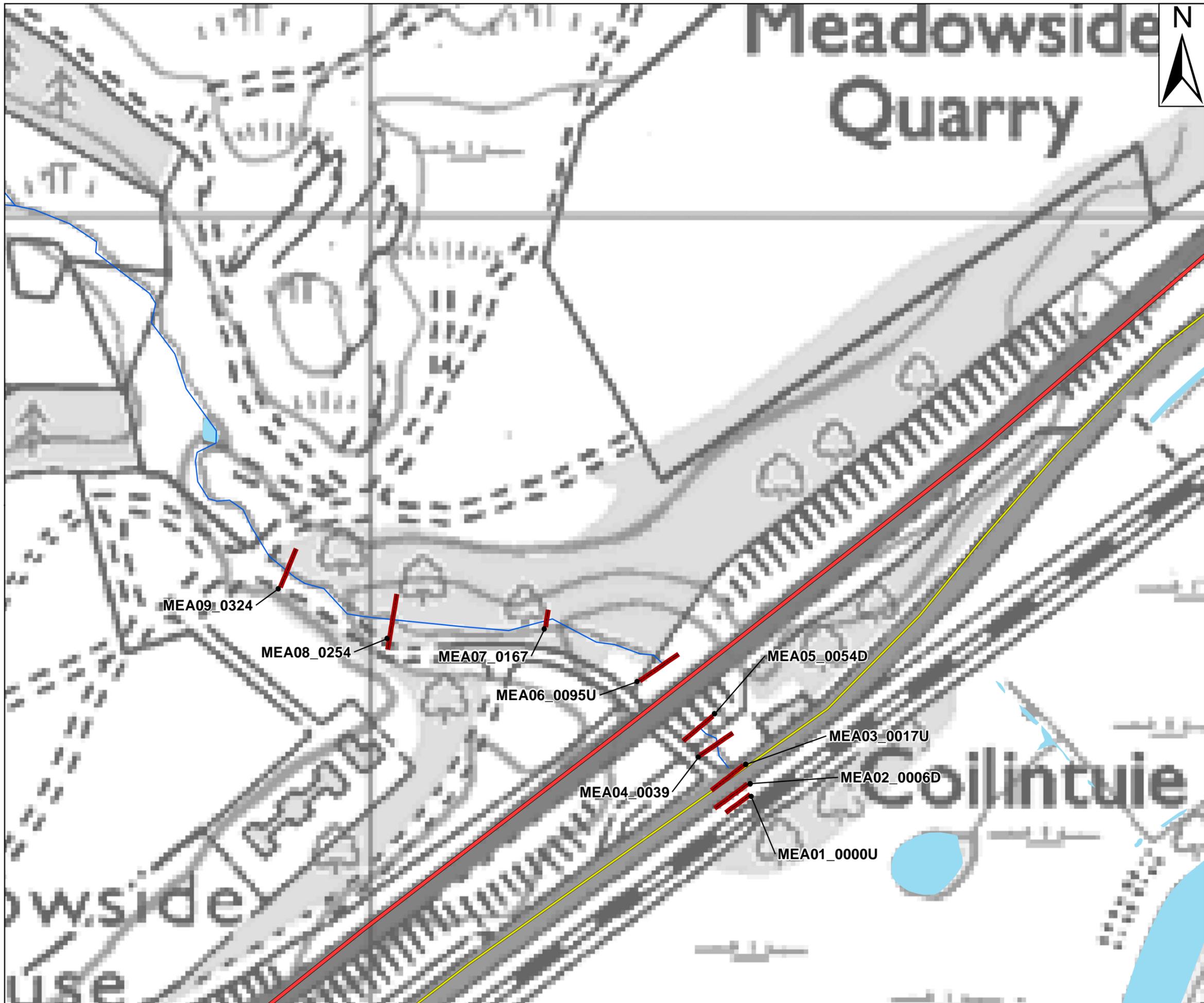
Meadowside Quarry

N

MEA09_0324

MEA08_0254

MEA07_0167

MEA06_0095U

MEA05_0054D

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NB: STUDY AREA LIES WITHIN CAIRNGORMS NATIONAL PARK

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Project

A9 DUALLING
PERTH TO INVERNESS
Kincraig to Dalraddy

Title

FIGURE 1.0
MEADOWSIDE Q200 + (20%CC)
SECTION LOCATIONS

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
A3	1:2,000	LG	EM	XX
		Date 22/10/13	Date 22/10/13	Date 22/10/13

