Norwich Western Link

Drainage Strategy Report Appendix 13: A47 / NWL Roundabout Design

Technical Note and A47 Stub presentation

Author: Ramboll

Document Reference: 4.04.13

Version Number: 00

Date: March 2024

Contents

1 Introduction 4
2 SWECO Model Differences 4
3 NWL Design Implications 6
4 Highway Drainage 7
4.1 Background 7
4.2 Optioneering 7
4.3 Difference in parameters 9
4.4 Hydraulic Modelling 11
4.5 A47 stub model 14
4.6 Alterations to the A47 model 16
4.7 Conclusion 21

Tables

Table 1 – Differences in modelled parameters 9
Table 2 – Modelled Scenarios 11
Table 3 – 1 in 100 year + climate change simulation results 12
Table 4 – NW Basin Summary 13
Table 5 - Pipe Upsizes Required to A47 Drainage 17
Table 6 - Upsized network results 19
Table 7 - Model 1 and Model 6 flooding comparison 19
Table 8 - Model 1 and Model 6 NW basin comparison 20

Figures

Figure 1: NWL – A47 interface 4
Figure 2: – SWECO design models contour profiles 5
Figure 3– SWECO Design Models level differences 5
Figure 4: Cross falls of current NWL and A47 Design models at interface 6
Figure 5 - NWL and A47 drainage interaction 8
Figure 6 - CD521 extract 10
Figure 7 - Flooding Locations 14

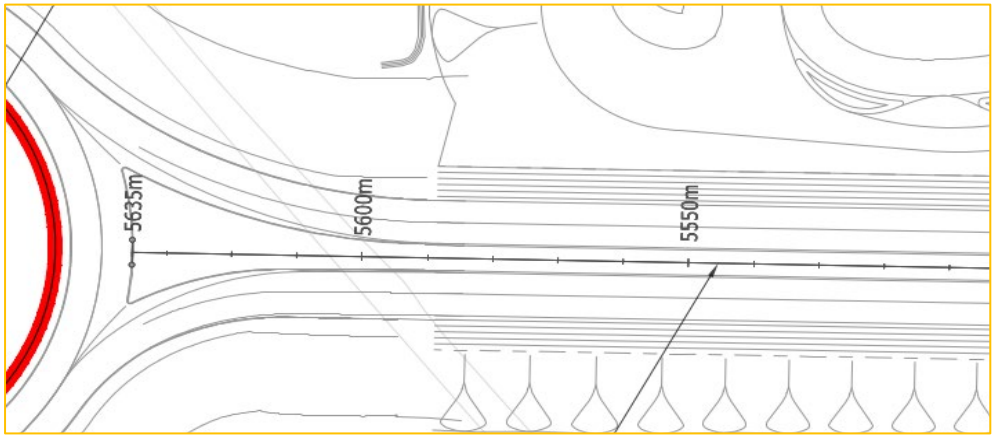
Figure 8 - Stub Drainage Layout 16
Figure 9 Pipe upsize locations 18
Figure 10 – Current NWL design and previous SWECO Design 3D contour surface 21

1 Introduction

During the Planning and Gateway 2 Design stages it was requested that Ramboll / Ferrovial include the A47 roundabout stub within their Norwich Western Link (NWL) design which in turn, would tie into the SWECO A47 roundabout design. The purpose of this report is to address the interface between the SWECO and Ramboll / Ferrovial designs and how each will need adjusting to compliment each other.

SWECO provided an initial 3D roundabout design in September 2022 which was used by Ramboll to revise the Norwich Western Link alignment to tie into the roundabout Inscribed Circle Diameter (ICD) as seen in Figure 1 below.

Figure 1: NWL – A47 interface



However, in June 2023, when Ferrovial contacted SWECO for the most current 3D design model for the roundabout to undertake elements of drainage design, it was noted that the Roundabout design had changed. The changes have been highlighted below in figures 2 and 3. The red boundary and blue hatch show the areas where the levels are different across the two models.

2 SWECO Model Differences

From figure 2, it can be seen from the respective model contours, that the roundabout surface has been redesigned to move the high spot from the north western section of the roundabout, further west towards the western arm entrance. In addition, the crossfall has been extended to run for the full northern portion of the

roundabout providing a constant cross fall rather than transitioning between cross fall and camber as previous.

