Memorandum

ARUP

To	Steve Henry	Date	25 February 2014
Copies		Reference number	
From	Faye Beaman	File reference	001Memo 21022014
Subject	A14 Existing Drainage Capacity Summary		

1 Introduction

This memo documents the check undertaken to determine the capacity of existing drainage structures for the Arup section of the A14 between Huntingdon and Cambridge.

2 Catchment Delineation

- Catchments were delineated based on Ordinance Survey (OS) 5m Contour data and LiDAR data (available within the vicinity of the proposed road corridor only). The best use of this data has been made alongside rationalisation of catchments from aerial photography, as-built survey information, and Highways Agency Drainage Data Management System (HADDMS) data.
- **Catchment plan:** \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-03 Drawings\2_Working_Area\FB
- **As-built data:** \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-04 Calculations\4-04-03 Civil\Drainage\As-builts
- **HADDMS Data:** Soft Copy – in folder

3 Hydrology

- The existing catchment flows have been assessed based on HA 106/04: Drainage of runoff from natural catchments.
- As defined in pg. 5/1 (HA 106/4) flows from natural catchments without defined watercourses shall be assessed for a return period of 75yr, and flow rates through culverts that convey permanent watercourses beneath roads should be assessed for anything up to 100yr return period.
- Flow rates inclusive of climate change have been assessed based on the recommendations of Planning Policy Statement (PPS) 25. A 20% increase on predicted flows was allowed.

- As all catchments are greater than 0.4km2, the flows passing towards these culverts have been determined using IH124 method (IH Report 12, 1994), assuming rural catchments with no allowance for urbanisation.
- A standard average annual rainfall (SAAR) value of 800mm (HA 106/4 - Figure 4) was assumed alongside a soil index (SOIL) of 0.45. The SOIL value was determined based on clayey and loamy soils with high runoff potential (100% S4) (HA 106/4 Table 5/1).
- Scaling factors of 2.25, 2.39, 2.83, 3.22 and 3.56 were used for 25, 30, 50, 75 ad 100yr return periods respectively.
- **Hydrology Calculations:** \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-04 Calculations\4-04-03 Civil\Drainage\Culvert Crossings\Hydrology

4 Culvert Capacity – Manning's Equation and Inlet and Outlet Control Assessments

- The existing culvert capacity has been assessed using Manning's equation and further HEC-RAS modelling where required.
- The Manning' s equation assumes pipe full, but not under pressure flows, with an assumed roughness for used reinforced concrete pipes of n=0.015 and corrugated iron of 0.025.
- Culvert IL's have been extracted from HADDMS data, and where this data was not available a minimum culvert grade of 1/300 was assumed.
- The capacity of the existing culverts was assessed assuming they were free flowing and without an allowance for blockage. However, it is noted that some HADDMS indicate that blockage in some culverts, due to siltation, is present. It is assumed that culverts will be cleared and maintained negating the need to assess a blockage scenario.
- Based on manning's equation assessments culverts 1, 2, 4, 5, 7 and 8 are adequately sized to pass the computed flow from the upstream catchment and provide immunity to the A14 in 100yr+CC conditions.
- Culverts 3 and 6 are not adequately sized (for neither 75yr nor 100yr return period) and are further assessed with hydraulic (HEC-RAS) modelling.
- Assessing flow rates for lower return periods indicates that culverts 3 and 6 are adequately sized for a return period of 50yr and culvert 6 for 10yr.
- All culverts were assessed to determine culvert control (Inlet or Outlet). This assessment indicated that culverts 3 and 6 were sized for ~75yr and 25yr respectively.
- The majority of the culverts (1, 2, 3, 5, 6, 8 and 9) are inlet controlled. With culverts 4 and 7 outlet controlled.
- Culvert 6 is significantly undersized.
- **Manning's equation:** \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-04 Calculations\4-04-03 Civil\Drainage\Culvert Crossings\Culvert_Schedule