Drawing Number	Rev
5109850_WAT_FIG1.0	01
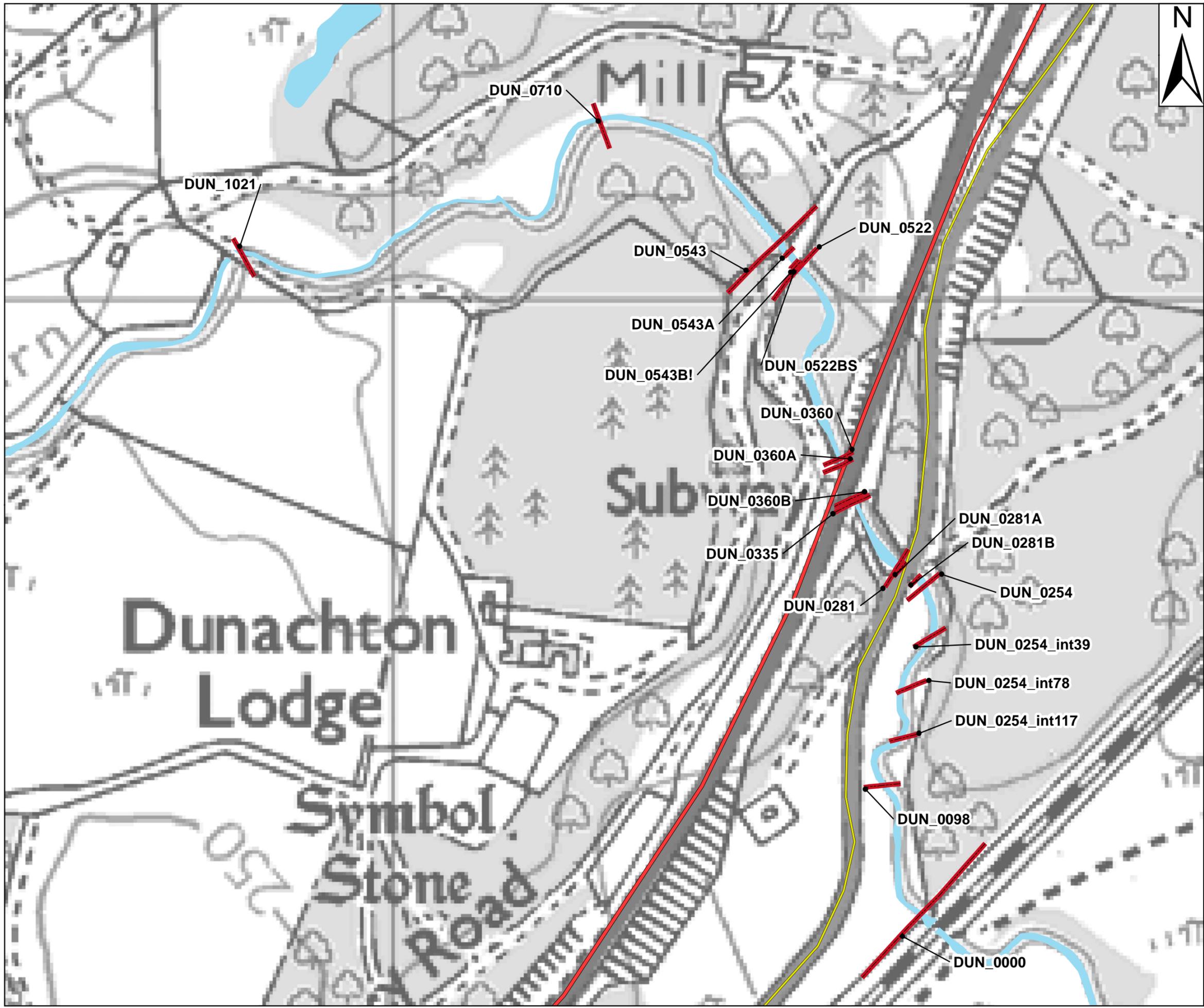
FIGURE 2.1
DUNACHTON
RIVER MODEL CROSS SECTIONS

N

LEA_0215D

LEA_0215

LEA_0087

LEA_0000

LEA_0495

LEA_0182

LEA_0713

Lealt Burn

Kincraig Farm

Ford

258 Loch Cottage

231

Sheepfold

Kincraig House

River

Ford

FB

245 Mon

Hotel

MS

PO

Kincraig Bridge

Kincraig

Leault Farm

Ford

Subway

Sch

Title

FIGURE 3.0
LEAULT BURN
RIVER MODEL CROSS SECTIONS

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
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		Date 22/10/13	Date 22/10/13	Date 22/10/13