Figure 2: – SWECO design models contour profiles

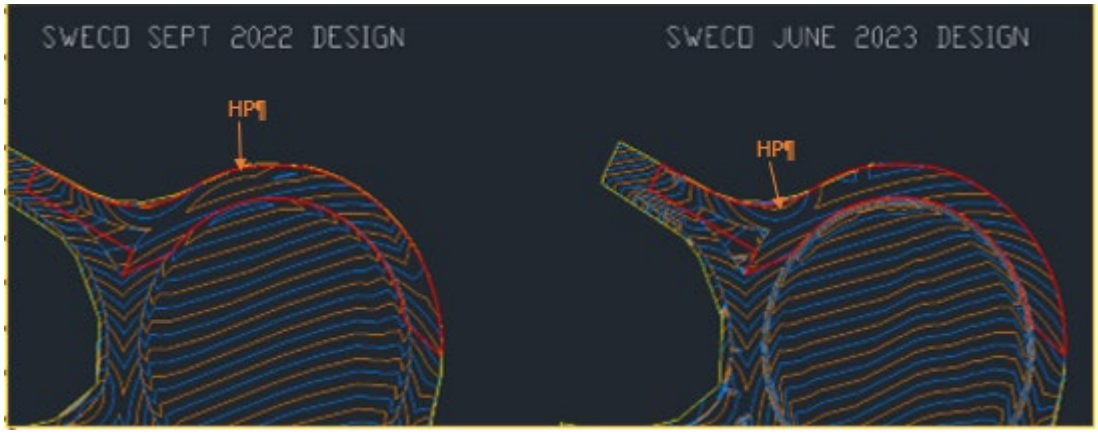
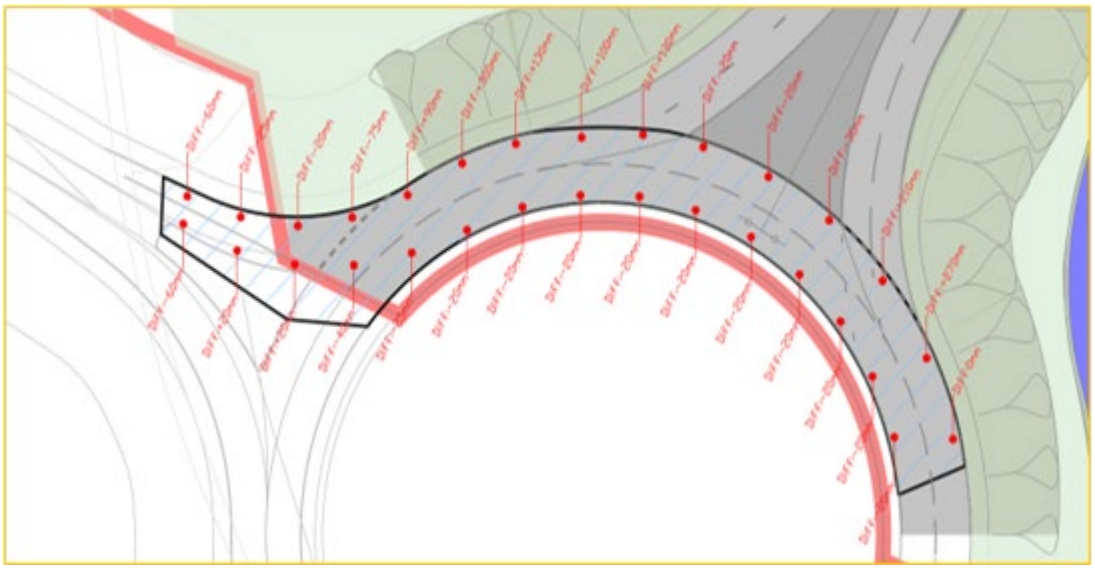


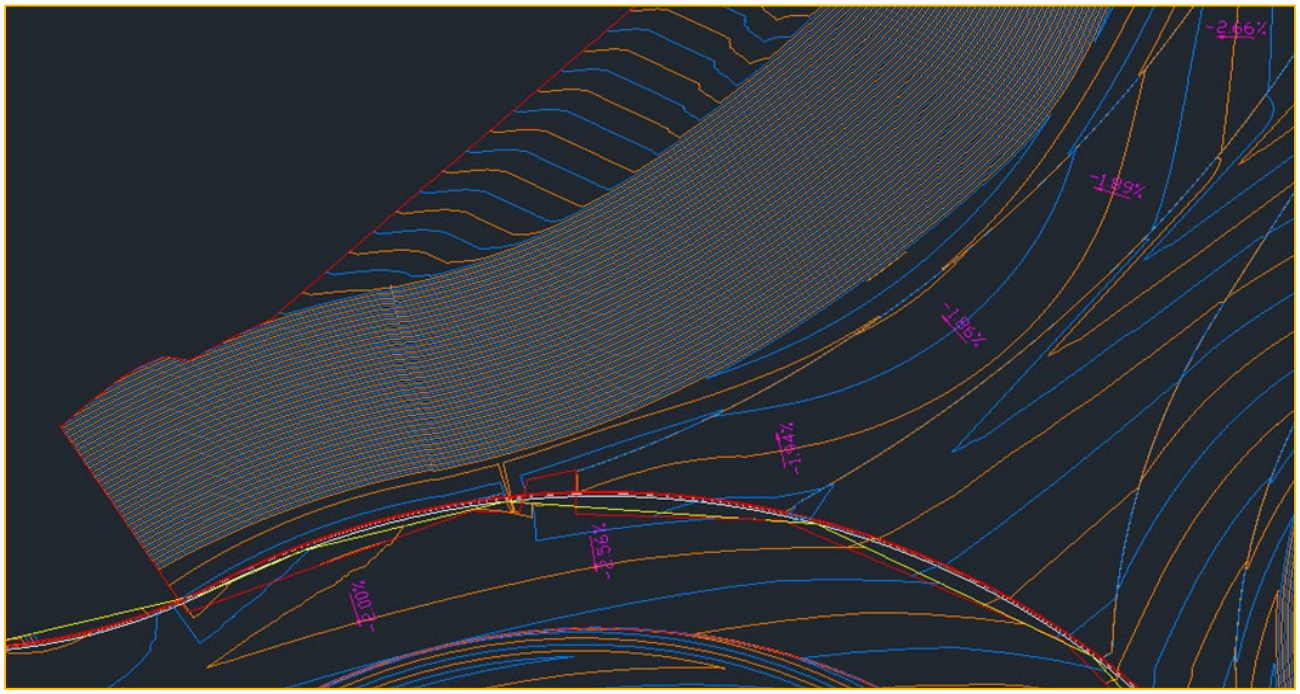
Figure 3– SWECO Design Models level differences



3 NWL Design Implications

Due to the significant change in levels, the NWL alignment no longer ties in at the interface between the two models. The Northbound carriageway is approximately up to 300mm adrift, whereas the southbound carriageway is up to 270mm adrift. However, due to the crossfall of the Northbound carriageway, tying into the current SWECO model would present a significant change in carriageway profile. As seen in figure 4, the roundabout is cross falling south, whilst the NWL corridor is cross falling north west.

