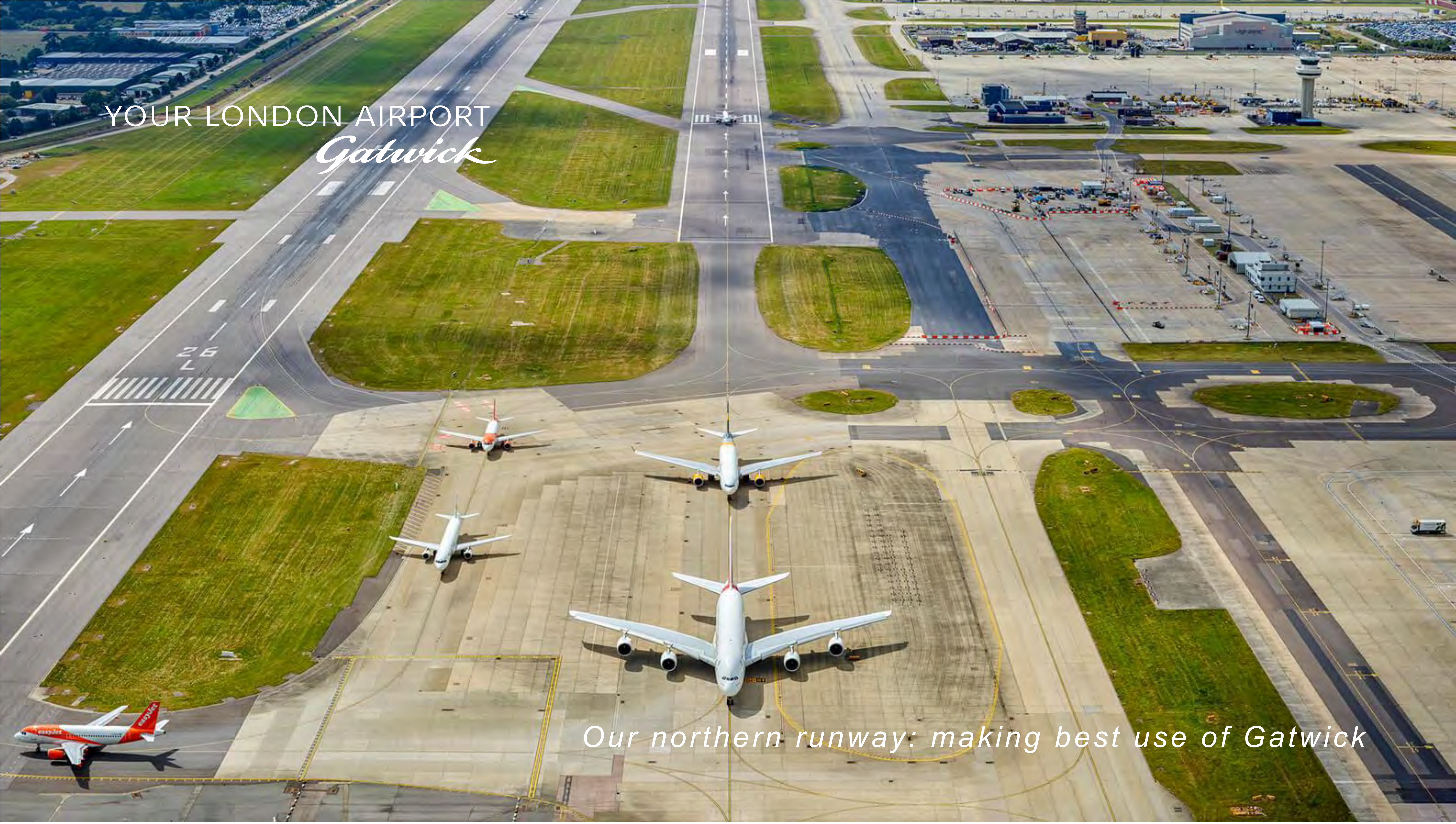


Preliminary Environmental Information Report
Appendix 11.9.4: Water Supply Assessment

September 2021

1 Baseline Forecast

1.1 General

1.1.1 This document forms Appendix 11.9.4 of the Preliminary Environmental Information Report (PEIR) prepared on behalf of Gatwick Airport Limited (GAL). The PEIR presents the preliminary findings of the Environmental Impact Assessment (EIA) process for the proposal to make best use of Gatwick Airport's existing runways (referred to within this report as 'the Project'). The Project proposes alterations to the existing northern runway which, together with the lifting of the current restrictions on its use, would enable dual runway operations. The Project includes the development of a range of infrastructure and facilities which, with the alterations to the northern runway, would enable the airport passenger and aircraft operations to increase. Further details regarding the components of the Project can be found in the Chapter 5: Project Description.

1.1.2 This document provides the Water Supply Assessment for the Project.

1.2 Existing Consumption

1.2.1 The following data considers consumption at existing buildings and predictions for changes in demand based on previous studies.

Data Source

1.2.2 In order to complete the calculation of forecasted demands any existing demand forecast information must be verified and amended as necessary. All information used to understand existing and forecast future demands has been taken from a previous study commissioned by GAL, titled 'London Gatwick Water Masterplan 2020 & 2028 Forecast - Full Backing Report' (2018) which has been included as Annex 4.

1.2.3 To confirm and update baseline consumption, the forecasted demands were compared to annual recorded data and the variance calculated. The predicted curve is then re-aligned to actual consumption figures and as the baseline forecast only extends to 2028 the curve was also then extrapolated out to 2039, which is the design horizon for the Project.

Forecasted passenger numbers

1.2.4 From the internal review in 2018, passenger forecasts for both the 2020 and 2028 scenarios (without the Project) are used to help in calculating passenger consumption and forecasting demand. The review projected both best and worst case consumption scenarios for both 2020 and 2028, for the purposes of the Project the 'worst-case' (highest demand) predictions have been included in Table 1.2.1.

Table 1.2.1: Predicted passengers for 2020 and 2028.

Component	2020	2028
Predicted passengers (millions)	48.4	62.8

1.3 Forecasted water consumption

1.3.1 The previous demand study details the forecasted total water consumption for Gatwick for 2017 which was compared with actual metered consumption data, received on 04/09/2019. Table 1.3.1 and Diagram 1.3.1 detail the comparison of the predicted and actual consumption values.

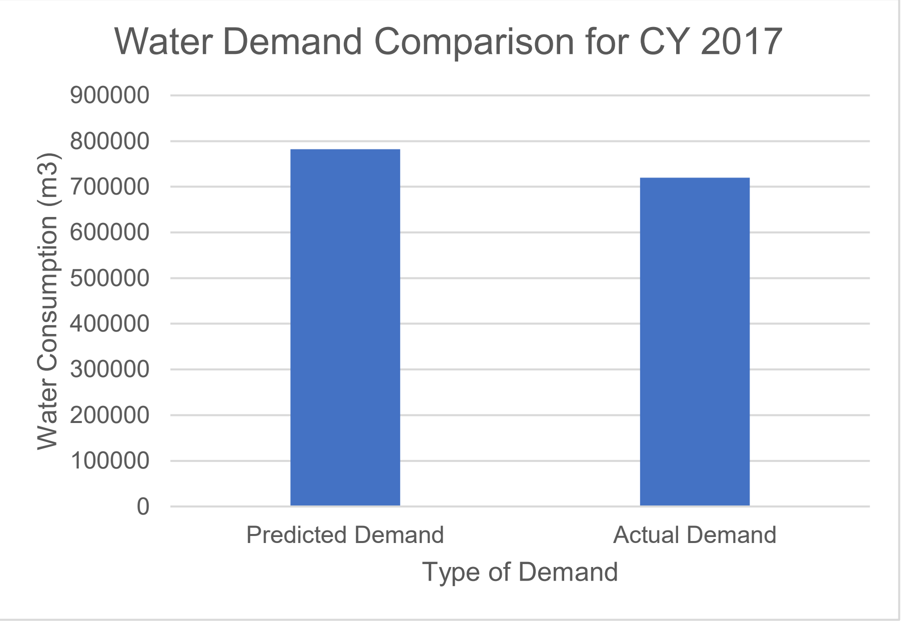
Table 1.3.1: Predicted and Actual demand results for 2017.

Month	Predicted Demand* (m^3/yr)	Actual Demand** (m^3/yr)	Percentage Error
Jan – Jun	362,652	358,034	-1.3%
Jul - Dec	419,290	361,960	-15.8%
Total water consumption	781,942	719,994	-8.6%

*Predicted demand results based from information provided in Water Masterplan 2020 & 2028 Forecast - Full backing report.

**Actual demand data obtained from GAL.

Diagram 1.3.1: Total demand comparison for predicted and actual 2017 data (m^3/year)



1.3.2 There was an over estimation of 61,948 m^3 of water consumption which equated to an 8.604% variance from the predicted to the actual demand for 2017. This percentage variance has been used as a factor to adjust the values for the previously forecasted water consumption years of 2020 and 2028 (see Table 1.3.2 below).

Table 1.3.2: Comparison of Predicted demands and Adjusted predicted demands

Forecasted Year	Third Party Predicted Demand (m^3/yr)	Adjusted Third Party Predictions (m^3/yr)
2020	764,446	703,884
2028	786,052	723,778

1.4 Water Efficiency Measures

1.4.1 The previous study recommended the use of the water efficiency measures summarised in Table 1.4.1. GAL responses indicate that a number of these recommendations have already been implemented on site at Gatwick, as indicated.

Table 1.4.1: List of possible water efficiencies and responses received from GAL.

Water efficiency method	Adoption by GAL
Installation of Automatic Reading Meters	Approximately 14 sub-meters are installed to date. It is planned to gradually increase this over coming years.
Mains pressure reduction to reduce leakage	Pressure reduction has been designed in at mains system level. No pressure reduction has been introduced at campus network level. Majority of networks are combined domestic / fire systems serving hydrants and so no pressure reduction plans are in place for these.
Installation of controllers on basin taps and urinals in offices, workshops and older buildings at Gatwick	Majority of public and staff toilet facilities have flow controllers and taps are generally low flow.
Re-used water for fire-fighting	Currently no system in place for this.
Re-used water for aircraft washing	Currently no system in place for this. Potable water is currently used for aircraft de-icing and vehicle wash down due to the machinery requiring good water quality.
Rainwater harvesting at existing buildings with large roof areas	Technical standards make this a prerequisite for designers to assess for inclusion in all new buildings. To date just one small building has had a system installed and due to a design issue, it has had to be taken out of service. Pier 6 Extension has a rainwater system 'designed in' and this is the expectation for all large extension and new build facilities in the future.
Grey water reuse	Technical standards make this a prerequisite for designers to assess for inclusion in all new buildings, however, to date no new build facilities have included this technology. This would not be ruled out to be applied in the future, but a trial location/system needs to be identified to prove the system technology.
	There is a grey water facility airside (water recycled from storm water ponds) that has fallen into disrepair. There are plans to refurbish it in the next 2 years and try to encourage its use for low quality water uses such as irrigation, cleaning, jetting etc. If this is successful there seems a possibility that GAL should/could consider a landside facility. Hotels generate massive opportunity for grey water, which should be investigated.
Automatic reading meters installed at main sewage pump stations and gravity outfall sewer leaving Gatwick (to help identify levels of building water wastage)	Technical standards make this a prerequisite for designers to assess for inclusion in all new buildings, however, to date no new build facilities have included this technology. This would not be ruled out to be applied in the future, but a trial location/system needs to be identified to prove the system technology.
Cooling tower water consumption	There are some old meters and flow measurement, however no reliable Automated Meter Read (AMR) and to date no further work is planned. We would not rule this out in the future.

1.5 Updated Baseline Consumption: Existing Facilities

1.5.1 Table 1.5.1 summarises the baseline forecast of water demand for existing facilities only, updated against actual demand data in 2017 from Section 1.3. This data is based on the annual average flow for 2017 for consistency due to the original baseline consumption using the annual average flow data to obtain their predictions for 2017, 2020 and 2028 in the 'Water Masterplan 2020 & 2028 Forecast – Full backing report' included in Annex 4.

1.5.2 The peak flow has also been considered for a peak flow updated baseline consumption as a worst-case scenario based on the peak flow months in 2017 and is detailed in Annex 1.

Table 1.5.1: Comparison of the Average and Peak Flow updated baseline consumption for each forecasted year.

Year Start	Average Flow - Updated Forecasted Baseline Consumption (m^3/yr)	Peak Flow - Updated Forecasted Baseline Consumption (m^3/yr)
2017	719,944	878,332
2018	706,070	861,405
2019	704,977	860,072
2020	703,884	858,738
2021	706,371	861,772
2022	708,858	864,806
2023	711,344	867,840
2024	713,831	870,874
2025	716,318	873,908
2026	718,805	876,941
2027	721,291	879,975
2028	723,778	883,009
2029	726,268	886,047
2030	728,759	889,086
2031	731,251	892,127
2032	733,745	895,169
2033	736,240	898,212
2034	738,735	901,257
2035	741,232	904,303
2036	743,730	907,351
2037	746,229	907,351
2038	748,729	913,449

2 Construction Consumption

2.1 Construction Consumption Criteria

2.1.1 During the construction phase of the project, it is anticipated that there will be extra water demand required, for the contractor and the equipment that may be used such as for dust suppression or equipment cleaning. The construction phase of the programme is to last for 15 years starting in 2023 with pre-construction enabling works and the main works running from 2024 to completion in 2038.

Table 2.1.1: Construction Timing (extract from Chapter 5: Project Description of this PEIR Table 5.5.1)

Element of the Project	Key Parameter for Assessment
Phasing	
Commencement of main construction phase	2024-2029
Year of opening	2029
Completion of construction works	2038

Table 2.1.2: Chronological timeline of construction components of the Project and impact on water supply

Component of the Project	Anticipated Phasing	Influence on water supply during construction?	Influence on water supply after commissioning?
Pre-construction activities (including surveys for any unexploded ordnance and any necessary pre-construction surveys)	2023	No	No
Early works (set up of compounds, fencing, early clearance and diversion works)	2024	Yes	No
Alterations to the existing northern runway	2024 - 2027	No	No
Works to existing taxiways and construction of new taxiways	2029 – 2031	Yes	No
Amendments to stand arrangements	2024 – 2031	Yes	No
Pier 7	2030 – 2034	Yes	Yes
Reconfiguration of existing airfield facilities (Phase 1)	2024 – 2029	Yes	Yes
Further improvements to airfield facilities	2029 – 2034	Yes	No
Extensions to North and South Terminals	2024 – 2030	Yes	Yes
Hotel and commercial facilities	2024 – 2032	Yes	Yes
Car parking	2024 – 2035	Yes	No
Surface access improvements	2029 – 2032	Yes	No
Surface water drainage and management of foul water	2024 – 2038	Yes	No

2.2 Construction Component Consumption

2.2.1 Robust estimates for potential water requirements during the construction phase have been made based on previous experience. Based on information provided, estimated total required water is detailed below.

Table 2.2.1: Construction phase in order of start date and the forecasted water demand during the years of construction.

Component	Year Start	Year End	Duration (years)	Forecasted Water demand (m^3/yr)	Forecasted Total Water Demand (m^3/yr)
Early works (set up of compounds, fencing, early clearance and diversion works)	2024	N/A	1	3,916	3,916
Car Parking	2024	2035	11	6,198	68,178
Amendments to stand arrangements	2024	2031	8	1,065	8,520
Alterations to the existing northern runway	2024	2029	5	2,445	12,227
Reconfiguration of existing airfield facilities (Phase 1)	2024	2029	5	1,321	6,607
Extension to North and South terminals	2024	2030	6	4,116	24,696
Surface access improvements	2029	2032	3	9,955	29,866
Further improvements to airfield facilities	2029	2034	5	11,478	57,389
Surface water drainage and management of foul water	2024	2038	14	3,133	43,865
Hotel and Commercial Facilities	2024	2032	8	9,972	49,862
Pier 7	2030	2034	4	3,177	12,707

2.3 Total Construction Consumption per year

2.3.1 This consumption was then aligned against the programme and the annual required consumption during construction phase was calculated.

Table 2.3.1: Total water consumption from all construction per year during the construction phase of the Project

Year Start	Construction Demand (m^3/yr)
2024	28,426
2025	24,510
2026	24,510
2027	24,510
2028	24,510
2029	49,223
2030	48,634
2031	44,518
2032	43,453
2033	27,266
2034	27,266
2035	9,331
2036	3,133
2037	3,133
2038	3,133

3 Forecasted Demand for Future Facilities

3.1 Forecasted Consumption

3.1.1 From the programme of works for the Project, elements most likely to require potable water demand following completion were extracted from the programme and water consumption estimated based on information available. Table 3.1.1 lists the elements considered for water demand calculations.

Table 3.1.1: Extract from Chapter 5: Project Description of the PEIR showing the facilities that will have an impact on water supply in the future

Element of the Project	Key Parameter for Assessment
Development consent application area	838 hectares
Works within existing GAL land ownership	760 hectares
Permanent land take (third party)	73 hectares
Temporary land take (third party)	4 hectares
Pier 7	
Pier 7 footprint	10.1 hectares
Pier 7 maximum height	18 metres
Terminal Extension	
Terminal extension footprint: North Terminal IDL	6,300 m^2
Terminal extension footprint: North Terminal baggage reclaim	650 m^2
Terminal extension footprint: North Terminal baggage hall	6,552 m^2
Maximum height of terminal extension: North Terminal IDL	32.5 metres
Maximum height of terminal extension: North Terminal baggage reclaim	7 metres
Maximum height of terminal extension: North Terminal baggage hall	12.5 metres
Terminal extension footprint: South Terminal IDL	3,780 m^2
Maximum height of terminal extension: South Terminal	30.5 metres
Hotel and Commercial Facilities	
South Terminal Hotel	400 bedrooms
South Terminal Hotel: Maximum building height	27 metres
North Terminal Hotel	400 bedrooms
North Terminal Hotel: Maximum building height	27 metres
Hotel (car rental location)	200 bedrooms
Hotel (car rental location): Maximum building height	16.3 metres
Office blocks – new footprint	1,024 (x3) m^2
Office blocks – new floorspace	9,000 m^2
Maximum height of office blocks	27 metres
South Terminal roundabout expansion: footprint	[TBC]
South Terminal roundabout expansion: height	10 metres

3.1.2 Based on the current timeline for completion of works there would be three components of the Project that would have a permanent impact on water supply after construction.

- 2024 onwards – **Extensions to the North and South Terminal**
- 2024 onwards – **Extensions to the North and South Terminal + Hotels and Commercial Facilities**
- 2030 onwards – **Extensions to the North and South Terminal + Hotels and Commercial Facilities + Pier 7**

Pier 7

3.1.3 A new Pier 7 is proposed to the north west of Pier 6. This pier would occupy an area of approximately 10.1 hectares and would contain commercial facilities. Construction is programmed to be completed in 2034.

3.1.4 Assuming Pier 7 would have a water demand of 100 m^3/ha per day from Table 1.6 in Twort's Water Supply 6th Edition (Johnson Ratnayaka Brandt, 2009), the calculation for annual water demand would be as follows:

100 m^3/ha x 10.1ha = 1,010 m^3 per day

1,010m^3 x 365 days = **368,650 m^3 per year**

Extension to the North and South Terminal

3.1.5 Planned extensions to the North and South Terminals are due to be completed in 2030.

3.1.6 Assuming the use of the North and South Terminal extensions would result in a water demand of 100 m^3/ha per day from Table 1.6 in Twort's Water Supply 6th Edition (Johnson Ratnayaka Brandt, 2009) , the calculations for annual water demand is presented in Table 3.1.2.

Table 3.1.2: Breakdown of terminals and their impact on forecasted water demand

Terminal	Component	Extra Capacity	Water demand (m^3/day)	Water demand (m^3/year)
North Terminal	Extension to the International Departure Lounge (IDL), providing mix of retail, catering and general circulation space	6,300 m^2 = 0.63ha	63	22,995

Terminal	Component	Extra Capacity	Water demand (m^3/day)	Water demand (m^3/year)
	Extension to the baggage hall	6,552 m^2= 0.65ha	65	23,725
	Extension to baggage reclaim	650 m^2 = 0.065ha	6.5	2,373
Total Water Demand (m3/yr) per year for North Terminal				**49,093**
South Terminal	Extension to the IDL, providing a mix of retail, catering and general circulation space.	3,780 m^2 = 0.37ha	37	13,505
Total Water Demand (m3/yr) per year for South Terminal				**13,505**
Total Water Demand (m3/yr) per year for both terminals				**62,598**

Hotel and Commercial Facilities predicted demand

3.1.7 The following are proposed for hotels to be constructed from 2024 to 2032:

- a new South Terminal (up to 400 bedrooms);
- a new North Terminal (up to 400 bedrooms); and
- a new hotel at the current car rental location (200 bedrooms).

3.1.8 The following commercial facilities are proposed to be constructed from 2024 – 2029.

- 3 new office blocks for internal airport uses, 27m high with approx. 9,000 m^2 of floor space.

3.1.9 According to Twort's Water Supply 6th Edition (Johnson Ratnayaka Brandt, 2009), Table 1.6, the consumption allowance for hotels is 250 – 400l/day per bed. For this assessment the worst-case scenario of 400l/day per bed (0.4 m^3/day) will be used. The consumption allowance for offices is 50-75 l/day per employee.

3.1.10 According to the Health and Safety Executive (HSE), the minimum work space in the office should be 11 m^3 per employee therefore allowing 5 m^2 (assuming height of 2.5 metres) per employee. Assuming office space of 9,000 m^2, the assumption is that the maximum number of employees is 1,800 (9,000 / 5 m^2) and using the worst-case scenario of 75 l/day per employee (0.075 m3/day).

3.1.11 Although the Hilton and BLOC hotels are not part of the Project, they will impact water demand on the Gatwick site and therefore have been retained to give a complete estimate of future water requirements.

Table 3.1.3: Breakdown of hotels and commercial facilities and their impact on forecasted water demand

Component	Extra Capacity	Water demand (m^3/day)	Water demand (m^3/year)
South Terminal Hotel	400 bedrooms	(400 x 0.4) = 160	58,400
North Terminal Hotel	400 bedrooms	(400 x 0.4) = 160	58,400
Hotel	200 bedrooms	(200 x 0.4) = 80	29,200
BLOC hotel extension	200 bedrooms	(200 x 0.4) = 80	29,200
Hilton hotel reconfiguration	50 bedrooms	(50 x 0.4) = 20	7,300
3 new office blocks	9,000 m^2	(0.075 x 1,800) = 135	(260 x 135) = 35,100
Total Water Demand (m3) per year			**217,600**

*Assuming offices only open on weekdays (52 weeks x 5 days = 260 days per year).

3.1.12 Assuming construction for the hotel and office facilities finishes in 2032, this would be an increase in demand of 217,288 m^3/yr from 2032 onwards.

3.1.13 As a cross-check, demand was also calculated based on forecast increase in passengers (pax) against current calculated pax per customer. Based on the information provided in project description, the Project could enable an increase of 13 million passengers per annum (mppa) by 2038 and based on the previously forecasted consumption as detailed in Water Masterplan 2020 & 2028 forecast document worst-case consumption is 15.9 l/PAX. Therefore, this will result in a potential water consumption increase of (13,000,000 x 15.9)/1000 = 206,700 m^3 by 2038. This is less than 5% variance on the calculated value, giving confidence in the consumption value to be applied.

3.2 Total Future Facilities' Demand

3.2.1 Based on the calculated consumption as detailed in the previous section and the programmed completion dates, the following annual consumption values have been calculated. See Annex 3 for full details of the Total Components' Demand.

Table 3.2.1: Total demand for all future project facilities without water efficiencies implemented.

Year Start	Total Components' Demand (m^3/yr)
2029	0
2030	217,600
2031	217,600
2032	217,600
2033	280,198
2034	280,198
Consumption per annum 2035 onwards	648,848

3.3 Introducing Water Efficiencies

3.3.1 There are a few water efficiency methods that can be utilised for as part of the Project. An example of these are presented in Table 3.3.1.

Table 3.3.1: Water Efficiencies that can potentially be implemented into the new facilities.

Water Efficiency Method	Potential Facilities for savings	Potential reduction savings (%)
Installation of Automatic Reading Meters	Airfield Facilities Pier 7 North and South Terminal Hotels Offices	AMI/AMR does not actually save water but allows for more accurate recording of consumption data.
Mains pressure reduction to reduce leakage	Pier 7 North and South Terminal	TBC – Can be estimated through hydraulic modelling
Grey water re-use	Hotels and Facilities	Requires further investigation.
Installation of controllers on basin	Hotels and Facilities Pier 7	60 %* of relevant consumption.

Water Efficiency Method	Potential Facilities for savings	Potential reduction savings (%)
taps and urinals in offices, workshops	Extensions to North and South Terminal	It is not possible at this stage to calculate demand requirements for toilet facilities. More information is required.
Re-use water for firefighting (rainwater harvesting)	Airfield facilities	Previous on-site evidence suggests possible 20 % savings, however further investigations. It is not possible at this stage to calculate demand requirements for toilet facilities. More information is required.
Rainwater harvesting	Pier 7 Extensions to North and South Terminal Hotels Offices	25 % 25 % 36 % 46 %
Re-use water for aircraft washing	Airfield Facilities	Previous on-site evidence suggests 20 % savings however further investigations. It is not possible at this stage to calculate demand requirements for toilet facilities. More information required.

*Similar studies have recorded 60% savings for washroom facilities consumption from applying water efficiencies.

Pier 7

Table 3.3.2: Breakdown of water consumption savings for Pier 7

Component	Water demand before water efficiencies (m^3/yr)	Water savings from 25% reduction from rainwater harvesting (m^3/yr)	Water savings from water efficient fittings in toilet facilities (m^3/yr)	Total Water Demand after water efficiency savings (m^3/yr)
Pier 7	368,650	92,163	TBC	**276,487**

Extension to the North and South Terminal savings

Table 3.3.3: Breakdown of water consumption savings for both terminals

Component	Water demand before water efficiencies (m^3/yr)	Water savings from 25% reduction from rainwater harvesting (m^3/yr)	Water savings from water efficient fittings in toilet facilities (m^3/yr)	Total Water Demand after water efficiency savings (m^3/yr)
North Terminal	49,093	12,273	TBC	**36,820**
South Terminal	13,505	3,376	TBC	**10,129**
Total for both terminals	**N/A**	**N/A**	**N/A**	**46,949**

Hotels and Commercial Facilities savings

3.3.2 Based on information from WRAP – Achieving water efficiency on projects – information sheet report, figures for water efficiency savings for hotels and offices can be applied to the forecasted water demand. For example, using current available technologies water savings of 25-50% can be seen for showers, 40% savings with urinals, and 33-50% on taps.

Table 3.3.4: Total water demand per year of new hotel facilities after water efficiency savings of 47.3%* was applied (*see Annex 3 for full calculation details)

Component	Water demand (m^3/yr) before including water efficiency savings	Water savings from water efficiencies (m^3/yr)	Water demand (m^3/yr) with water efficiency savings
South Terminal Hotel	58,400	27,623	**30,777**
North Terminal Hotel	58,400	27,623	**30,767**
Hotel	29,200	13,812	**15,388**
BLOC hotel extension	29,200	13,812	**15,388**
Hilton hotel reconfiguration	7,300	3,453	**3,847**
Total Water Demand	**182,500**	**86,323**	**96,178**

Table 3.3.5: Total water demand per year of the new office facilities after water efficiency savings of 80.5%* was applied (*See Annex 3 for full calculation details)

Component	Water demand (m^3/yr) before water efficiency savings	Water demand (m^3/yr) with water efficiency savings
3 Office Blocks	35,100	**6,845**
Total Water Demand	**35,100**	**6,845**

Total Water Savings per year

Table 3.3.6: Breakdown of the Total Water Savings for each forecasted year

Forecasted Year	Pier 7 water savings (m^3/yr)	Extensions to the North and South Terminal water savings (m^3/yr)	Hotels and Commercial Facilities water savings (m^3/yr)	Total Water Savings (m^3/yr)
2029	N/A	N/A	N/A	**N/A**
2030	N/A	46,949	N/A	46,949
2031	N/A	46,949	N/A	46,949
2032	N/A	46,949	N/A	**46,949**
2033	N/A	46,949	103,023	**149,972**
2034	N/A	46,949	103,023	**149,972**
Consumption per annum 2035 onwards	276,487	46,949	103,023	**426,459**

4 Total Forecast Demand

4.1.1 This section presents the breakdown of all water consumption for all the forecasted years to the completion of the project in 2038.

4.2 The Worst-Case Scenario Demand

4.2.1 The worst-case scenario is with no water efficiencies implemented for future developments.

4.2.2 The worst-case scenario demand includes:

- the (average flow) updated baseline consumption;
- total construction demand (years impacted, 2024 – 2038); and
- the Project facilities' demand (post-construction) (years impacted, 2030 onwards)

Table 4.2.1: Total Water Consumption for the Worse-Case scenario

Year Start	Total (m^3/yr)
2019	704,977
2020	703,884
2021	706,371
2022	708,858
2023	711,344
2024	1,058,643
2025	1,057,214
2026	1,059,701
2027	1,062,187
2028	1,064,674
2029	1,091,877
2030	1,363,331
2031	1,361,707
2032	1,363,136
2033	1,132,156
2034	1,134,651
2035	1,119,213
2036	1,115,513
2037	1,118,012
2038	1,120,512

4.3 The Best-Case Scenario Demand

4.3.1 The best case scenario includes all possible water efficiencies implemented with future developments. The best-case scenario demand includes:

- the (average flow) updated baseline consumption;
- total construction demand (years impacted, 2024 – 2034)
- the Project facilities' demand (post-construction) (years impacted, 2030 onwards)
- all water efficiencies that can be implemented for the Project's facilities based on the information provided, however these savings can potentially be increased in the future if more information can be provided on water consumption facilities such as restrooms for example.

Table 4.3.1: Total of Water Consumption for the Best-Case Scenario

Year Start	Worst-Case Scenario (m3/yr)	Total water savings (m3/yr)	Best-Case Scenario Demand (m3/yr)
2019	704,977	N/A	**704,977**
2020	703,884	N/A	**703,884**
2021	706,371	N/A	**706,371**
2022	708,858	N/A	**708,858**
2023	711,344	N/A	**711,344**
2024	1,058,643	N/A	**1,058,643**
2025	1,057,214	N/A	**1,057,214**
2026	1,059,701	N/A	**1,059,701**
2027	1,062,187	N/A	**1,062,167**
2028	1,064,674	N/A	**1,064,674**
2029	1,091,877	N/A	**1,091,877**
2030	1,363,331	46,949	1,316,382
2031	1,361,707	46,949	1,314,758
2032	1,363,136	46,949	1,316,187
2033	1,132,156	149,972	982,184
2034	1,134,651	149,972	984,679
2035	1,119,213	426,459	692,754
2036	1,115,513	426,459	689,054
2037	1,118,012	426,459	691,553
2038	1,120,512	426,459	694,053

4.4 Design Year 2038 Total

4.4.1 The forecasted number of passengers for 2038 with the Project is 75 mppa, a 13 mppa increase from the original future baseline.

4.4.2 Due to there being no detailed breakdown of the proportion of the increase in forecasted passengers related individually to the completion of the North and South Terminal extensions (expected in 2029) and the Pier 7 (expected in 2034), total water consumption can only be calculated for the Design Year of 2038 using the 2038 forecasted passenger numbers.

4.4.3 Due to there being no additional information provided on washroom facilities required for Pier 7 and the North and South Terminal extensions, the additional passengers' consumption (m^3/pax) has been used in the table below to assume the water consumption for these washroom facilities.

Table 4.4.1: Breakdown of the Total Water Consumption for the Design Year of 2038.

Component	Average Flow Water Consumption (m^3/yr)	Peak Flow Water Consumption (m^3/yr)
Updated Baseline Consumption	748,729	913,449
Construction Demand	3,133	3,133
Extensions to the North and South Terminal	62,598	62,598
Hotels and Commercial Facilities	217,600	217,600
Pier 7	368,650	368,650
Total	**1,400,710**	**1,565,430**

5 References

Gatwick Airport Ltd (2018) 'London Gatwick Water Masterplan 2020 & 2028 Forecast - Full Backing Report'.

Johnson Ratnayaka Brandt (2009) Twort's Water Supply 6th Edition.

WRAP (n.d.) Information Sheet: Achieving water efficiency on projects. [Online] Available at: http://www.wrap.org.uk/sites/files/wrap/Achieving%20water%20efficiency%20on%20projects_0.pdf

6 Glossary

6.1 Glossary of Terms

Term	Description
AMR	Automated Meter Reader
GAL	Gatwick Airport Ltd
HSE	Health and Safety Executive
mppa	Million passengers per annum
PEIR	Preliminary Environmental Information Report
SESW	Sutton and East Surrey Water
WRAP	Waste and Resources Action Programme

Annex 1

Updated Baseline Consumption

A1.1 An update of current and future baseline water consumption figures was completed using actual data for 2017 and 2018, and growth information for 2020 and 2028 as indicated in Table A1.1 and Graph A1.1 to inform the environmental impact assessment for the baseline, interim and Project coemption years .

Table A1.1: Updated Baseline Consumption Projections

Year	Original Baseline Consumption (m^3/yr)	(Average Flow) Updated Baseline Consumption (m^3/yr)	(Peak Flow) Updated Baseline Consumption[7] (m^3/yr)
2017	781,942[1]	719,944[2]	878,332
2018		706,070[2]	861,405
2019		704,977[4]	860,072
2020	764,466[1]	703,884[3]	858,738
2021		706,371[5]	861,772
2022		708,858[5]	864,806
2023		711,344[5]	867,840
2024		713,831[5]	870,874
2025		716,318[5]	873,908
2026		718,805[5]	876,941
2027		721,291[5]	879,975
2028	786,052[1]	723,778[3]	883,009
2029		726,268[6]	886,047
2030		728,759[6]	889,086
2031		731,251[6]	892,127
2032		733,745[6]	895,169
2033		736,240[6]	898,212
2034		738,735[6]	901,257
2035		741,232[6]	904,303
2036		743,730[6]	907,351
2037		746,229[6]	910,400
2038		748,729[6]	913,449

[1]Forecasted water consumption from the '*Water Masterplan 2020 & 2028 Forecast – Full backing report*'

[2]Actual data obtained from 'GAL Water Consumption Balance 280819_MB'.

[3]Data obtained from using the percentage error calculated (-8.604%) from the annual predicted data to the annual actual data in 2017 and applying it to the original baseline consumption.

[4]Data obtained from the average of 2018 and 2020 in the average flow updated baseline consumption.

[5]Data obtained from the difference of 2028 and 2020 in the average flow updated baseline consumption column then increased in increments of that difference over 8 years between 2020 to 2028.

(Year 2028) 723,778 – (Year 2020) 703,884 = **19,894 m^3**.

19,894 m^3 / 8 years = **2,487 m^3**.

[6]Data was obtained from calculating the percentage change of each year from the previous year of the average flow updated baseline from 2021 to 2028 which started at a 0.353% increase in 2021 and with the percentage increase dropping by 0.001% every consecutive year.

[7]Applied a factor of 1.22 to the average flow updated baseline consumption to obtain the values in the peak flow column.

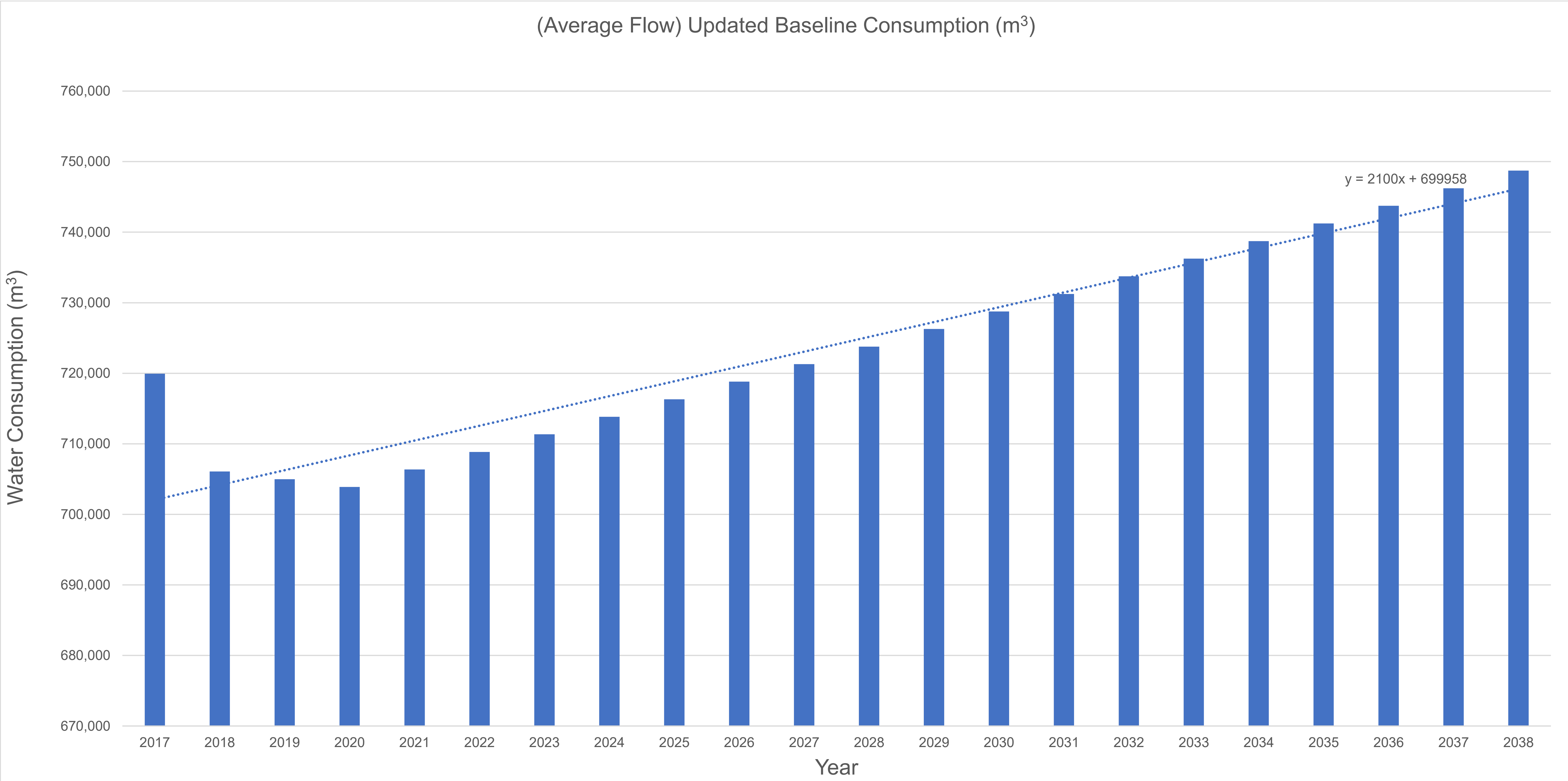
Table A1.2: Calculation for Peak Flow Consumption for 2017.