Drawing Number	Rev
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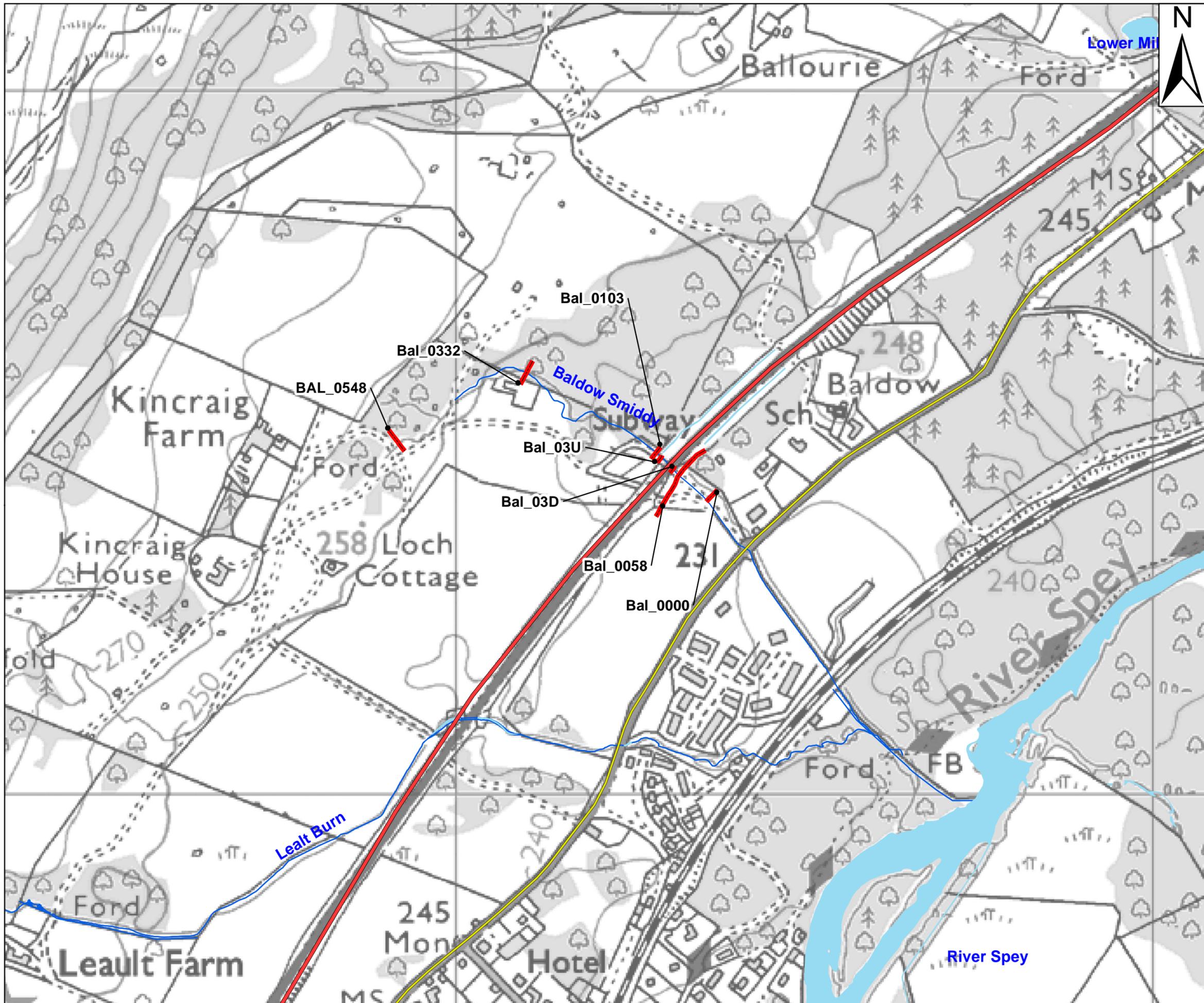
FIGURE 4.0
BALDOW SMIDDY
RIVER MODEL CROSS SECTIONS

N

220

230

Unn_06

Unn_03

Unn_02

Unn_0000

Unn_07

Fords

Unn_08

Dalraddy

220

230

QUAD
TRE

**NB: STUDY AREA LIES WITHIN
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**A9
DUALLING**
PERTH TO INVERNESS
Kincraig to Dalraddy

Title

FIGURE 5.0
DALRADDY
RIVER MODEL CROSS SECTIONS

Sheet Size	Original Scale	Designed / Drawn	Checked	Authorised
A3	1:2,500	LG	EM	XX
		Date 22/10/13	Date 22/10/13	Date 22/10/13

Drawing Number

5109850_WAT_FIG_5_0

Rev
01

FIGURE 6.0
ALLT AN FHEARNA
RIVER MODEL CROSS SECTIONS

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Sheet Size	Original Scale	Designed / Drawn LG	Checked EM	Authorised XX
A3	1:3,944	Date 16/10/13	Date 16/10/13	Date 16/10/13

Drawing Number: 5109850_WAT_FIG_6_0

Rev: 01