Figure 4: Cross falls of current NWL and A47 Design models at interface



Therefore, and to ensure that the NWL ties in adequately into the A47 roundabout, the detailed design of the stub needs to be completed using the Sweco September 2022 model.

The conclusion of this assessment is that NH/Sweco's needs to revert to the original September 2022 3D model.

4 Highway Drainage

4.1 Background

The previous design, included passing flows from Basin 6 to the SWECO natural catchment network system at an agreed controlled rate of 5l/s. The flows would connect into the SWECO system at culvert CV/906/A. Subsequently, ground water flows around Basin 6 and the NWL mainline cutting between CH.5500 and CH.5600 were estimated to result in an additional 0.84l/s of flow. Due to level and outfall constraints, these groundwater flows would need to discharge into the A47 scheme. As flows of 5l/s had previously been assessed and could be accommodated within the SWECO design, the outflow from Basin 6 was reduced to 4l/s. This gave a total flow of 4.84l/s that would be passed onto culvert CV/906/A. Reducing the outflow from Basin 6 to 4l/s increased the stored volume in the basin but still maintained the required 0.3m freeboard for the 1 in 100 year + 45% climate change scenario.

4.2 Optioneering

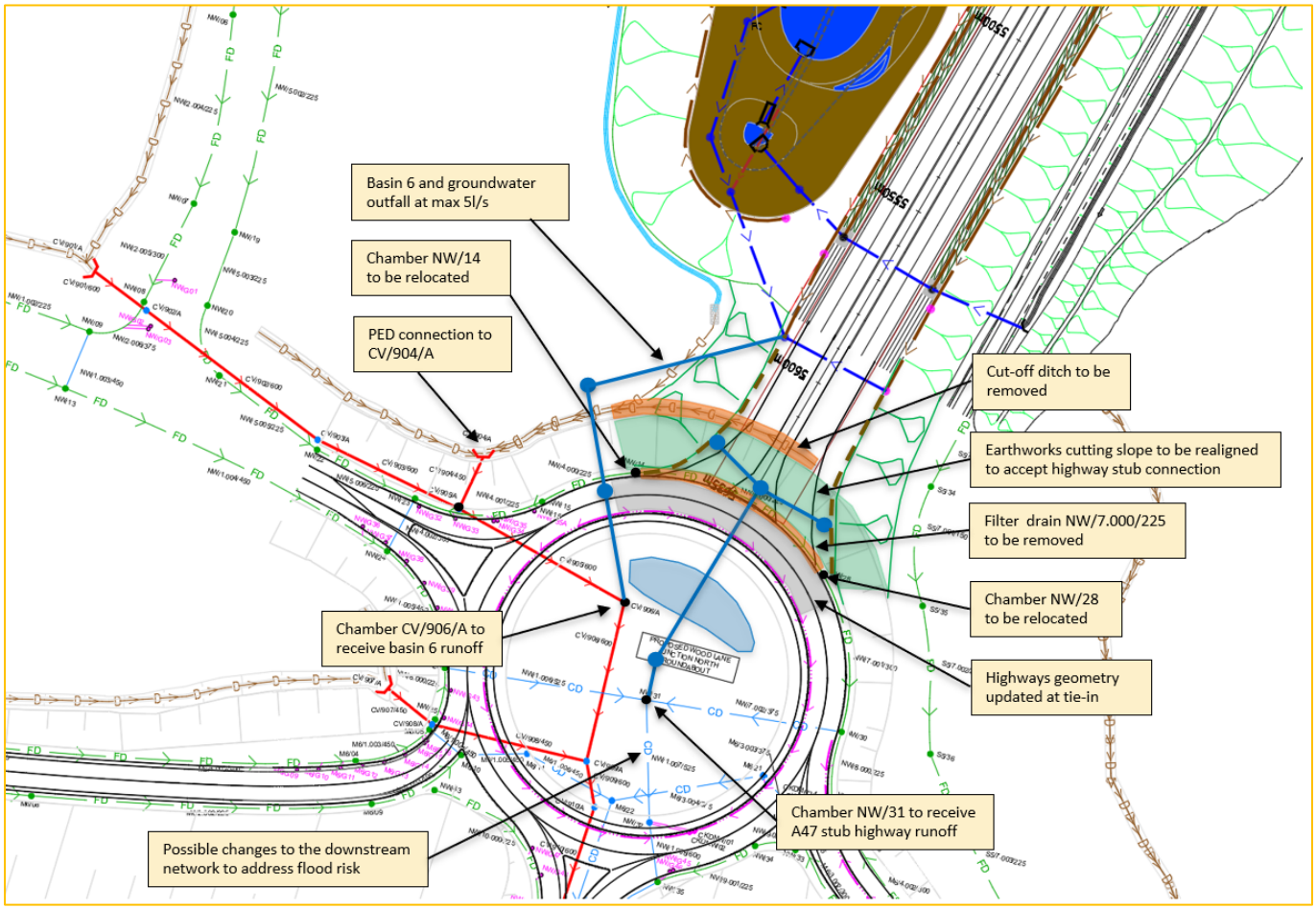
As a result of the instruction to include the A47 roundabout stub from CH.5590 to CH.5635 in the NWL scheme, a number of options were assessed and are described below:

- A47 stub connecting into Basin 6 in existing location – Discounted due to the need to lower Basin 6 by 1.0m to ensure the additional stub section could connect into Basin 6. Lowering Basin 6 would increase an already large cutting and exacerbate groundwater issues at this location.
- A47 stub connecting into alternative Basin 6 location (closer to A47 roundabout) – Discounted due to the significant impact on other disciplines, red line boundary limitations and lack of data in proposed locations (Groundwater monitoring, GI, Topographical survey etc)
- A47 stub connecting into A47 scheme – Preferred option due to site levels, efficiency of design and available capacity within the A47 “NW Basin”. This option does have an impact on the SWECO designed “NW”

network, adding additional flow to the network which is likely to result in pipe upsizing within the network.