Component	Peak Month	Peak Flow Consumption (m^3/month)	Peak Flow Consumption (m^3/yr)
South Terminal (all meters)	August	35,654	427,848
North Terminal Povey Cross	June	37,750	453,000
Total	**-**	**-**	**880,848**

Table A1.3: Calculation for Peak Flow Factor

Component	Average Flow	Peak Flow	Percentage Change from average flow to peak flow.
2017 Consumption	719,994	880,848	22.3%
Peak Flow Factor	-	-	1.22

Graph A1.1: (Average Flow) Updated Baseline Consumption Projections



Annex 2

Construction Demand Details

Table A2.1: Chronological order of construction activities and water consumption by year

Year Start	Construction Activities in Project Genesis (m³/yr)												
	Early works	Works to existing taxiways	Car Parking	Amendments to Stand Arrangements	Alterations to the existing northern runway	Reconfiguration of existing airfield facilities (Phase 1)	Extensions to North and South Terminals	Surface Access Improvements	Further improvements to airfield facilities	Surface water drainage and management of foul water	Hotel and Commercial Facilities	Pier 7	Total Construction Water Demand (m³/yr)
2024 – 25	3,916	-	6,198	1,065	2,445	1,321	4,116	-	-	3,133	6,232	-	28,426
2025 – 26	-	-	6,198	1,065	2,445	1,321	4,116	-	-	3,133	6,232	-	24,510
2026 – 27	-	-	6,198	1,065	2,445	1,321	4,116	-	-	3,133	6,232	-	24,510
2027 – 28	-	-	6,198	1,065	2,445	1,321	4,116	-	-	3,133	6,232	-	24,510
2028 – 29	-	-	6,198	1,065	2,445	1,321	4,116	-	-	3,133	6,232	-	24,510
2029 – 30	-	3,280	6,198	1,065	-	-	4,116	9,955	11,478	3,133	6,232	-	49,223
2030 – 31	-	3,280	6,198	1,065	-	-	-	9,955	11,478	3,133	6,232	3,177	48,634
2031 – 32	-	3,280	6,198		-	-	-	9,955	11,478	3,133	6,232	3,177	44,518
2032 – 33	-	3,280	6,198		-	-	-	-	11,478	3,133	-	3,177	43,453
2033 – 34	-	3,280	6,198		-	-	-	-	11,478	3,133	-	3,177	27,266
2034 – 35	-	-	6,198	-	-	-	-	-	-	3,133	-	-	27,266
2035 – 36	-	-	,	-	-	-	-	-	-	3,133	-	-	9,331
2036 – 37	-	-	-	-	-	-	-	-	-	3,133	-	-	3,133
2037 – 38	-	-	-	-	-	-	-	-	-	3,133	-	-	3,133

Construction Demand Parameters

A2.1 Table A2.2 summarises the parameters selected for each construction phase. The water source is assumed to be Mains supply/standpipe for all choices.

A2.2 The duration of all activities in Table A2.2 are assumed to be the entire contract timeline. The programme has been assumed to run for the years listed in Chapter 5: Project Description on the PEIR, for example construction of Pier 7 runs from 2030 to 2034 therefore it is four years. In the calculator this is chosen as 01/01/2030 to 31/12/2034.

Table A2.2: Design Parameters for Construction Demand Calculator

<table>
<tr><th>Component</th><th>B - Dust Suppression</th><th>C – Site Welfare Facilities</th><th>D – General Cleaning</th></tr>
<tr><td>Early works, including establishment of compounds, fencing, early clearance and diversion works and re-provision of essential replacement services</td><td>B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1
Duration - 1 hours/day, 1 days/month</td><td rowspan="10">C.1 – Canteen
C.2 – Toilet Facilities
Urinal (with water management system) x 6
Toilets (Dual Flush Toilet 4 litres) x 6
C.3 – Showers x 2
C.4 Hand Washing
Method – Tap aerator (Twist/Lever Top)
Basins x 4</td><td rowspan="3">D.1 Boot Washing
Method – Pressure Wash Station
Duration – 0.2 hours/day, 4 days/month
D.2 Plant and Equipment Cleaning
Method – Pressure washer (Electric Pump 150 bar)
Duration - 1 hour/day, 2 days/month</td></tr>
<tr><td>Works to existing taxiways and construction of new taxiways</td><td>B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1
Duration - 1 hours/day, 3 days/month
B.3 - Road Sweeping
Method – Truck Mounted Road Sweeper (Typical flow rate)
Duration – 2 hours/day, 4 days/month</td></tr>
<tr><td>Car Parking</td><td>B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1
Duration - 1 hours/day, 4 days/month</td></tr>
<tr><td>Amendments to stand arrangements</td><td>N/A</td><td rowspan="2">D.2 Plant and Equipment Cleaning
Method – Pressure washer (Electric Pump 150 bar)
Duration - 1 hour/day, 2 days/month</td></tr>
<tr><td>Alterations to the existing northern runway</td><td rowspan="4">B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1
Duration - 1 hours/day, 4 days/month</td></tr>
<tr><td>Reconfiguration of existing airfield facilities (Phase 1)</td><td rowspan="2">D.1 Boot Washing
Method – Pressure Wash Station
Duration – 0.2 hours/day, 4 days/month
D.2 Plant and Equipment Cleaning
Method – Pressure washer (Electric Pump 150 bar)
Duration - 1 hour/day, 2 days/month</td></tr>
<tr><td>Extension to North and South terminals</td></tr>
<tr><td>Surface access improvements</td><td>D.2 Plant and Equipment Cleaning
Method – Pressure washer (Electric Pump 150 bar)
Duration - 1 hour/day, 2 days/month</td></tr>
<tr><td>Further improvements to airfield facilities</td><td>B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1
Duration - 1 hours/day, 1 days/month</td><td rowspan="2">D.1 Boot Washing
Method – Pressure Wash Station
Duration – 0.2 hours/day, 4 days/month
D.2 Plant and Equipment Cleaning
Method – Pressure washer (Electric Pump 150 bar)
Duration - 1 hour/day, 2 days/month</td></tr>
<tr><td>Surface water drainage and management of foul water</td><td>B.1 – Damping and Misting
Method – Misting Cannon (reduced power) x 1</td></tr>
</table>

Component	B - Dust Suppression	C – Site Welfare Facilities	D – General Cleaning
	Duration - 1 hours/day, 2 days/month		
Hotels and Commercial Facilities	B.1 – Damping and Misting		
Pier 7	Method – Misting Cannon (reduced power) x 1 Duration - 1 hours/day, 4 days/month		

Annex 3

Forecasted Demand for Future Facilities

Table A3.1: Breakdown of the individual facilities and total demand.

Year Start	Pier 7 and Stand Amendments (m^3/yr)	Extensions to the North and South Terminal (m^3/yr)	Hotel and Commercial Facilities (m^3/yr)	Total Components' Demand (m^3/yr)
2029	-	-	-	-
2030	-	62,598	-	62,598
2031	-	62,598	-	62,598
2032	-	62,598	-	62,598
2033	-	62,598	217,600	280,198
2034	-	62,598	217,600	280,198
2035	368,650	62,598	217,600	648,848
2036	368,650	62,598	217,600	648,848
2037	368,650	62,598	217,600	648,848
2038	368,650	62,598	217,600	648,848

A3.1 Based on The Waste and Resources Action Programme (WRAP) – Achieving water efficiency on projects 'Water efficiency within buildings.' water efficiencies have been categorised as:

- **Standard practice** – 'consumption typical of buildings fitted with current baseline practice fittings and appliances';
- **Enhanced practice** – 'consumption typical of buildings where a majority of fittings and appliances would be classified as efficient (on average)'; and
- **Leading-edge practice** – 'consumption typical of buildings where a majority of fittings and appliances would be classified as highly efficient, and where additional measures are taken to minimise and substitute demand for potable water'.

A3.2 Standard practice was used to consider the worst-case scenario with no water efficiencies in place and leading-edge practice was used to consider the best-case scenario with the recommended water efficiencies.

Table A3.2: Extract from WRAP – Achieving water efficiency on projects, fig. A1.7.

Building type	Standard practice	Enhanced practice	Leading-edge practice
Hotels (room only, excluding staff use, pool, laundry and restaurant) (litres/room/day)	110	98 – Assumes 6/4 l dual flush WCs and low flow basin taps, offsetting a full-sized bath and high flow rate shower.	58 – Assumes 4.5/2.5 l dual flush WCs, with 75 per cent of flush demand met by rainwater harvesting; 10 l/min shower.

A3.3 Calculating from the standard practice of 110 (litres/room/day) to the leading-edge practice of 58 (litres/room/day) a percentage calculation was made to estimate the savings hotels can produce based on optimising technology for toilets, basins and showers and utilising rainwater harvesting.

- **Percentage saving** = 110 - 58 = 52 l/room/day
  = (52 / 110) x 100% = 47.27…%
  = **47.3%**

Table A3. 3: Extract from WRAP – Achieving water efficiency on projects, fig. A1.7.

Building type	Standard practice	Enhanced practice	Leading-edge practice
New offices (excluding canteen) (litres/person/day)	41	27 – Assumes taps and shower have flow rates below efficient practice, but dishwasher has baseline consumption.	8 – Assumes highly efficient fittings, with 75 per cent of flush demand met by rainwater harvesting.

A3.4 Calculating from the standard practice of 41 (litres/room/day) to the leading-edge practice of 8 (litres/room/day) a percentage calculation was made to estimate the savings offices can produce based on optimising technology for taps and showers and utilising rainwater harvesting.

- **Percentage saving** = 41 - 8 = 33 l/room/day
  = (33 / 41) x 100% = 80.487... %
  = **80.5%**

Annex 4

Water Masterplan 2020 & 2028 Forecast - Full backing Report, 2018

-

London Gatwick - Water Masterplanning

Gatwick Airport Ltd

Water Masterplan 2020 & 2028 Forecast - Full backing report

| Final

04 January 2018

London Gatwick - Water Masterplanning

Project No:	GADD009A
Document Title:	Water Masterplan 2020 & 2028 Forecast - Full backing report
Revision:	Final
Date:	17 November 2017
Client Name:	Gatwick Airport Ltd
Client No:	N/A
Project Manager:	Lucy Chapman
Author:	Mark Goldberg, James Cullinane, Jamie Shotter
File Name:	GADD009A_Water Masterplan 2020 & 2028 Forecast - Full backing report

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Document history and status

Revision	Date	Description	By	Review	Approved
1	18/8/17	For client review	MG, JC, JS	MS	LC
2	27/10/17	Final report	MG, JC, JS	MS	LC
3	04/01/2017	Final report	MG, JC, JS	MS	LC

Important note about your report

The sole purpose of this report and the associated services performed by Jacobs is to provide Gatwick Airport Limited (GAL) ('The Client') with a description of GAL's water management today and how this has changed in recent years with reference to the volumes reported in the 2012 master plan. This shall be conducted in accordance with the scope of services set out in the contract between Jacobs and the Client. That scope of services, as described in this report, was developed with the Client.

In preparing this report, Jacobs has relied upon, and presumed accurate, any information (or confirmation of the absence thereof) provided by the Client and/or from other sources. As otherwise stated in the report, unless specifically stated Jacobs has not attempted to verify the accuracy or completeness of any such information. If the information is subsequently determined to be false, inaccurate or incomplete, then it is possible that our observations and conclusions as expressed in this report may change.

Jacobs derived the data in this report from information sourced from the Client (if any) and/or available in the public domain at the time, or times, outlined in this report. The passage of time, manifestation of latent conditions or impacts of future events may require further examination of the project and subsequent data analysis, and re-evaluation of the data, findings, observations and conclusions expressed in this report. Jacobs has prepared this report in accordance with the usual care and thoroughness of the consulting profession, for the sole purpose described above and by reference to applicable standards, guidelines, procedures and practices at the date of issue of this report. For the reasons outlined above, however, no other warranty or guarantee, whether expressed or implied, is made as to the data, observations and findings expressed in this report, to the extent permitted by law.

This report should be read in full and no excerpts are to be taken as representative of the findings. No responsibility is accepted by Jacobs for use of any part of this report in any other context.

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Through the data collection exercise a number of gaps in data availability have been identified. Wherever possible, assumptions have been made to permit a meaningful assessment of the management of water. The limitations of the assessment are included in a detailed methodology summary in Appendix B.

Executive Summary

Gatwick Airport Ltd (GAL) has undertaken passenger forecasts to understand the future airport development for two growth scenarios. The focus of interest for GAL is their Decade of Change (DoC) water target end point (2020) and the single-runway airport's development in the assessment year (2028). A forecast has been produced for each of these years. The outputs from these forecasts will be used to develop the water use, water quality and flood risk and surface water management input to the masterplan.

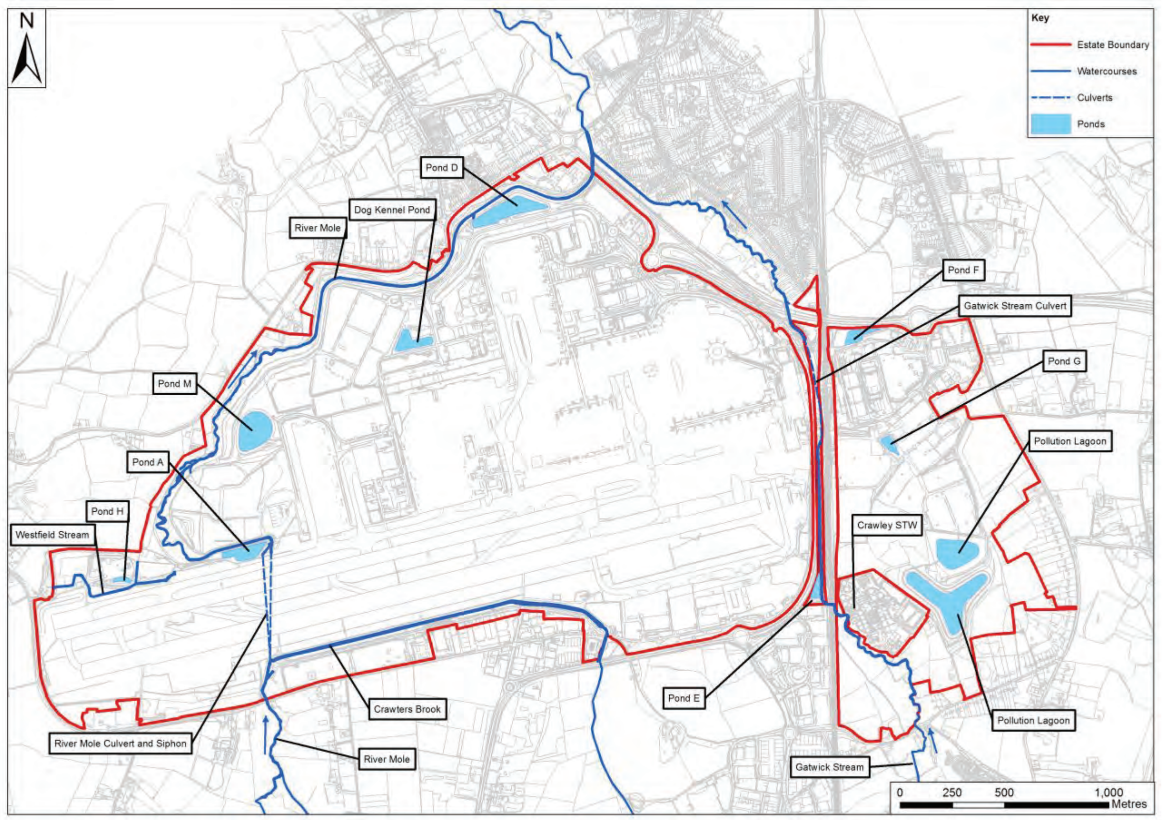
Airports and Water

Airports have a potentially significant impact upon all stages of the water cycle. Gatwick used 676 Megalitres of water in 2015 or 17 litres per passenger, not just for services for passengers but also airplane operations such as de-icing. Consequently, a similar volume of wastewater requires treatment before being discharged back to watercourses. There is the potential for Gatwick to generate large volumes of rainfall runoff from impermeable areas including runways, taxiways and buildings, which if unmanaged could increase flood risk to those downstream, consequently the airport has an extensive drainage system to manage this risk.

GAL collaborates with a number of organisations through the supply and disposal of water at the airport. Water is supplied by Sutton and East Surrey (SES) Water and is disposed of either to the Thames Water (TW) Crawley Sewage Treatment Works (STW) or TW Horley STW for foul or to local watercourses for rainfall runoff. If the latter is of insufficient quality, it is also drained to the STW for further treatment. The EA consent discharges to the local watercourses (Gatwick has 11); the quality standards to be met by Gatwick vary by consent. If the runoff does not meet the required standard it is retained within the system for further treatment. New development at Gatwick would be expected to limit surface water runoff to greenfield rates to reduce flood risk.

The key elements of water management at Gatwick are identified in Figure 1-1.

Figure 1-1 : Key Water Management Features



Water Usage

The historic data has been taken from the Gatwick water fiscal meters. The water supply to Gatwick is provided by Sutton and East Surrey (SES) Water and within the Gatwick estate is composed of four supply areas; North Terminal and the airfield area served by 1 fiscal meter at Povey Cross, South Terminal served by 4 fiscal meters, East of Rail (EOR) served by 1 fiscal meter, and other areas served by 24 fiscal meters. In 2016 the Povey Cross Meter Area (which includes the North Terminal) accounted for 52% of the water consumption, South Terminal 25%, EoR 20% and other 3%.

Figure 1-2 : GAL Water Supply Areas

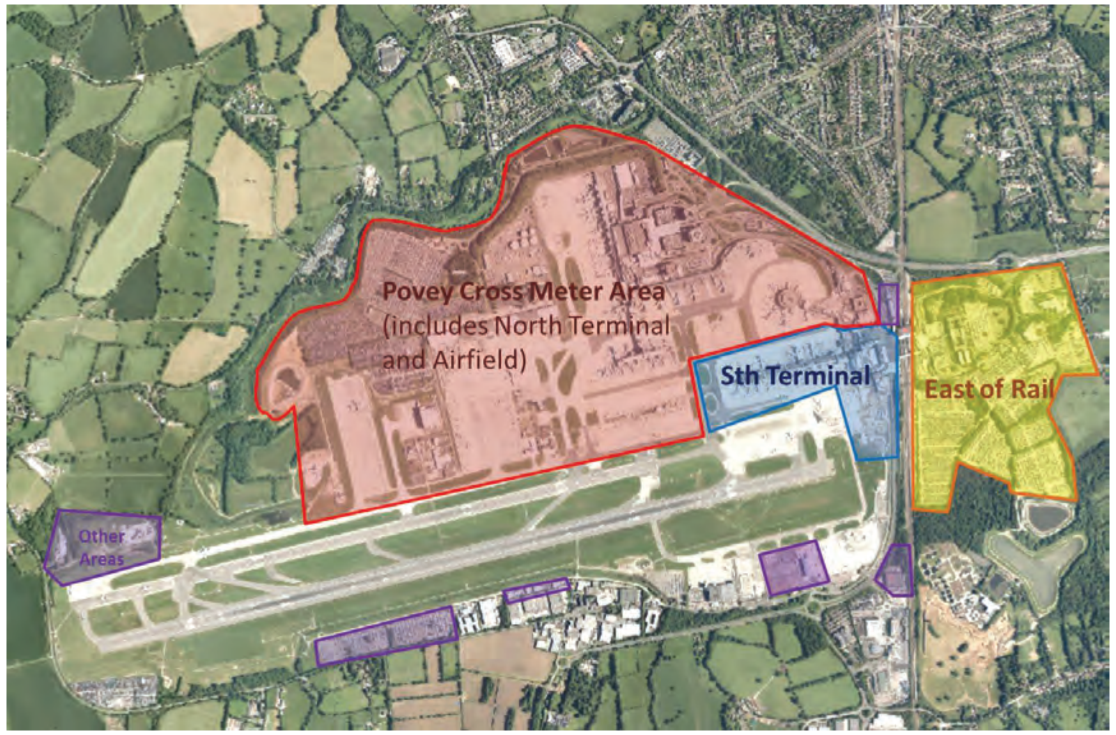
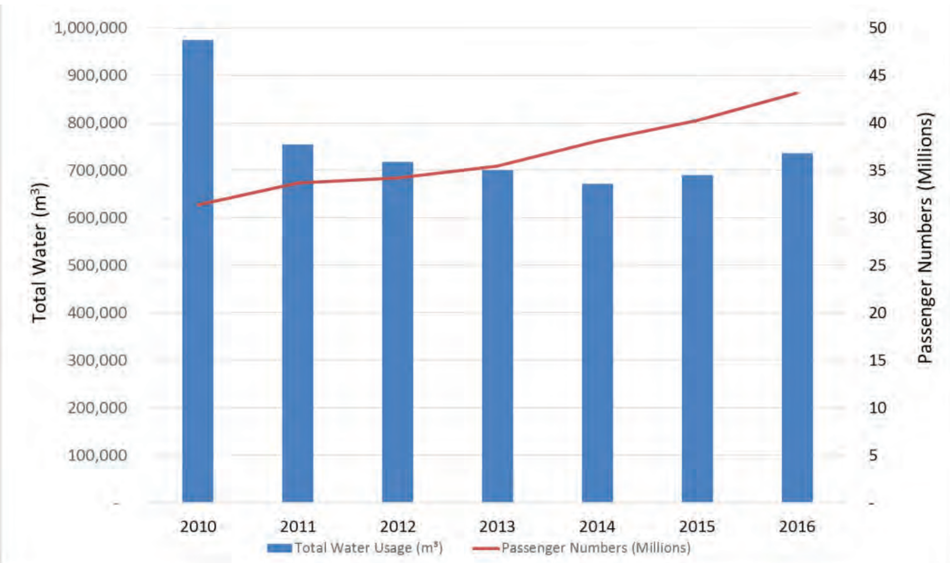


Figure 1-3 : Gatwick Water Consumption and Passenger Numbers

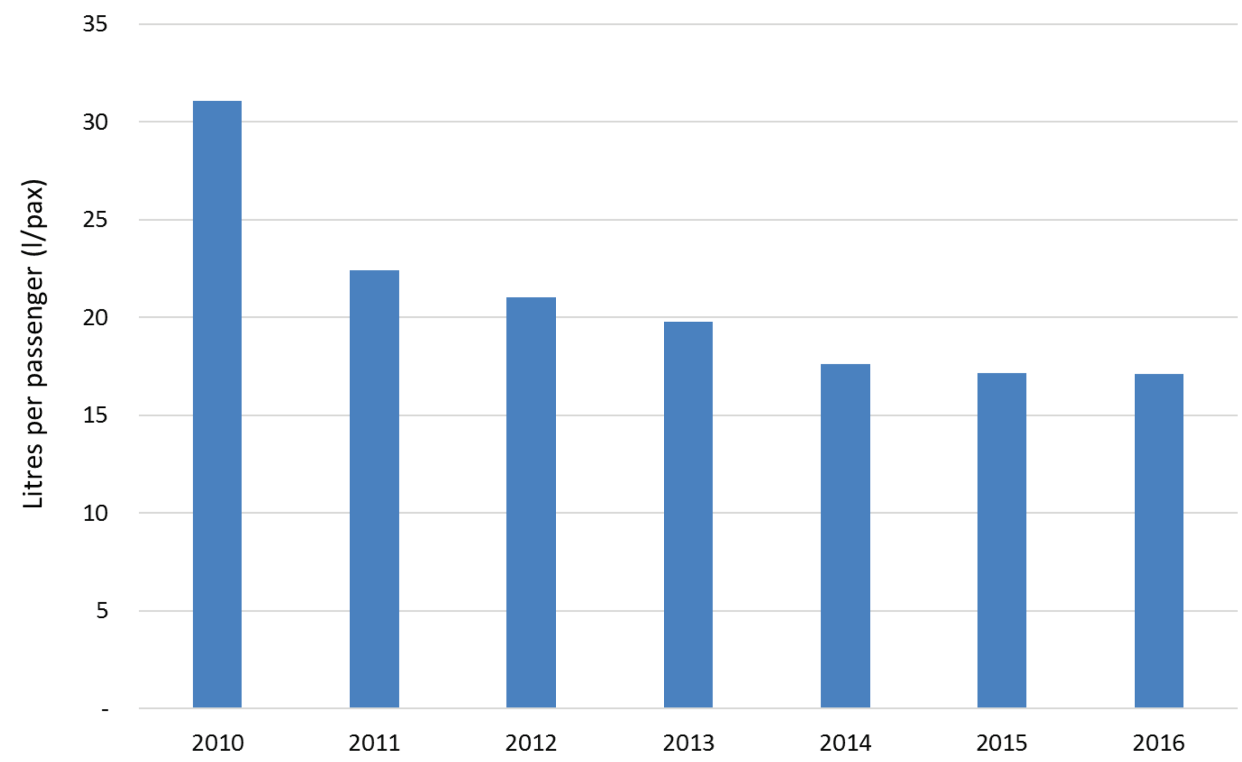


Water consumption decreased sharply from 2010 to 2014. This was due to leakage management, and water efficiency programmes, such as continued use of water efficient toilet facilities. Additionally, key assets reductions such as the part closure of Pier 5 for refurbishment and Pier 1 demolition.

Consumption increased from 2014 to 2016, potentially due to the reopening of Pier 5 and construction of Pier 1 and Bloc Hotel. This could also be due to leakage reduction programmes finding it more challenging to identify new leaks, compared to earlier easier success.

Over the same period from 2010 to 2016 passenger numbers have increased from 31.3 million to 43.1 million. As passenger numbers have been increasing the consumption per passenger has decreased from 31.1 litres/pax (2010) to 17.1 litres/pax (2016); see Figure 1-4.

Figure 1-4 : Gatwick Water Consumption per Passenger



Forecasts for water consumption in 2020 and 2028 have been based on medium trends in water consumption from 2012 to 2016, and taking into account asset changes expected to be implemented prior to 2020 with further changes anticipated by 2028.

The forecast water consumption in 2020 is estimated to be 764,000 m³ which is higher than any of the previous years, apart from 2010. This is a 20% reduction on the consumption in 2010, and compares to the target launched in the Decade of Change Report in 2010 of a 20% reduction, but which has now been stretched to 25% to spur further water efficiencies as the airport grows. The 2020 forecast suggests that this target will not be met.

Consumption in 2020 will be similar to that of 2011, but with a reduced unit consumption of 16 l/pax, compared to more than 22 l/pax in 2011. Calculation figures and results are summarised in Table 1.

Table 1 : 2020 Water Consumption Forecast

2020 Water Forecast	
	Meters Cubed
Business as usual consumption	730,144
Asset Changes	34,302
Total 2020 Consumption	764,446
Scenario 1 (litres / PAX)	15.8
Scenario 2 (litres / PAX)	15.9
2010	
Total Consumption	974,067
Consumption per PAX (lites per PAX)	31.1
DOC Original target - 20%	
Target 2020 Consumption	779,254
Target reduction against 2010 baseline	20%
DOC Stretch target - 25%	
Target 2020 Consumption	730,550
Target reduction against 2010 baseline	25%
Predicted reduction against 2010 baseline	-5%
Reduction in consumption per PAX	49%

The forecast water consumption in 2028 is estimated to be 786,000 m^3, but with a further unit consumption of less than 14 l/pax. The provision of the 2028 forecast is subject to the realisation of the asset changes detailed in this report. The main sensitivity lies with the Boeing Hangar and its consumption per floor area being similar to that of the Virgin Hangar. Calculation figures and results are summarised in Table 2.

Table 2 : 2028 Water Consumption Forecast

2028 Water Forecast	
	Meters Cubed
Business as usual consumption	741,987
Asset Changes	44,065
Total 2028 Consumption	786,052
Passanger Nos Scenario 1 (million)	53
Scenario 1 (litres / PAX)	14.7
Scenario 2 Passanger Nos (million)	55.3
Scenario 2 (litres / PAX)	14.2
Consumption change against 2020	2.8%
Consumption per PAX change against 2020 Scenario 1	-7%
Consumption per PAX change against 2020	-11%

Water Efficiency Measures

There is significant scope for improvement in water efficiencies at Gatwick.

The first priority is to reduce the currently high levels of unaccounted for water by improving metering at GAL and installing automatic reading meters at key facilities to monitor the water consumption pattern throughout the day and night. Leakage and water losses in facilities are estimated to be significant and warrant attention.

An enhanced leakage control and reduction programme is recommended to find leaks more effectively and implement repairs. Additionally consideration is to be given to mains pressure reduction during periods of low demand, but ensuring pressure can be restored quickly and adequately when demands suddenly increase for firefighting emergencies.

In buildings and facilities improvements have already been realised through the use of controllers on basin taps and urinals in the main terminal buildings. Similar controls should be rolled out to offices, workshops and older buildings at Gatwick.

Consideration will also be given to water reuse through rainwater harvesting at existing buildings with large roof areas, and for new buildings and facilities grey water reuse and/or rainwater harvesting to be incorporated where evaluated to be feasible.

Consideration should also be given to the monitoring of foul wastewater flows in the main sewage pump stations and main gravity outfall sewer leaving Gatwick for Thames Water sewage works. Automatic reading meters similar to those used on the main water supply are recommended for installation. When installed these will help identify levels of building water wastage and infiltration present and where savings can be made.

Water Quality

Biological Oxygen Demand (BOD) has been identified as a key performance indicator of water quality at Gatwick. GAL therefore use the number of BOD exceedances of an adopted 10mg/l threshold at the discharge point from Pond D as a reportable indicator of water quality. The main contributor to a number of events when BOD is greater than 10mg/l has been identified as de-icers both for aircraft and pavement use. Limited capacity for storing and treating runoff from the airfield on site over the winter period means that, by the end of the season, GAL could have to discharge potentially high BOD excess runoff to local watercourses. Jacobs has used Chemical Oxygen Demand (COD) loading as an indicator of potential future BOD exceedances within surface waters.

Due to the predicted increase in Air Traffic Movements (ATMs) at Gatwick de-icer usage has been predicted to increase from the current 1,080,000 litres/yr to around 1,190,000 litres/yr in Scenario 1 (airport growth model C55-53) or 1,240,000 litres/yr in Scenario 2 (airport growth model C60-C55) by 2028.

Pavement de-icer usage is also likely to increase to 2028 due to new developments at the airport increasing the amount of hardstanding requiring de-icing. The increase will be of around 15,000 l/yr from a current average of 1,270,000litres/yr to a predicted 1,280,000 litres/yr. This could lead to increased COD loading and consequently an increased potential for BOD exceedances. Four options were considered to project future COD loading to the surface water drainage system, it is understood that Option 2 is being considered and Option 3 is being implemented where practical.:

- Option 1: “Do Nothing” baseline – does not include the positive future impacts of current management strategies;
- Option 2: Aircraft de-icer recovery increase (from 20% to 40%);
- Option 3: The continued use of less polluting potassium acetate-based de-icers instead of glycol-based de-icers (e.g. ECO2) wherever possible; and
- Option 4: Both Option 2, aircraft de-icer recovery and Option 3, use of potassium-based de-icers wherever possible.

If no mitigation strategies are implemented, the COD load to surface water is projected to increase by 5-7% before 2028, due to increased de-icer usage for aircraft and pavements. However, the ongoing adoption of potassium acetate based de-icer wherever possible together with an increase in the recovery of pavement de-icer are adopted (Option 4), COD loading could decrease by around 44% to 46%.

A high-level options assessment has been undertaken of future surface water quality management at Gatwick. The assessment reviews options for water quality management including reduction in usage, reducing pollution impacts through product changes, increased water storage and treatment options for glycol in order to identify opportunities for improvement. Recent consideration of a different aircraft de-icer recovery technique through use of two as opposed to one de-icer recovery vehicle have noted that there may be potential benefits in reviewing the feasibility of treatment/separation of de-icer saturated recovery water immediately following recovery, rather than allowing recovered de-icer to mix with less contaminated runway runoff. Other opportunities may exist as a result of the necessity to negotiate a new effluent discharge agreement with Thames Water, which may make other forms of water treatment on-site more viable.

Flood Risk and Surface Water Management

The primary sources of flood risk to Gatwick are fluvial (river) and surface water (from exceedance of the drainage network capacity). Based on hydraulic modelling Gatwick Airport is considered to be at risk of fluvial flooding on average between the 1 in 20 annual chance (5% AEP) and the 1 in 50 annual chance (2% AEP) events. The airport is served by an extensive surface water drainage network which would be overwhelmed by extreme rainfall events, which is predicted to flood on average for the 1 in 10 annual chance (10% AEP) event. The location at highest risk of surface water flooding is the North Terminal.

As part of the Gatwick Masterplan, over the next decade there are plans for a number of proposed developments across the airport to ensure Gatwick has sufficient capacity, to grow and to become the airport of choice for London. This Phase 2 Masterplan report assesses at a high level the potential fluvial and surface water flood risk to these proposed developments, how they may impact on existing levels of flood risk, identifies potential mitigation measures to ameliorate their impact and provides suggestions for how Gatwick should strategically manage flood risk over the next decade and beyond.

An assessment has been undertaken of the fluvial and surface water flood risk to the proposed development locations. It should be noted that this assessment is limited by the storm event results that are available from the hydraulic modelling undertaken for GAL previously. Fluvial storm event results were available for the 1 in 5 annual chance (20% AEP), 1 in 20 annual chance (5% AEP), 1 in 50 annual chance (2% AEP), 1 in 75 annual chance (1.33% AEP), 1 in 100 annual chance (1% AEP) and the 1 in 100 (1% AEP) plus 20% for climate change event. Surface water storm event results were available for the 1 in 10 annual chance (10% AEP), 1 in 100 annual chance (1% AEP) and 1 in 100 (1% AEP) plus 20% for climate change event. The assessment is an approximation; the modelling of additional storm events would increase the accuracy of the assessment. National planning policy requires that all new development remain safe for users throughout its operational life. Therefore, assuming a 100 year design life, all new development as a minimum would be expected to be flood resilient up to and including the 1 in 100 annual chance (1% AEP) event plus an allowance for climate change.

For fluvial flood risk most of the proposed developments are at low risk of flooding and are located in areas that would not necessitate the provision of mitigation measures. The domestic/CTA baggage reclaim and Boeing Hangar developments are at greatest risk of flooding. It is understood that the Boeing Hangar development has been granted planning permission.

For surface water the majority of the developments are in locations at significant risk of surface water flooding. In accordance with national planning policy the development proposals would need to demonstrate that they would be safe for their lifetime.

The assessment of changes to impermeable area is a net change, taking into account the current surface type. An increase in impermeable area would result in an associated increase in runoff to the surface water drainage network, potentially increasing flood risk downstream if unmitigated. Development proposals at Gatwick would need to consider the impact of increased runoff on the available storage in the attenuation ponds.

A number of measures have been identified that could be implemented by Gatwick over the life of the masterplan to manage flood risk at the airport:

- Flood defences to protect the airport from flooding from the Gatwick Stream and River Mole;
- The identification of measures to make critical infrastructure resilient to flood events to minimise disruption;
- Incorporation of surface water attenuation storage for all new development;
- Confirm the capacity of the surface water drainage network and identify critical sewers;
- A review of the operation of the surface water drainage network, to rationalise the system;
- Consideration of the use of SuDS measures, safeguarding notwithstanding, such as green roofs to reduce runoff from new development; and
- Consideration of sacrificial storage of flood water above ground in non-critical areas of the airport.
- Collaborating with the Environment Agency to progress flood mitigation schemes; and
- Investigation options to increase the pumping output at Pond D to increase capacity in the upstream surface water drainage network across the airport.

In addition a number of best practice measures from other airports and industries have been identified for consideration and potentially incorporation into new development.

GAL should give consideration to the development of a site wide flood mitigation strategy to direct the reduction in flood risk over the next ten years and beyond.

Contents

Figures

Tables

1. Introduction

Gatwick Airport Limited (GAL) has identified a requirement for a forecast to help understand the water aspects related to the development of the airport. It is anticipated that this forecast will be used to help prepare a new publically available masterplan for the airport although a timetable has not yet been fixed. The forecast reflects the development needs of the existing single-runway airport (including key asset changes) based on information provided by GAL listed in Appendix A.