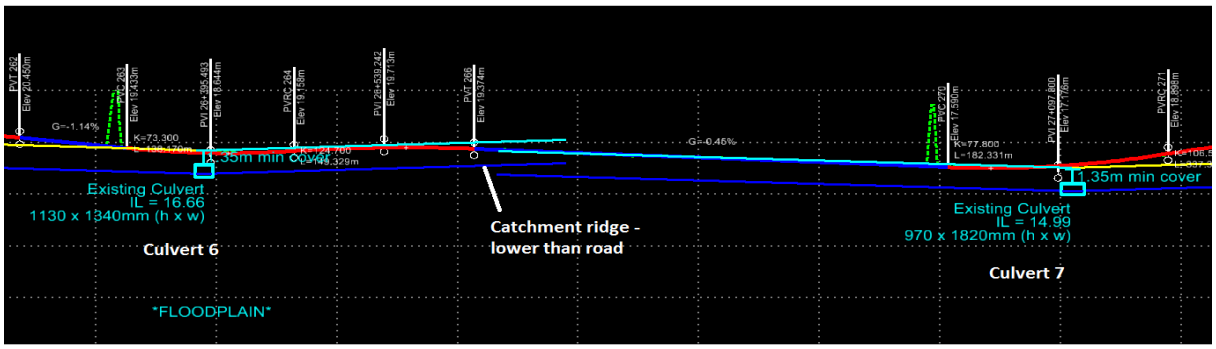
- **Control Spreadsheet**: \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-04 Calculations\4-04-03 Civil\Drainage\Culvert Crossings

5 Culvert Capacity – HEC RAS Modelling

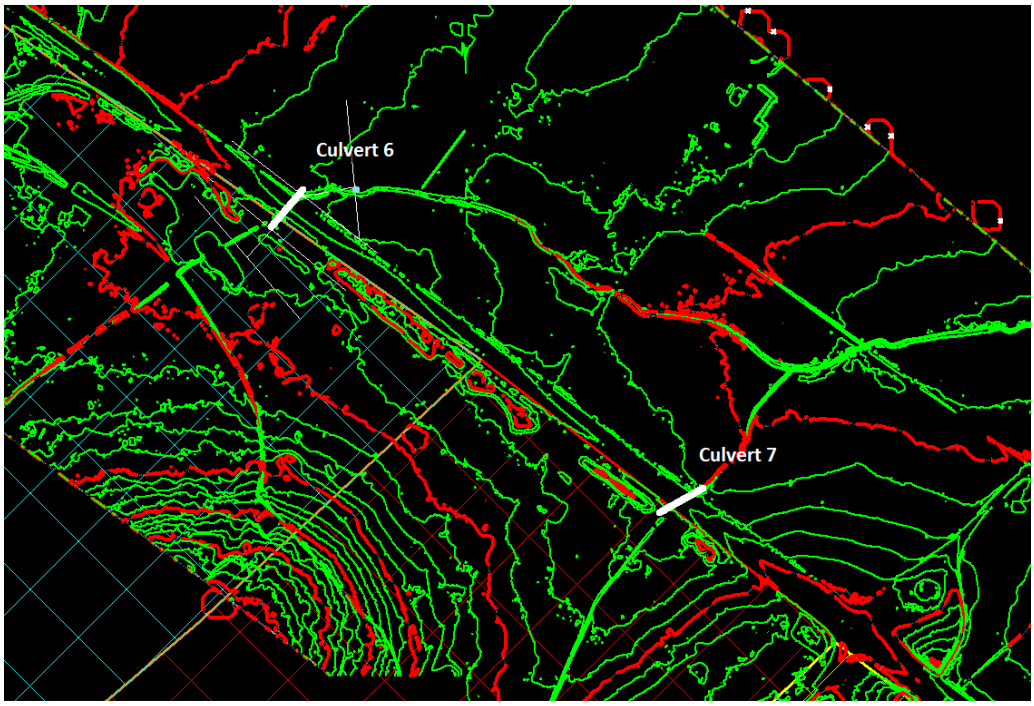
- Culverts 3 and 6 were further assessed. HEC RAS models were constructed to represent the upstream and downstream channel geometry, culvert crossing and road embankment.
- Road long-sections in HEC-RAS are one continual level as taken from cross-section.dgn data. The longitudinal profile of the road is not represented.
- Assuming a manning's roughness of 0.03 (for grassed farmland) and steady state, mixed flow regime assessments the culverts were still not adequately sized to provide the required immunity to the A14.
- Culvert 3 shows a 75yr immunity can be achieved (comparable to inlet/outlet control assessment). However, 100yr immunity is close to being achieved.