The A47 stub connecting into the A47 scheme was selected as the option to be developed. An indicative drainage layout showing the interaction between the A47 and NWL scheme can be seen in Figure 5.

Figure 5 - NWL and A47 drainage interaction



From above, the following changes will be required to A47 Drainage to incorporate the A47 stub connection:

- Chambers NW14 and NW28 to be moved to suit revised alignment of new stub.
- Filter drain NW/7.000/225 (for cutting) to be removed.

- A47 stub highway drainage connection to chamber NW/31 with a 300 dia carrier drain running underneath the circulatory lanes and the roundabout central island.
- Basin 6 and groundwater outfall connection to chamber CV/906/A with a 225 dia carrier drain running underneath the circulatory lanes and the roundabout central island.
- Drainage changes downstream of connection points NW/31 to resolve flooding issues created by additional flows from A47 stub drainage. Refer to table 3 for details of flooding and further discussions in following sections for drainage changes.

4.3 Difference in parameters

After assessing the SWECO NW MicroDrainage model it became clear that there were a number of differences between NWL parameters and A47 parameters. The differences are summarised in the table below:

Table 1 – Differences in modelled parameters

Parameter	NWL	A47
Climate change for 1 in 100 year return period*	45%	40%
MADD coefficient**	0	2.0
PIMP %***	14	26
Catchment descriptors	Catchment data taken from the north of the NWL scheme	Point descriptor taken from west of the stub

*Climate change guidance was updated between the submission of the A47 planning application and the NWL design. The recommended climate change percentage was increased from 40% to 45%

** MADD coefficient is a global value used in hydraulic modelling to account for additional storage volume available in a network for unmodelled drainage elements such as gully pots, gully leads, combined kerb drainage (CKDs) etc. MicroDrainage states that a value of between 2-5 is commonly used. The LLFA has stated that the MADD coefficient should be set at 0 for the NWL scheme.

***The PIMP (Percentage Impervious) percentage is defined in CD521 Table 5.6.2 and 5.6.3. The permeability has been taken as low due to poor infiltration rates identified across the extents of NWL. See extract from CD521 in Figure 6

Figure 6 - CD521 extract

5.6.2 Values of the run-off coefficient coefficient α may be estimated from:

Table 5.6.2 Run-off coefficients for cuttings

Soil type	Antecedent wetness	α
High permeability	low medium high	0.07 0.11 0.13
Medium permeability	low medium high	0.11 0.16 0.20
Low permeability	low medium high	0.14 0.21 0.26

Propsed Scheme
A47

5.6.3 Appropriate choices of antecedent wetness for Northern Ireland, Scotland, Wales and English counties may be chosen from Table 5.6.3.

Table 5.6.3 Antecedent wetness categories

Low	Medium	High
Bedfordshire	Berkshire	Northern Ireland
Buckinghamshire	Cleveland	Scotland
Cambridgeshire	Derbyshire	Wales
Essex	Durham	Avon
Greater London	East Sussex	Cheshire
Hertfordshire	Hampshire	Cornwall
Norfolk	Hereford & Worcester	Cumbria
Rutland	Humberside	Devon
Suffolk	Isle of Wight	Dorset
	Kent	Gloucestershire
	Leicestershire	Greater Manchester
	Lincolnshire	Lancashire
	North Yorkshire	Merseyside
	Northamptonshire	Somerset
	Northumberland	Wiltshire
	Nottinghamshire	
	Oxfordshire	
	Shropshire	
	South Yorkshire	
	Staffordshire	
	Surrey	
	Tyne & Wear	
	Warwickshire	
	West Sussex	
	West Yorkshire	

NOTE The basis of the data in Tables 5.6.2 and 5.6.3 is explained in Appendix C.

It was assumed that the A47 parameters had been accepted for the SWECO proposed design, however, it was important to understand the impact different parameters would have on the A47 drainage network.

4.4 Hydraulic Modelling

Five scenarios were modelled to assess the impacts different parameters would have on the network with the addition of the stub to the A47 model. Model 1 was the SWECO NW model received on the 5th July 2023 and served as a baseline for the study. For models 2-5, an outline design for the stub was added to the baseline model. The A47 stub section would connect into the SWECO NW network at manhole NW/31. Other connection points were explored, however NW/31 was deemed to be the most appropriate due to levels and other connection points being more sensitive to change. The model including the A47 stub was then ran with different parameters as shown in Table 2. The hydraulic model can be adjusted to use different values for climate change (by changing drained areas) and PIMP but the MADD coefficient is a global parameter that is applied to the entire network model.

Table 2 – Modelled Scenarios

MODEL ID	1	2	3	4	4	5
MODEL DESCRIPTION	**BASELINE A47 w/o stub (A47)**	**A47 w/ stub (A47)**	**A47 w/ stub (NWL)**	**A47 w/ stub (combined)**	**A47 w/ stub (combined)**	**A47 w/ stub (worst-case sc.)**
STUB INCLUDED	NO	YES	YES	YES	YES	YES
SET OF PARAMETERS	A47	A47	NWL	Combined	Combined	Combined
SET OF PARAMETERS	A47	A47	NWL	A47 network	stub network	A47 & Stub
CC %	40	40	45	40	45	45
MADD	2	2	0	0	0	0
PIMP %	26	26	14	26	14	26
CATCHMENT DESCRIPTIONS	West stub	West Stub	NWL scheme	West stub	West stub	West Stub

For the purpose of the study, all models were run for the 1 in 100 year + climate change return period. It is not known what other design criteria has been applied to

the A47 drainage design but this return period was selected as no flooding leaving the site for the 1 in 100 year + climate change has tended to the most critical scenario for sizing pipes and basins across the NWL scheme and often resulted in other design requirements being met (No surcharge for 1 in 1 year + climate change, no flooding for 1 in 30 + climate change etc).