GAL has undertaken passenger forecasts to understand the future airport development for two growth scenarios. The focus of interest for GAL is their Decade of Change (DoC) water target end point (2020) and the single-runway airport's development in the assessment year (2028). A forecast has been produced for each of these years. The outputs from these forecasts will be used to develop the water use, water quality and flood risk and surface water management input to the masterplan.

The forecast material delivered under this commission will be used in its entirety for internal planning purposes but may be summarised if included in a future, public masterplan document. The material includes text, data and graphics which describe GAL's current and future water use and strategies to reduce water demand, water quality and strategies to improve it and flood risk and surface water management and strategies to mitigate and improve it.

This report supports the overall Gatwick Airport Masterplan in relation to water performance. It provides a forecast for consumption, quality and flood risk levels in 2020 and 2028. The forecasts are derived by evaluating historical trends and predicted impact of changes. The narrative and graphical presentation is presented at airport level (suited to masterplan summary use). The Executive Summary offers a high-level commentary on the water forecast and their associated methodology. The main text of this report provides text and data which describes GAL's historic trends, the forecast model methodology, verification of the forecasts using 2017 data and considerations and challenges.

Broadly the approach taken was:

- Data collection, including information from GAL, external sources and interviews with key GAL staff;
- Forecasts of future water use, efficient, water quality and flood risk to 2028;
- Data analysis and interpretation to identify the key issues facing the management of water at Gatwick over the next ten years to 2028 and suggested measures for mitigation.

1.1 Scope

This report provides the evidence for the assessment of future water management impacts associated with projected passenger throughput air transport movements and new infrastructure development in the assessment year, 2028 to include:

- The estimation of water consumption, wastewater volumes based on development proposals (see Section 2 and Section 4);
- The estimation of water consumption in 2020 with reference to GAL's Decade of Change (see Section 2.5);
- The presentation of a strategy for enhancing the water quality of local watercourses (see Section 5);
- The estimation of future flood risk based on climate change and airport development proposals (see Section 6) and;

- The presentation of a strategy for the management of storm water runoff and other flooding events in order to meet GAL's targets for flood protection and Committee for Climate Change recommendations (see Section 6.5); and

- Impact of compliance with local and national planning policies in the assessment year and longer term (see Appendix H).

1.2 Passenger Forecast

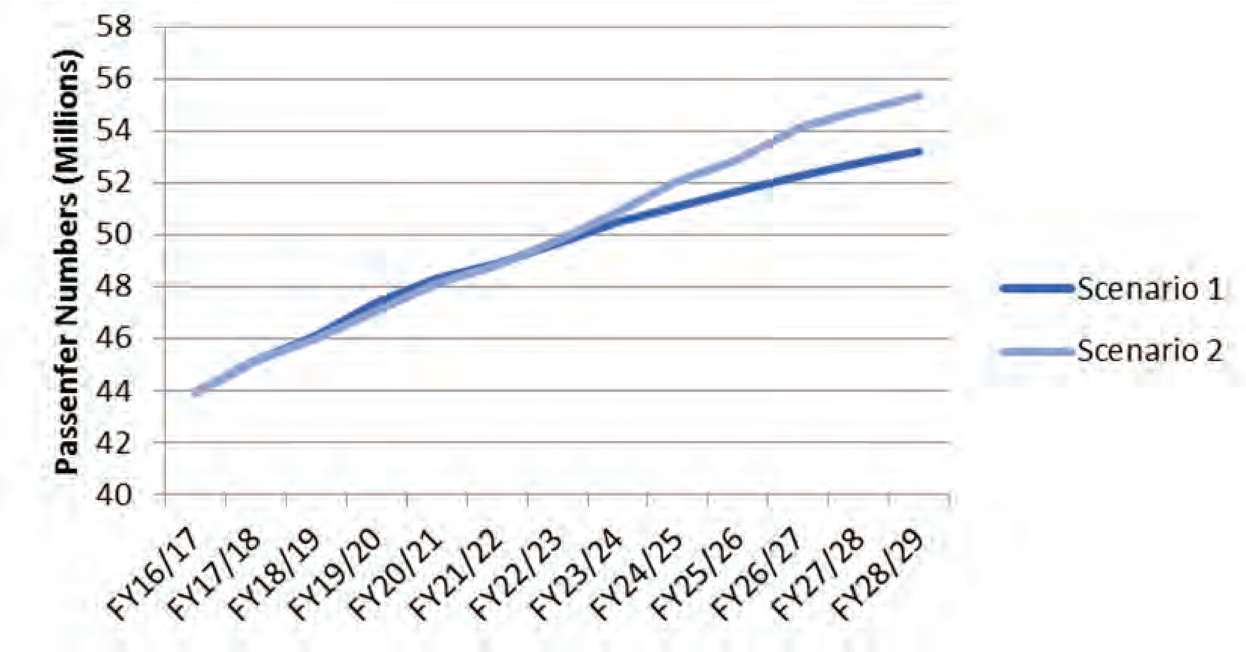
GAL has undertaken passenger forecasts to understand the future airport development for two growth scenarios. This is taken from the "Primary forecasts both scenarios" spreadsheets. Scenario 1 is taken from ICF Masterplan Outputs C55-53 (09.06.17) and Scenario 2 taken from ICF Masterplan Outputs C60-55 (09.06.17).

- Scenario 1: Passenger numbers are predicted to increase by 21% from FY16/17 to FY28/29 (1.8% of FY16/17 per year).

- Scenario 2: Passenger numbers are predicted to increase by 26% from FY16/17 to FY28/29 (2.2% of FY16/17 per year); and

- Both scenarios represent a reduced rate of growth compared to recent historic growth, when passenger numbers increased by 38% from 2010 to 2016 (6.3% per year). Airport passenger number growth is strongly linked to passenger demand and wider economic factors (e.g. GDP), but the reduced rates of growth considered in part reflect capacity constraints both from the airport approaching runway capacity for air traffic movements with a single runway and limitations linked to terminal capacity.

Figure 1-1 : Passenger Forecast Scenarios



2. Water Usage

2.1 Introduction

Phase 1 of the masterplan assessed the historic trends of GAL's water use. In order to establish a sound basis for the forecasting process, historic data has been revisited to identify trends and key drivers for water consumption. The subsequent sections draw on the historic data and trends to generate the forecasts.

2.2 Historic Trends

Historic data was obtained from the Gatwick water fiscal meters. Water is supplied to Gatwick by Sutton and East Surrey (SES) Water company and within the Gatwick estate is composed of four supply areas; North Terminal (also known as Povey Cross) served by 1 fiscal meter, South Terminal served by 4 fiscal meters, East of Rail (EoR) served by 1 fiscal meter, and 'other' areas served by 22 fiscal meters. In 2016 the Povey Cross Meter Area serving North terminal and the airfield accounted for 52% of the water consumption, South Terminal 25%, EOR 20% and 'other' 3%.

Figure 2-1 indicates the total water consumption at Gatwick, alongside passenger numbers. As can be seen:

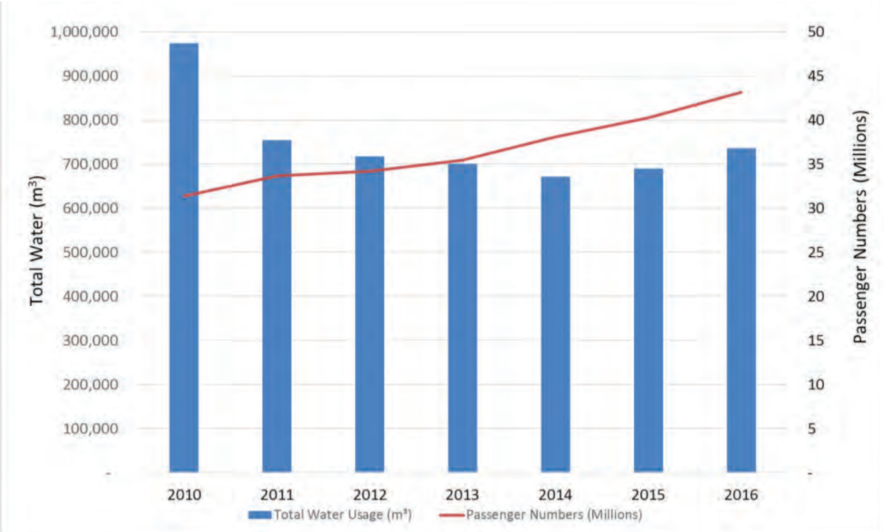
- Consumption decreased sharply from 2010 (956,539m^3) to 2011 (754,599m^3). This is potentially due to a leak reduction programme Gatwick implemented, as referred to in Project Acorn[1];

- Consumption continued to decrease from 2011 to 2014 (663,061m^3). As discussed in Phase 1, this is most likely due to further leakage management, and continued use of water efficient urinals. The Pier 5 partial closure for refurbishment and Pier 1 demolition, may have had a marginal effect on reduction in consumption, but water consumption is generally driven by passenger numbers and water use efficiency.

- Consumption has increased from 2014 to 2016 (731,047m3). This is potentially due to the reopening of Pier 5 and construction of Pier 1 and Bloc Hotel. This could also be due to leakage reduction programmes finding it more challenging to identify new leaks, compared to earlier successes. Also, there is a noticeable trend increase in the water nightline for EoR, and a significant leak found and isolated in the area, discussed further in Section 3. Over the same period passenger numbers have increased from 31.3 million to 43.1 million.

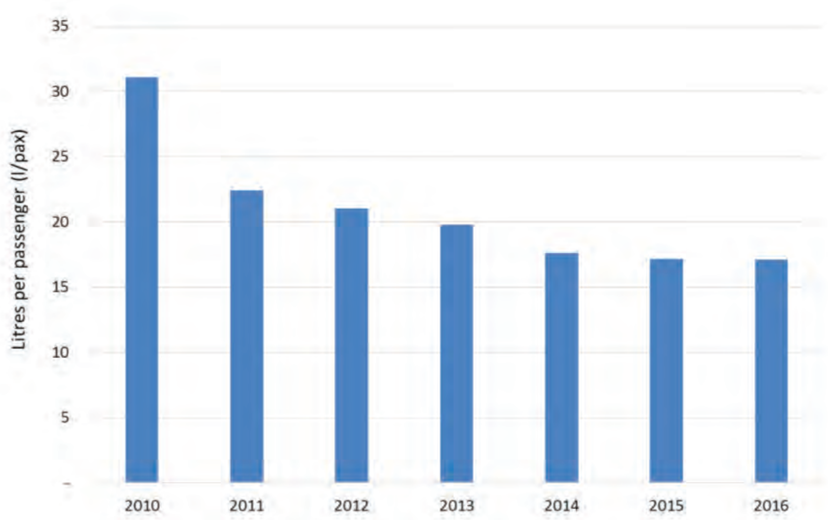
[1] The Project Acorn study was undertaken to understand the likely impact of planned capital and other projects at Gatwick Airport on the current typical consumption of energy and water.

Figure 2-1 : Gatwick Water Consumption



As passenger numbers have been increasing the relative consumption per passenger has decreased from 30.6 litres/pax (2010) to 17.0 litres/pax (2016). This is shown in Figure 2.2.

Figure 2-2 : Gatwick Water Consumption per Passenger



2.2.1 Monthly Profiles

In order to understand the dependencies of consumption, monthly water consumption profiles have been produced, along with the passenger profile for Gatwick.

Figure 2-3 indicates the monthly passenger profile for Gatwick. The number of passengers at Gatwick has increased by 38% from 2010 to 2016. This has translated to a relatively even incremental year on year increase and the monthly profile has remained similar for each year but more importantly, passenger numbers are also increasing in the typically quieter shoulder months when water use per passenger is normally at its highest. Generally the lowest passenger numbers occur in January and highest in August. For 2016 the difference in monthly passenger numbers from the lowest point in January to the peak in August was 2.3 million (or a 92% increase from the lowest to the peak month).

Figure 2-3 : Gatwick Passenger Monthly Profile from Jan 2010 to Jun 2017

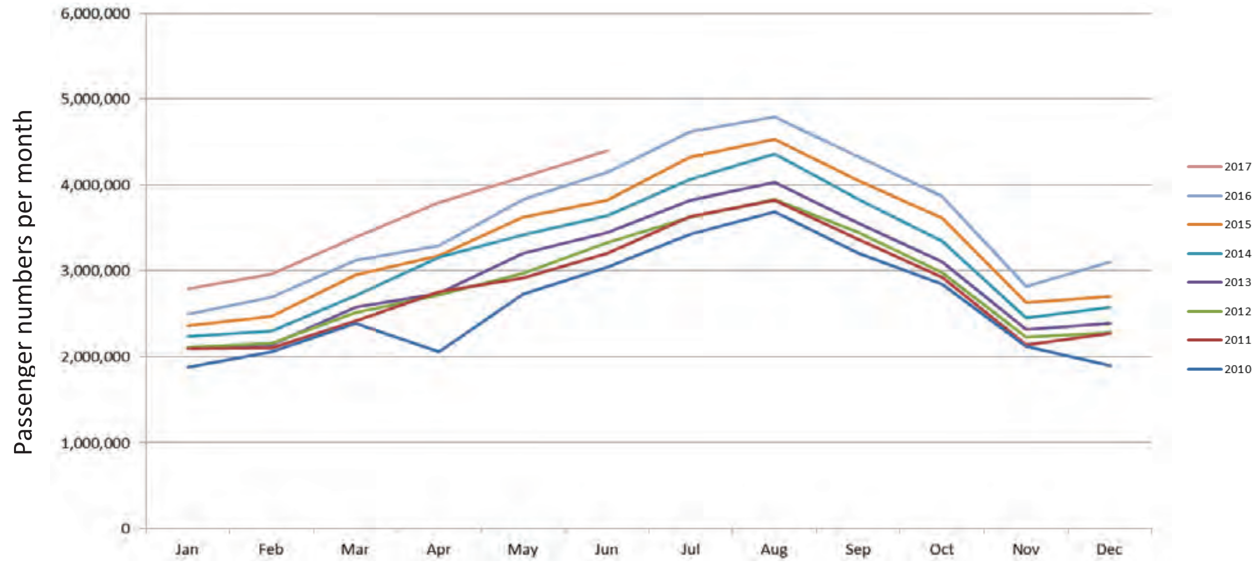


Figure 2-4 : Gatwick Monthly Water Consumption (m^3/month)

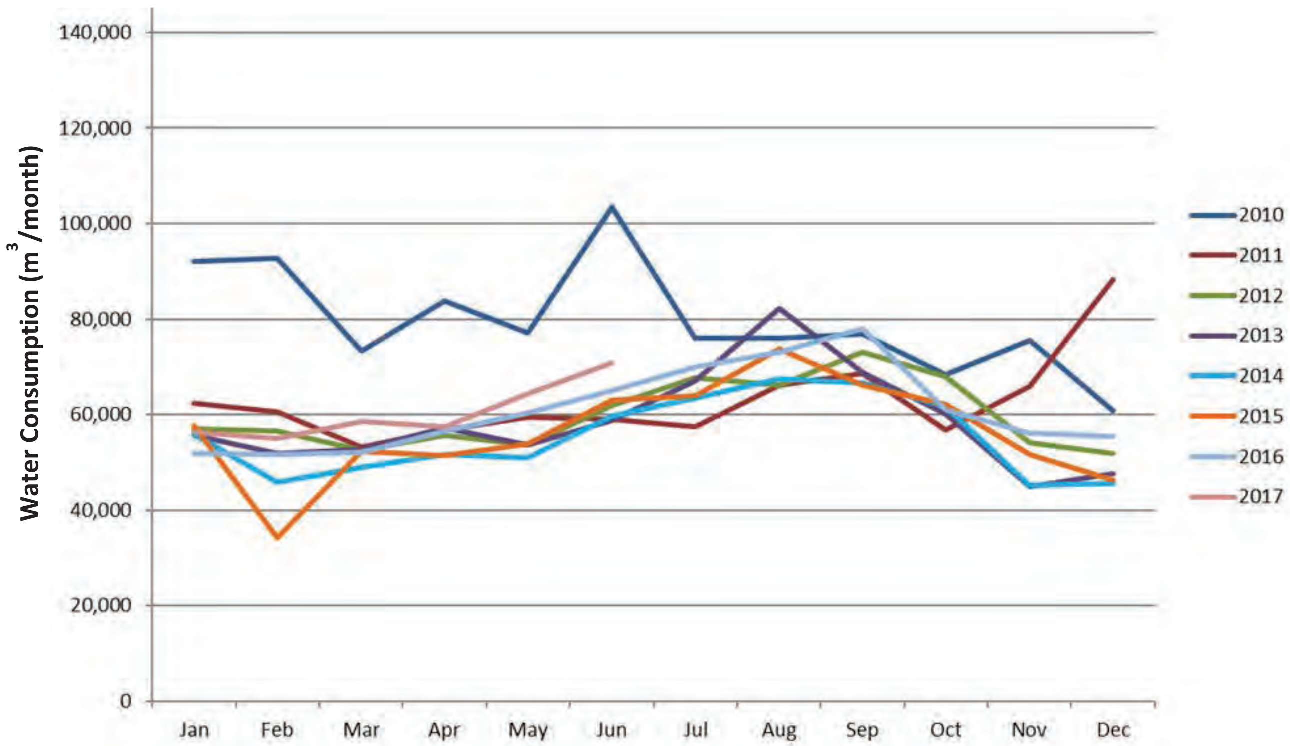


Figure 2-4 indicates the monthly profile of Gatwick's water consumption. The following can be noted:

- In general the annual profile is similar to that for passengers; however some years have their maximum consumption peak in September rather than August, and some fiscal meters are only read bi-annually;

- Water consumption does not increase at the same rate as passenger numbers, from January to August 2016 monthly water consumption increased by 34% (compared to a 92% increase in passengers);
- 2010 consumption does not appear reflective of a normal year, potentially due to the subsequent leak reduction programme;
- 2011 November consumption is high due to increased consumption at Povey Cross and 2011 December consumption is distorted due to the previous 18 months consumption at South Terminal chilling station being allocated to one month in December.

2.2.2 Historic Asset Changes

Gatwick assets have undergone several alterations over recent years, potentially influencing water use. The following asset changes have taken place within the period:

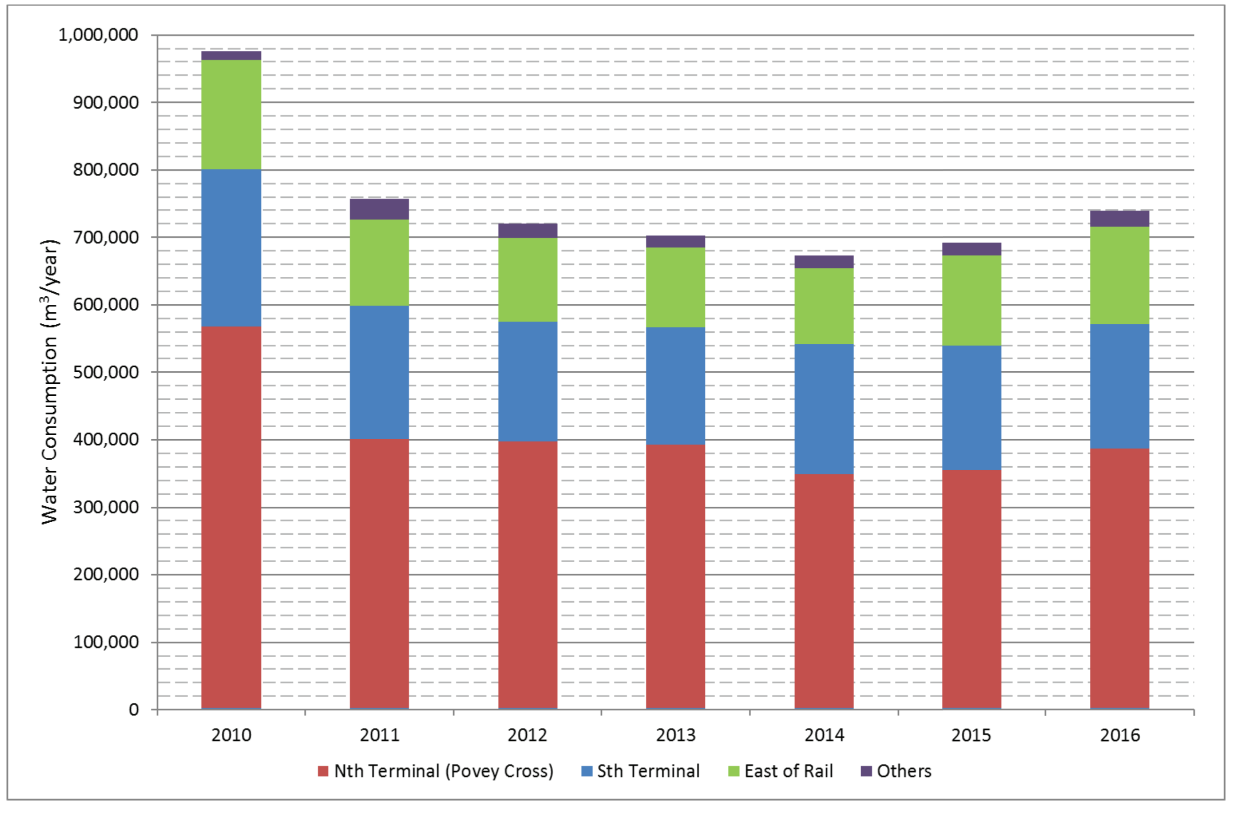
- **2010** - Ian Stewart centre closes, First Point opens;
- **2011** – Longbridge House and Southgate building 211 close, North Terminal extension and NT MSCP6 opens;
- **2012** – Southgate building Bay A9 closes, Norfolk refurbishment takes place, Viewpoint and Premier Inn open;
- **2013** – Hangar 1 and Pier 1 close, Pier 5 part closure / refurbishment commences Atlantic house extension, Hilton hotel and ST boiler house open;
- **2014** – Bloc Hotel, Airfield operations building and Ashdown house open;
- **2015** – NT MSCP temporary closes, ST IDL refurbished, Pier 5 reopens (Sept); and
- **2016** – Pier 1 reopens (April).

Due to the lack of historic sub-metering data it is not possible to fully analyse the impact of these changes. The impacts would depend on the water consumption of the building. Asset changes can cause leaks in a system if demolished assets are not properly isolated. Improved sub-metering and consumption analysis combined with active leak reduction programmes are required to keep a consistent level of consumption.

2.2.3 Main Fiscal Meters

A high level analysis has been undertaken of the annual consumption of the primary fiscal meters in order to further understand the trends and impact of any asset changes. North Terminal, South Terminal and EoR areas, supplied by AMR meters (Automatic Meter Reads), consume more than 95% of the water supplied to Gatwick, see Figure 2-5, and consequently have been classified as the primary meters.

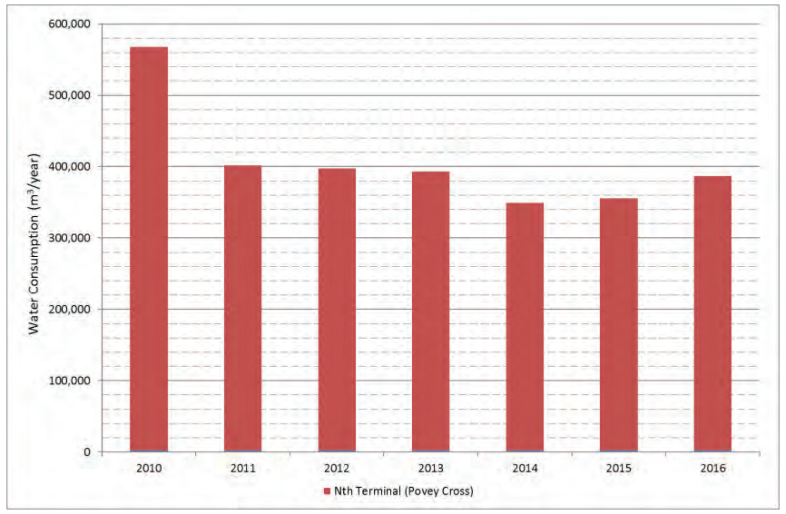
Figure 2-5 : Gatwick annual Water Consumption by areas – 2010 to 2016



Povey Cross Meter Area (North Terminal and airfield) Network

Figure 2-6 indicates the annual consumption of the Povey Cross Network fiscal meter. The consumption at Povey cross decreased from 2010 to 2011, potentially due to the leak reduction programme. Consumption remained relatively consistent from 2011 to 2013. Consumption then decreased in 2014, influenced by the repair of a large leak at NT MSCP5 in October 2013. The subsequent increase is potentially related to increases in passenger numbers, leakage and construction activities, such as the MSCP5 repairs

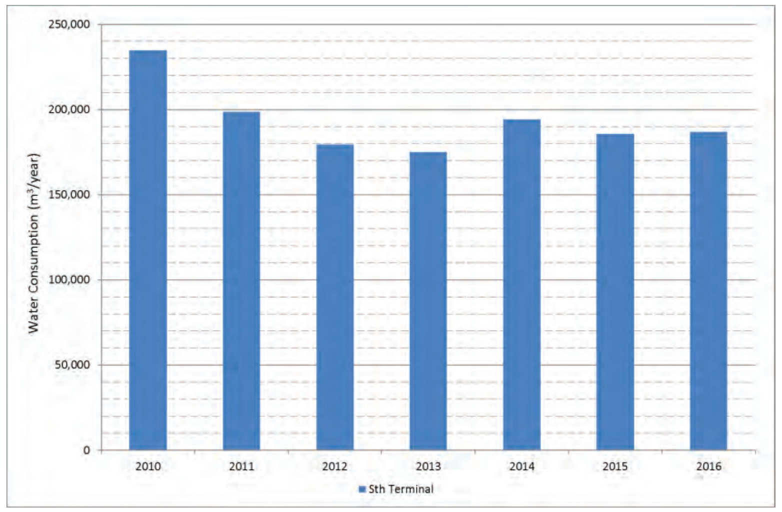
Figure 2-6 Povey Cross (North Terminal and Airfield) Consumption



South Terminal Network

Figure 2-7 shows the annual consumption of the four main south terminal fiscal meters, indicating that consumption has generally decreased from 2010 to 2014 in line with the overall Gatwick consumption. Consumption increased in 2014, potentially due to the construction and opening of Bloc Hotel 1, in March 2014. Consumption decreased in 2015, the same year the South Terminal International Departure Lounge was refurbished. But it cannot be fully ascertained if there is a link between the two. Consumption then increased in 2016 and this is likely to be attributed to the Pier 1 reopening in April 2016.

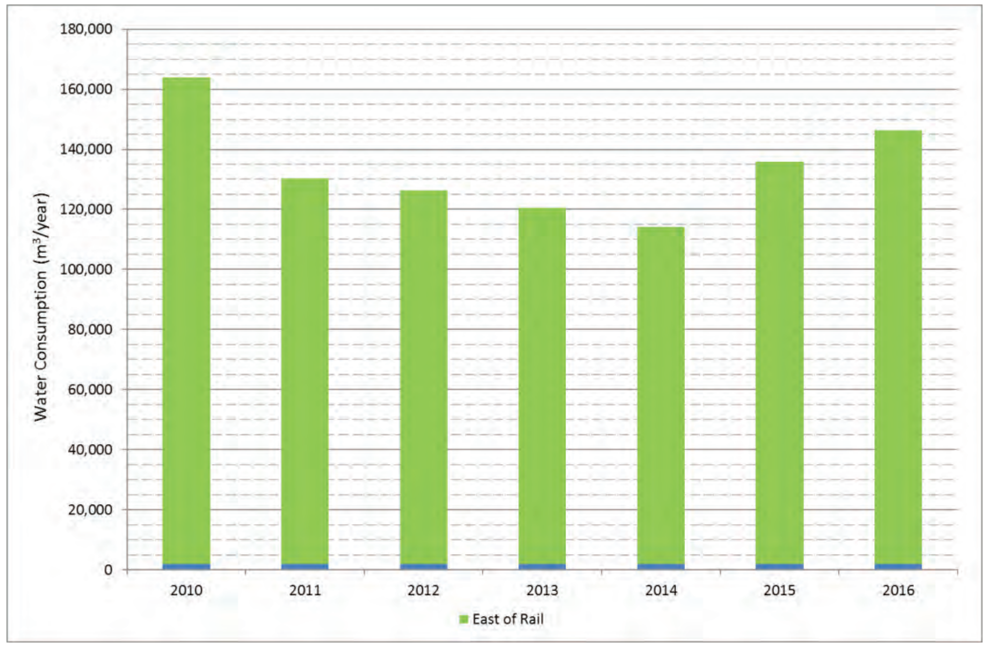
Figure 2-7 South Terminal Consumption



East of Rail (EoR)

Figure 2-8 indicates the annual consumption of the EoR fiscal meter. As can be seen consumption has generally decreased from 2010 to 2014 in line with the overall Gatwick consumption, but then increased from 2014 to 2016. This is believed to be due to an increase in leakage, based on observation of the diurnal flow graph for the period 2014 to 2017 – see Appendix C, section C.5. Section 3 provides further details on leakage and developments.

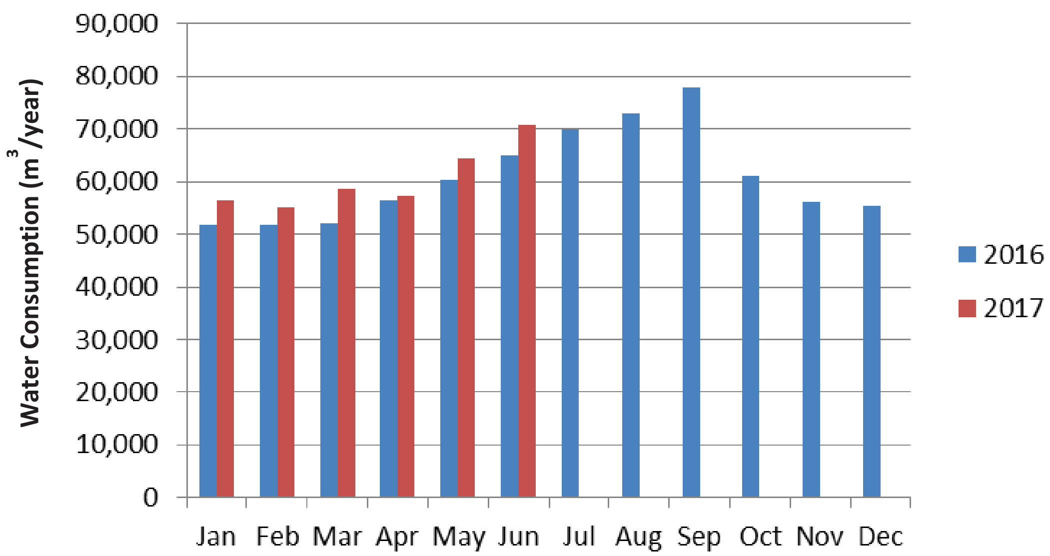
Figure 2-8 EoR Consumption



2.3 2017 Consumption

In 2017, it can be seen that water consumption for January to June is 7.5% above the same period in 2016. This suggests there will be an increase in total annual consumption. Figure 2-9 depicts the monthly water consumption profile for 2016 and 2017 to date. This increase is in line with passenger number increases and potentially due to Pier 1 reopening in April 2016, and the increase in leakage on the EoR network. Reduction occurred at the end of June, when a large leak on the Povey Cross Network was found and then isolated on 26 June, followed by repair in August 2017

Figure 2-9 Monthly Water Consumption for 2016 & 2017 - year to date



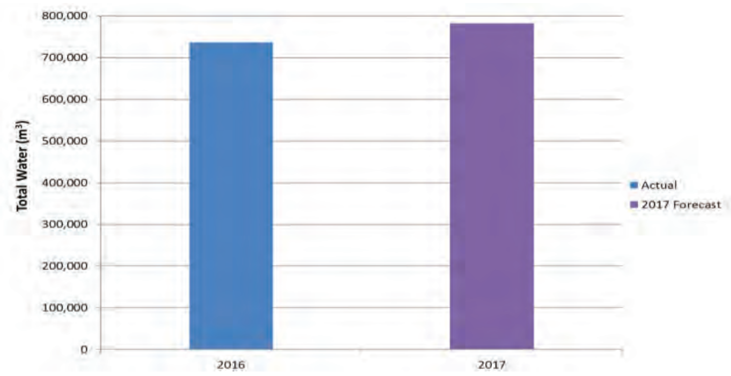
- Water consumption from January to June in 2016 was 337,488m^3 which accounted for 46% of the total annual consumption.

- Average water consumption from January to June (for 2011 to 2016) was 330,219m^3, on average accounting for 47% of the total annual consumption (2010 was discounted due to the reasons discussed in the previous section. due to the suspected high level of leakage present at the time), and

- Water consumption from January to June in 2017 was 362,652m^3.

Using the average percentage for January to June of the total annual water consumption and the consumption to date for 2017, a simple annual consumption forecast has been derived for 2017, as indicated in **Figure 2-10**. Forecast water consumption for 2017 is 781,942m^3.[2]

Figure 2-10 2016 and Forecast 2017 Annual Consumption



2.4 Forecasting Methodology

It has been agreed with GAL that the water forecast will be provided on a calendar year (CY) basis rather than financial year (FY). FY20/21 passenger data has been used for CY 2020 and FY28/29 passenger data for CY 2028.

The following conclusions are drawn from preceding sections which inform the forecasting methodology:

- 2017 is showing increased consumption compared to 2016, for the period January to June of the year. To ensure any forecast trends reflect the airport at full operation a forecast annual total for the full year January to December 2017 has been included for forecasting purposes;

- Increasing passenger numbers generally contribute to increasing consumption. But where high levels of unaccounted for water exist, as they do at GAL as discussed in Section 3, the increasing effect is less marked;

- Leak reduction and water efficiency programmes can decrease water consumption in the face of increasing passenger numbers, as has occurred between 2010 and 2014;

- The closure of Pier 1 and Pier 5 have potentially lowered the consumption in 2014 and 2015 and the reopening of them and construction of the Bloc Hotel has potentially contributed to the increase in consumption in 2016 and 2017;

- Leaks on the EoR and Povey Cross networks have contributed to the increased water consumption in 2017.

[2] Consumption since June suggests that this figure is likely to be slightly high, as only an annual consumption of 740-750,000m3 is now expected.

2.4.1 Future Asset Changes

As discussed in Section 2.2 asset changes are potentially having an impact on water consumption. GAL has several asset changes that are expected to be implemented prior to 2020 with further changes anticipated by 2028. These will have an impact on water consumption. Table 2.1 lists the future asset changes with associated water consumption implications. The majority of these projects are as identified by the Capital Investment Programme (CIP) however certain projects have been identified in conjunction with the GAL engineering team.

The Asset changes have been categorised as being pre 2020 or post 2020 for purposes of identifying which are applicable to which forecast. These asset changes have then been added to the BAU trend forecast to provide a total forecast consumption.

Table 2.1 : Future Asset Changes

Title	Pre or Post 2020	Additional Area (m^2)	Water Consumption (m^3)
Boeing Hangar	Pre 2020	17,393	11,302
Bloc Hotel 2	Pre 2020	4,320	23,000
Pier 6 extension	Post 2020	15,000	9,763
Pier 6: Rain/Greywater savings		-10%	-976
Total		36,713	43,088

Boeing Hangar

A new Boeing hangar will be in operation before 2020. An estimate of the water consumption for the Boeing Hangar was derived based on the new building footprint and the water consumption figure per unit of floor area for the existing Virgin hanger as the most representative figure for the new development.

Bloc Hotel 2

A new Bloc Hotel is expected to be constructed by 2020, which GAL has confirmed will double the size of the hotel. This was assumed to have similar water consumption to Bloc Hotel 1 per floor area.

Pier 6 Extension

An extension to Pier 6 is expected to be constructed by 2028. An estimate of the consumption for the Pier 6 extension was derived from the existing water use of Pier 6 based on the floor area and consumption. Additionally an allowance has been made for water savings on the new Pier 6 extension. Whereas savings in residential settings can be in the order of 50% of total water consumption, savings in airports will be less since only washing water can be re-used, and this will be limited to restaurants, offices and toilets. The potential for savings on a pier extension are even less, with only hand wash water being available, plus the rainwater component. Accordingly, a preliminary estimate of 10% savings has been allowed for in Table 2.1 above.

2.4.2 Business as Usual (BAU) Trend Development

In order to capture the overall consumption BAU trends occurring at GAL a top down approach (where the trends in total consumption at GAL are analysed) has been adopted. This is in preference to a bottom up approach, where trends would be analysed at the building or category level, as it is felt that this approach may not capture all changes occurring at the airport, and has an increased margin of error due to the use of multiple trend lines.