  Due to the accuracy of topographic data, catchment delineation, hydrology and HEC-RAS model construction to date it is assumed that this culvert can provide immunity in the order of 75yr/100yr (current conditions – excluding climate change). Further modelling, with allowance for storage and an unsteady flow assessment is likely to show further immunity is achieved.
- Culvert 6 shows a 25yr immunity can be achieved. Even accounting for the limited accuracy of data and modelling at this stage this culvert would not be sufficient to pass the required flow.

  However, this culvert lies to the west of culvert 7 and both culverts drain into the same watercourse downstream of the A14. Both culverts lie within a valley with only a small ridge separating them. This ridge is lower than the road alignment at this location, therefore would get overtopped before inundation of the road would occur. Consequently, it could be assumed that flows passing towards culvert 6 and 7 can be combined and the capacity of both culverts utilised to drain this combined flow. Refer figures below.



Long section: Showing that flow passing from culvert 6 will head towards culvert 7 before overtopping the road.



Contour data: showing the direction of flow upstream of the A14 passes to both Culvert 6 and 7 and that these watercourses combine downstream

- The flow from both catchments 6 and 7 for 75yr and 100yr current conditions is 8.25 and 9.12m3/s respectively. Based on a manning's equation Culverts 6 and 7 combined can pass 8.04m3/s.

  Note that the capacity of culvert 7 is based on an assumed grade of 0.5%. HADDMS report this culvert as having a negative grade; however this appears to be due to siltation. It is assumed that the culvert has been laid with positive grade and once cleared will flow accordingly. The grade assumption for this culvert makes a significant difference to its capacity and immunity that can be/is achieved to the A14.

- Regards culvert 6, if the upstream catchment does not currently pass to both culvert 6 and 7 flows can easily be diverted to ensure this is the case. This is unlikely to significantly impact the golf course upstream, however if impacts occurred due to the change in flow characteristics mitigation in the form of channel works immediately upstream or downstream of culvert 7 would be easy to implement, additional conveyance would be afforded by the proposed diversion drainage and there is potential to upsize the (assumed) attenuation ponds on the golf course..

- Lowering of the road in the location of culverts 3, 6 and 7 is not advised due to

- **HEC-RAS modelling:** \\global.arup.com\europe\Midlands\jobs\233000\233193-00 A14 C2H\4 Internal Project Data\4-04 Calculations\4-04-03 Civil\Drainage\Culvert Crossings\HEC_RAS

6 Summary

- Culvert capacities determined using manning's equation show that all culverts except 3 and 6 are adequately sized to pass the required flow to achieve 75yr or 100yr (inclusive of climate change) immunity to the A14.
- Further assessment of culvert 3 in HEC-RAS and from inlet/outlet control calculations shows that this culvert provides approximately 75yr immunity and potentially 100yr (current condition excluding climate change) immunity.
- Further rationalisation of culvert 6 shows that the combined capacity of 6 and 7 can accommodate the flow from the upstream catchment achieving close to 75yr immunity (current condition – excluding climate change) to the A14, if culvert 7 has a good positive grade (to be confirmed). Dependant on the grade of culvert 7 the immunity to the A14 may be greater.
- Further assessments that account for storage of the catchments upstream are likely to show higher immunity is achieved also.