The modelling results for each scenario can be seen in Tables 3 (flooding chambers) and 4 (basin storage) below:

Table 3 – 1 in 100 year + climate change simulation results

Model ID	1	2	3	4	5
MH	A47 Without Stub	A47 With Stub (A47)	A47 With Stub (NWL)	A47 With Stub (Combined)	A47 With Stub (Worse case sc.)
02NWL	-	-	-	-	0.177
07NWL	-	-	-	-	1.528
15	2.820	5.990	3.401	5.906	10.176
23	-	-	-	-	0.126
24	-	0.717	-	0.628	7.512
25	-	0.837	0.241	0.725	4.276
29	-	4.572	2.308	4.453	8.709
32	-	5.647	2.076	5.369	15.748
37	-	-	-	-	2.180
44	1.692	1.692	-	1.692	4.735
45	5.470	5.476	-	5.475	9.988
46	0.014	0.197	-	0.189	0.880
52	4.894	6.258	4.100	6.213	13.184
55	7.489	11.835	9.702	11.745	18.061
61	-	-	-	-	1.165

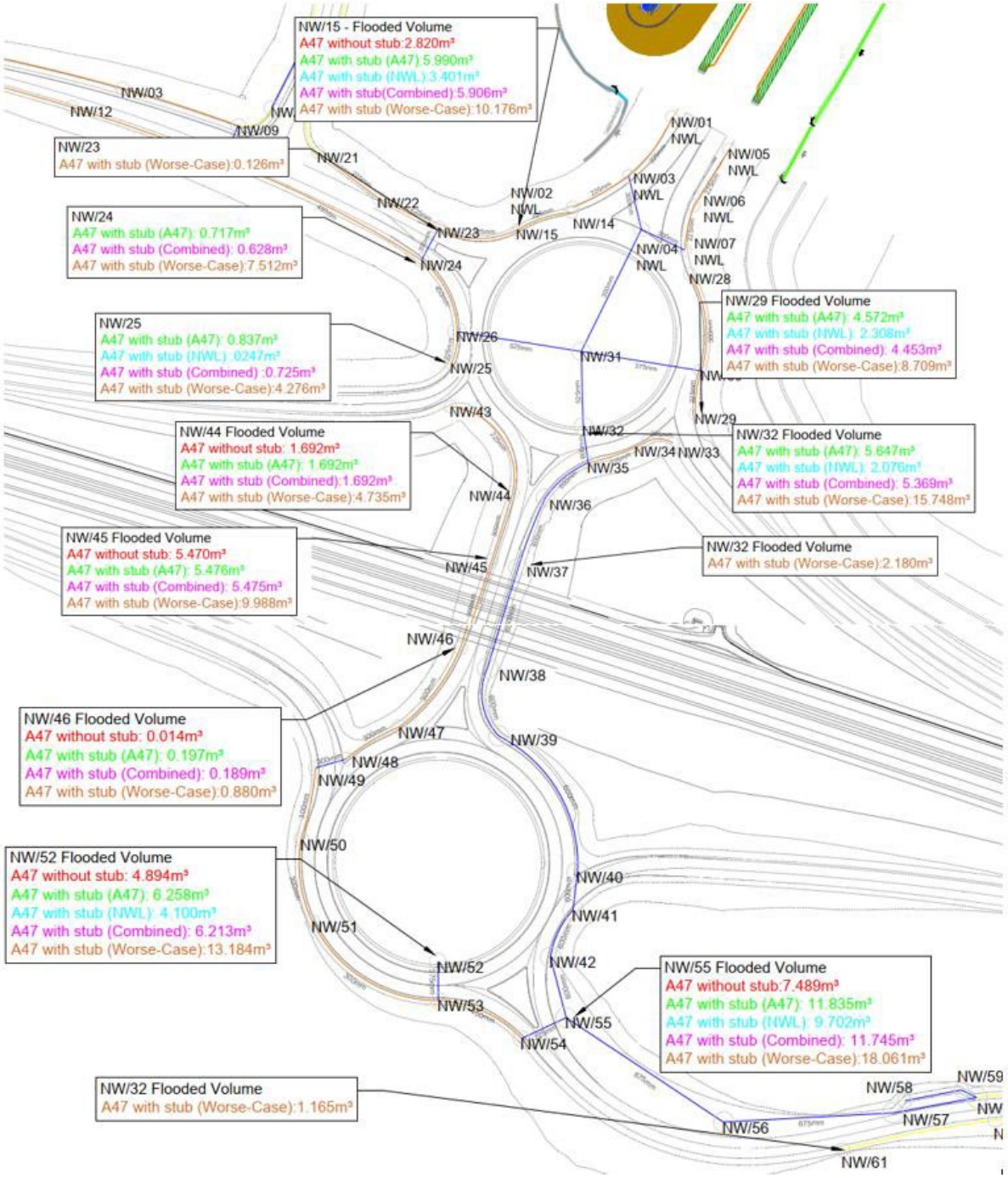
Table 4 – NW Basin Summary

Model	A47 Without Stub	A47 With Stub (A47)	A47 With Stub (NWL)	A47 With Stub (Combined)	A47 With Stub (Worse case sc.)
Stored Volume (m^3)	2370	2512	2336	2508	2615
Basin Top Water Level (m)	39.346	39.408	39.331	39.406	39.452
Outflow (l/s)	5.0	5.0	5.0	5.0	5.0

The basin crest level is at 39.8m therefore all scenarios provide at least 300mm freeboard.