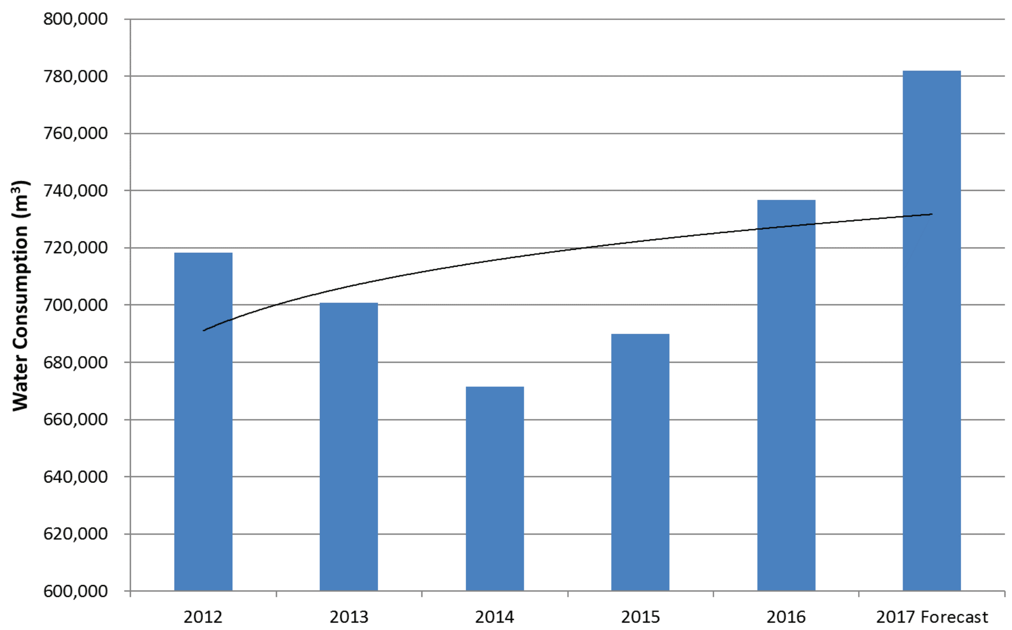
To establish a BAU trend, an associated trend line using the historic annual consumption was analysed over the following periods (reference to 2017 is based on the forecast 2017 consumption identified in Section 2.3):

- Short term (2014 to 2017) – Due to the increasing trend in consumption in recent years, potentially due to assets reopening and a leak on the EoR network, this trend projects a continued rate of increasing consumption which is not expected to be reflective of the airports future consumption.

- Medium term (2012 to 2017) – Due to the decreases in consumption made in the earlier years of this period, potentially as assets were out of use, and the increases seen in the later years, potentially as those assets reopened, the trendline for this data period is felt to be most reflective of Gatwick consumption moving forward. The trendline shows an increase overall in consumption which could potentially be caused by leak issues and passenger increases; and

- Long term (2010 to 2017) – Due to the substantial changes from 2010 to 2011 this data set did not best reflect the expected future trends in airport consumption.

Figure 2-11: Medium Term Consumption Trend



Example long term and medium term graphs are given in Appendix C.

A series of MS excel derived trend lines (Linear, Polynomial (Poly), Exponential (Exp), Logarithmic (Log) and Power (Pow)) were applied to these data sets. Power trend-lines were found to align best with the annual consumption and the expected consumption levels moving forward. Results for the different trend lines are contained in Appendix C.

2.5 2020 Forecast

Table 2.2 gives the results for the 2020 forecast. This includes the BAU trendline results, as discussed in Section 2.5.2, and the asset changes discussed in Section 2.5.1. These have been combined to produce an overall forecast for 2020.

Water Masterplan 2020 & 2028 Forecast - Full backing report

JACOBS

Table 2.2 : 2020 Forecast

2020 Water Forecast	
	Meters Cubed
Business as usual consumption	730,144
Asset Changes	34,302
Total 2020 Consumption	764,446
Scenario 1 (litres / PAX)	15.8
Scenario 2 (litres / PAX)	15.9
2010	
Total Consumption	974,067
Consumption per PAX (lites per PAX)	31.1
DOC Original target - 20%	
Target 2020 Consumption	779,254
Target reduction against 2010 baseline	20%
DOC Stretch target - 25%	
Target 2020 Consumption	730,550
Target reduction against 2010 baseline	25%
Predicted reduction against 2010 baseline	-5%
Reduction in consumption per PAX	49%

- BAU 2020 water consumption (730,144m^3) is similar to 2016 (736,772m^3), but is less than the 2017 forecast (776,744m^3);

- Overall 2020 water consumption (with asset changes) is **764,446m^3** which is higher than any of the previous years, apart from 2010; and

- Scenario 1 and 2 have similar passenger numbers for 2020 (48.3 million and 48.1 million respectively) so consumption per passenger is similar, both having a total consumption per PAX of 15.9 litres.

2.5.1 Decade of Change

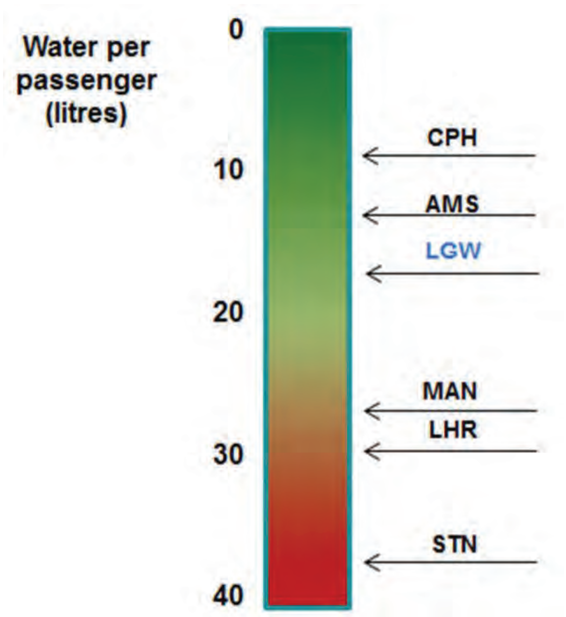
In 2010, GAL launched its Decade of Change (DoC) which set out GAL's sustainability targets with the view of achieving these by 2020. In relation to water the DoC report sets out an ambition that by 2020 GAL will reduce water usage by 20% (against a 2010 baseline). The intention now is to stretch this target to 25% to spur further water efficiencies as the airport grows.

The forecast 2020 water consumption predicts an 20% reduction against the 2010 figure and therefore suggests that the target will be met. The additional 5% reduction to meet the stretch target may be possible through water efficiency measures as detailed in Section 3, although this is not borne out by current information available.

Consumption in 2020 will be similar to that of 2011, despite a substantial increase in passenger numbers over this period. This is partially as passenger numbers do not appear to have a strong impact on water consumption, as established in Section 2.2, and also potentially due to water efficiency improvements helping to mitigate any impact of increased passenger numbers. Using relative (rather than absolute) metrics, a reduction of 47% in gross unit consumption per passenger has been achieved in this period (30.6 litres/PAX to 15.9

litres/PAX). Compared to other UK airports (Manchester, Stansted and Heathrow), GAL performs well, but not as good as some European airport e.g. Copenhagen and Amsterdam – see Figure below (extracted from Jacobs 2016 Report, *Airport Infrastructure Exemplar Sustainability Route Map).*

Unit Water Consumption compared to other UK and European Airports



The 2012 Masterplan expected the number of passengers for 2020 to be 39.1 Million. This was exceeded in 2015 with expected passenger numbers in 2020 now 48.3 Million for Scenario 1 and 48.1 Million for Scenario 2. If passenger numbers in 2020 had only reached 39.1 million (and assuming the water consumption was broadly similar to that forecast now) that would have equated to a consumption per passenger of 20.1 litres/PAX and only a 34% reduction in consumption per PAX since 2010.

2.6 2028 Forecast

The medium term trend lines used in the 2020 forecast have been extended to 2028. The additional asset changes, as included in Section 2.5.1, have then been applied to the BAU consumption profile.

Table 2.3 gives the results of the 2028 forecast:

- BAU 2028 water consumption is predicted to be **741,987m³**. An increase of 11,843 m³ against the BAU figure of 2020;
- Overall water consumption (with asset changes) is **786,052m³**. An increase of 21,606 m³ against the 2020 predicted figure;
- Scenario 1 has fewer passengers for 2028 than scenario 2 (53.3 Million and 55.3 Million respectively). For Scenario 1 total consumption per PAX is 14.7 litres and for Scenario 2 is 14.2 litres.

The provision of the 2028 forecast is subject to the realisation of any of the asset changes detailed earlier in this report. The main sensitivity lies with the Boing Hangar and its consumption per floor area being similar to that of the Virgin Hangar.

Table 2.3 : 2028 Forecast

2028 Water Forecast	
	Meters Cubed
Business as usual consumption	741,987
Asset Changes	44,065
Total 2028 Consumption	786,052
Passanger Nos Scenario 1 (million)	53
Scenario 1 (litres / PAX)	14.7
Scenario 2 Passanger Nos (million)	55.3
Scenario 2 (litres / PAX)	14.2
Consumption change against 2020	2.8%
Consumption per PAX change against 2020 Scenario 1	-7%
Consumption per PAX change against 2020	-11%

Figure 2-12 indicates the forecast consumption, BAU. As can be seen from the graph the consumption decreases from 2017 to 2020, returning to a similar level as 2016. It then increases slightly to 2028.

Figure 2-12 Forecast Consumption BAU

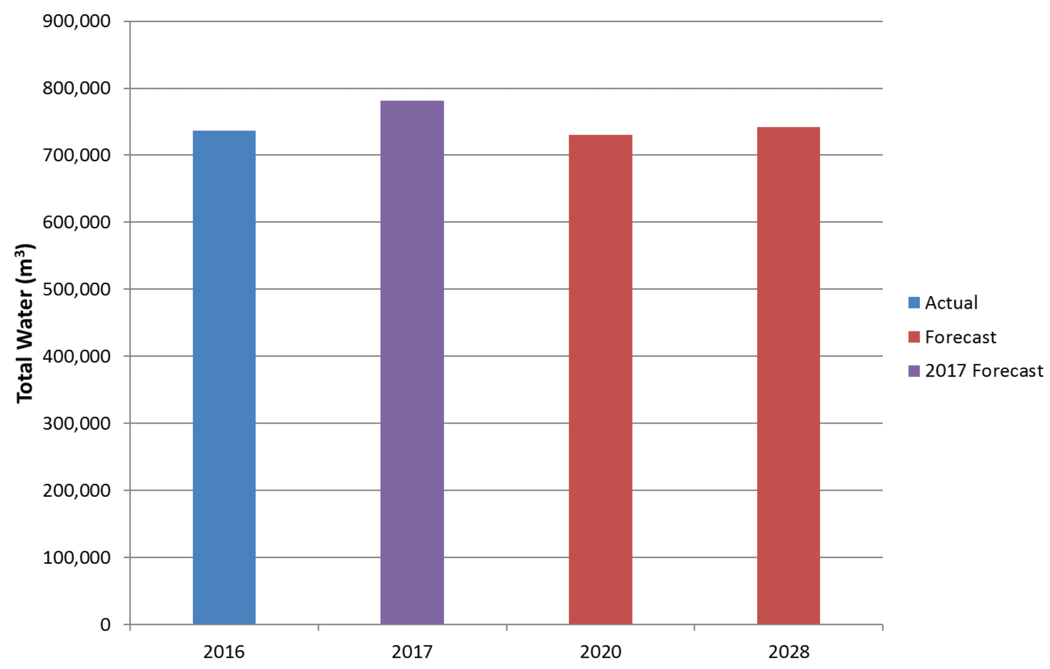
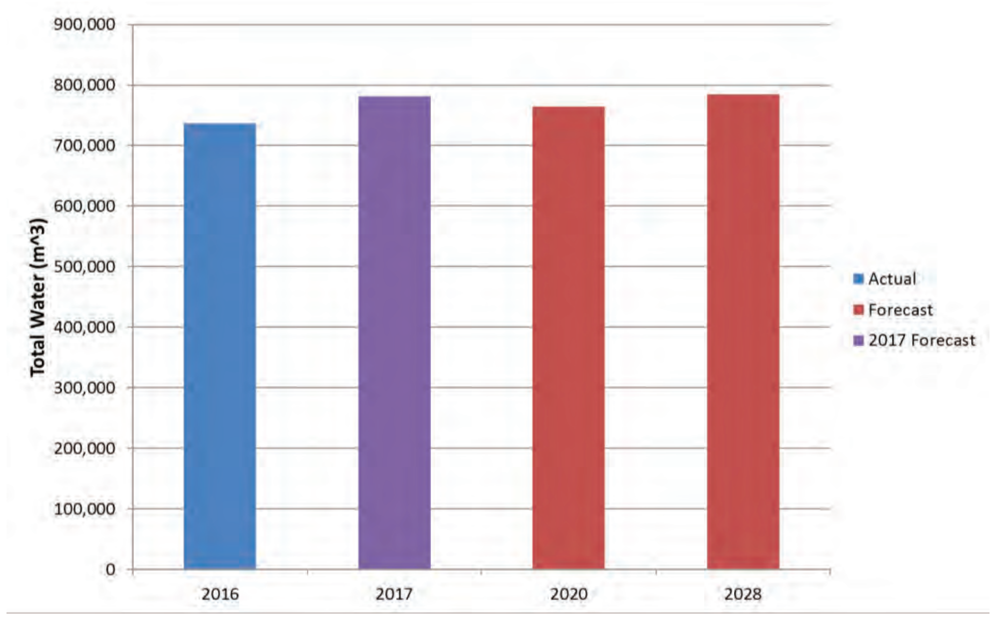


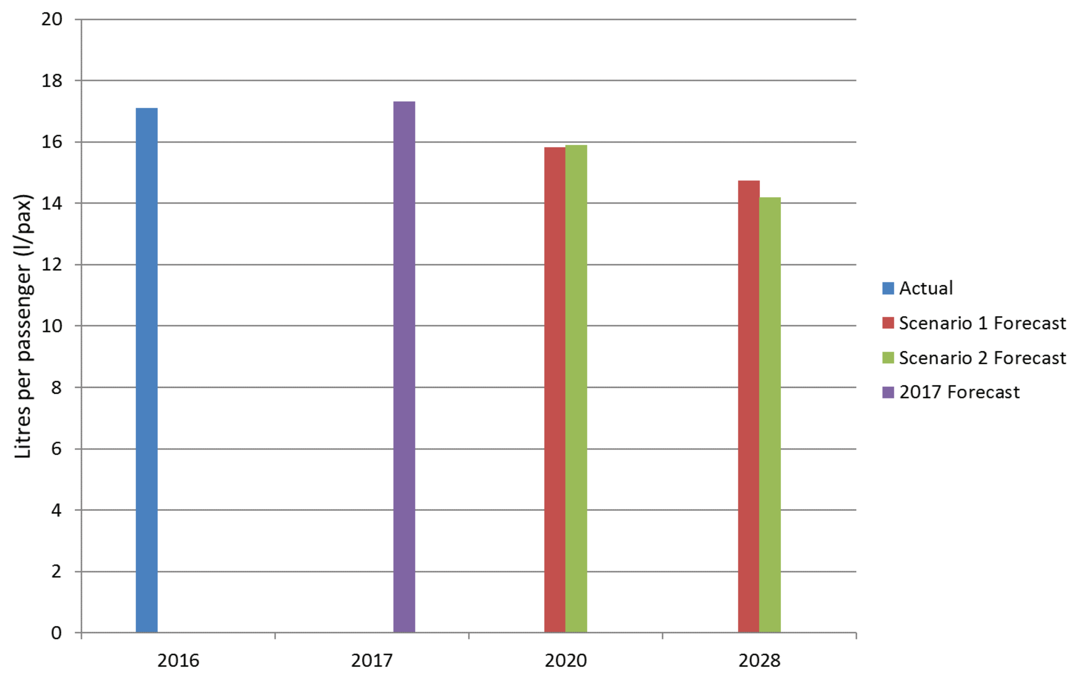
Figure 2-13 indicates the forecast consumption with asset changes. As can be seen from the graph the consumption increases from 2017 to 2028 due to the proposed asset changes.

Figure 2-13: Forecast consumption with asset changes



As passenger numbers are increasing at a greater rate than consumption it is forecast that there will be a decrease in consumption per PAX (with asset changes) of 7% for Scenario 1 compared to 2020 and 11% for Scenario 2 compared to 2020; see Figure 2-14. It is forecast that consumption would be approximately 15 litres /PAX for both scenarios.

Figure 2-14: Gatwick Consumption per PAX Forecast



2.7 Conclusions

The following conclusions can be drawn from the forecast:

- A 6.3% increase in water consumption is expected to be seen from 2016 to 2017 potentially due to leakage and Pier 1 reopening;
- Trend lines predict increasing consumption from 2017 to 2028;
- Total annual consumption in 2020 is forecast to exceed 2017 due to the construction of the Boeing Hangar and Bloc Hotel 2;
- 2020 total consumption is forecast to be 20% lower than the 2010 baseline and will meet the DoC target of 20% (or the stretch target of 25%); however consumption per PAX is forecast to decrease by 48% compared to a 2010 baseline;
- 2028 total consumption is forecast to be marginally more than 2020 due to the increasing BAU trend and construction of the Pier 6 extension;
- Consumption per PAX is forecast to decrease due to increasing passenger numbers with evidence to support a potential consumption per PAX of 15 litres by 2028. This is generally better than other UK airports, but not as good as certain European airports. Through the GAL Airport Infrastructure Exemplar Sustainability Route Map, the exemplar water management performance is benchmarked as water consumption of 10 litres / passenger (total); and
- A forecast verification has been conducted in Section 3.5 and collaborates these results.

2.7.1 Caveats

The following caveats apply to the forecast:

- The forecast is based on historic trends. A deviation or step change from these will impact the forecast.
- The BAU forecast trend is based upon a forecast annual consumption for 2017. If actual consumption differs significantly from this short term forecast, the trends may be impacted. As such a review of this forecast could be considered post 2017 when the actual data is received.
- Asset changes are as detailed in Section 2.5.1, and are as provided by GAL. Changes to these and the timing of these would impact the forecast. Key sensitivities would be items such as Boeing Hangar having a similar consumption per floor area as the Virgin Hangar.
- It is assumed the leak on the EoR network will be fixed and therefore is only a temporary increase in consumption; and
- The Net Unit water consumption approach to forecasting in Section 3.5 assumes a Fixed Unaccounted for Water (UFW) consumption and Fixed 8.1l/pax for net unit water consumption.

2.7.2 Recommendations

Recommendations for additional measures aimed at further reduction of water use are as follows:

- Analysis of the North Terminal water usage sub-meters indicates that unaccounted water is approximately 41%. The South Terminal sub-meter coverage is significantly less than the provision for the North Terminal therefore that area was not analysed. Improved analysis of water efficiency can be achieved by installing further sub-meters in both areas. This will assist in the identification of leakage and areas of unexpectedly high consumption;
- Installation of additional sub-meters to facilitate the identification of areas of leakage and poor water efficiency;

- Investigation into further water efficiency measures, particularly in the areas of the airport where none have yet been implemented; and
- Enhanced leakage management techniques, discussed in Section 3.

3. Water Efficiency Measures

3.1 Introduction

There are a variety of methods of improving water efficiency at Gatwick Airport. In summary the following issues and opportunities have been identified and will be discussed in this section:

- Unaccounted for Water (UFW),
- "Nightline" flow analysis,
- Leakage,
- Facility water wastage (i.e. uncontrolled urinals and taps left running),
- Re-used water for fire-fighting,
- Re-used water for aircraft washing,
- Grey water re-use,
- Rainwater harvesting.

UFW has to be first priority in any water efficiency programme, as it is high at Gatwick, in the order of 374,000m^3/year and representing more than 50% of total supply of 731,047m^3/year. Improved understanding of usage would aid the identification of water efficiency measures.

3.2 Terminology and application to Gatwick

Terms used in the breakdown and analysis of UFW and Leakage are:

Unaccounted for Water (UFW) is defined as the difference between the water supplied to a network and the water used at customer facilities. At GAL it is the sum of the fiscal meters into water supply, less the sum of all the facility sub-meters. There is the complication at GAL in that of the estimated 161 facility sub-meters, 47 are not working, missing or not read. Nonetheless the UFW is calculated on the difference between the total of the fiscal supply meters and the 114 sub-meters that are read.

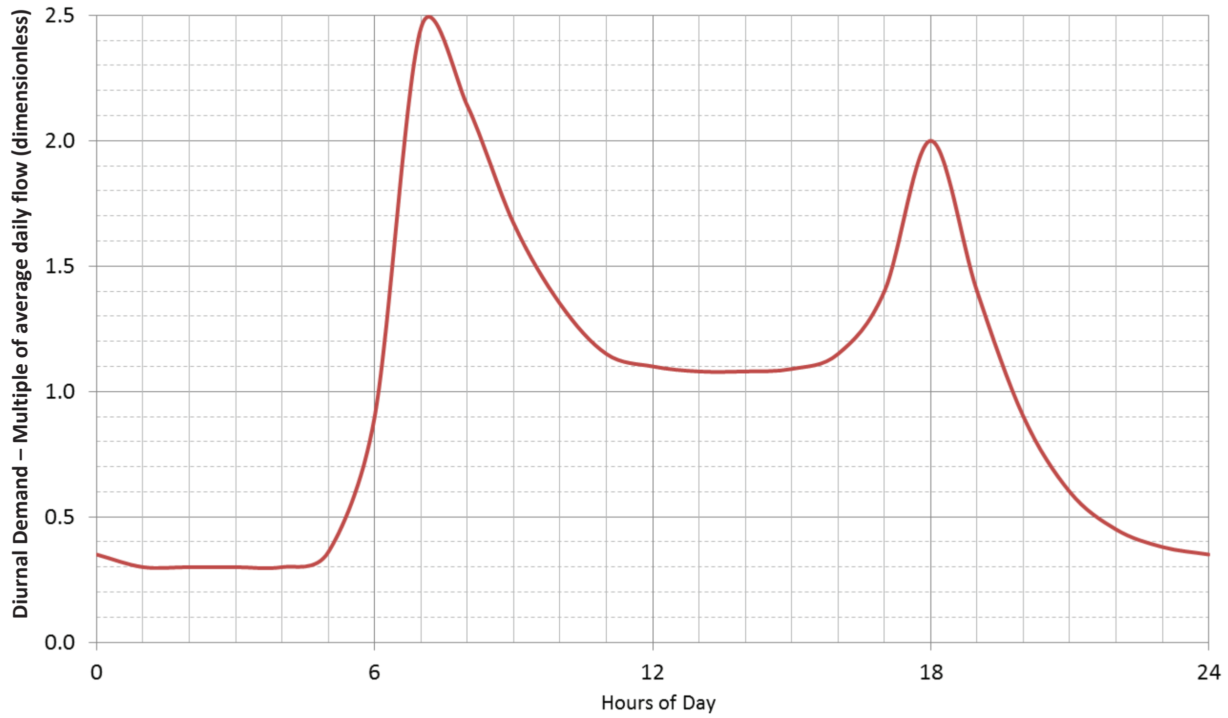
The "nightline" is the observed straight line often seen on graphs of diurnal water demand plotted over a 24 hours day. Typically between 1am and 5am for domestic supply, but at Gatwick varies between 1am to 3am in summer, and 1am to 5am in winter – an example is included in Figure 3-1.

Leakage is different to UFW and is defined as water lost from pipes underground. There are two components – mains leakage downstream of main supply meters and "customer side" or facility leakage downstream of facility sub-meters from leaks in underground or above ground pipework.

Facility water wastage is generally defined as water wasted downstream of facility sub-meters, typically inside buildings and typically consists of uncontrolled urinal flushing, taps left running, continuous overflows for water tanks etc.

A District Meter Area is a section of network pipes where all inflows and outflows are metered and any unmetered cross-connections to adjoining areas are closed. It is understood from discussions with GAL that the water supply areas for North Terminal, South Terminal and EoR represent DMAs and do not have open interconnecting boundaries. However as will be shown later in Section 3.4.2, there is reason to suspect that this may not be the case.

Figure 3-1 : Typical Domestic Example (not Gatwick) of 24 hour diurnal water demand showing "nightline" in early hours of morning



A summary of these aspects applicable to Gatwick are provided in Table 3.1.

Table 3.1 : Typical components of UFW and "Nightlines"

Water Loss	UFW	"Nightline"
Unmetered Consumption	YES	YES
Metered consumption (night-time allowance)	N/A	YES
Meter errors / not working	YES	N/A
Open boundaries between DMAs	YES	YES
Leakage - from pipes	YES	YES
Water wastage – i.e. urinals, running taps and tank overflows	N/A	YES

3.3 Analysis of "Nightline" from the ARM (Automatic Reading) meters

The 6 No. ARM meters cover about 95% of the water supplied to Gatwick, and consequently the analysis of the nightline for the three areas (North and South Terminals and EoR) is a good indicator of unaccounted for water and leakage (see Figure 2-5, page 7)

The diurnal water consumption for these three areas are given in Appendix C, sections C3, C4 and C5 and provide an illustration of the nightlines observed at Gatwick in July 2017, during the last 3 months and covering a 3 years period since readings started in 2014.

Observation results for the nightlines (for the 6No. ARM Meters only, but which cover more than 95% of GAL's consumption) are summarised in Table 3.2, which includes the UFW results, and given more fully by areas in Appendix C.6.

Table 3.2 : Unaccounted For Water and "Nightline" Analysis

GAL TOTAL	Apr14-Mar15	Apr15-Mar16	Apr16-Mar17	Current
	2014	2015	2016	Jul-17
Total SES Fiscal Meters: GROSS Supply	663,307	676,626	731,227	
Total Sub-meters: NET Consumption	338,189	333,976	356,914	
Unaccounted For Water (m^3/year) (UFW)	325,118	342,650	374,313	
Unaccounted For Water (m^3/hour) [1]	37.09	39.09	42.70	
Unaccounted For Water (%)	49%	50.6%	51.2%	
Estimate Average Annual Nightline (m3/h)	missing data in ST area		42.6	42.0
Passenger numbers	38,653,099	40,788,058	43,958,160	
GROSS Water Consumption (l/pax)	17.2	16.6	16.6	
NET Water Consumption (l/pax)	8.7	8.2	8.1	

161	Total No. of Sub-meters
47	No. of Sub-meters NOT WORKING
29%	% of Sub-meters NOT WORKING

Note [1] Unaccounted for water for 2014 estimated assuming 2.0m3/hr lower than in 2015 - this is based on the changes observed in nightlines from 2014 to 2015.

3.4 Unaccounted for Water (UFW) and improved metering

3.4.1 Calculation of UFW

The UFW has been determined using monthly readings of the sub-meters supplying facilities at Gatwick, and deducting from the sum of the fiscal supply meters to the three main areas. There are 161 sub-meters as follows:

- North Terminal – 94 sub-meters (of which 26 are not working or not read);
- South Terminal – 43 sub-meters (of which 16 are not working or not read); and
- East of Rail – 24 sub-meters (of which 5 are not working or not read),

A monthly plot of UFW from April 2015 to March 2017 is given in Figure 3-2 and a composite summary, together with nightline results, is recorded in Table 3.2.

3.4.2 Analysis of UFW and Nightline flow

There is some noticeable difference between UFW and nightlines in the three individual areas, but there is good concurrence when comparing the total overall figures of 42.6m^3/hr UFW and total nightline of approximately 42.0m^3/hr:

- Povey Cross (North Terminal/Airfield) - UFW 19.71 m^3/hr < Nightline 28 m^3/hr,
- South Terminal - UFW 16.58 m^3/hr > Nightline 5.6 m^3/hr,
- East of Rail - UFW 3.76 m^3/hr < Nightline 9 m^3/hr,
- There are a variety of reasons as to why the UFW and nightline can be different, namely;
  - High number of night time users, such as hotels in the EoR area, making the nightline higher than monthly UFW;
  - Meter errors in South Terminal as UFW are higher than nightline flows, and
  - And, open boundaries between DMAs or areas – experience shows this is very common within the water industry, even where operators believe they have closed boundaries, which can be readily verified, as explained in Appendix E.

Figure 3-2 : Gatwick Monthly water consumption and UFW: April 2015 to March 2017

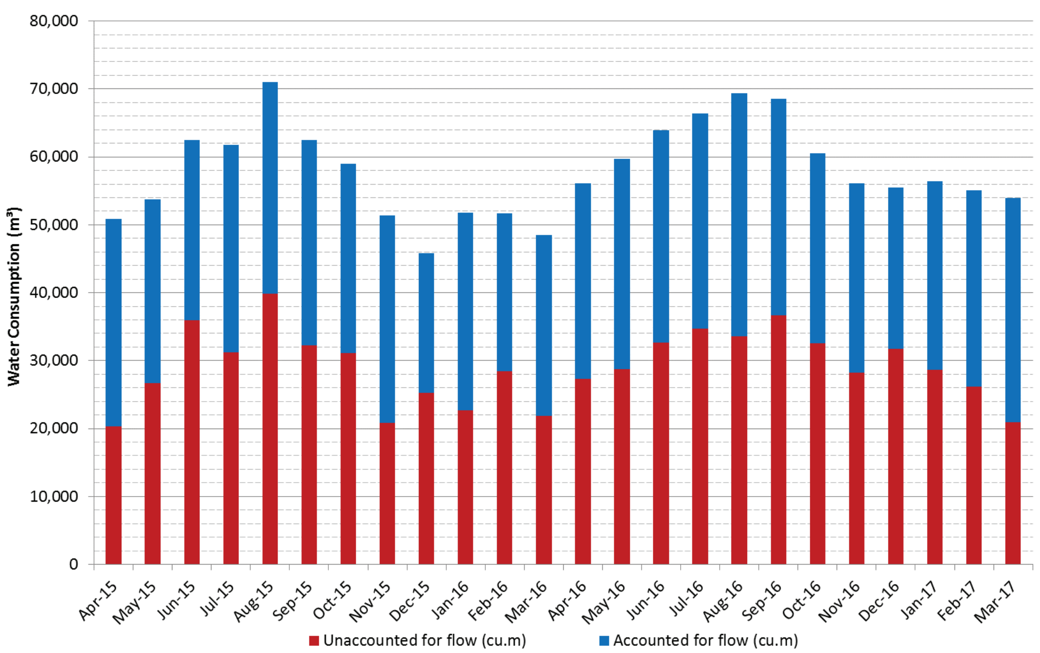


Figure 3-2 indicates the seasonal variation in UFW, low in winter and high in summer. If leakage was the dominant factor we would expect to see UFW following more or less a flat-line across the year. The variation suggests that meters not working/not read and water wastage inside buildings are a significant factor.

From for minimum month UFW it can be deduced, with some caution, that leakage and facility water wastage inside buildings might be in the order of 20,000m³/month (240,000m³/year) or 28m³/hr. The remainder of the total UFW (from Table 3.2) of 374,133 – estimated leakage of 240,000m³/year, say 130,000m³/year (in round figures) is probably attributed to UFW from meters not working or not read.

The nightline for 2016 is estimated at 42.6m³/hr. As the nightline is measured between 1am and 3am, typically 2am, then it is expected that in the airport only night staff will be on duty and that normal workings at the airport are not taking place. The numbers of staff involved are not known, but are thought to comprise the Police, Fire station staff and Security Staff – a figure of 1000 is assumed. Other night users are expected to be the ST Boiler house, chilling station and hotels supplied from Gatwick water supply system. An estimate of the anticipated night time user are given in Table 3.3.

Table 3.3 : Estimate of night time water consumption

Night Time Water Consumption	Average 2016		Estimated nightline	
	m³/yr	m³/hr	%	m³/hr
Premier Inn	32,886	3.75	50%	1.88
Sofitel Hotel	48,786	5.57	50%	2.78
Hampton Hilton Hotel	12,112	1.38	50%	0.69
Bloc Hotel	11,380	1.30	50%	0.65
Yotel	179	0.02	50%	0.01
ST Boiler House	673	0.08	100%	0.08
ST Chilling Station	13,736	1.57	100%	1.57
Hilton Hotel	68,562	7.83	50%	3.91
Airport Staff	1000 pax, at	0.6	l/pax/hr	0.60
			Total Estimate	12.17

Note that the assumption of 0.6 litres/person/hour is the normal water industry allowance for night time consumption. This then leaves the remainder of the total nightline (Table 3.2) of 42.6 – night time consumption (Table 3.3) of 12.2 = 30.4 m³/hr, or 266,000m³/year, which is then the combined leakage and water wastage in buildings. This concurs well with the estimate taken the monthly UFW of 28 m³/hr.

Based on limited information, it is estimated that leakage and wastage is in the order of 28 m³/hr and that unaccounted for metering is in the order of 14m³/hr. it is not possible to break the figures down any further. When the 47 No. meters, currently not working or not read, are resolved to give a more accurate figure of UFW, then the leakage and water wastage figures can be separated out from the Nightline flows. Additionally it is recommend to install ARM Meters of the boiler house, chilling station and hotels. It is strongly suspected that leakage rather, than building water wastage, will prove to be the major factor. In formula terms these can be expressed as;

- *Leakage = (accurate) UFW – permitted unmetered consumption,*
- *Leakage = Nightline – Total night-time usage,*
- *Water wastage in buildings = Total night-time usage – Legitimate night-time usage.*

3.4.3 Improved metering

A comprehensive list and hierarchy of the facility sub-meters was provided in the Appendices of the Phase 1 Report, a summary is given in Table 3.4.

Table 3.4 : Gatwick Facility Sub-Meters

Supply Area	SES Fiscal Meter	SES Meter reading frequency	GAL Sub-Meters	GAL 2nd level sub-meters
North Terminal and Airfield Area	Povey Cross OUT23DM - 189689	Automatic Reading (ARM) to SES-Gatwick website	15 No. direct – 4 not used	None
			Bulk Meter 2	None: direct to 230 Stands batching plant
			Bulk Meter 3	5 No. total: 3 working, 1 with no meter and 1 not in use
			Bulk Meter 4	7 No. total: 4 working, 2 with no meter and 1 not working
			Bulk Meter 5	7 No. total: 5 working, 1 with no meter and 1 not working
			Bulk Meter 5A	3 No. total: 2 working,1 not working
			Bulk Meter 6	42 No. total: 30 working and 12 with no meters
			Bulk Meter 7 – not used	None – supply point not in use
			"Bulk Meter 8" – no meter, just a meter area	5 No. total: 3 working, 2 with no meters
			Bulk Meter 9	None – direct to Snow Base Area
			Total of 94 No. GAL sub-meters (26 out of use or not working)	
South Terminal	ST Arrivals - 189319	Automatic Reading (ARM) to SES-Gatwick website	29 No. – 14 not in use	None
	ST Departures 1 and 2 – 189313 and 189314		11 No. – 1 with no meter, and 1 unfound,	None
	ST Concorde House - 189325		3 No.	None

Supply Area	SES Fiscal Meter	SES Meter reading frequency	GAL Sub-Meters	GAL 2nd level sub-meters
			Total of 43 No. GAL sub-meters (16 out of use or not working)	
East of Railway	East of Railway - 189323	Automatic Reading (ARM)	21No. direct	None
			Bulk Meter 1	2No. – Taxi Feeder Park and ST Car Hire
			Total of 24 No. GAL sub-meters (5 out of use or not working)	
Other Areas	24No. SES Meters	23 – biannual 1 - monthly	None – all direct supplied	None

Of the total of 161 facility sub-meters, 47 are not in use or not working, and thereby not read or accounted for.

An inspection survey of all facilities where meters are not read, or located or not working should be undertaken with a view to closing off these loopholes and ensuring working readable meters are in place.

3.5 Leakage – Control and Reduction Measures

Leakage management to detect, find and fix leaks is traditionally done by sounding techniques (e.g. using listening sticks / dopplers) on metal pipes. This is still practiced, but the principle of detecting and analysing acoustic noise from leaks in pipes can be enhanced using state of the art technology. Also techniques are used to verify permanent sub-division of water supply areas and sub-divide and isolate water supply areas on a temporary basis for testing.

A description of the appropriate techniques to be applied to Gatwick are given in Appendix E and summarised in the following sub-sections.

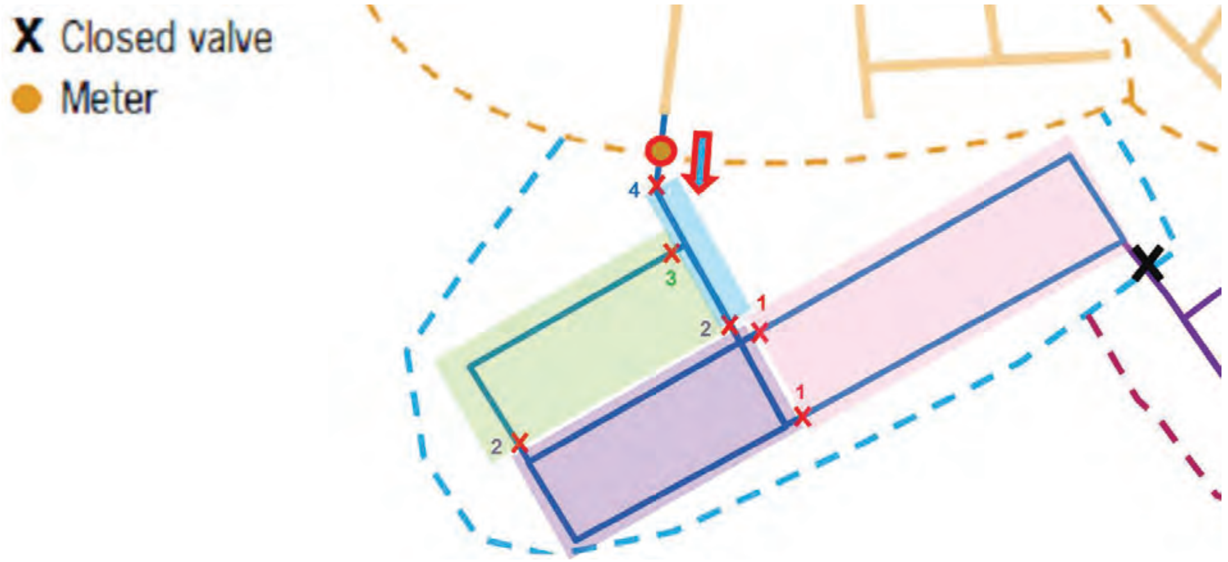
3.5.1 Verification of District Meter Areas (DMAs) water supply boundaries

As mentioned in Section 3.4.2 above, open boundaries between DMAs will invalidate attempts to monitor water consumption within set boundaries. Where this is suspected, pressure tests are undertaken, typically during a 2 to 3 hour period at night, to determine if all the valves known and unknown are closed on boundary – see Appendix E.1.

3.5.2 "Step Testing" within DMAs

This involves sub-dividing a DMA water supply area, again during the silent hours of the night. The main supply meters are monitored, whilst prearranged sub-divisions within the DMA are closed sequentially. "Steps" in the nightline flow are then observed – see Figure 3-3. The results when analysed will indicate leakage levels in each sub-divided area for further investigation. For more details – see Appendix E.2.

Figure 3-3 : Example of a DMA undergoing a "Step Test" - in 4 steps, closing valve sets 1, 2, 3 and 4 sequentially on the 4 areas



3.5.3 Leak noise correlation

Traditional sounding techniques with listening sticks are effective in identifying the presence of leakage, but cannot easily pinpoint a leak in an underground pipe. Current technology using leak noise correlators can do this making connections on two positions of a pipe, which must be metallic. Analysis by the machine displayed on a laptop can pin point the leak position – see Appendix E.3.

3.5.4 Acoustic noise loggers

Alternatively in busy areas where access during silent night-time hours is not possible, an array of acoustic noise loggers can be deployed en-masse across a DMA or entire network. The noise loggers, which also correlate the leaks, are left in position for a period of typically 1 to 2 weeks, and then analysed to determine leaks and leak positions. Verification with a ground microphone or leak noise correlator is recommended before excavating for the leak – see Appendix E.4.

3.5.5 Pressure management

Pressure reduction on network offers quick fix solution to reduction of leakage across DMAs, which can be applied before or after carrying out leak detection surveys. The pressure at GAL as measured for North Terminal (see Appendix C.3) varies between 5 and 6 bar – 5 bar at peak times of day and 6bar at night. There is therefore clearly scope to reduce pressure during night time, and even day time on a "need to have" basis.

Typically a Pressure Reducing Valve (PRV) is installed and a controller connected to regulate the downstream pressure setting, rather than keeping the downstream at a fixed pressure. The controller will ensure that the minimum required pressure is always available to consumers and will open up automatically when high flows are required in emergencies, such as fire-fighting.

Protection measures are also introduced so that the fail-safe positions for PRVs are acceptable for the water supply operations.

Buildings which have pressure requirements for sprinklers can be provided with their own booster pump systems, rather than pressurise an underground network of pipes to unnecessarily high pressures, and exacerbating leakage.

Pressure management is extremely effective in saving on leakage, but it has to be continuously monitored and, where economic to do so, backed up with "find and fix" leakage techniques. For more details – see Appendix E.5.

3.6 Facility Water Wastage – improved efficiency in water use appliances

Water wastage inside buildings typically consists of continuous flows from uncontrolled urinals, taps stuck open and left running and tank overflows from faulty float valves. With good maintenance wastage from faulty equipment is rare, however the water wastage by uncontrolled automatically flushing urinals can be very high and is typically a major contributor to out of hours water usage in large institutions.

The airport main terminal buildings with public access all have "state of the art" passive infra-red (PIR) detectors for urinal flushing, basin tap and WC flushing in compliance with latest GAL Standards for toilets, *20000-XX-Q-XXX-STD-000066 Toilets Technical Standard*, issued 2012 and revised 2016. A pilot 2016 public toilet refurbishment project, using latest GAL standards, has produced approximately a 30% saving in water use.

But older buildings and offices around the Gatwick airport and airfield side may not have this and may still use traditional control settings of the flushing cisterns operating once every 20 minutes. Old and abandoned buildings should also be checked and water switched off in the same way that electricity is isolated from unused buildings for safety reasons.

An inspection survey of all buildings outside the main public access terminals should be inspected and where there are urinals in place, without proper controls, then these should be introduced.

In addition to the design laid out in the GAL Toilets Technical Standard, using PIR activated urinal flushes, there are other options, where retrofitting to existing appliances. These typically include:

- Installing control devices on water pipes on existing urinals, without sensors, that only permit flushing when urinals have been used:
  - activated by PIR movement detectors,
  - or by pressure drop valves, and
  - or door opening actuated devices.
- Alternatively waterless urinals can be introduced into any existing building, but will require plumbing alterations and introduce a weekly maintenance regime. Waterless urinals are generally not recommended in high usage facilities due to their maintenance requirements and risk regarding hygiene; and
- Removal of urinals altogether and fitting WC s only, as with ladies toilets.

3.7 Other water efficiency measures

In addition to managing metering, leakage and water wastage in buildings there are other water efficiencies that can be practiced at Gatwick. But it needs to be considered that the priority should deal with the leakage and wastage, which is estimated to be equivalent to 370,000m^3/year, and represents more than 50% of the total water supplied to Gatwick.

3.7.1 Fire fighting

The main areas where recycled water is used in place of potable water is for the airfield fire ring main, which is filled with pressurised 'dirty' water from Ponds D and E. This is effectively "Rainwater Harvesting", and is reported as such by other airports.

Generally firefighting is undertaken using fire tenders filled with potable water in their tanks and water from the 'dirty' side of the surface water drainage system as a secondary resource should fire tenders exhaust on-board supplies.

The dirty pond water is not preferred by fire-fighters, as it can damage their pumps and clean water is needed for making foam.

Apart from possible future use of rainwater harvesting there appears to be limited opportunity to improve on water efficiencies in fire-fighting.

3.7.2 Aircraft washing

Potable water is currently used for aircraft de-icing and vehicle wash down. There is limited scope in these areas to use recycled water because good quality water is required for mixing de-icing sprays for aircraft, and similarly clean water is required for washing down.

A portion of the water used for de-icing is recovered and recycled. In 2015 of 684 m^3 of water used for de-icing, 128 m^3 was recovered, approximately 20%.

But keeping things in perspective, the 128m^3 saved represents only 0.02% of the 676,240m^3 of water used in 2015, compared to UFW which for 2015 was 342,273m^3 or 50%.

3.7.3 Grey water re-use

Grey water re-use involves the practice of taking "sullage" water, wastewater from sinks, basin, showers, baths etc, i.e. wastewater containing non-faecal matter.

It has the potential to save on water use, by reusing this element of water for other purposes, such as toilet flushing, irrigation of plants or even washing cars. However for safety and hygiene reasons, the water requires treatment, which is typically a small scale treatment plant with operational requirements and risks. Studies by CIRIA in Guidance *C539 "Rainwater and greywater use in buildings" 2001,* found that in trials none were economic and payback periods were in the order of 15 to 20 years.

This does not mean that grey water is not feasible, but there are sufficient risks and challenges to not retrofit this to existing buildings. For new buildings, it can always be a consideration, where the opportunity exists to design the water and sanitary pipework, storage tanks and treatment plant accordingly. Regulations regarding identification of pipes and the water hygiene risks are also issues to be taken into account.

There is currently no known use of grey water at Gatwick, and comparisons with Heathrow suggest it is not in use there either. Manchester is reportedly trialling rainwater and grey water in its road sweepers, but few other cases are known.

Because of the requirement to treat the water, it is not recommended to attempt to retrofit grey water re-uses to existing facilities, but could be considered in new buildings.

3.7.4 Rainwater harvesting

Rainwater harvesting involves collecting water from roofs or paved areas for re-use.

Rainwater harvesting is used at the Airfield Operations Building and previously used at the NT Sanitation block, but is not otherwise widely used across the airport. Plans are under way to refurbish the rainwater harvesting system in the NT sanitation block. The harvested rainwater is proposed to be used for construction, irrigation, filling tankers and paved surface sweepers The system is also connected to the dirty water fire water system.

The prospects of introducing rainwater harvesting have been discussed in meetings between Jacobs and GAL staff, and there is broad agreement that these measures work well in new buildings, where it is part of the design and operational philosophy, but the practical constraints of retrofitting this into existing buildings are difficult to implement.

Examples of rainwater harvesting at comparative airports:

a) Heathrow has implemented rainwater harvesting at Terminal 5, assumed to come from the large terminal building roof area. The 2015 sustainability report gives the following figures;

Water use (m^3/year)	2009	2010	2011	2012
Total Water used at Heathrow (from ~85% mains, 15% boreholes)	2,486,774	2,227,668	2,265,944	2,220,772
Terminal 5 roof rainwater Harvesting (%)	27,597	31,183	4,367	0

Water use (m³/year)	2009	2010	2011	2012
	(1.1%)	(1.4%)	(0.2%)	(0%)

Source: Heathrow 2012 Sustainability Performance Summary

However the utilisation is low at marginally over 1% of the total water used at Heathrow, and the use of rainwater harvesting appears to have reduced in 2011 and 2012 for reasons unknown.

b) At Changi airport, Singapore, the rainwater runoff from runaway are used for rainwater harvesting. Saving a reported 30% of water usage. The water is used for fire-fighting and toilet flushing. [3]

c) Frankfurt airport, the largest in Germany, reuses 100,000m³/year of rainwater. The water is used for toilet flushing, irrigation of plants and cleaning of the air conditioning systems. [4]

d) East Midlands airport in the UK uses rainwater harvesting for toilet flushing and claims this has helped reduced the passenger unit water consumption by 19%.[5]

Rainwater harvesting does have great potential for saving water, but it is recommend ensuring that the end use does not require any treatment other than minor screening. Roofs are clearly preferred over paved areas, as the water is generally cleaner, but it depends on the end use.

3.8 Conclusions and Recommendations

There is potential to make improvement in water efficiency at Gatwick.

With unaccounted for water, leakage and building water wastage amounting to 50% of supply, it is recommended to focus on these areas first, with rainwater harvesting being considered for large existing buildings and all new buildings.

In summary the recommended actions are:

- Inspect and survey all facilities where meters are not working, or not being read and replace as required and add to reading schedule. Consider the re-introduction of ARM meters for facility sub-meters;
- Monitor nightlines after improved metering and compare against UFW to help quantify the extent of leakage from building water wastage;
- Conduct an inspection survey of toilets in older buildings to check on urinal controls, and other potential sources for water wastage, outside taps, roof tank overflows, isolate unused buildings, etc.;
- Carry out enhanced leakage surveys, consider feasibility and benefits of:
  - o Step-testing areas,
  - o Widespread use of an array of acoustic noise loggers,
  - o Use of leak noise correlators to find and repair leaks,
  - o Pressure reduction in mains network, using modulate Pressure Reducing Valves (PRVs), with protection measures and contingencies for emergency water demands; and
- Consider Rainwater Harvesting for large buildings and all new buildings.

[3] http://www.rainwaterharvesting.org/international/singapore.htm
[4] Climate Culture Communications Lab, https://ccclab.info/2013/10/15/rainwater-harvesting/
[5] Manchester Airport Sustainability Group,, http://www.magworld.co.uk/sr2009/environment/water.html

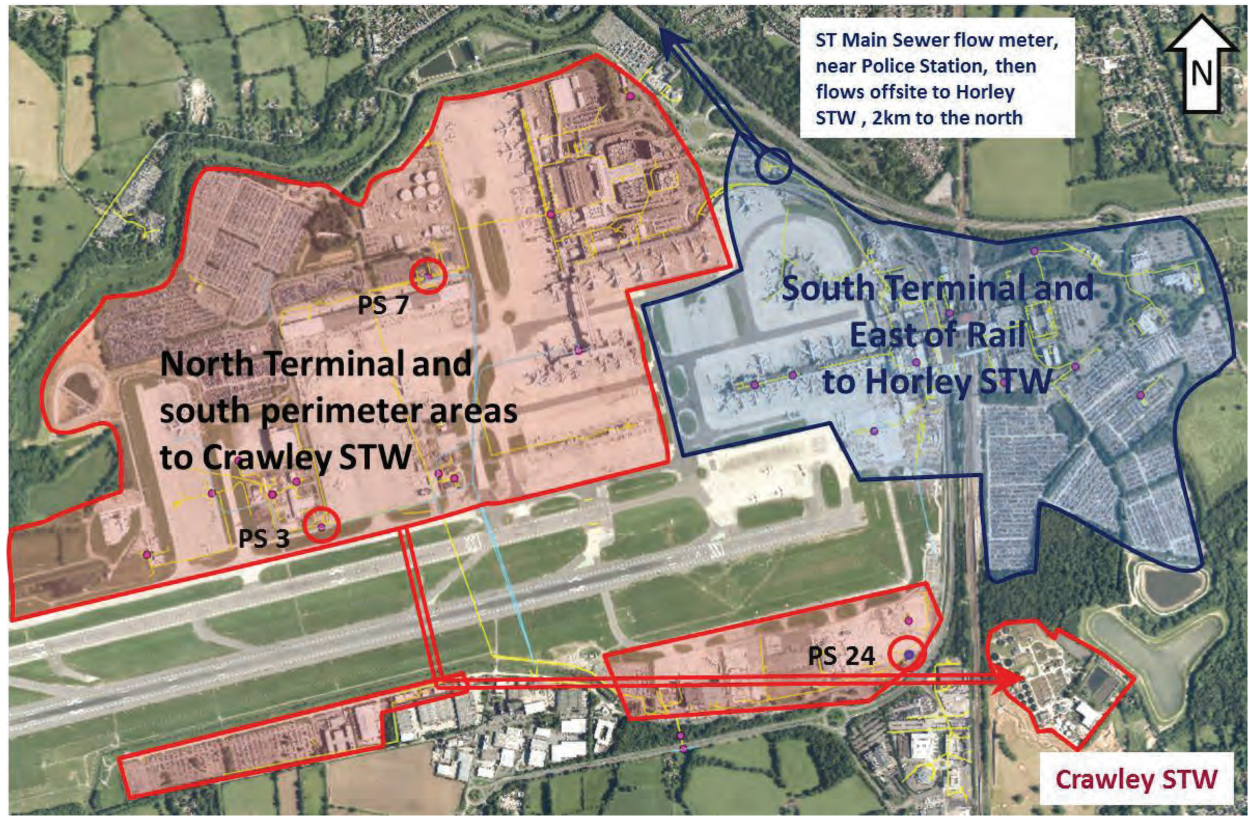
4. Foul Wastewater

4.1 Foul sewer catchment areas

The wastewater flow from Gatwick is divided into two areas:

- North Terminal and building along the southern perimeter discharging to Thames Water Crawley Sewage Treatment works (STW),
- South Terminal (ST) and East of Rail (EoR) all collect in a main gravity sewer, believed to be 400mm pipe size, which then discharges off site near the Police Station and then is conveyed to Thames Water Horley STW.

Figure 4-1: Plan Layout of Sewer Network Areas



4.2 Measured sewer flow rates

The flow rates discharging to Crawley STW are measured from flow meters at the terminal pump stations, PS 3, PS 7 and PS 24. Flow meter readings from the main sewer near the Police station discharging to Horley STW are not available, consequently an estimate of the flows from South Terminal and EoR to Horley STW cannot be determined.

Flow data available from the 3 No. terminal pump stations in the North Terminal area are provided in Table 4.1.

Table 4.1 : Gatwick Foul Sewer Flow measurements 2010 to 2016

Year	Flow to Crawley STW (m³/yr)				Flow to Horley STW (m³/yr)	Total (m³/yr)	Water Usage (m³/yr)	Wastewater as a % of Water Usage
	PS3	PS7-1	PS7-2	PS24	Gravity Pipe			
2010	16,511	117,596	407,467	Not available	Flowmeter readings not available	**541,574**	956,471	**57%**
2011	59,931	89,390	304,789	30,476		**484,586**	754,599	**64%**
2012	59,090	100,352	336,146	40,800		**536,388**	718,326	**75%**
2013	58,798	133,569	225,391	37,916		**455,674**	700,902	**65%**
2014	72,067	183,547	217,434	48,351		**521,400**	663,061	**79%**
2015	67,385	176,576	212,613	38,139		**494,713**	676,249	**73%**
2016 (m3/yr)	53,621	299,247	98,832	34,857		**486,558**	731,047	**67%**
2016 (l/sec)	**1.70**	**9.48**	**3.13**	**1.10**		**15.42**	**23.17**	

Pump Station Capacities and Thames Water Peak Flow Discharge Consents

Item	PS3	PS7-1	PS7-2	PS24	Horley STW
Pump Capacity (l/sec)	30	27	20	11	n/a
Peak Consent (l/sec)	**30**	**54**		n/a	**65**

flow rates from meter reading sheets

4.3 Foul sewer flow forecasts for 2020 and 2028

If the sewer catchment areas matched the water supply areas in Figure 4.1, then an attempt could be made to compare sewer flows for North Terminal against water consumption, and estimate the South Terminal and EoR sewer flow pro-rata from its water consumption but due to the mismatch in areas this will not be possible.

Wastewater flow data is incomplete, therefore the forecast of wastewater flow can only be based on the water usage forecast with an assumed relationship factor. In the UK, where irrigation is minimal, and in the absence of any better information the relationship is assumed to be a 100% match, water to sewer flows.

Total wastewater flow from Gatwick in the forecast has been estimated based on the water use forecasts provided in Sections 2.5 and 2.6 above.

- Foul wastewater volume in 2020 is forecast to be 785,981 m³
- Foul wastewater volume in 2028 is forecast to be 807,587 m³

The relationship assumed is highly speculative due to the incomplete nature of the historical foul wastewater flow data.

Forecasting wastewater volume with any accuracy has not been possible because a large proportion of the wastewater leaving the site not being recorded.

4.4 Recommendations

It is recommended that the flow meter in the main sewer from the South Terminal and East or Rail, believed to be 400mm size, is repaired or replaced. During the course of the project, a question was raised by GAL regarding the cost of installing a new flow meter in the main sewer near the Police station.

Accordingly enquiries with specialist companies have been made and we can report that the cost for installing a suitable flow and monitoring device with controller and datalogger, including installation and training at approximately £5,400 excl. VAT.

The flow and depth monitoring device is relatively small and would be installed unobtrusively on the sewer invert, normally in the channel in a manhole.

This can not only provide weekly cumulative flow readings, as are recorded at present but also a complete set of diurnal flow recordings, as well as daily or weekly readings, similar to the ARM meters installed by SES on the water meters.

Further it is recommended that GAL consider a project to not only install a new flow meter in the Police Station main sewer, but also to connect all flowmeters to dataloggers at the main sewage pump stations PS 3, PS 7, PS 24 and any other location of particular interest. In terms of meter compatibility, it may be necessary to replace any meters not found to be suitable for digital connections.

Once this is done GAL will be able to interrogate sewer flows, diurnally as well as weekly, this will provide a powerful tool in determining the sewer nightflows. The sewer nightflows between say 1am and 3am can be expected to consist of:

a) Legitimate sewer use;

   i. GAL staff on duty – normal allowance as for water use is 0.6l/pax/hour, which for say 1000 person is only 0.6m³/hour,

   ii. Hotels (as water night-time usage in Table 3.3),

   iii. Boiler house and chilling station etc.

b) Infiltration.

c) Water wastage - i.e. uncontrolled urinals and taps left running.

Experience shows that the latter two - infiltration and water wastage - are the dominant factors in sewer nightflows.

5. Water Quality

Gatwick discharges runoff to watercourses around the airport, including Gatwick Stream, Crawter's Brook and the River Mole. The runoff is managed via a number of ponds, with 'dirty' water (that does not meet GAL's minimum standards for discharge) conveyed and treated at either Pond D or the pollution lagoons at Crawley STW prior to final discharge off-site.

In its 2015 Decade of Change performance report, GAL set its own minimum surface water quality guidance limits to be met before being discharged. However, in some circumstances, unavoidable discharge occurs that does not meet these thresholds. These discharges are recorded and reported within the water section of GAL's annual Decade of Change performance report.

The highest numbers of exceedances are of GAL's Biological Oxygen Demand (BOD) threshold; the Phase 1 stage of this project identified that these occur following a period of peak de-icer use and a lack of storage capacity at the end of the season, usually February-April. Therefore this section will assess the potential impact of de-icer use on receiving surface waters of GAL's current management strategies, focussing on two scenarios up to 2028, as outlined in Section 5.1 of this report.

5.1 Forecasting Methodology Summary

The primary indicator of water pollution at the airport is the BOD of the water. This is the amount of oxygen required by bacteria while stabilising decomposable organic matter under aerobic conditions. This can depend on the type of microbes, the temperature or the oxygen content of the water, and is thus very specific to the sample. A more comparable measure of the amount of oxygen required to fully oxidise all of the oxidizable pollutants in the water is measured using the Chemical Oxygen Demand (COD), expressed in mg/l. This can be used to determine a COD load; i.e. the absolute amount of oxygen required to fully oxidise a product, expressed as a weight of oxygen. COD cannot be directly equated to BOD, but does give an indication of the likely relative BOD.

The predicted increase in Air Traffic Movements (ATMs) will potentially result in an increase in de-icer usage. Therefore it is assumed that the number of BOD exceedances will increase as ATMs and use of de-icer increase. Note that GAL has current management strategies in place, as stated within the 2015 and 2016 Decade of Change performance reports to reduce the pollution loading of de-icer to surface waters, via increasing the direct recovery of aircraft de-icer and the use of less polluting pavement de-icing salts.

In order to provide a "do nothing" baseline for forecasts, an average has been developed for the period 2010/11 to 2015/16; the period before the management strategies as laid out in the 2015 and 2016 DoC reports were implemented. The dataset provided by GAL that this average is calculated from is not complete: aircraft de-icer figures run from 2010-2016, however full pavement de-icer data runs from 2004-2013.

Scenarios have been developed to forecast the future water quality implications of de-icer use from the established average use based on historic data: a "do nothing" baseline (Option 1) has been developed assuming that the current management strategies are not implemented, but the airport is subject to increased usage over time (and thus increased de-icer application). The potential impact of GAL's current management strategies on surface water quality have been assessed by developing two extrapolations of COD load up to 2028, assuming both current management strategies are implemented separately. These are referred to as Options 2 & 3. Finally, a "management" prediction has been developed, based on full implementation of the management strategies proposed in the 2015 and 2016 DoC reports. This is referred to as Option 4.

The assessment year runs from 1 May to 30 April to retain the winter de-icing period in a single assessment year. Calculations to develop these indicative options have been provided in Appendix G.

5.2 Water Quality in 2028

5.2.1 Air traffic movements

Information provided by Gatwick indicates that annual ATMs are predicted to rise by 10-14% to 2027/28 which is likely to result in a proportionate rise in the application of aircraft de-icer, and an increase in COD load discharged to the drainage system. This is based on Gatwick's ICF Masterplan two Growth Scenarios - Scenario 1 (C55-C53 09.06.17) predicting a 10% ATM growth and Scenario 2 (C60-C55 09.06.17) predicting a 14% ATM growth. The predicted increase in ATMs for both scenarios are presented in Figure 5-1.

Figure 5-1 : Predicted Air Traffic Movements 2016-2028

Note: This graph is based on the ICF Masterplan Outputs C55-53 (09.06.17) Scenario1 and C60-C55 (09.06.17) Scenario 2.

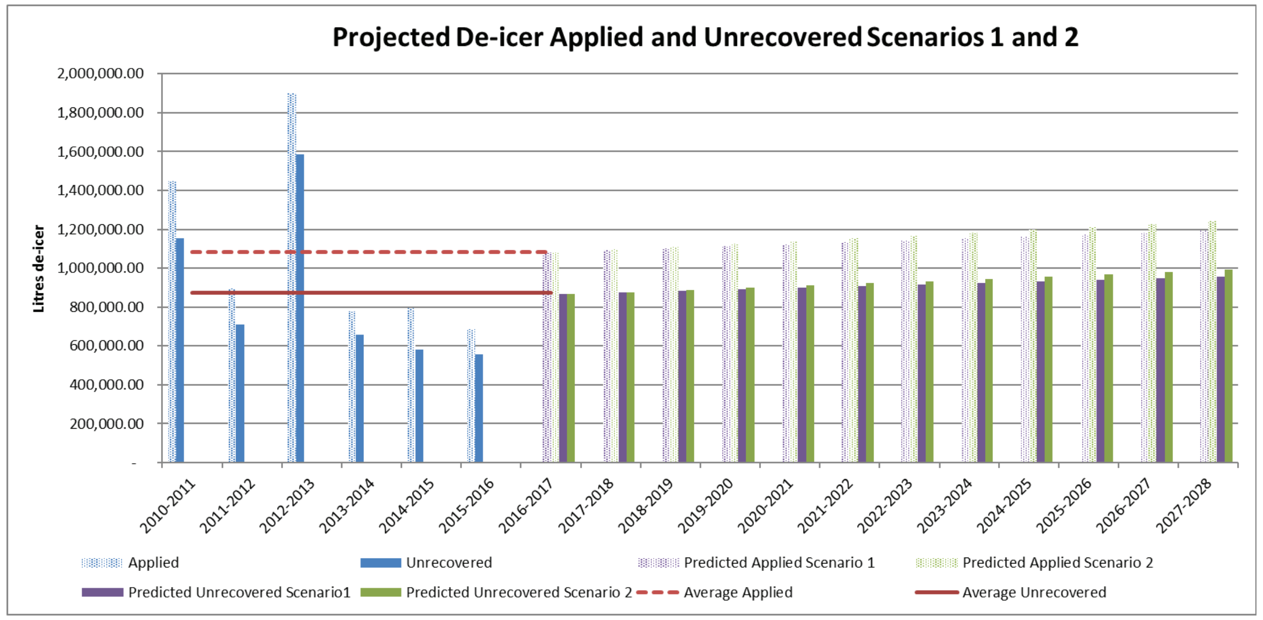
5.2.2 Changes in pavement de-icer application

Annual increase of ATMs has been linearly extrapolated to de-icer usage. Consequently a 10-14% increase in ATMs will equate to a similar increase in aircraft de-icer application. By 2028 based on current average use, aircraft de-icer consumption will increase from approximately 1,080,000 litres/yr to approximately 1,190,000 litres/yr in Scenario 1 and 1,240,000 litres/yr in Scenario 2. The increase in aircraft de-icer use applied for both scenarios has been presented in **Figure 5-2.**

5.2.3 Changes in aircraft de-icer recovery

A proportion of aircraft de-icer is recovered directly after application, reducing the volume entering the surface water drainage system. Over recent years (2010/11 to 2015/16) de-icer recovery has remained fairly stable, at around 20%. The unrecoverable de-icer is channelled into the drainage system. An average volume of unrecovered de-icer has been calculated and presented in Figure 5-2 with the data extrapolated over the period up to 2027/28 for Scenarios 1 and 2.

Figure 5-2 : Aircraft de-icer runoff and predicted runoff to 2028



Note: The increase in the predicted applied de-icer is based on the C55-53 and C60-C55 Scenarios as per Figure 5-1. *See Jacobs' Phase 1 report for a fuller commentary on previous years' de-icer usage trends. The current average recovery rate of 20% has been extrapolated to future years.*

An assumed COD load of 1.46 kg O_2/litre aircraft de-icer is predicted to result in an increase of between approximately 120,000 to 175,000 kg O_2/yr over the ten-year period to 2028.

The key variable is temperature which has a significant effect on de-icer use as indicated in Phase 1 stage of this project. For example, de-icer use in 2012/13 was double that in adjacent years due to the cold winter. Thus, the variation in the 'baseline' years of 2010/11-2015/16 is greater than the trend. However, our projection takes into account the data from a number of years which is averaged, which should reduce the uncertainty from years of greatest variance from the average.

5.2.4 Pavement de-icer

The second significant use of de-icer at Gatwick is that applied to areas of hardstanding, including the runway, taxiways or vehicle and pedestrian areas. According to data provided by GAL; on average between 2010/11 and 2015/16 approximately 1,270,000 litres is used for pavement de-icing per annum.

There are a number of new developments proposed before 2028 which are estimated to result in an increase of approximately 53ha of impermeable area by 2028. See Section 6.6 for a breakdown of this figure which provides an explanation of which developments are included. This would increase the volume of runoff that would enter the drainage system and would result in further BOD exceedances related to high flows. It has also been assumed this would increase pavement de-icer use by a corresponding 1%. This assessment has focused on the increase of the amount of de-icer applied, and does not take into account the possibility of high flows caused by the increase of hardstanding area, covered in Section 6

As there are a number of different de-icer products used at Gatwick, the application of each has been multiplied by the manufacturers' reported CODs where provided by GAL, in order to weight the different types of de-icer by its impact on surface water quality. With reference to Table 5.1, glycol-based de-icers have a higher COD load, and are the heaviest used; on average around 1,000,000 litres/yr of glycol-based de-icers are applied, compared to around 270,000 litres/yr of acetate-based de-icer applied.

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Table 5.1 : Comparison of pavement de-icers

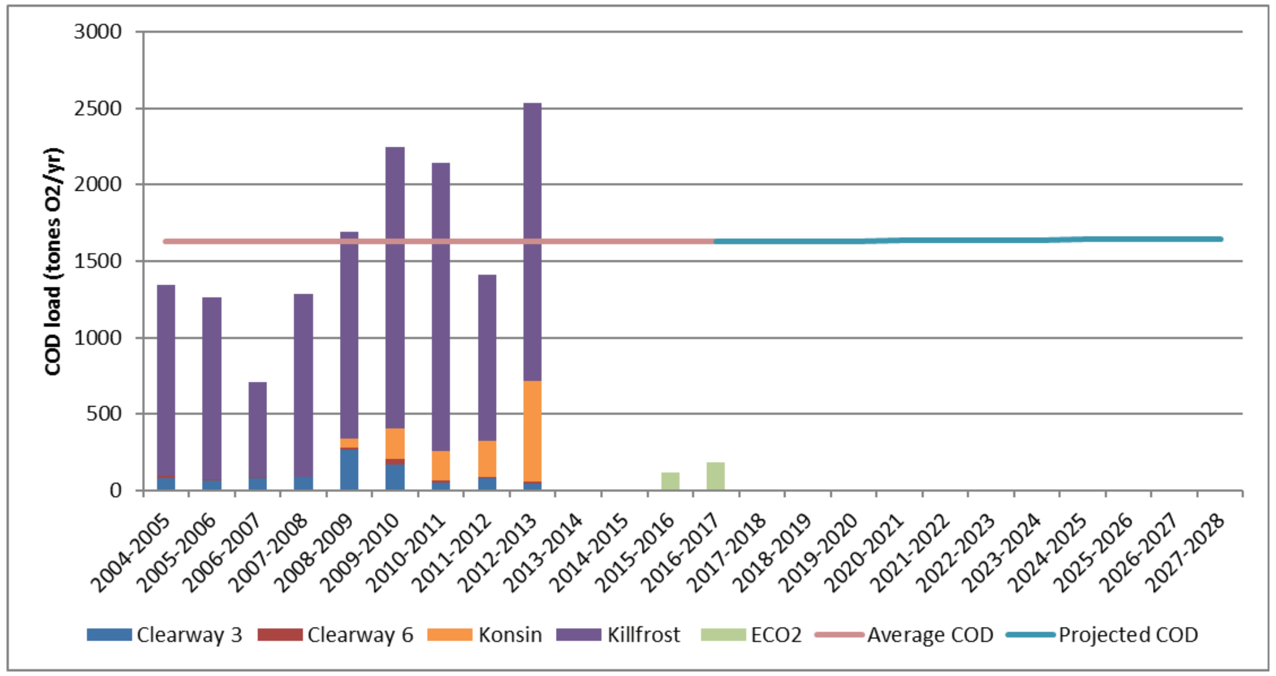
	Clearway 3	Clearway 6	Konsin	Killfrost	ECO2
Active chemical	Potassium acetate-based	Sodium acetate-based	Ethylene glycol-based	Propylene glycol-based	Potassium acetate-based
Quoted undiluted COD load	320 mg O_2 / g	561mg O_2/g	1290 mg O_2/g	1390 mg O_2/g	Assumed Clearway 3 as a potassium-acetate de-icer
Quoted densities	1.3 g/cm³	800 kg/m³	1.1 g/cm³	1.1 g/ml	1.3 g/cm³
Calculated COD load	416,000 mg O_2/l de-icer	448,000 mg O_2/l de-icer	1,419,000 mg O_2/l de-icer	1,529,000 mg O_2/l de-icer	416,000* mg O_2/l de-icer

Note: ECO2 technical datasheet not provided, so figure stated here is the same as Clearway 3 as an equivalent potassium acetate-based de-icer.

Assuming that the same proportion of hardstanding surface area is de-iced as existing, the increase in the application of pavement de-icers would result in an increase of COD load of pavement de-icer from 1,606 tonne O_2/yr to 1,682 tonnes O_2/yr, equating to an increase of around 1%.

It has been assumed that none of the pavement de-icer is recovered after application; all pavement de-icer applied enters the surface water drainage system.

Figure 5-3 : COD load from predicted pavement de-icer increases until 2028



Notes:

- *No data for de-icer applications during the winters of 2013/14 or 2014/15 have been received.*
- *Data has been provided for 2015/16 and 2016/17, but has not been used to establish the average.*
- *Average COD based on total COD from different de-icers for each year averaged between 2004/05 and 2012/13.*
- *Note the high COD load in the abnormally cold winter of 2012/13.*
- *No data was received for the abnormally wet winter of 2013/14.*

- *The average COD has been taken forward to 2015/16, then an upwards projection has been developed from the winter of 2016/17.*

5.2.5 Current management strategies

Potential positive impacts on water quality are likely to result from strategies already in place. The change in contractor for aircraft de-icer recovery which according to GAL has recently taken place is estimated to increase aircraft de-icer recovery from around 20% to approximately 40%, which could result in a corresponding decrease in the COD load to the surface water drainage system. The replacement wherever possible of glycol-based pavement de-icers with a high COD load with ECO2, a potassium acetate based pavement de-icer with approximately a third of the COD load, could also reduce the COD load. Note that the use of ECO2 has already been partly implemented wherever possible for non-airfield use as shown in the 2015/16 and 2016/17 data, which was issued to Jacobs on the 5th December 2017.

When calculating the decrease in COD load from the change of pavement de-icer brand to a potassium acetate based product it is assumed that the same volume of de-icer will be applied but the COD load will decrease, resulting in approximately a 70% decrease of COD load from pavement de-icing to around 1,600 tonnes O_2/yr to around 520 tonnes O_2/yr over the 10 year period.

5.2.6 Potential options for reducing COD loading

Without action and based on extrapolation of the 2010/11 to 2015/16 data the COD loading will increase by between 2,882 tonnes (Scenario 1, C55-53) and 3,071 tonnes annually (Scenario 2 C60-55). However, there are two water quality management strategies already in place that could positively impact on the COD load, as described in Section 5.1. The options presented in Figure 5-4 and Figure 5-5 that have been considered as baselines up to 2028 are:

- Option 1: “Baseline” – does not include the positive future impacts of current management strategies;
- Option 2: Aircraft de-icer recovery increase (from 20% to 40%) assuming the addition of a second de-icer recovery vehicle;
- Option 3: Continued use of ECO2 instead of glycol-based de-icers wherever possible (100% replacement has been assumed for the purposes of this assessment); and
- Option 4: Both aircraft de-icer recovery and use of ECO2.

These options have been developed for both growth Scenarios in Figure 5-4 and Figure 5-5.