The location of the flooding manholes can be seen in the Figure 6.

Figure 7 - Flooding Locations

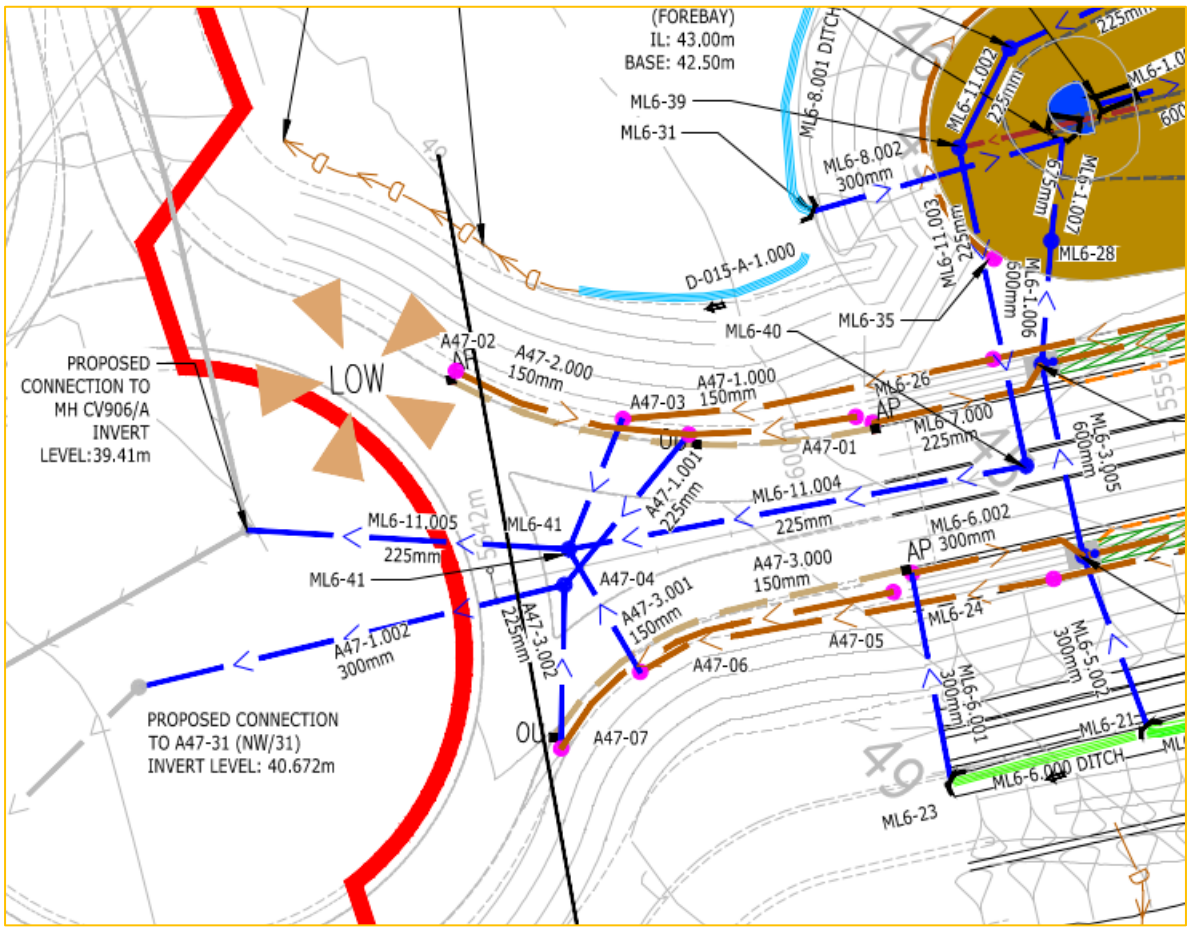


4.5 A47 stub model

It was agreed with NCC that Model 4 would be used as the core scenario for the development of the A47 stub drainage design. This scenario provides a set of design

parameters that can be implemented using a combination of NWL and A47 project-specific parameters for climate change and PIMP in conjunction with the MADD global factor of 0 which represents the worst case for network storage calculations. Due to design development from both highways and drainage, the final stub model varies slightly from the model above. CKD's will be used to drain the highway on the approach to the roundabout with filter drains on either side of the stub to drain the cutting. Both the filter drains and CKD's from each side of the stub will then be taken into carrier drains before flowing into the SWECO network at manhole NW/31. As in the previous design, the outflow from Basin 6 and the groundwater filter drains will connect into culvert chamber CV/906/A at a controlled rate of no more than 5l/s. For more details of the proposed stub drainage design layout see Figure 7.

Figure 8 - Stub Drainage Layout



4.6 Alterations to the A47 model

This A47 stub model has been used to establish what changes may be required to the NW SWECO network to account for the additional flow from the stub without significantly increasing the flooding volumes from the baseline model (Model 1).