Figure 5-4 : Total predicted COD load to 2028 – C55-53 Scenario 1

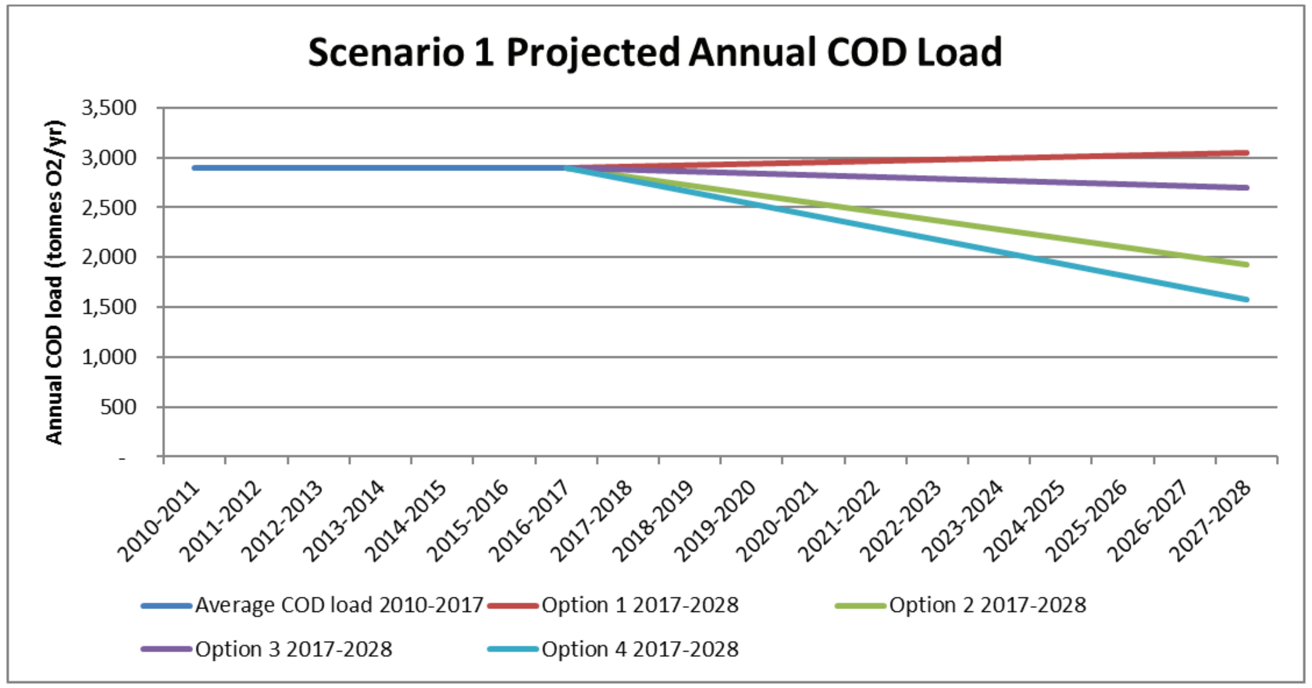
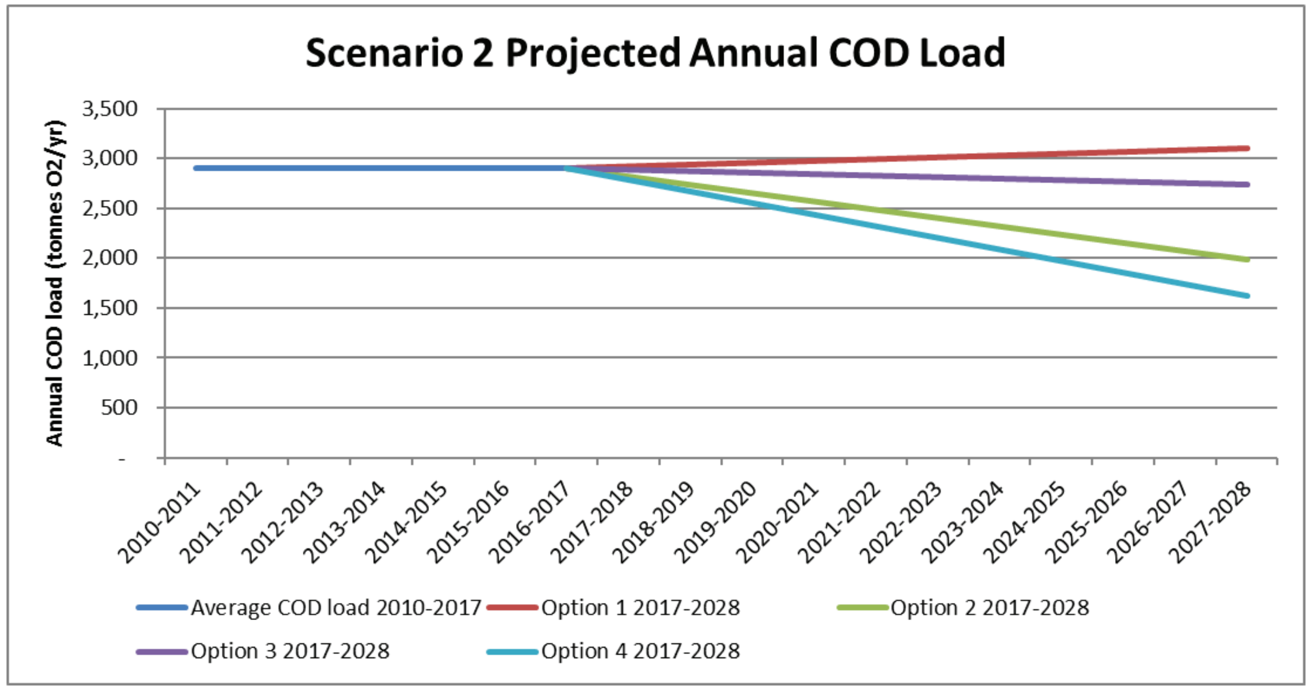


Figure 5-5 : Total predicted COD load to 2028 – C60-C55 Scenario 2



The two forecast scenarios produce a similar result as their variance in COD load is relatively small compared to the total for the airport.

Option 1 (current management strategies are not implemented) is the worst case. In isolation, Option 2 (improved recovery of aircraft de-icers) does not produce a significant reduction in overall COD load over the timescale of the study due to the increase in ATMs. Option 3 (ECO2 is used more widely as a pavement de-icer in place of glycol-based de-icers) results in a more significant decrease in COD of approximately 32%-34% (subject to the growth scenario). However, ECO2 has a smaller operating temperature range than glycol-based de-icers and it is unlikely that glycol can be entirely replaced and there would be occasions, such as during colder weather, where glycol application will be required. The greatest absolute decrease occurs when existing management measures are maintained (Option 4 -both methods used); equating to a 44%-64% decrease on current COD loads subject to the growth scenario considered. These results are presented in Table 5.2 and Table 5.3.

Table 5.2 : Future COD load for Growth Scenario 1 (C55-C53)

2028 COD load, tonnes O2/yr (percentage of current average) (Scenario 1 C55-C53)	Increase in hardstanding	Change of de-icer
Increase in aircraft numbers	3,041 (5% increase) Option 1 (worst case)	1,982 (68% decrease) Option 3
Increase in recovery rate	2,954 (7% decrease) Option 2	1,891 (46% decrease) Option 4 (best case)

Table 5.3 : Future COD load for Growth Scenario 2 (C60-C55)

2028 COD load, tonnes O2/yr (percentage of current average) (Scenario 2 C60-C55)	Increase in hardstanding	Change of de-icer
Increase in aircraft numbers	3,097 (7% increase) Option 1 (worst case)	1,982 (32% decrease) Option 3
Increase in recovery rate	3,006 (6% decrease) Option 2	1,891 (44% decrease) Option 4 (best case)

5.3 Potential Water Quality Management Improvement Measures

Initial options for further reduction of COD load have been developed and assessed by Jacobs and assessed on its likely cost, implementation timescale, land take, environmental impact, potential benefits and potential issues. Further details of the assessment are included in Appendix H.

5.3.1 Reduce de-icer usage

This option involves applying less de-icer to hardstanding either through reduction in overall use or application to selective areas to reduce the volume washed off during precipitation events, and consequently a lower COD load in the surface water drainage network. Changing the current procurement mechanism for de-icer application may encourage increased efficiency, i.e. not paying by volume applied. It may be possible for GAL to directly change the use of pavement de-icer by reviewing the hardstanding de-icing policy to reduce application volumes.

Applying less de-icer would have a cost saving in terms of reduced treatment, and environmental benefits from the reduced COD load, but it would also reduce costs as less de-icer will need to be purchased.

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5.3.2 Less polluting de-icer usage

The de-icer used for aircraft is currently glycol-based. A switch to an acetate-based de-icer when possible would reduce the COD load entering the surface water drainage system. However, acetate-based de-icers tend to operate at a higher temperature range than glycol-based de-icers, consequently acetate-based de-icers would be favoured under warmer conditions. While such innovation may be led by the airlines or the Civil Aviation Authority, GAL are in a position to influence its implementation as a member of a pan-airport group sharing industry de-icing innovations.

5.3.3 Increase upstream water storage on-site

This option involves creating extra water storage ponds on-site to avoid discharging water with higher levels of BOD to Crawley STW, or to local watercourses. There are two additional benefits with this option: it will have a positive impact on flood risk, as increased storage results in a reduced peak flow and selective storage of locally recovered water, for example from dedicated de-icing stands followed by treatment including near de-icer application areas could also provide water quality benefits.

After 2019 GAL's water treatment agreement with Thames Water ends and treatment costs will revert to standard business rates, which could increase the cost of sewage treatment off-site.

5.3.4 Higher aircraft de-icer recovery on site

Higher de-icer recovery will reduce the amount entering the surface water drainage system, thus reducing the COD load and the requirement to treat runoff.

Recovery from de-icing stands is already being considered by GAL, with initial estimates suggesting that recovery rates may increase from 20% to 25%. However, with dedicated drainage from de-icing areas, runoff would be collected, not just that which has pooled during de-icing. This could lead to de-icer recovery rates increasing significantly. It is understood that GAL are selectively trialling the use of remote de-icing (push and hold) stands where de-icing salts are applied in a specific area of the airport with recovery via a mobile vehicle after each wave of aircraft. The GAL 2016 DoC performance report states that this has been partly successful due to the viscosity of the water/de-icer mix but no specific data on overall recovery is available.

There is also a known phenomenon where excess de-icer 'shears' off the wings during take-off. Extra de-icer could be collected from dedicated drainage systems at these areas on the runway, increasing recovery rates, and reducing COD load on the system. Further data should be collected and assessed to establish how much of this 'sheared-off' de-icer is dropped on the runway, and how much can be recovered.

5.3.5 Increase water treatment on site

Increased treatment on-site could reduce the volume and chemical contamination of runoff being conveyed to Crawley STW. This could save GAL money as their trade waste agreement is due to expire in 2018/2019 and costs are likely to increase as a result.

However, intensive water treatment is relatively expensive per unit volume and potentially less intensive solutions such as reed bed/aeration systems could be considered in collaboration with smaller volume higher intensity treatment such as desalination-type processes. The latter may be suited to part-time operation during the winter and spring and as such does not need to maintain a biomass, so could be subject to longer term shut-downs. Feasible location of facilities need to be carefully considered and high intensity options would almost certainly need to be on airport near the point of deposition to maximise their benefit.

For a full assessment of possible water treatment options, see the Jacobs report (Treatment Feasibility Assessment is GAD7013E-GAL-DOC-00000004).

5.3.6 Increased treatment off-site

Off-site treatment could either be via transport polluted runoff off-site for treatment by tanker or a piped network conveyed to Crawley STW. This is the most expensive option, as treatment costs are high.

Transporting off-site by tanker is expensive as there are transportation and treatment costs. However, GAL currently tanker recovered de-icer off-site for treatment.

5.3.7 Conclusions

Due to the increase in ATMs, continuing with current management measures could result in the overall COD load from de-icer would increase by 5-7% by 2028 (depending on the growth scenario). The contamination from runoff is mainly due to the use of de-icing salts, so is concentrated in winter, and varies considerably due to 'cold' or 'warm' winters. Current strategies for managing the high COD of surface water discharges are being trialled, and could have a positive impact on surface water quality if implemented fully, potentially reducing current COD loads by up to 46% by 2028.

5.3.8 Recommendations

It is recommended that consideration of a selection of options are taken forward for quantitative assessment of cost, lead-in times and land take, and this should be balanced against the impact on water quality for consideration by GAL.

6. Flood Risk and Surface Water Management

6.1 Introduction

The Phase 1 Water Masterplan Report (Jacobs, 2017) assessed the flood risk to Gatwick Airport from all sources including fluvial, surface water, pluvial, groundwater, reservoirs, foul drainage systems and the failure of flood defences. The assessment established that the primary sources of flood risk to Gatwick are fluvial (river) and surface water (from exceedance of the drainage network capacity).

Fluvial flood risk to the airport emanates from the watercourses which surround it: primarily the River Mole and the Gatwick Stream. Based on hydraulic modelling Gatwick is considered to be at risk of fluvial flooding events that are predicted to occur on average between the 1 in 20 annual chance (5% Annual Exceedance Probability AEP) and the 1 in 50 annual chance (2% AEP) events. The airport is served by an extensive surface water drainage network which would be overwhelmed by extreme rainfall events, which is predicted to flood on average once every ten years (or a 10% chance of occurrence in any one year). The location at highest risk of surface water flooding is the North Terminal. Further details of the risk of flooding from all sources and the nature and operation of the drainage network are included in the Phase 1 Water Masterplanning Report.

6.2 Objectives

Over the next decade there are plans for a number of proposed developments across the airport to ensure Gatwick has sufficient capacity, to grow and to become the airport of choice for London. This Phase 2 Masterplan report assesses at a high level the potential fluvial and surface water flood risk to these proposed developments, how they may impact on existing levels of flood risk, identifies potential mitigation measures to ameliorate their impact and provides suggestions for how Gatwick should strategically manage flood risk over the next decade and beyond.

6.3 Methodology

The following methodology was adopted in order to assess the fluvial and surface water flood risk to and from the proposed development over the next decade:

- The fluvial and surface water flood extents adopted to assess flood risk to the developments were taken from the fluvial and surface water hydraulic modelling work undertaken by CH2M for Gatwick since 2010 which is the basis of the assessment of flood risk. These flood extents are available for a number of return period events (see Section 6.4), further details on how they were developed are included in the Phase 1 Water Masterplan report;

- The layout and nature of the proposed developments were outlined in a presentation titled "*Gatwick Airport Master Plan Production Workshop*" presented by GAL on the 4 May 2017. The presentation contains a series of layouts of development drawings and boundary lines for the proposed developments;

- The proposed development footprints were compared to the predicted fluvial and surface water flood extents to determine if they would be in areas at risk of flooding; and

- The change in impermeable area as a result of the developments was estimated to determine the potential impact on runoff volumes and consequently how they would impact upon the existing surface water drainage network and flood risk.

6.4 Predicted Flood Risk

The fluvial and surface water flood extents used for the assessment of flood risk originated from the fluvial and surface water hydraulic modelling work undertaken by CH2M for GAL previously, full details are provided in the Phase 1 Water Masterplan report. The hydraulic models simulate fluvial and surface water flooding for the existing Airport. The fluvial model includes the Upper Mole Flood Alleviation Scheme (including the Clay's Lake scheme currently under construction), the Gatwick Stream Flood Alleviation Scheme and the Crawter's Brook Attenuation

Areas. Fluvial flood extents were available for the 1 in 5 annual chance (20% AEP), 1 in 20 annual chance (5% AEP), 1 in 50 annual chance (2% AEP), 1 in 75 annual chance (1.33% AEP), 1 in 100 annual chance (1% AEP) and the 1 in 100 (1% AEP) plus 20% for climate change event.

The surface water model is a sub-catchment based model where individual catchments are assigned to individual carrier drains as opposed to a direct rainfall-runoff model consequently the model does not simulate overland surface water flow paths before they enter the drainage systems. The model simulates flooding arising from the surface water drainage system once it reaches capacity and simulates overland flow if the collected surface water runoff exits the surface water drainage system. As the Masterplan and proposed developments progress it is recommended that a direct rainfall-runoff model is developed to simulate overland surface water flow paths before surface water runoff enters the surface water drainage system to optimise the proposed developments with regard to surface water flood risk. Surface water flood extents were available for the 1 in 10 annual chance (10% AEP), 1 in 100 annual chance (1% AEP) and 1 in 100 (1% AEP) plus an allowance of +20% for climate change event.

While these models have been relied upon as the best available data to assess the flood risk implications of the proposed developments, it should be noted that recent reviews undertaken by GAL of the models have identified the following amendments that are required to increase the accuracy of the prediction of flood risk:

- In August 2016 GAL commissioned Jacobs to undertake a flood resilience review of the hydraulic modelling undertaken by CH2M for which a report was produced titled “Gatwick Resilience Review” (Jacobs, 2016 - Report No. GADD001A_1) which documents Phase 1 of the hydraulic model reviews. This report presents actions for GAL and CH2M to address. The main actions relate to the verification and calibration of the fluvial model, a discrepancy between the fluvial and surface water models and the level of model documentation. At the time of our assessment CH2M were acting on the Jacobs fluvial model review findings and producing the revised fluvial flood extents. To our knowledge the surface water modelling comments are not being addressed presently. As such revised models were not available to use for this fluvial and surface water flood risk assessment. However, the existing outputs from the CH2M fluvial and surface water modelling is regarded as the most accurate representation of the current flood risk to Gatwick Airport and have therefore been adopted as the best estimate of flood risk to the proposed developments presently available;

- The Upper Mole Flood Alleviation Scheme has been included in the fluvial model developed by CH2M with Clay’s Lake Flood Alleviation Scheme also included although it has yet to be fully constructed on site. Once constructed it is recommended that the Clay’s Lake representation in the fluvial model is checked against final “As-Built” drawings to ensure the potential fluvial flood risk is accurately represented; and

- The climate change uplift factor of +20% adopted in the CH2M hydraulic models has subsequently been superseded by updated guidance from the Environment Agency (EA). The Masterplan assessment year of 2028 falls within the 2015 to 2039 time interval specified by the updated guidance. Consequently an uplift factor of 15 or 25% should be applied subject to the nature of the development and which flood zone within which it is located. As a result, the existing +20% predicted flood extents provide an acceptable median figure to apply an assessment of risk for the purposes of the Masterplan, although flood extents for the new guidance should be developed by GAL.

It is recommended that as the Masterplan and associated proposed developments progress the prediction of fluvial and surface water flood risk should be re-visited once these amendments have been implemented.

6.4.1 Fluvial Flood Risk

It is predicted that the current standard of protection at Gatwick Airport against fluvial flooding is between the 1 in 20 annual chance (5% AEP) and 1 in 50 annual chance (2% AEP) events. The cause of the flood risk being the restricted capacity of the culvert on the Gatwick Stream adjacent to the South Terminal, which is exceeded and

causes increased upstream flood levels and hence places the South Terminal at risk of flooding. Appendix C of the Phase 1 Water Masterplan report indicates the maximum fluvial flood extents for these events.

6.4.2 Surface Water Flood Risk

It is predicted that the current standard of protection at Gatwick Airport against surface water flooding is approximately 1 in 10 annual chance (10% AEP) event (see Appendix C of the Phase 1 Water Masterplanning report). This relates to the capacity of the pumps at Pond D, which when overwhelmed result in water backing up placing the North Terminal at risk of flooding as occurred in 2013. GAL has identified critical infrastructure for which flood resilience reviews are underway.as part of the Phase 2 Flood Resilience Review Project. A number of these assets are estimated at risk of flooding from fluvial and/or surface water sources (i.e. water levels above ground level) and possible resilience measures are being recommended for these.

6.5 Climate Change

National recommendations for the consideration of climate change for new development and for nationally significant infrastructure are subject to change as new information becomes available. The EA updated its guidance on the climate change uplift factors to be incorporated for new development in February 2016. The scientific evidence that underpins the guidance: the United Kingdom Climate Change Projections (UKCP09) is due to be updated in 2018, which could lead to further revisions in the uplift factors to be incorporated for new development.

Both the fluvial and surface water hydraulic modelling undertaken by CH2M incorporated the predicted impact of climate change by applying an uplift factor of +20% to the 1 in 100 annual chance (1% AEP) event. **However, it should be noted that this was completed before the latest guidance was published in 2016 which new development would be expected to comply with and would potentially require them to incorporate a higher allowance for the predicted impact of climate change than included in this modelling (subject to proposed design life).**

The climate change uplift is included to provide an estimate of potential flood risk to Gatwick Airport for the 1 in 100 annual chance (1% AEP) event in the future, in the case of this Masterplan study, up to the year 2028. The risk of flooding is likely to increase due to the predicted impact of climate change.

6.6 Risk of Flooding to Proposed Development

The risk of fluvial and surface water flooding has been assessed for all development proposals provided by GAL, as summarised in Table 6-1. In addition the table indicates the estimated change in impermeable area as a result of each development proposal. Additional detail on the development proposals and the predicted impact to and from the proposed developments regarding flood risk is included in Appendix F in the form of a detailed summary table and a series of fluvial/surface water flood risk maps for each proposed development location.

Table 6-1: Risk of Flooding to Proposed Development and Impermeable Area Changes

Ref	Description	Surface Water Drainage Catchment	Flood Risk		Increase in Impermeable Area (m^2)
			Fluvial	Surface Water	
1	Pier 6 Extension	Pond D	1 in 100	1 in 100	0
2	Re-aligned Quebec Taxiway	Pond D	1 in 100+20%	1 in 10	5,333
3	A380 Relocation to Pier 5	Pond D	>1 in 100+20%	1 in 10	0
4	Remote Parking Stands	Pond M, Pond D & Dog Kennel Pond	>1 in 100+20%	1 in 10	15,710

5	Push & Hold Stands	Pond D	>1 in 100+20%	1 in 10	5,968
6	Lima Taxiway	Pond D	>1 in 100+20%	1 in 10	3,045
7	Domestic/CTA Baggage Reclaim	Pond D	1 in 50	1 in 10	0
8	Long Stay Car Parking	Pond G	Outside model extent	Outside model extent	0
9	Multi-Storey Car Park 4	Pond F	>1 in 100+20%	Outside model extent	2,018
10	Multi-Storey Car Park 7	Pond D	>1 in 100+20%	1 in 10	0
11	Boeing Hangar	River Mole and / or Man's Brook	1 in 75	1 in 10	17,393
12	South Terminal Car Rental Re-location	Uncertain	>1 in 100+20%	Outside model extent	285
13	Gatwick Airport Rail Station	Uncertain	1 in 100	1 in 100	3,229
TOTAL					52,981

Climate change would be expected to increase the frequency of storms of equivalent severity, e.g. hypothetically an event with a current 1 in 50 annual chance (2% AEP) could in the future be expected to occur with greater frequency, e.g. have a 1 in 30 annual chance (3.33% AEP) of occurring. As a result new development needs to consider the predicted impact of climate change on peak river flows and rainfall.

Table 6-1 indicates the most frequent modelled storm events that the development location is predicted to experience flooding from, for both fluvial and surface water events. It should be noted that this assessment is limited by the storm event results that are available from the hydraulic modelling undertaken for GAL previously. The assessment is an approximation; the modelling of additional storm events would increase the accuracy of the assessment. However, with specific regard to a suitable design standard of protection for safe, continued operation of Gatwick Airport during a flood over its lifetime, it is recommended that the minimum design standard is the 1 in 200 annual chance (0.5% AEP) event for Critical National Infrastructure. Refer to Section 4.9.3 for a more detailed discussion on the standard of protection regarding flooding for Critical National Infrastructure like Gatwick Airport.

Table 6-1 indicates that for fluvial flood risk most of the proposed developments are at low risk of flooding and are located in areas that would not necessitate the provision of mitigation measures. The domestic/CTA baggage reclaim and Boeing Hangar developments are at greatest risk of flooding. It is understood that the Boeing Hangar development has been granted planning permission.

For surface water the majority of the developments are in locations at significant risk of surface water flooding. In accordance with national planning policy the development proposals would need to demonstrate that they would be safe for their lifetime.

The assessment of changes to impermeable area is a net change, taking into account the current ground surface type. An increase in impermeable area would result in an associated increase in runoff to the surface water drainage network, potentially increasing flood risk downstream if unmitigated. The development proposals at Gatwick would need to consider the impact on increased surface water runoff to the available storage in the attenuation ponds. The development proposals will require the inclusion of additional storage to attenuate the

surface water discharge to the existing surface water drainage system. This would reduce the hydraulic load on the existing drainage system and hence reduce flood frequency elsewhere at Gatwick Airport.

6.7 Management of Future Flood Risk

As stated in Section 6.4 climate change will increase the risk of fluvial and pluvial flooding to Gatwick. A review of fluvial and pluvial hydraulic modelling undertaken on behalf of GAL by CH2M indicates that for the 1% (1 in 100) AEP fluvial flood risk event the area of the airport at risk will increase to include the North Terminal, an area to the south-east of Pond M and areas to the south of the runway. Surface water modelling indicates that for the 1% (1 in 100) AEP event the increase in risk will include more extensive flooding at North terminal and an area to the east of the Dog Kennel Pond. Areas already at risk of flooding are likely to experience an increase in predicted flood depths across the airport.

Outlined in Section 6.7 are a variety of potential high level flood mitigation measures coming out of this Masterplan to study that could be employed to minimise the potential fluvial and surface water flood risk identified for each of the proposed developments in Section 6.6. These measures could be applied during the next decade; within the timescale of this Masterplan or beyond.

National and Local planning policy includes a presumption on the use of more sustainable methods of surface water management using green infrastructure (e.g. infiltration of runoff, swales, grassed attenuation ponds, etc.) which fall under the description of Sustainable Drainage Systems (SuDS). The objective of SuDS techniques is to minimise the impacts from a proposed development on the quantity and quality of the surface water runoff and to maximise the amenity and biodiversity opportunities. The traditional method of draining surface water runoff from urban areas (e.g. cities, airports, etc.) has been through underground piped systems. These traditional systems are designed to prevent flooding locally by conveying the water away from the site efficiently. However, there is a risk of increasing flooding to downstream receptors if appropriate flood risk mitigation is not incorporated. The philosophy of SuDS is to replicate, as closely as possible, the natural drainage from a site before development. In the UK the SuDS manual (CIRIA C753, 2015) details techniques that should be considered for SuDS. It is recognised that there are constraints to using SuDS at an airfield (e.g. open water channels convey water in an airfield may attract birds presenting bird strike risk, etc.). Nonetheless these sustainable water management methods should be evaluated as to how they can be implemented at Gatwick.

Considering GAL’s ambition to become the UKs most sustainable airport a high-level study has been undertaken to identify global best practice and innovation regarding flood risk management that could contribute to the sustainable management of water and flood risk at Gatwick Airport to 2028 and beyond, the findings are summarised in Table 6-2. The findings are primarily related to the innovative practices of other large airports around the world but some examples have been provided from other industries.

6.8 Flood Risk Mitigation Measures

Previous flood protection and resilience studies have been undertaken which have recommended measures to reduce fluvial and surface water flood risk to the airport, which are summarised in the subsequent sections.

6.8.1 Fluvial Flood Risk Mitigation

Fluvial flood risk mitigation measures that could be employed at Gatwick Airport regarding the proposed developments include:

- The introduction of a flood defence along the alignment of the Gatwick Stream that currently presents a flood risk to the Airport, this could be formed by a new hard flood defence wall or localised bank raising along the Gatwick Stream. Both options would retain the flow in channel during a major storm event up to the chosen design return period of the flood defence. The scheme may require the provision of floodplain compensation to replace the existing floodplain that would be removed by the scheme to prevent it increasing risk to third parties. This would seem to offer substantial improvement to the fluvial flood protection to Gatwick Airport. Jacobs have submitted a proposal titled "*Gatwick Stream Flood Wall (05/07/2017)*" to GAL to undertake optioneering for such a flood defence along the Gatwick Stream. This does not imply that a "Gatwick Stream Flood Wall" is definitively the solution at this stage. Rather, the proposal represents a good starting point, from which options may be considered and developed taking account of a range of constraints and specific engineering, environmental, stakeholder and economic factors. Proposed developments that would benefit from such a measure include the Pier 6 Extension, Quebec Taxiway Realignment, A380 Stand Relocation to Pier 5, Push and Hold Stands and Domestic/Common Travel Area Baggage Reclaim facility. Existing infrastructure such as the South Terminal Building, A23 underpass and South Terminal Tunnel, Pier 1 Baggage Hall, taxiways, aircraft stands, existing pier buildings, etc. would also benefit;

- There are significant flood extents predicted from the River Mole for the 1 in 75 annual chance (1.33% AEP) to the 1 in 100 annual chance (1% AEP) plus climate change events that cross the proposed Boeing Hangar site and onto Taxiway Uniform. Given the concentration of proposed large scale development in this area it would appear valid to investigate the provision of a hard flood defence along the River Mole in this location similar to that being considered on the Gatwick Stream. Proposed developments that could benefit from such a measure include the Boeing Hangar, Remote Parking Stands and Taxiway Lima Extension. Existing infrastructure such as Taxiway Uniform and its associated stands would also benefit. The Planning Statement for the development[6] states that it does not give rise to changes in flood risk downstream and is considered acceptable development within Flood Zone 3 classified as 'Less Vulnerable' in accordance with paragraph 066 of the National Planning Practice Guidance;

- Flood defences can always be overwhelmed when the severity of a flood event exceeds that which it was designed to withstand. Gatwick has been undertaking an exercise to identify infrastructure critical to its operation to ultimately ensure that it is resilient to such a scenario. Measures could involve additional protection works local to the asset, or resilience to ensure that there are backup services in place for operations to continue unaffected, or that the duration of outage is limited to minimise disruption. While all critical infrastructure could benefit from such measures, proposed development that would benefit from such measures are the Pier 6 building extension, Pier 5 building extension, Domestic/Common Travel Area Baggage Reclaim facility and the Boeing Hangar;

- In the event that fluvial mitigation measures are overwhelmed in exceptional circumstances, demountable flood defences could be deployed at the new development locations to protect critical infrastructure. The equipment would need to be purchased in advance which may also require enabling works and GAL staff should be trained appropriately in their deployment. However, detailed investigations will be required to look at such mitigation measures to identify and eliminate potential underground flow bypass routes to ensure demountable flood defences will be effective; and

- Regarding the proposed Gatwick Airport Rail Station extension it is noted that a section of the existing Gatwick Stream culvert will be beneath the development. It is recommended that the structural integrity of the culvert is assessed to determine if it would withstand the additional loading, and remain operational for the design life of the proposed rail station extension. The proposed rail station development could be an opportunity to assess the viability of increasing the capacity of the existing culvert, to reduce the risk of blockage and its constriction of flows.

6.8.2 Surface Water Flood Risk Mitigation

Surface water flood risk mitigation measures that could be employed at Gatwick Airport regarding the proposed developments include:

- National and local planning policy requires that new development does not have a deleterious impact upon flood risk. Therefore for all of the proposed developments the proposed surface water drainage systems would need to incorporate attenuation storage (e.g. underground attenuation tank, oversized carrier drains, ponds etc.) to facilitate the restriction of the discharge rates to the existing site conditions

[6] Boeing Aircraft Hangar Gatwick Airport North West Development Zone Planning Statement, Vantage Chartered Town Planning, February 2017

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as a minimum requirement and not increase peak flows offsite, which is likely to require the provision of additional storage;

- There is notable surface water flooding predicted for the 1 in 10 annual chance (10% AEP) event at a number of the proposed development locations. This could potentially indicate the existing drainage system is close to capacity at certain locations in the downstream drainage system. Gatwick should therefore give consideration to increasing the drainage network capacity via additional storage at suitable locations, which given the available space would primarily be below ground;

- The use of green roofs on proposed new buildings (e.g. Pier 6 Extension, Pier 5 building extension, Domestic/Common Travel Area Baggage Reclaim facility, etc.) would potentially reduce the hydraulic loading on the airport surface water drainage system by reducing peak flows from the new development. Soil layers would reduce the rate of runoff to the wider surface water drainage system while a proportion of the intercepted runoff would be lost to the atmosphere through evapotranspiration, reducing the volume entering the surface water drainage system. Safeguarding is an important factor to consider when proposing such elements into a development at Gatwick. Consequently such development proposals would need to be agreed with the Gatwick safeguarding team;

- Provision of a large diameter low level surface water sewer to intercept the various drainage systems at the airport. This would be an expensive option and a major construction project but would improve hydraulic performance and collection of surface water runoff and would provide long-term benefits to Gatwick;

- For high intensity, short duration storm events, e.g. 1 in 100 annual chance (1% AEP), 30 minute duration, it is likely that surface water drainage collection areas would be overwhelmed due to the high rate and runoff volumes. To account for such a rare occurrence proposed development critical infrastructure should be made resilient to such surface water flooding. Resilience measures could include raising building thresholds above flood levels, raising electrical equipment above flood levels, etc.);

- For locations such as car parks, pedestrian footpaths, etc. that are not subject to de-icer use or other potentially harmful contaminants there is a possibility to install pervious paving. In suitable ground conditions they would permit infiltration of rainfall to ground thereby reducing runoff to the surface water drainage system. Where ground conditions are not appropriate for infiltration pavement sub-base layers could be surrounded with impermeable liner to provide attenuation storage prior to discharge to the surface water drainage system;

- A number of the proposed development footprints are crossed by existing surface water drainage systems (see Appendix F). In such cases the hydraulic capacity and structural integrity of these existing drainage systems will need to be assessed such that they cope with climate change, withstand the loading from the proposed developments and achieve the proposed design life;

- It is noted that the footprint of the proposed Multi-Storey Car Park (MSCP) 7 development is crossed by a large (approximately 3m) diameter surface water sewer which conveys runoff from a large part of the airport to Pond D. Pond D is the most critical surface water drainage pond in the network and it would be advisable to avoid having such a critical asset beneath MSCP 7. Consideration should therefore be given to re-routing the sewer around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewer should be assessed to confirm, that it can withstand the additional loading. The development could have an impact on the ability of GAL to maintain the sewer, which is critical to draining much of the airport;

- With regards to the proposed Boeing Hangar development to mitigate the encroachment of the potential surface water flooding from Taxiway Union a flood bund could be installed to provide a barrier to the flooding encroaching on the site.

A summary table is included in Appendix J which details the fluvial and surface water flood risk initial high level mitigation measures applicable to each of the proposed developments.

6.8.3 Global Best Practice and Innovation

Table 6-2 summarises the findings from a high-level desk study into global best practice and innovation with regards to fluvial and surface water flood risk management primarily from airports and urban areas. The primary innovations are the incorporation of green drainage infrastructure to provide more sustainable drainage solutions; including green roofs, bio-retention areas, permeable pavements, wetland installation, rainwater harvesting, etc. The utilisation of such sustainable drainage methods aids the reduction of runoff rates and volumes, provides runoff treatment (e.g. settle out suspended sediments, etc.), addresses climate change with a holistic approach and enhances biodiversity.

Table 6-2: Innovative Flood Management Measures

Sustainable Flood Management/Innovation	Description	Source / Application Location
Rainwater Harvesting	This source describes the potential for the use of rainwater harvesting at Schiphol Airport. Roof surfaces at Schiphol Airport would be used to collect rainwater which can then be stored and used for non-potable water uses at the airport (e.g. plane washing, toilet flushing, etc.). This would also reduce direct runoff to the surface water drainage system (Kuller, M., Dolman, N., Vreeburg, J.H.G. & Spiller., M., 2016).	Airport – Amsterdam Airport Schiphol (EU)
Green Drainage Infrastructure & Rainwater Harvesting (Water Vision Schiphol 2030)	The "Water Vision Schiphol 2030" study (Royal HaskoningDHV, 2014) is an exploration and adaptation strategy to create a strong and resilient Amsterdam Airport Schiphol. Actions in studies underway from flood risk/water use standpoint include: (i) Maximising the installation of green infrastructure and sustainable drainage systems to manage surface water runoff; (ii) Growing vegetation and developing water storage facilities which are favourable from an ecosystems and biodiversity perspective but are not attractive to birds; Rainwater harvesting for decrease use of potable water in toilet flushing and fire-fighting (and reducing direct runoff to the surface water drainage system).	Airport – Amsterdam Airport Schiphol (EU)
Sustainable Drainage – Infiltration Methods	At Munich Airport the rainfall runoff from buildings, roads, flight operation areas and other paved surfaces that collects over large areas or in drainage channels is permitted to soak into the ground onsite, preferably using soakage facilities near the surface such as pits or trenches. The surface water is filtered through the infiltration process, ensuring protection of groundwater (Munich Airport, 2017).	Airport – Munich (EU)
Large Surface Water Interceptor Sewer	This source describes the Copenhagen Airport "Water Motorway" which is a potential 2 to 3 kilometre long deep sewer under the airport which would lead water away from the wider drainage network to a pumping station on the coast by the Oresund Sound (Ministry of the Environment and Food of Denmark, 2014).	Airport – Copenhagen (EU)
Sustainable Drainage – Infiltration Methods	In 2016 Luton Airport installed a new surface water treatment system, the first of its kind in the UK. The system combines SuDS measures and attenuation tanks with vortex separation to remove substances such as suspended particulate matter in addition to oils and de-icing chemicals adhered to suspended particulate matter from the water to mitigate pollution. The remaining surface water is then directed into one of three receptors: Luton Hoo Lake, the River Lea and an	Airport – London Luton (EU)

	underlying Chalk Aquifer (i.e. groundwater recharge – sustainable water disposal) (Brockett, J., 2016).	
Green Drainage Infrastructure (e.g. Biofiltration planters, car park biofiltration units, etc.)	This source explores the use of green infrastructure for drainage at Hartsfield Jackson Atlanta International. A goal of the airport is to adopt the City of Atlanta's policy to use green infrastructure and runoff reduction practices that require the first 1.0" (≈25mm) of rainfall to be managed on-site. Proposed projects include the use of biofiltration planters, biofiltration on car parking units and implementing tree wells for existing parking areas (i.e. reduce paved area) (Emanuel, B. & Sattler, P., 2015).	Airport - Hartsfield Jackson Atlanta International (USA)
Green Drainage Infrastructure (e.g. green roofs, permeable pavements, etc.)	At Chicago O' Hare Airport they have undertaken a project in the South Cargo area to use more green infrastructure methods for surface water drainage. This includes five green roofs and three permeable pavement car parks (i.e. infiltration) to contribute to the volume control and treatment of the surface water runoff. The vegetated green roofs are especially effective in Chicago at limiting runoff because of the local rainfall characteristics (i.e. vegetated green roofs evapotranspirate and absorb up to 25mm of rainfall. Given local rainfall characteristics 90%-95% of precipitation falling on the green roofs never reaches the drainage system (Antonoglu, E., 2017).	Airport - Chicago O'Hare International (USA)
Sustainable Drainage – Infiltration Methods	Los Angeles International airport is proposing a $40 million project to treat pollution in millions of gallons of surface water runoff (i.e. presently large volumes of contaminated surface water discharge to Santa Monica Bay). A large volume of the runoff could be discharged to an underground storage facility and subsequently pumped to infiltration galleries. The soil will filter the runoff naturally and the treated water will discharge to the aquifer recharging groundwater reserves, and reducing the need for a surface water drainage network (Morin, M., 2015).	Airport - Los Angeles International (USA)
Green Drainage Infrastructure (e.g. permeable pavements, etc.)	As part of San Francisco International Airports Sustainability Plan (Esmaili, H., 2013) they propose the use of permeable pavements where soil conditions are appropriate for car parks, footpaths, etc. Permeable pavements would reduce the rate of runoff (i.e. percolate through the pavement and into soil to recharge groundwater).	Airport - San Francisco International (USA)
Green Drainage Infrastructure (e.g. Bio-retention areas, etc.)	Chattanooga Airport is helping the local community revitalize their land. The airport purchased two abandoned car parks within the airport's Runway Protection Zone. Collaborating with Chattanooga city, the land was used to tackle surface water flooding locally. The project demonstrated how to prevent surface water entering the city's sewer system using green infrastructure. The project improved the soil, levelled the land to mimic natural water patterns, created bio-retention areas to hold surface water and recreated vegetation cover whilst extending the airport's Runway Protection Zone. The project received the 2013 Governor's Environmental Stewardship Award for sustainable performance (Chattanooga Airport, 2017).	Airport - Chattanooga Airport (USA)
Green Drainage Infrastructure (e.g. swales, attenuation	The aim of the Llanelli RainScape project (Welsh Water, 2017) is to reduce the amount and rate of runoff to the Llanelli sewer system reducing flood risk. The innovative surface water management techniques, developed in partnership with Carmarthenshire County Council, include installing attractive planted areas and green space	Urban Area – Llanelli (UK)

ponds, permeable pavements, etc.)	that will absorb water (e.g. during a rain event a swale can collect the water, let it gradually seep into a below ground storage unit, before releasing it to the surface water drainage network. A series of other projects including other forms of green drainage infrastructure (e.g. attenuation ponds, etc.) are proposed throughout Llanelli to reduce runoff rates.	
"Blue" Urban Corridors	A Croydon Council report titled "Developing Urban Blue Corridors - Scoping Study" (URS Corporation, 2011) describes the concept of urban blue corridors. Urban Blue Corridors encompass the idea that both new and existing development within the urban environment is planned around watercourses, overland flow paths and surface water ponding areas creating a network of urban corridors designed to facilitate natural hydrological processes whilst minimising urban flooding, enhancing biodiversity and helping to adapt to climate change. 'Urban Blue Corridors' is the collective name (and linking mechanism) for interconnecting features including, but not limited to, overland flow paths, ponding areas, rivers and canals, wetlands, flood storage areas, historic river channels, floodplains, etc.	Urban Area – London Borough of Croydon (UK)
"Blue – Green" Drainage Solutions	Nature Based Solutions (NBS) – green infrastructure installations such as green roofs, tree wells and swales can yield multiple urban benefits. These include reduction of water and air pollution, mitigation of flood risk and heat islands, as well as provision of areas for recreation and urban agriculture. The Blue Green Solutions Guide (Bozovic, R., Maksimovic, C., Mijic, M., Smith, K.M., Suter, I. & van Reeuwijk, M., 2017) presents the innovative, systematic framework created by Imperial College London researchers, with the support of Climate KIC (the EU's main climate innovation initiative), to harness the power of NBS to deliver attractive cities and developments that are resilient (including surface water flood risk), sustainable and cost-efficient.	Urban Areas – Research Guidance from Imperial College London (UK)
Natural Fluvial Flood Management – Slowing the Flow at Pickering	This study based at Pickering (North Yorkshire) looks at how changes in land use and land management can help to reduce fluvial flood risk (i.e. can be investigated for River Mole, Gatwick Stream, etc.). The overall aim of the project was to demonstrate how the integrated application of a range of land management practices can help reduce fluvial flood risk at the catchment scale, as well as provide wider multiple benefits for local communities. Mitigation measures assessed include the planting of riparian woodland to reduce runoff from land, provision of woody dams to attenuate flow volumes, planting woodland to improve infiltration of water to the soil, etc. (Forest Research, 2017).	Urban Area – Natural Fluvial Flood Management Research

6.9 Flood Risk Management Strategy

The review of the development proposals for Gatwick and global best practice has identified a number of features that Gatwick should give consideration to including in their management of flood risk over the next decade and beyond.

6.9.1 Flood Risk Management Strategy

GAL should develop a strategy that covers all aspects of flood risk management at Gatwick. The strategy would provide a framework for new development and the mitigation of flooding to the existing airport. The new

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developments present opportunities to consider them as a whole, measures at one development may be able to mitigate for the impacts of another thereby reducing the cost and future maintenance requirements at the airport.

In particular it is recommended that an airport-wide surface water drainage strategy is developed. This is to facilitate the effective management and disposal of surface water to minimise surface water flood risk to Gatwick Airport as opposed to addressing surface water management on a piecemeal basis as and when new developments are required. An airport-wide surface water drainage strategy should look to the future at potential developments and plan ahead with regards to attenuation storage and discharge arrangements (e.g. minimising pumping). The potential use of infiltration methods across the airport should also be investigated as a means of surface water disposal. Surface water disposal via infiltration is the preferred method by the Environment Agency (EA) as it reduces direct surface water runoff to the main surface water drainage system and recharges groundwater. As an example, a large project requiring significant capital investment such as a potential second runway is a prime opportunity to think strategically about surface water management. A large diameter low level surface water relief sewer could be investigated to intercept the majority of surface water drainage at the airport. Such a low level surface water relief sewer could provide additional attenuation storage capacity and minimise the requirement for local pumping from individual developments (i.e. a low level sewer would enable development to drain by gravity with pumping utilised within the low level sewer to discharge to nearby treatment facilities and/or local watercourses). Equally a large diameter low level surface water relief sewer could also be investigated for the existing single runway Gatwick Airport to intercept the existing surface water drainage systems.

6.9.2 Strategic Approach

Reviewing where the new development is proposed may reduce the mitigation required. For example it may be possible to provide all the mitigation for the proposed developments in the Pond D catchment at one location thereby reducing the scale and extent of mitigation works.

6.9.3 Standard of Protection

The existing standard of flood protection provided at the airport varies. Under national planning policy future development needs to be safe for users for its lifetime, including the consideration of climate change. In 2011, the UK Cabinet Office produced a report: "Keeping the Country Running: Natural Hazards and Infrastructure" which provided guidance to improve the resilience of critical infrastructure and essential services. This document noted that there is no national standard for the resilience of infrastructure in the UK. The report also refers to recommendations from the Pitt Review (2007) which highlighted concerns about the existing level of resilience of critical infrastructure to disruption as a result of flooding, which is considered to be the greatest natural hazard to the UK. The Pitt Review concluded that: "*for the purposes of building resilience in the critical infrastructure, a minimum standard of 1 in 200 (0.5%) annual probability would be a proportionate starting point [for all forms of flooding]*".

The Cabinet Office report (2011) also states:

"The flood resilience standard, as suggested in the Pitt Review, provides a useful aspiration and guide to longer term planning and investment beyond regulatory price reviews and investment cycles. But the standard should be viewed in terms of the broader approach to resilience consisting of the components of resistance, redundancy, reliability, response and recovery. Thus a more useful benchmark is that "as a minimum essential services provided by Critical National Infrastructure (CNI) in the UK should not be disrupted by a flood event with an annual likelihood of 1 in 200 (0.5%)". Infrastructure owners and, where relevant, regulators should consider the cost/benefits of individual projects when determining which projects to fund and whether they can achieve this resilience standard for flooding. Actual levels of resilience for CNI should be monitored through the Sector Resilience Plans".

Therefore, with specific regard to a suitable design standard for safe, continued operation of Gatwick Airport during a flood, it is recommended that the minimum design standard is the 1 in 200 annual chance (0.5% AEP) event for critical infrastructure.

6.9.4 Drainage Network Review

GAL should undertake a review of the surface water drainage network to identify potential efficiencies and redundancy. For example at present water is potentially pumped numerous times before leaving the airport, minimising pumping would reduce energy consumption.

Alongside potential benefits to water quality, treating de-icer use at source could reduce the pollutant load to the drainage ponds. The provision of SuDS measures throughout the airport and integrated into new development would also increase the quality of the runoff entering the drainage ponds, thereby increasing the volumes that could be discharged from the airport directly without additional treatment and reducing pumping requirements.

As part of this review GAL should also identify areas of the airport that could be designated to sacrificially store flood waters on the ground surface. These would be less critical areas that could temporarily store flood waters, returning the water to the drainage system when downstream levels recede. Opportunities could include car parking areas during winter when passenger numbers are lower.

6.9.5 Critical Infrastructure Resilience

GAL are currently progressing a review of critical infrastructure, this should be progressed to undertake works to make the airport resilient to a suitable standard of flood protection.

6.9.6 Unused Impermeable Area

GAL should undertake a review of their existing impermeable areas to determine if any could be removed and returned (for example) to grassland which would reduce runoff to the surface water drainage system. This would benefit the system by reducing the rate and volume of runoff.

6.10 Conclusions

The Phase 1 Water Masterplan report identified fluvial (river) and surface water (from exceedance of the surface water drainage system capacity) as the primary sources of flood risk to Gatwick Airport. This Phase 2 Masterplan report has therefore assessed the fluvial and surface water flood risk to the proposed developments associated with the Gatwick Masterplan and identified measures that could be adopted by GAL to manage future flood risk at the airport.

Regarding fluvial flood risk the flood extents from the Gatwick Stream impacts on the following proposed developments:

- Pier 6 Extension – the proposed Pier 6 Extension development is impacted by the 1 in 100 annual chance (1% AEP) and the 1 in 100 annual chance (1% AEP) event plus 20% climate change uplift fluvial flood extents;
- Quebec Taxiway Realignment – the proposed Quebec Taxiway Realignment development is impacted by the 1 in 100 annual chance (1% AEP) event plus 20% climate change uplift fluvial flood extents;
- A380 Stand Relocation to Pier 5 – the proposed A380 Stand Relocation to Pier 5 development is impacted by the 1 in 100 annual chance (1% AEP) event plus 20% climate change uplift fluvial flood extents; and
- Domestic/Common Travel Area Baggage Reclaim facility – the proposed Domestic/Common Travel Area Baggage Reclaim development is impacted by the 1 in 50 annual chance (2% AEP), 1 in 75 annual chance (1.33% AEP), 1 in 100 annual chance (1% AEP) and the 1 in 100 annual chance (1% AEP) event plus 20% climate change uplift fluvial flood extents.

The proposed Push and Hold Stands, Long Stay Car Parking facility, Multi-Storey Car Park 4, Multi-Storey Car Park 7, South Terminal Car Rental facility and the Gatwick Airport Rail Station Extension are outside the fluvial flood extents from the Gatwick Stream up to and including the 1 in 100 annual chance (1% AEP) plus 20% climate change uplift event.

The fluvial flood extents from the River Mole for the 1 in 75 annual chance (1.33% AEP), 1 in 100 annual chance (1% AEP) and the 1 in 100 annual chance (1% AEP) plus 20% climate change uplift impact on the Boeing Hangar development. The proposed Remote Parking Stands and Taxiway Lima developments are located marginally outside the fluvial flood extents from the River Mole up to and including the 1 in 100 year annual chance (1% AEP) plus 20% climate change uplift. However, the potential fluvial flooding from the River Mole on Taxiway Union could impact accessibility to the proposed Remote Parking Stands and proposed Taxiway Lima depending on the flood depths.

The majority of the proposed developments are at risk of surface water flooding due to their proximity to the extensive surface water drainage system serving Gatwick Airport the capacity of which is exceeded for the 1 in 10 annual chance (10% AEP) event. It is evident that the surface water drainage systems serving the existing car parking facilities in the vicinity of the proposed Multi-Storey Car Parks 4 and 7, Long Stay Car Parking, South Terminal Car Rental, Remote Parking Stands and Taxiway Lima developments have not been hydraulically modelled. Therefore, the existing surface water flood risk cannot be fully evaluated. Surface water drainage models should be developed for the existing car parking facilities at these locations.

A range of potential mitigation measures have been identified that could address the fluvial and surface water flood risk at Gatwick Airport both within the masterplan timescale of 2028 and beyond. Briefly the flood mitigation measures include the introduction of a hard flood defence along the Gatwick Stream, incorporating flood resilience measures (i.e. building threshold raising, etc.) into proposed developments, employing green drainage infrastructure (e.g. swales, attenuation ponds, green roofs, etc.) to reduce runoff rates and volumes, etc.

6.10.1 Recommendations

In light of the fluvial and surface water flood risk assessment undertaken as part of this Phase 2 Masterplan report the following is recommended to mitigate future flood risk at Gatwick both within the next decade and beyond:

- The current EA climate change guidance is incorporated into both the fluvial and surface water hydraulic models and simulations undertaken to confirm predicted future flood risk;
- The assessment of flood risk to and from the proposed Gatwick Masterplan developments is revisited once the hydraulic models are amended of Jacobs findings documented in the report titled "Gatwick Resilience Review" (Jacobs, 2016 - Report No. GADD001A_1) and incorporated the current EA climate change guidance;
- Surface water drainage models are built for any existing car parking facilities within the vicinity of the proposed developments to enable the full evaluation of surface water flood risk and determination of allowable discharge rates;
- The existing Gatwick Airport surface water drainage model held by CH2M should be updated with the relevant comments from the flood resilience review undertaken by Jacobs titled "Gatwick Resilience Review" (Jacobs, 2016 - Report No. GADD001A_1) which documents Phase 1 of the hydraulic model reviews;
- GAL should continue to collaborate with the EA and Lead Local Flood Authority (LLFA) to identify and progress flood mitigation measures that would benefit the airport and local communities. For example, works in Ifield, the Withy Brook and the River Mole. Such measures could include increases to the discharge capacity of Pond D and in turn reduce the risk of surface water flooding to the airport;
- The viability of collected surface water runoff disposal via infiltration methods should be examined as part of the Flood Risk Assessment (FRA) and surface water drainage strategies required for each development. Disposal of clean surface water via infiltration methods is preferred by the Environment Agency (EA) as it mirrors natural drainage process: delaying discharge to nearby watercourse by encouraging infiltration through the ground formation and recharges local groundwater. The constraints to delivery of such measures could be assessed within the timescale of this Masterplan;

- The provision of flood defences along the River Mole immediately downstream of the culvert under the runway should be investigated. Flood defences like those mentioned for the Gatwick Stream could reduce the risk of fluvial flooding to the proposed Boeing Hangar, Remote Parking Stands and Taxiway Lima developments. It could also reduce the fluvial flood risk to the existing Taxiway Union;

- A number of the proposed development footprints are crossed by existing underground surface water drainage systems. As part of each proposed development work package the hydraulic capacity and structural integrity of the existing surface water drainage at the affected locations will need assessment. This is to ensure its adequacy over the design life of the proposed developments planned as part of the Gatwick Masterplan;

- GAL should review and update their flood resilience technical standards to meet current national Standard of Protection guidance; and

- A portion of the existing Gatwick Stream culvert will be covered by the proposed Gatwick Airport Rail Station Extension. The structural integrity of the Gatwick Stream should be assessed to understand its ability to withstand the construction loading and its ability to last the design life of the proposed Rail Station Extension. This could also be an opportunity to assess the viability of replacing and upsizing the Gatwick Stream culvert to improve flood risk upstream.

- An airport-wide flood risk management strategy should be developed. This is to facilitate the effective management of flood risk from all sources (i.e. fluvial, surface water, groundwater, reservoir failure, etc.) to minimise flood risk to Gatwick Airport as opposed to addressing flood risk management on a piecemeal basis as and when new developments are required and to identify opportunities to reduce pumping within the surface water drainage system. For example, an airport-wide surface water drainage strategy should look at future potential developments and plan ahead for the use of infiltration measures or attenuation storage and discharge arrangements (e.g. minimising pumping) as appropriate for the geology.

7. Future Local and National Planning Policy

A summary of how compliance standards may change in the near term is included in Appendix H. In brief emerging national policy documents such as the call for evidence for the future of aviation strategy and the emerging Aviation National Policy Statement are not expected to lead to a change in standards. Recommendations are made for the emerging masterplan based on existing policy approaches.

Crawley Borough Council adopted their Local Plan to 2030 in December 2015 and subsequently adopted a Planning and Climate Change Supplementary Planning Document (SPD) in October 2016. Their Local Development Scheme (LDS) for the period 2015-2018 refers to an update of the Gatwick Airport SPD in 2017, but there is no evidence of progress with this. The draft of the next LDS is expected in September 2017 and GAL should monitor this. Mole Valley and Tandridge District Council have not progressed to new Local Plans and these will need to be monitored. Reigate and Banstead and Mid Sussex have emerging Local Plans which do not appear to raise new issues.

It is understood that BREEAM standards are likely to be updated in Spring 2018 and work on new climate change projections may also emerge in 2018 – see Section 6.5, which may change the planning requirements for future management of water at Gatwick

8. Conclusion

8.1 Water Use Forecasts

Historic data from 2012-16 has been analysed to generate a trend for water consumption which has been applied to the GAL growth forecasts to estimate future water demands in 2020 and 2028 at Gatwick.

The forecast water consumption in 2020 is estimated to be 764,446m^3, which is higher than any of the previous years, apart from 2010. This is a 20% reduction of the consumption in 2010 and compares to the target launched in the Decade of Change Report in 2010 of a 20% reduction, but which has now been stretched to 25% to spur further water efficiencies as the airport grows. The 2020 forecast suggests that this target will not be met.

The business as usual (without proposed infrastructure changes) water use forecast in 2028 is estimated to be 741,987m^3, an increase of 11,843 m^3 against the BAU figure of 2020.

The forecast water consumption in 2028 is estimated to be 786,052 m^3, but with a further unit consumption of less than 14 l/pax based on the proposed asset changes at Gatwick. The consideration of the Boeing hanger is a significant sensitivity; its impact has been based on assumed figures from the operation of the Virgin hanger.

8.2 Water Efficiency

There is potential to make improvements in water efficiency at Gatwick.

With unaccounted for water, leakage and building water wastage amounting to 50% of supply, it is recommended to focus on these areas first, with rainwater harvesting being considered for large existing buildings and all new buildings.

In summary the recommended actions are:

- Inspect and survey all facilities where meters are not working, or not being read and replace as required and add to reading schedule. Consider the re-introduction of ARM meters for facility sub-meters;
- Monitor nightlines after improved metering and compare against UFW to help separate the quantify the extent of leakage from building water wastage;
- Conduct an inspection survey of toilets in older buildings to check on urinal controls, and other potential sources for water wastage, outside taps, roof tank overflows, isolate unused buildings, etc.;
- Carry out enhanced leakage surveys, consider feasibility and benefits of:
    - Step-testing areas,
    - Widespread use of an array of acoustic noise loggers,
    - Use of leak noise correlators to find and repair leaks,
    - Pressure reduction in mains network, using modulate Pressure Reducing Valves (PRVs), with protection measures and contingencies for emergency water demands; and
- Consider Rainwater Harvesting for large buildings and all new buildings.

8.3 Foul wastewater

It is recommended that the flow meter in the main sewer from the South Terminal and East or Rail, believed to be 400mm size, is repaired or replaced. Further it is recommended that GAL consider a project to not only install a new flow meter in the Police Station main sewer, but also to connect all flowmeters to dataloggers at the main sewage pump stations PS 3, PS 7, PS 24 and any other location of particular interest.

Subsequently GAL will be able to interrogate sewer flows, diurnally as well as weekly, this will provide a powerful tool in determining the sewer nightflows.

8.4 Water Quality

Due to the predicted increase in ATMs at Gatwick de-icer usage has been predicted to increase from the current 1,080,000 litres/yr to around 1,190,000 litres/yr in Scenario 1 (airport growth model C55-53) or 1,240,000 litres/yr in Scenario 2 (airport growth model C60-C55) by 2028.

Pavement de-icer usage is also likely to increase to 2028 due to new developments at the airport increasing the amount of hardstanding requiring de-icing. The increase will be of around 15,000 litres/yr from a current average of 1,270,000 litres/yr to a predicted 1,280,000 litres/yr. This could lead to increased COD loading and consequently an increased potential for BOD exceedances. Four options were considered to project future COD loading to the surface water drainage system, it is understood they are presently in their early stages of implementation, but Jacobs has projected that COD load could reduce by 44-46% by 2028.

It is recommended that consideration of a selection of options are taken forward for quantitative assessment of cost, lead-in times and land take, and this should be balanced against the impact on water quality for consideration by GAL.

8.5 Flood Risk and Surface Water Management

The primary sources of flood risk to Gatwick are fluvial (river) and surface water (from exceedance of the drainage network capacity). Based on hydraulic modelling Gatwick Airport is considered to be at risk of fluvial flooding on average between the 1 in 20 annual chance (5% AEP) and the 1 in 50 annual chance (2% AEP) events. The airport is served by an extensive surface water drainage network which would be overwhelmed by extreme rainfall events, which is predicted to flood on average for the 1 in 10 annual chance (10% AEP) event. The location at highest risk of surface water flooding is the North Terminal.

Flood risk from both fluvial (river) and surface water sources is predicted to increase within the next ten years as a result of climate change if no mitigation measures are implemented. Such an impact would increase beyond the life of this masterplan.

A number of the proposed developments at Gatwick would be at risk of fluvial flooding from the 1 in 100 annual chance (1% AEP) event:

- Pier 6 Extension;
- Quebec Taxiway Realignment;
- A380 Stand Relocation to Pier 5; and
- Domestic/Common Travel Area Baggage Reclaim facility.

The majority of the proposed developments are at risk of surface water flooding.

A range of potential mitigation measures have been identified from other airports and industries.

It is recommended that GAL develop an airport-wide flood risk management strategy in order to coherently direct the management of flood risk from all sources and minimise flood risk to Gatwick Airport as opposed to addressing flood risk management on a piecemeal basis as and when new developments are required. Such an approach would also identify opportunities to reduce pumping within the surface water drainage system.

Appendix A. Data Sources

A.1 Water Consumption and Waste Water

Water Data

In addition to the data provided during Phase 1, GAL also provided:

- Water meter data to end of June 2017 for all SES fiscal meters and GAL sub-meters,
- Water meter diurnal flow readings and charts for SES 6No. ARM fiscal meter up to 25th July 2017
- Wastewater meter data for PS3 and PS7 for 2010 to 2016.
- Wastewater meter data for PS24 for 2011 to 2016.

Passenger Numbers

Decades of Change 2015 Performance Summary Report.

Traffic by Terminal May 2017.

Forecast Passenger Numbers

Primary forecasts both scenarios. Scenario 1 is taken from ICF Masterplan Outputs C55-53 (09.06.17) and Scenario 2 taken from ICF Masterplan Outputs C60-55 (09.06.17).

Future Asset Changes

Meeting with Gatwick staff on 5/7/17 – Clare Belsey, Doug Waters, Martin Bilton, Stephen Fuller & David Livesley.

2017 CIP Projects.

A.2 Flood Risk and Surface Water Management

The data utilised for the assessment of flood risk was primarily obtained during Phase 1, via a site visit and a number of meetings with personnel from GAL and CH2M. The key data and documentation provided by GAL which has been used is as follows:

- PowerPoint presentation titled *"Gatwick Airport Master Plan Production Workshop"* delivered by GAL on the 4 May 2017 which at a high level describes the proposed developments likely to pursued as part of the Gatwick Masterplan – Obtained Phase 2;

- Planning application drawings for the proposed Boeing Hangar development which are also available on the Crawley Borough Council website at the webpage below. Drawing No's: 777-D5A-00-XX-DR-A-010-0002 and 777D5A-00-XX-DR-A-010-003 - Obtained Phase 2;

  http://www.crawley.gov.uk/pw/Planning_and_Development/Planning_Permission___Applications/Planning_Applications_Search/index.htm?accept=Search&pRecordID=41441&pApplicationNo=0116&pAD=yes&pAppNo=CR/2017/0116/FUL

- A report drafted by Gatwick Airport Station Development (GASD) team titled "Gatwick Airport Station Development - Single Option Concept Report" (Gatwick Airport Ltd, 2016 - Report No. 142637-COT-REP-EAR-000001) which describes the concept design for the proposed Gatwick Airport Rail Station Extension – Obtained Phase 2;

- Layout drawings illustrating the location of various structures and taxilane/stand identification across Gatwick Airport (i.e. GAL Drawing No's: GALGDTMM-000030Z00001 and GALGDTMM-000031Z00001) – Obtained Phase 2;

- Fluvial and surface water flood risk information from the EA website at https://flood-warning-information.service.gov.uk/long-term-flood-risk/risk?address=10091951274 - Obtained Phase 2;

- Data included on the Gatwick SAFE GIS system (viewed June/July 2017) – Phase 2;

- Surface water and fluvial modelling outputs (i.e. flood extents) from the CH2MILL hydraulic models – Obtained Phase 1;

- CH2M draft model build and calibration report, Upper Mole Flood Modelling Study (CH2M, 2015) – Obtained Phase 1;

- Layout drawings and GIS data (i.e. shapefiles, base mapping, etc.) illustrating the airport layout, the location of existing infrastructure, pond locations, surface water drainage system layout, etc. Obtained Phase 1;

- Report documenting the Christmas 2013 flood events at Gatwick Airport titled "Disruption at Gatwick Airport Christmas Eve 2013" (McMillan, 2014) by David McMillan – Phase 1; and

- Report drafted by Jacobs titled "Gatwick Airport – Flood Resilience Review" (Jacobs, 2016) which details a high-level review of the CH2M hydraulic models undertaken by Jacobs in order to understand the existing flood risk posed to Gatwick Airport, understand the infrastructure at risk of flooding, with particular attention to infrastructure critical to airport operations and comment on the surface water and fluvial flood risk, and proposed measures to address the flood risk.

A.3 Water Quality:

In addition to the data provided at Phase 1, GAL provided a record of the types and volume of pavement de-icer annual usage from 2004-2013 (spreadsheet entitled Use Comparison 2013).

Jacobs also downloaded technical datasheets for the different types of de-icer used to establish COD loads.

Appendix B. Assumptions

B.1 General

- It is assumed the data provided by GAL is complete, correct and reflective of full airport operation.

2017 Forecast Annual Consumption

- It is assumed that the average monthly breakdown percentage for 2011 to 2016 is reflective of what can be expected for 2017.

Trend Lines

- The forecast is based on historic trends. A deviation or step change from these will impact the forecast; and
- The predicted trend is based upon a forecast annual consumption for 2017. If actual consumption differs from predicted, the trends may vary. As such a review of this forecast could be considered post 2017 when actual data is available.

Future Asset Changes

- Asset changes are limited to those listed in Section 2.5.1;
- It is assumed the listed asset changes are additional to business as usual operations;
- Floor areas of new build assets are as those provided in the 2017 CIP project slides;
- The asset changes will take place either pre 2020 or post 2020 as provided;
- Boeing Hangar. Consumption per m^2 is assumed to be similar to the existing Virgin Hangar, taken from FY16/17;
- Pier 6 Extension. Consumption per m^2 is assumed to be similar to the existing Pier 6, taken from FY16/17; and
- Bloc Hotel 2. Consumption is assumed to be similar to the existing Bloc Hotel 1, taken from FY16/17.

B.2 Forecast Water Consumption per Passenger

- The consumptions per passenger given are for the forecast passenger numbers. A change in the passenger numbers may result in a change in the consumption per passenger.

B.3 Waste Water Flow Forecast

- Historical data is incomplete therefore a total wastewater flow is unknown;
- A metered area of the wastewater collection system could not be matched with a metered area of the water supply system therefore a relationship between water usage and wastewater could not be established;
- Total wastewater flow has been assumed to be equal to the total water usage flow and this relationship is assumed to be constant in the forecast;

Water Masterplan 2020 & 2028 Forecast - Full backing report

- The wastewater flow from the North Terminal is known from data from flowmeters at the three pumping stations (PS3, PS7 and PS24) that transfer sewage to Crawley Sewage Treatment Works. However a large proportion of the flow to Horley Sewage Treatment Works from the remainder of Gatwick is not recorded (the Police Station flowmeter). Table 8 shows the relationship between the metered wastewater flow and the total water usage flow;
- The wastewater collection system for North Terminal does not match directly the water supply system for North Terminal therefore a ratio of water usage to wastewater cannot be established by that method;
- In a perfectly isolated water/wastewater system “water-in” equals ”water-out”, however, it is normal to have gains and losses to and from the systems;
- Typical losses include:

  - leakage from pipe joints and cracked pipes

  - water exported by users at the point of delivery

- Typical gains include:

  - infiltration to the wastewater system,

  - water imported by users from off-site,

  - surface water drains connected to the wastewater system.

- The forecast total wastewater flow in the forecast has been estimated by assuming that the ratio between the total water usage to total wastewater flow to the sewage treatment works is 1:1, i.e. wastewater flow is assumed to be equal to the water usage. However this ratio has a very wide band of uncertainty which would be narrowed considerably by the collection of data from the Police Station flowmeter.

B.4 Flood Risk and Surface Water Management:

With regards to the existing surface water drainage system, in Phase 1 of the Gatwick Masterplan Jacobs reviewed the data provided and discussed various aspects with GAL and CH2M. Refer to the report titled “Jacobs Flood Resilience Review” (Jacobs, 2016 - Report No. GADD001A_1) which documents the findings. Phase 1 identified a number of discrepancies in the information provided regarding the existing surface water drainage system which are summarised in Section A4.2 of the Phase 1 report and also pertain to Phase 2. Further assumptions and limitations associated with Phase 2 are as follows:

- Jacobs undertook a review of the CH2M fluvial hydraulic models the findings of which are documented in the report titled “Jacobs Flood Resilience Review” (Jacobs, 2016 - Report No. GADD001A_1). It is understood that CH2M are presently addressing Jacobs findings regarding the fluvial model. Therefore, revised fluvial flood extents are not yet available. This flood risk assessment has been undertaken with the flood extents generated from the hydraulic models prior to Jacobs findings as it is the best flood risk data set available at present;
- The EA climate change guidance was updated in February 2016. Therefore, the +20% adopted in the CH2M fluvial and surface water hydraulic models is superseded and should be amended to match with EA current climate change guidance which will alter the hydraulic model outputs;
- The proposed development footprints are based on those included in the PowerPoint presentation titled “Gatwick Airport Master Plan Production Workshop” delivered by GAL on the 4 May 2017. This information on the proposed development layouts, proposed location on the airfield, etc. has been used

to generate development footprints to facilitate this flood risk assessment. This information from GAL on the proposed development is assumed to be correct and representative of the Masterplan;

- It was evident from this assessment of flood risk that the surface water drainage systems for the existing car parking facilities east of the airfield were not modelled (i.e. no flood extents available). Therefore, the existing surface water flood risk could not be assessed. It is recommended that hydraulic modelling of these car parking facilities is undertaken to inform the flood risk;

B.5 Water Quality

In general, the information provided has been relied upon and presumed accurate. The following assumptions have been made:

Baseline

- The 'worst case' do-nothing baseline has assumed steady recovery rates at historical averages (recovery rate of 20%).
- Climate change has not been factored in, including change in average winter temperature or average rainfall.
- Annual variation in de-icer application has not been factored in to calculations; the predicted COD load can change by a factor of 2-3 depending on winter conditions.

Aircraft de-icer

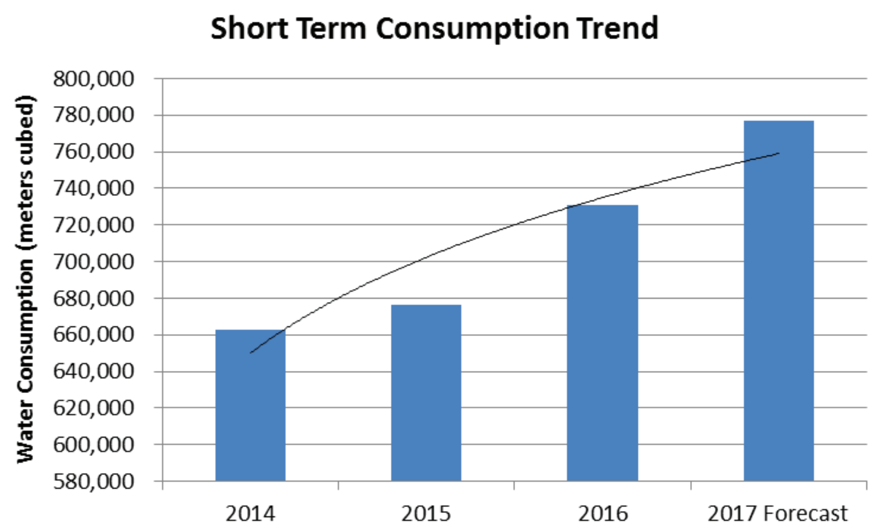
- Aircraft de-icer application is linearly correlated to ATMs.
- Aircraft de-icer used at Gatwick has an average COD of 1.46 kg O2/l. This has been taken from other glycol-based de-icers in use within the industry.
- Improvements in the rate of de-icer recovery will be a rapid change over the first 4-5 years, followed by a steady maximum recovery rate of 40%.

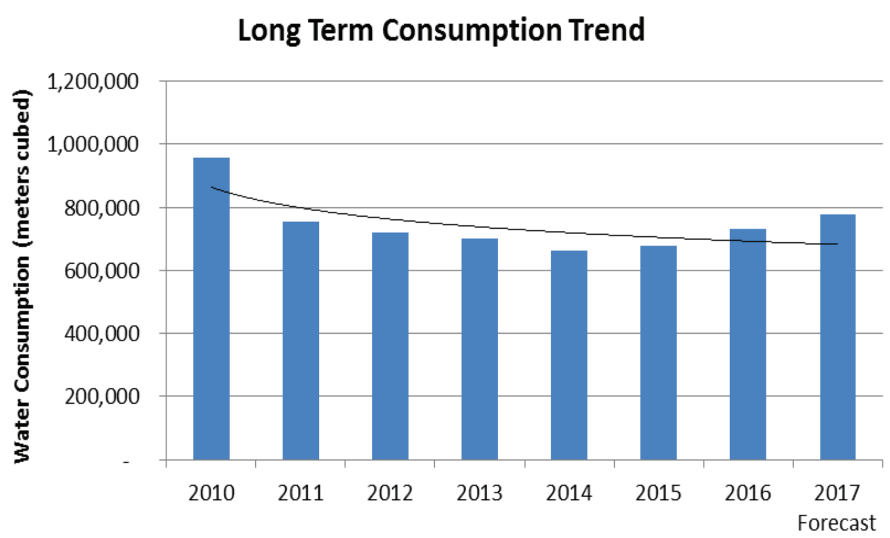
Pavement de-icer

- No change in the percentage of hardstanding de-iced.
- No change in the relative volumes of glycol-based pavement de-icers used.
- The hardstanding increase will happen steadily before 2028.
- It has been assumed that glycol de-icers will be 100% replaced by acetate de-icers, and that this replacement will occur by 2020.
- ECO2 has a COD load of 320 mg O2/l; this has been taken from similar acetate-based de-icers.