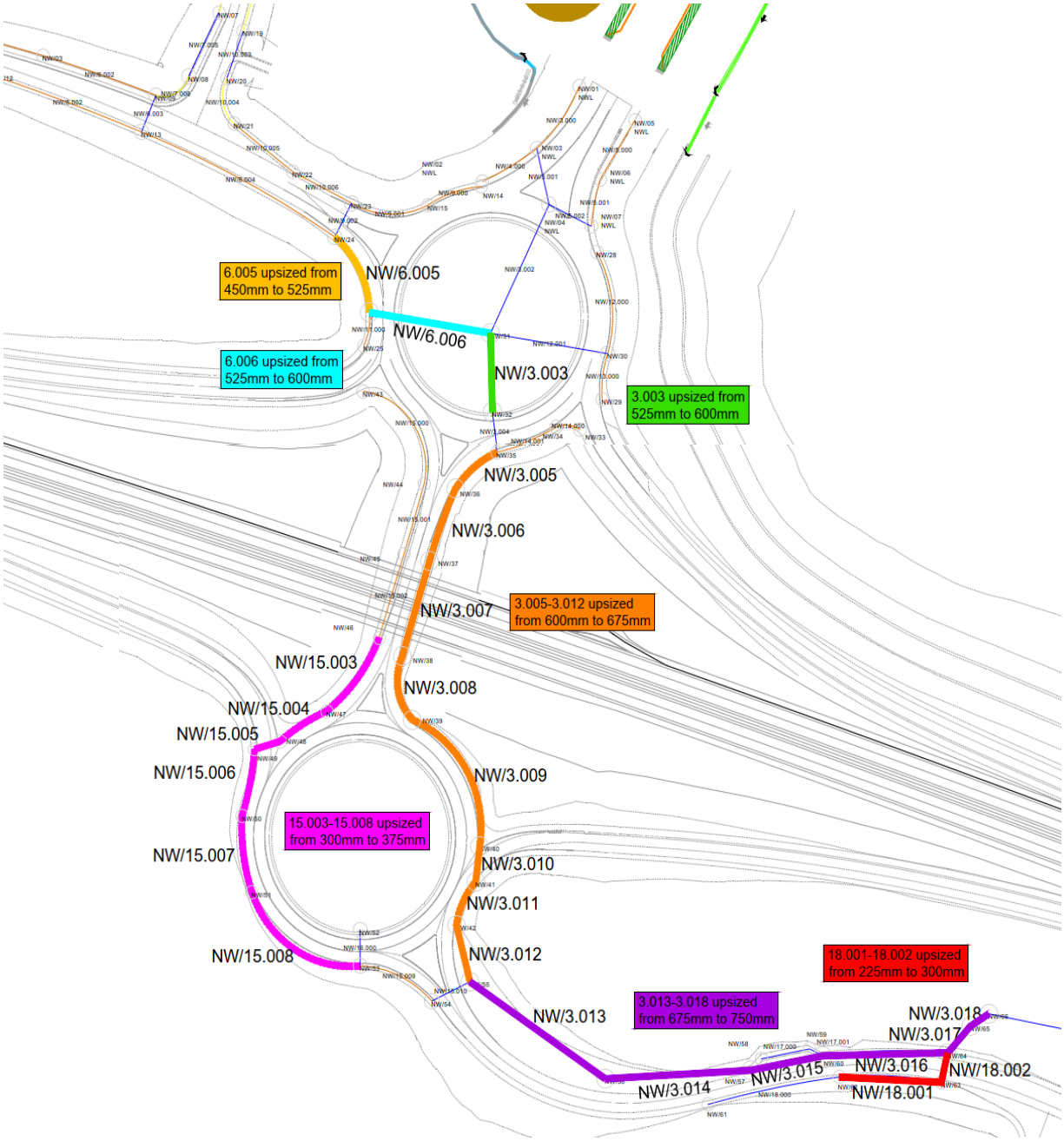
In Model 4, flooding for the 1 in 100 year + climate change storm occurs when the water level in Basin NW rises above the soffit of the incoming pipe to the basin, causing surcharging and flooding of the upstream network. The additional flow from the A47 stub means the majority of pipes directly downstream from the connection point require upsizing. This includes pipes downstream of flooding manhole NW55 (the most downstream of flooding manholes). Additionally, pipes 6.005 and 6.006 (originally 1.005 and 1.006 in the NW SWECO model) require an upsize due to

increased surcharging causing backing up of flows within this pipe run. A summary of the pipe upsizes can be seen in Table 5 and Figure 9.

Table 5 - Pipe Upsizes Required to A47 Drainage

Pipe Reference (Model 1)	Pipe Reference (Model 4)	Previous Diameter (mm)	Suggested Diameter (mm)
1.005	6.005	450	525
1.006	6.006	525	600
1.007	3.003	525	600
1.009-1.016	3.005-3.012	600	675
1.017-1.022	3.013-3.018	675	750
10.003-10.008	15.003-15.008	300	375
13.001-13.002	18.001-18.002	225	300

Figure 9 Pipe upsize locations



The upsized model (Model 6) gave the following results for the 1 in 100 year + climate change storm:

Table 6 - Upsized network results

Pipe Number	US /MH Name	Event	US / CL (m)	Water Level (m)	Surcharged Depth (m)	Flooded Volume (m^3)	Flow / Cap.	Maximum Vol (m^3)	Maximum Velocity (m/s)	Pipie Flow (l/s)	Status
16.000	52	30 minute 100 year Winter I+40%	40.945	40.945	1.444	0.045	1.03	2.096	1.9	209.4	FLOOD

The above pipe was previously flooding for the 1 in 100 year + climate change event by 4.894 m^3 (see Table 7).

Table 7 and 8 show the upsized model (Model 6) flood volume and NW basin results compared with the baseline model (Model 1) results for the 1 in 100 year + climate change:

Table 7 - Model 1 and Model 6 flooding comparison

Model ID	1	6
MH	A47 Without Stub	A47 With Stub (Combined) with upsize
02NWL	-	-
07NWL	-	-
15	2.820	-
23	-	-
24	-	-
25	-	-
29	-	-
32	-	-
37	-	-
44	1.692	-
45	5.470	-
46	0.014	-
52	4.894	0.045
55	7.489	-
61		-

Table 8 - Model 1 and Model 6 NW basin comparison

Model ID	1	6
Model	**A47 Without Stub**	**A47 With Stub (Combined) with upsize**
Stored Volume (m^3)	2370	2487.472
Basin Top Water Level (m)	39.346	39.396
Outflow (l/s)	5.0	5.0

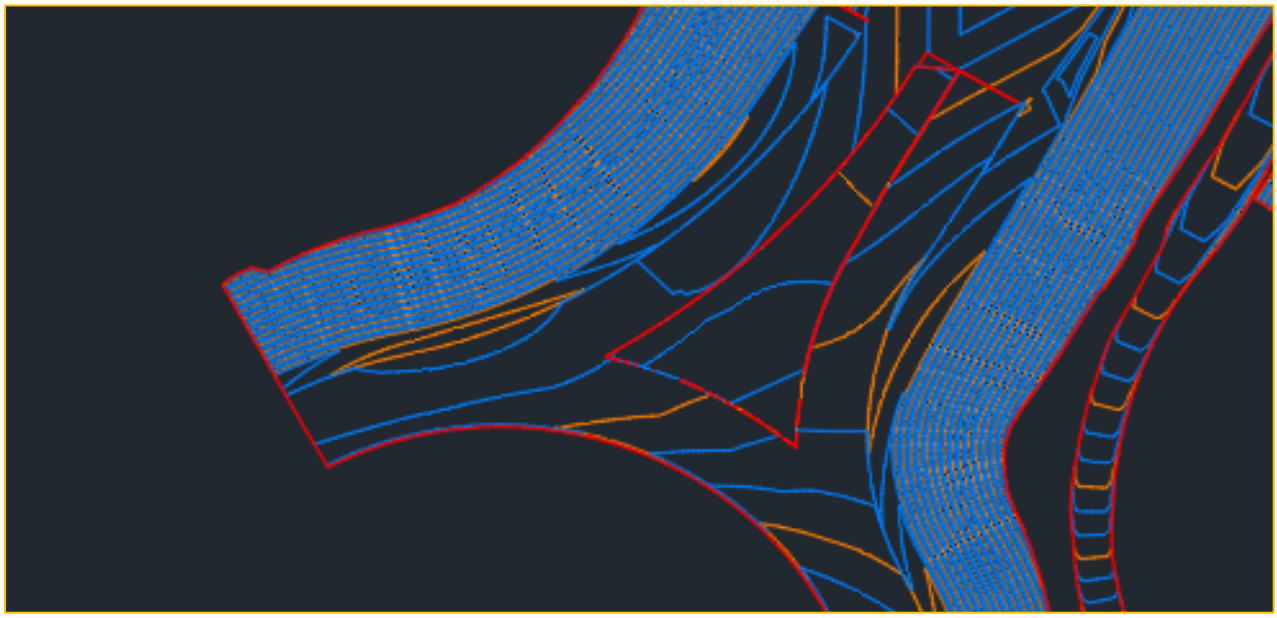
The results show that for the upsized model, flooding has been eliminated at manholes 15, 44, 45, 46, 52 and 55 with flooding at manhole 52 also reducing. There is no additional flooding as a result of adding the A47 stub flows into the NW SWECO network in conjunction with the upsizing of pipes as described above.

Note the above changes made to the NW SWECO network are an outline design to demonstrate that the additional flow from the A47 stub can be managed by pipe size increases. No additional consideration has been given to invert levels or gradient changes. Additionally, no consideration has been given to the feasibility of upsizing pipes in the locations indicated (clashes with other infrastructure and verge constraints) which would need to be carried out by the A47 design. As noted in 4.4, it is not known what other design criteria has been applied to the A47 model design so the modelling has focused on the 1 in 100 year + climate change checks as this has tended to the most critical scenario for sizing pipes and basins across the NWL scheme. Checks for no surcharge for 1 in 1 year + climate change, no flooding for 1 in 5 year + climate change and no flooding for 1 in 30 year + climate change, have been undertaken and the design is compliant with these DMRB and LLFA requirements.

4.7 Conclusion

The current NWL Design and September 2022 SWECO design, as seen in figure 10, complement each other and provide a high quality and compliant design to standard. Keeping the June 2023 SWECO design would result in a poorer driving experience and introduce potential safety issues due to the adverse camber that would be present.

Figure 10 – Current NWL design and previous SWECO Design 3D contour surface



In Figure 2, we can see that the changes made to the design only affect the interface area where the SWECO and NWL designs meet. The changes are also further localised to the areas where SWECO have updated their design as highlighted in Figure 2. Due to this, the proposed change to return to the previous design would not impact upon the rest of the roundabout. Reverting to the previous design would still allow the surface water runoff to flow to the same outfalls requiring negligible changes to the drainage strategy of both the NWL and SWECO designs.

It is strongly recommended that the SWECO roundabout design is reverted to the September 2022 design to avoid the potential safety risk which is inherent if the NWL design was to be updated to suit the current SWECO (June 2023) design.

In terms of highway drainage, the A47 stub drainage requires a 300 dia pipe connection to be made to the A47 chamber NW/31 in the roundabout island, with some upgrading of downstream pipes sizes to accommodate the additional flows generated as indicated in Figure 8 and Table 5 and described in section 4.6. The NWL basin 6 outfall and stub filter drains collecting groundwater will require a 225 dia connection to chamber CV/906A in the roundabout island.

Further modifications to the A47 drainage are required to make physical space for A47 arm at the junction involving movement of chambers NW14 and NW28 as well as the removal of filter drain NW/7.000/225. No changes are expected for the NW basin which has sufficient capacity to take the A47 stub drainage.