Appendix C. Additional Graphs and Tables on Water Consumption Trends

C.1 Trend line graphs

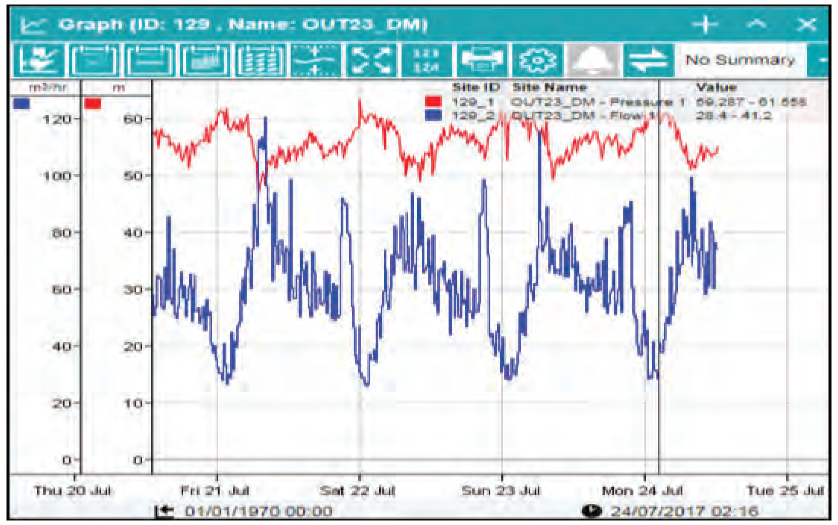


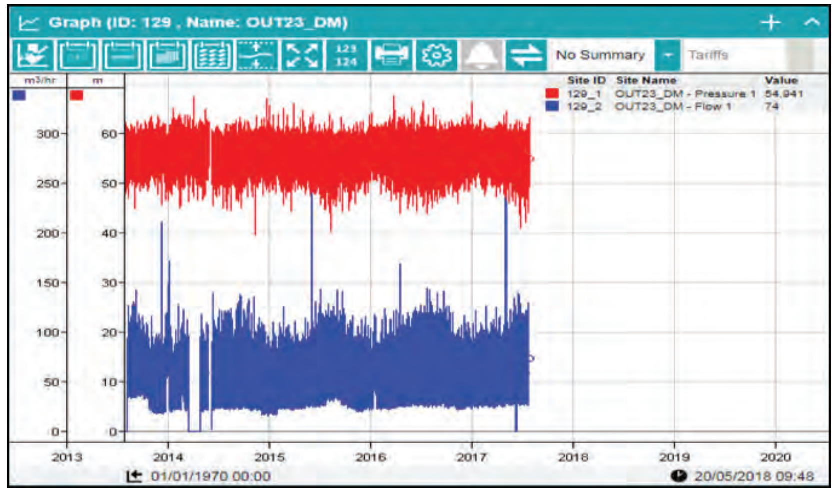


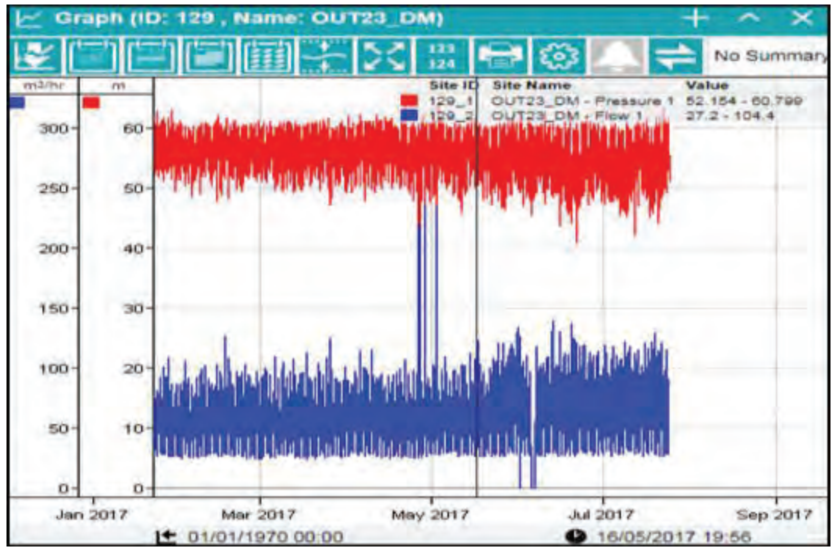
C.2 Medium Term Trendline Results

Trendline	2017	2020	2028
Linear	739,312	773,212	863,612
Polynomial	780,178	1,108,252	3,061,732
Exponential	737,694	772,343	872,907
Power	722,692	730,144	741,987
Linear	724,302	32,024	744,137

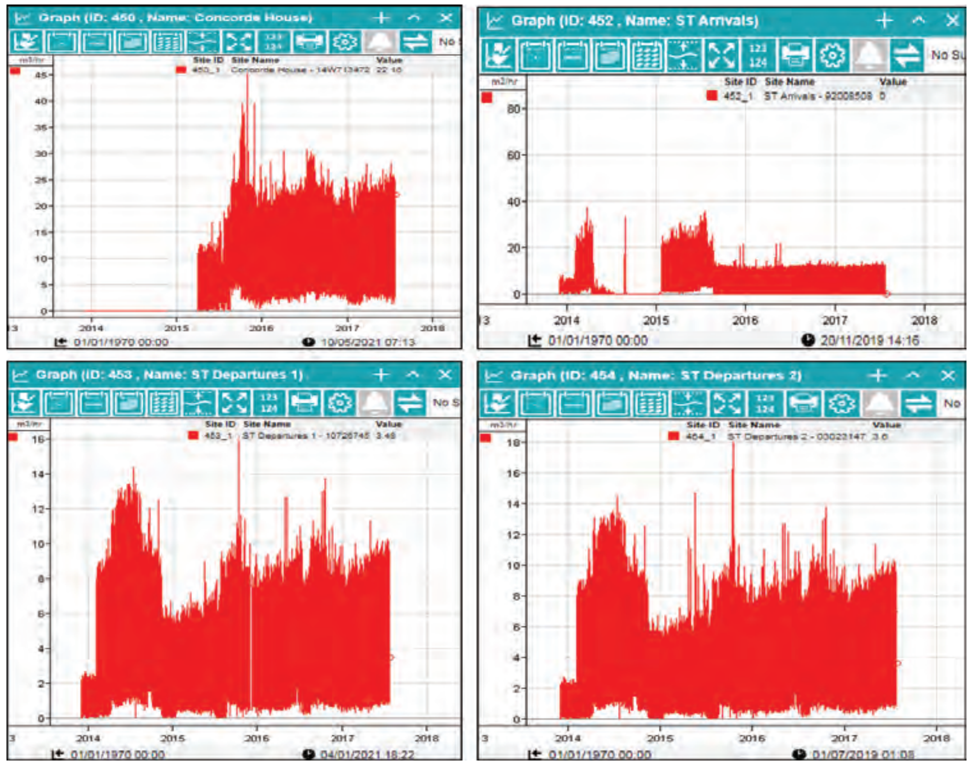
C.3 North Terminal (Povey Cross ARM Meter) Diurnal Water Consumption

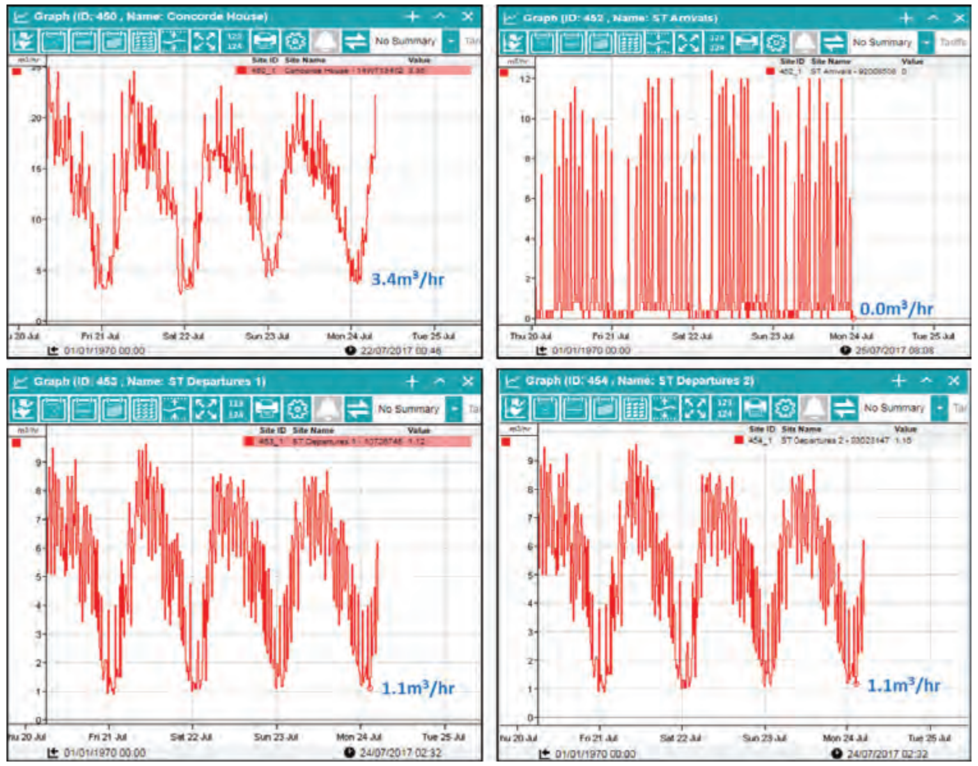




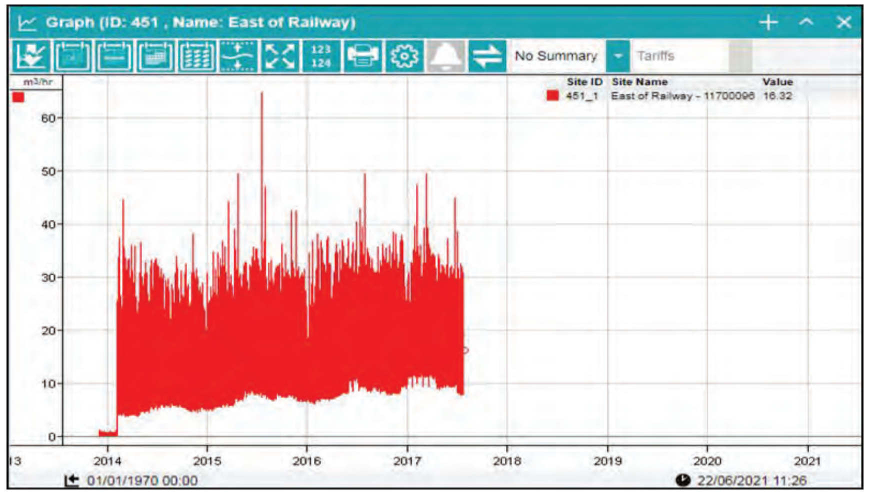


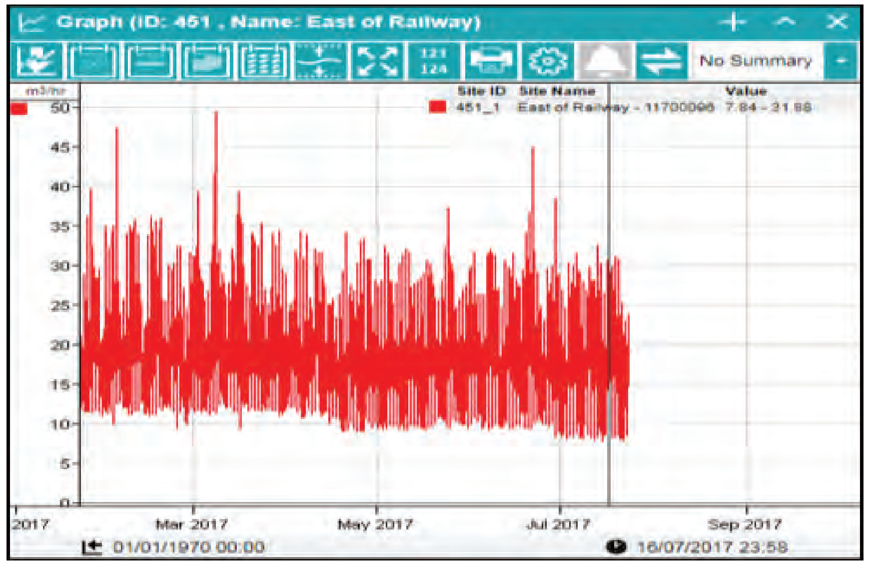
C.4 South Terminal (4No. ARM Meter) Diurnal Water Consumption

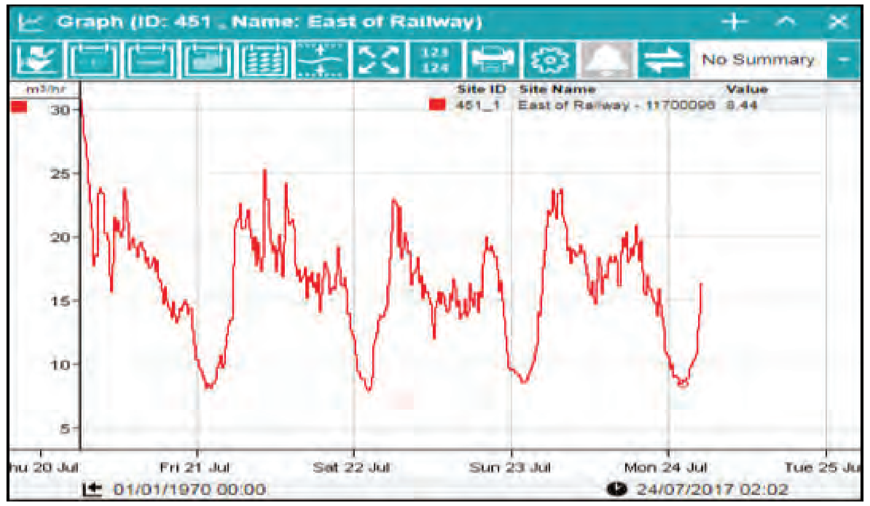




C.5 East of Rail (ARM Meter) Diurnal Water Consumption







C.6 Unaccounted for Water and "Nightline" Analysis by DMA areas

	Apr14-Mar15 2014	Apr15-Mar16 2015	Apr16-Mar17 2016	Current Jul-17		
EAST OF RAIL						
SES Fiscal ARM Meter: Supply	110,683	131,212	143,115			
Total Sub-meters: Consumers		104,708	110,116		24	Total No. of Sub-meters
Unaccounted For Water (m^3/year)		26,504	32,999		5	No. of Sub-meters NOT WORKING
Unaccounted For Water (m^3/hour)		3.02	3.76		21%	% of Sub-meters NOT WORKING
Unaccounted For Water (%)		20.2%	23.1%			
Estimate Average Annual Nightline (m3/h)	5.0	7.0	9.0	8.4		
SOUTH TERMINAL						
4No. SES Fiscal ARM Meters: Supply	189,859	179,949	183,384			
Total Sub-meters: Consumers		33,713	38,026		43	Total No. of Sub-meters
Unaccounted For Water (m^3/year)		146,236	145,358		16	No. of Sub-meters NOT WORKING
Unaccounted For Water (m^3/hour)		16.68	16.58		37%	% of Sub-meters NOT WORKING
Unaccounted For Water (%)		81.3%	79.3%			
Estimate Average Annual Nightline (m3/h)	*missing data - See Fig 3.2*		5.6	5.6		
NORTH TERMINAL (Povey Cross)						
SES Fiscal ARM Meter: Supply	343,053	346,457	381,530			
Total Sub-meters: Consumers		195,555	208,772		94	Total No. of Sub-meters
Unaccounted For Water (m^3/year)		150,902	172,758		26	No. of Sub-meters NOT WORKING
Unaccounted For Water (m^3/hour)		17.21	19.71		28%	% of Sub-meters NOT WORKING
Unaccounted For Water (%)		43.6%	45.3%			
Estimate Average Annual Nightline (m3/h)	28.0	28.0	28.0	28.0		
Total SES Fiscal Bi-annual meters (24 No.): Supply	19,712	19,008	23,198		0	Total No. of Sub-meters

GAL TOTAL	Apr14-Mar15 2014	Apr15-Mar16 2015	Apr16-Mar17 2016	Current Jul-17		
Total SES Fiscal Meters: GROSS Supply	663,307	676,626	731,227			
Total Sub-meters: NET Consumption	338,189	333,976	356,914		161	Total No. of Sub-meters
Unaccounted For Water (m^3/year) (UFW)	325,118	342,650	374,313		47	No. of Sub-meters NOT WORKING
Unaccounted For Water (m^3/hour) [(1)]	37.09	39.09	42.70		29%	% of Sub-meters NOT WORKING
Unaccounted For Water (%)	49%	50.6%	51.2%			
Estimate Average Annual Nightline (m3/h)	*missing data in ST area*		42.6	42.0		
Passenger numbers	38,653,099	40,788,058	43,958,160			
GROSS Water Consumption (l/pax)	17.2	16.6	16.6			
NET Water Consumption (l/pax)	8.7	8.2	8.1			

Note [(1)] Unaccounted for water for 2014 estimated assuming 2.0m3/hr lower than in 2015 - this is based on the changes observed in nightlines from 2014 to 2015.

C.6.1 North Terminal (from Povey Cross Meter):

- Highest nightline over all areas, is approximately 28.0 m^3/hr from 21st to 24th July 2017.
- In 2014 and 2015 some variation in the nightline were observed, between 20 and 30m^3/hr, and with loss of recordings in March and April 2014.
- But the overall trend over the last 3 years shows the nightline relatively flat-lined at about 28m^3/hr, and therefore the leakage in this area has been high.

C.6.2 South Terminal (from 4No. ARM Meters):

- Current nightline for period 21st to 24th July 2017 from the 4 meters is:
  - Concorde House = 3.4m^3/hr,
  - ST Arrivals = 0.0m^3/hr,
  - ST Departures 1 = 1.1m^3/hr,

- ST Departures 2 = 1.1m³/hr,
- Total = 5.6 m³/hr.

- Trends over the last 3 years are variable showing –
  - Concorde House - missing data for all of 2014.
  - ST Arrivals – gaps in data from mid-2014 to January 2015.
  - ST Departures 1 and 2 show variations between 0 and 2m³.hr in 2014 and 2015, but overall at much the same level as current.
  - The similarities between the two graph plots of ST Departures meters 1 and 2 is because the two meters are located in parallel pipes at the same location.

C.6.3 East of Rail:

- Current nightline 21st to 24th July 2017 is approx. 8.4m³/hr,
- Trend since ARM meter recordings started show a steady increase from 4m³/hr in January 2004 to 10m³/hr in January 2017,
- In January 2017 the nightline increased to 12m³/hr, but then reduced to 10m³/hr on or about 18th April then reduced again to approx. 8m³/hr on 28th June. The latter reduction concurs with a leak being found and isolated at the end of June by GAL,
- The rising trend is of concern and suggests that leakage has been increasing over the last 3 years.

Water Masterplan 2020 & 2028 Forecast - Full backing report

Appendix D. Verification of 2020 and 2028 Water Consumption Forecasts

The high level of Unaccounted For Water (UFW) observed on the water supply system suggests that another approach to forecasting future water consumption can be made to the forecasting given earlier in Sections 2.5 and 2.6.

As described above this essentially consists of splitting the water consumption into its two main components:

- Net water consumption – Gross water consumption **less** UFW;
- UFW – Difference between main fiscal supply meters and facility sub-meters.

It is uncertain if all the facilities are adequately metered at this stage, estimates are based on the best available data, summarised at the bottom of Table 3.2.

To verify forecasts using net water consumption, it is assumed that in future the unit net water consumption remains at 8.1l/pax and that UFW continues unchanged at 42.68m³/hour as at present. The results of these forecasts, based on passenger forecast numbers for scenarios 1 and 2 in passenger forecasts is given in Figure 8-1 and Figure 8-2.

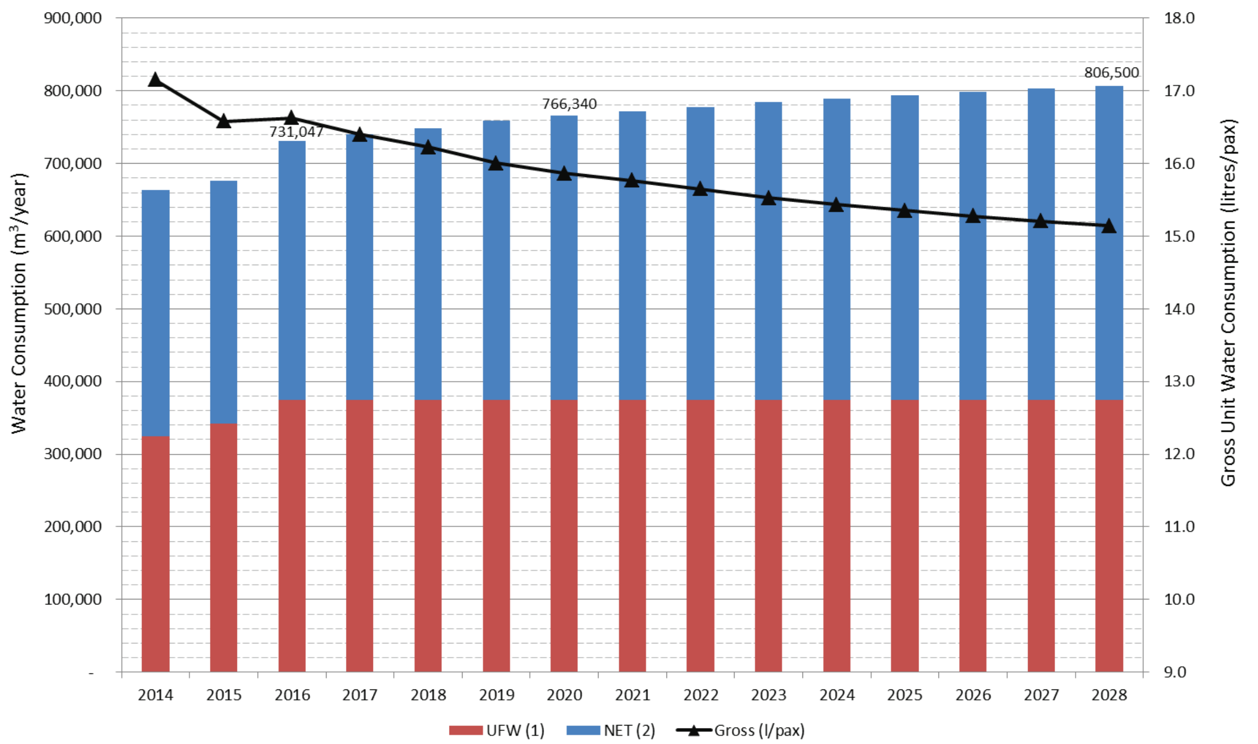


Figure 8-1 : Scenario 1 (C55) – forecast Water consumption – based on a Fixed UFW and Fixed unit net water consumption of 8.1l/pax.

The results compare well with the medium term trend lines, coupled with known asset changes – see Sections 2.5 and 2.6.

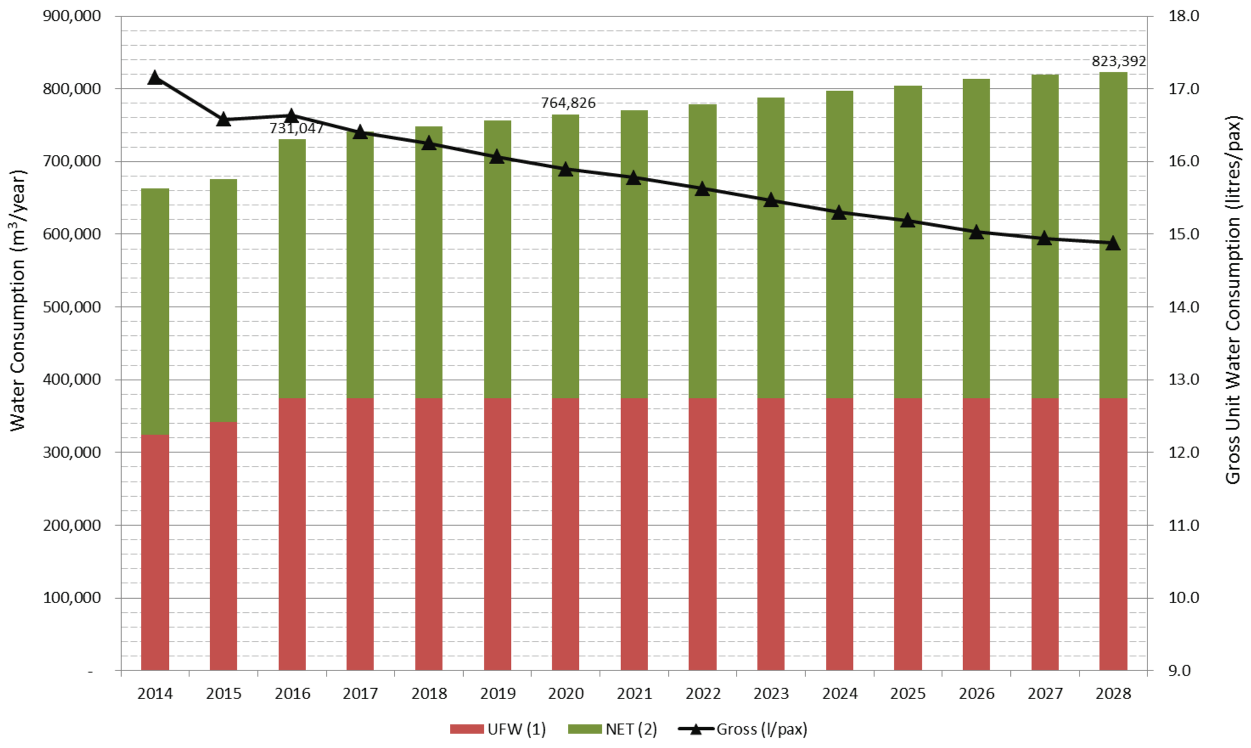


Figure 8-2 : Scenario 2 (C60) – forecast Water consumption – based on a Fixed UFW and Fixed NET UNIT water consumption of 8.1l/pax.

Table D.1 : Comparison of Forecast Water consumption by different methods :

Forecast Year	Scenario	Medium Term Trending with Asset Changes		Fixed UFW and Fixed Net UNIT water consumption of 8.1l/pax	
		Gross Water Consumption (m³/yr)	Gross UNIT Water Consumption (l/pax)	Gross Water Consumption (m³/yr)	Gross UNIT Water Consumption (l/pax)
2020	1	785,981	16.3	766,340	15.9
	2		16.3	764,826	15.9
2028	1	807,587	15.2	806,500	15.1
	2		14.6	823,392	14.9

As can be seen from the above table, although there is a minor difference in the forecast figures for 2020, the two methods concur well for 2028. Note both methods effectively assume that UFW effectively remains the same going forward.

There is clearly scope for improvement, since the estimate given in Section 0 based on current estimates, 240,000m³/yr is attributed to leakage and wastage, whilst 130,000 m³/yr is attributed to unaccounted for metering. The latter can be resolved and will not significantly change the water consumption, but the leakage and wastage can be reduced. If for example the leakage and wastage can be halved in the next 10 years, then the gross consumption will reduce by 120,000m³/yr, and result in consumption in the broad range of 687,000 to 704,000m³/yr. If achieved this will result in a reduction in water consumption and the gross unit consumption figure to below 13l/pax.

Appendix E. Leakage – Control and Reduction Techniques

Leakage management to detect, find and fix leaks is traditionally done by sounding techniques (e.g. using listening sticks / dopplers) on metal pipes. This is still practiced, but the principle of detecting and analysing acoustic noise from leaks in pipes can be enhanced using state of the art technology. Also techniques are used to verify permanent sub-division of water supply area and sub-divide and isolate water supply areas on a temporary basis.

E.1 Verification of District Meter Areas (DMAs) water supply boundaries

Open boundaries between DMAs will invalidate attempts to monitor water consumption within set boundaries. Where this is suspected, all known valves on boundaries should be checked that they are closed. Then verification is undertaken by undertaking a "pressure-zero test" on the DMA. The main supply valves are slowly closed at night, and pressure is monitored at high frequency (once or twice per minute) at locations (typically fire hydrants) along both sides of the boundaries. It is also important to know in advance the direction of closure of valves, if there are irregularities these can also be checked during a night-time operation. During the operation hydrants can be checked for loss of pressure, but the post operation analysis of the pressure monitors is more succinct in confirming if the boundary was open or closed, during the pressure zero test, as the pressure-time graph will show this clearly – see Figure 8-3.

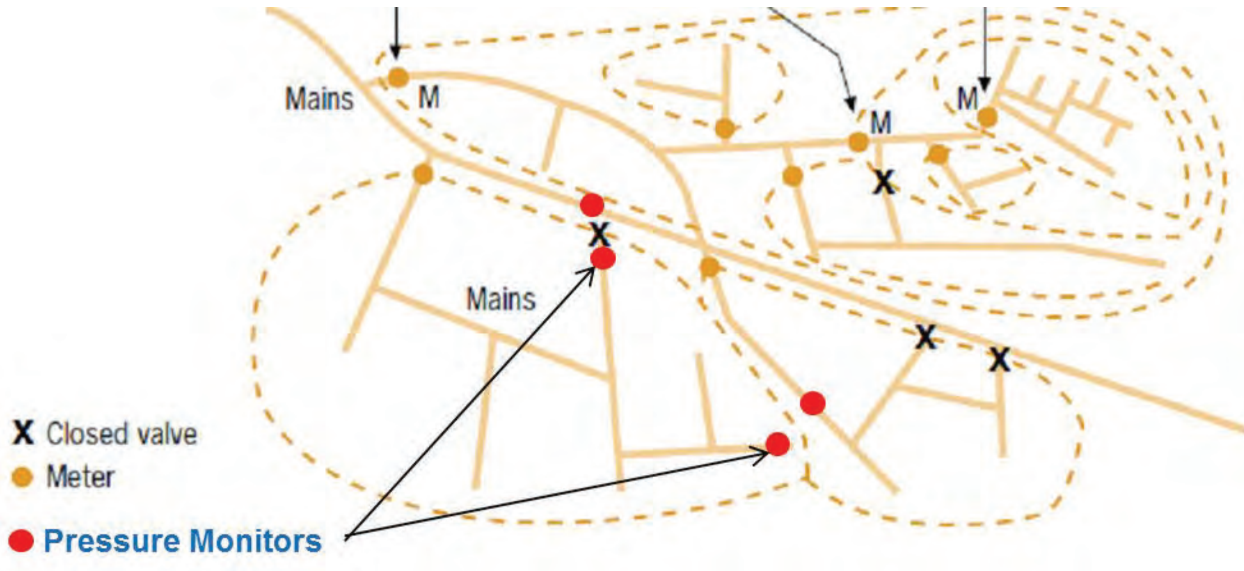


Figure 8-3 : Example "Pressure-Zero Test" to validate DMA boundaries *(Source: background figure; Farley 2001, with additional annotation by Jacobs)*:

These techniques can be done in the space of 2 or 3 hours during silent night hours, and can be done at Gatwick if required.

E.2 "Step Testing" within DMAs

"Step testing" involves sub-dividing a DMA water supply area, again during silent hours in the night. The main supply meters are monitored but the frequency of monitoring is increased from 15 minutes to 15 or 30 seconds. The prearranged sub-divisions within the DMA are then closed sequentially, starting from those furthest from supply meters, and the "step" in the nightline is then observed – see Figure 8-4.

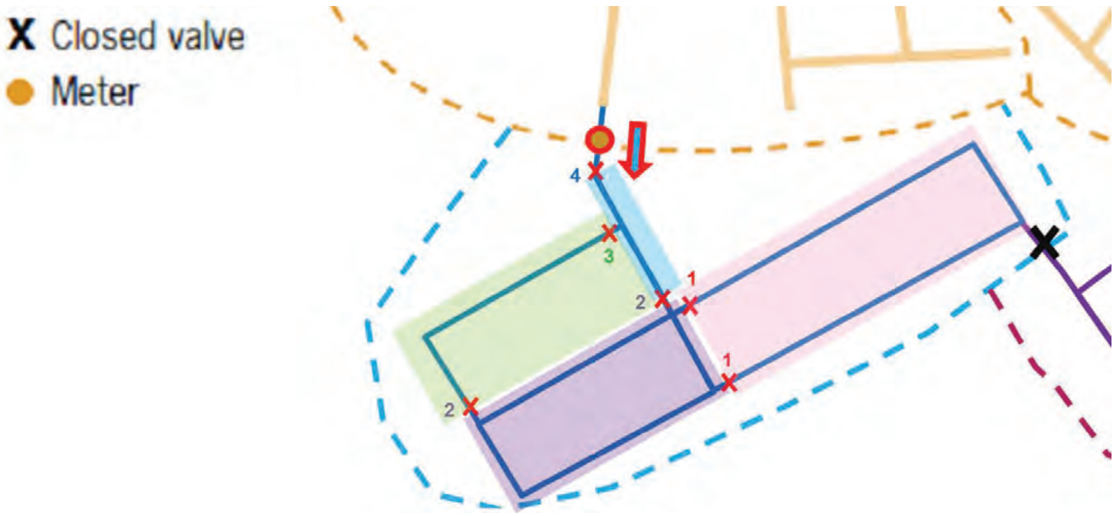


Figure 8-4 : Example plan layout of a DMA undergoing a “Step Test” - in 4 steps, closing valve sets 1, 2, 3 and 4 on 4 areas

There needs to be sufficient time (20 to 30 mins) allowed for the flow to stablise and to obtain meaningful readings before moving onto isolate next sub-division. At the end of the test the sub-divisions are reopened sequentially again, although often at a quicker pace. The results when analysed will indicate leakage levels in each sub-divided area for further investigation – see Figure 8-5. From the example DMA illustrated in Figure 8-4 and Figure 8-5. It can be seen that sub-area 2 has the largest “step” drop in water consumption when shut-off and thereby indicates the highest leakage.

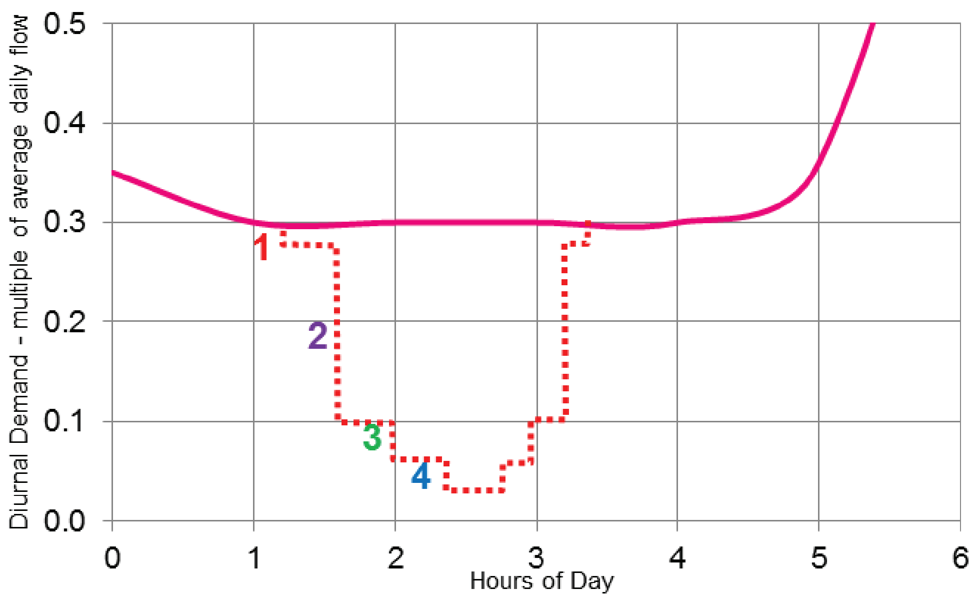


Figure 8-5 : Example results for a “Step Test”

E.3 Leak noise correlation

Traditional sounding techniques with listening sticks are effective in identifying the presence of leakage, but cannot easily pinpoint a leak in an underground pipe. Current technology using leak noise correlators can do this making connections on two ends of a pipe, on something metal, usually a valve cap or stem. Analysis by the machine displayed on a laptop can pin point the leak position – see Figure 8-6.

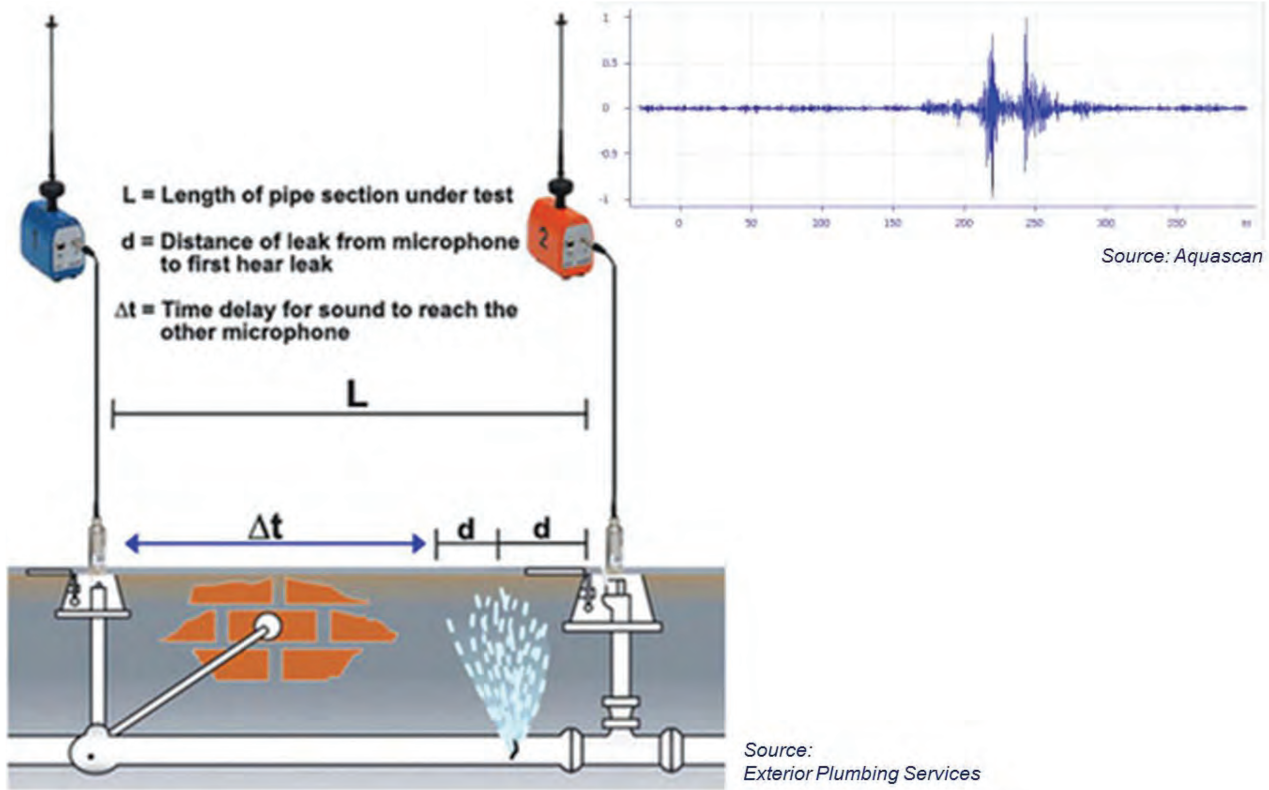


Figure 8-6 : Use of leak noise correlators

Note that it is important to fix leaking valves first, before connecting leak noise correlators. The technique can be used on plastic pipes, using hydrophones, inserted through hydrants up to 300m spacing. But it is best used on small diameter metallic pipes in networks and is less effective on large diameter trunk mains.

In traffic busy areas it is best done at night to minimise background noises.

E.4 Acoustic noise loggers

Alternatively in busy areas where access during silent night-time hours is not possible, an array of acoustic noise loggers can be deployed en masse across a DMA or entire network. They can be used on metallic or plastic pipes, and reportedly better on trunk mains than using manual leak noise correlators. The noise loggers, which also correlate the leaks, are left in position for a period of typically 1 to 2 weeks, and then analysed to determine leaks and leak positions. These can also be used on trunk mains. Verification with a ground microphone or leak noise correlator is recommended before excavating for the leak – see Figure 8-7 ci-dessous.

Figure 8-7 : Acoustic noise loggers/correlators (*Source: Primayer*)

E.5 Pressure management

Pressure reduction on network offers quick fix solution to reduction of leakage across DMAs, which could be applied before or after carrying out leak detection surveys.

It has been found through tested experience that the relationship between reduction of leakage and reduction of average area pressures is governed by the following relationship;

$$\frac{L_1}{L_0} = \left(\frac{P_1}{P_0}\right)^{n1}$$

where P_0 and L_0 are initial values of pressure and leakage and P_1 and L_1 are the reduced values. The indicy, *n1* is not 0.5 (square root) as might be expected for a fixed hole, but because leak holes expand with pressure, the indicy, *n1* has been found from widespread international observation to be 1.15. But for planning purposes, and in making conservative predictions on savings, *n1* =1 is normally used.

The pressure at GAL as measured for North Terminal varies between 5 and 6bar – 5bar at peak times of day and 6bar at night. There is therefore clearly scope to reduce pressure during night time, and even day time on a "need to have" basis.

Typically a PRV is installed and a controller connected to regulate the downstream pressure setting, rather than keeping the downstream fixed. The controller can be:

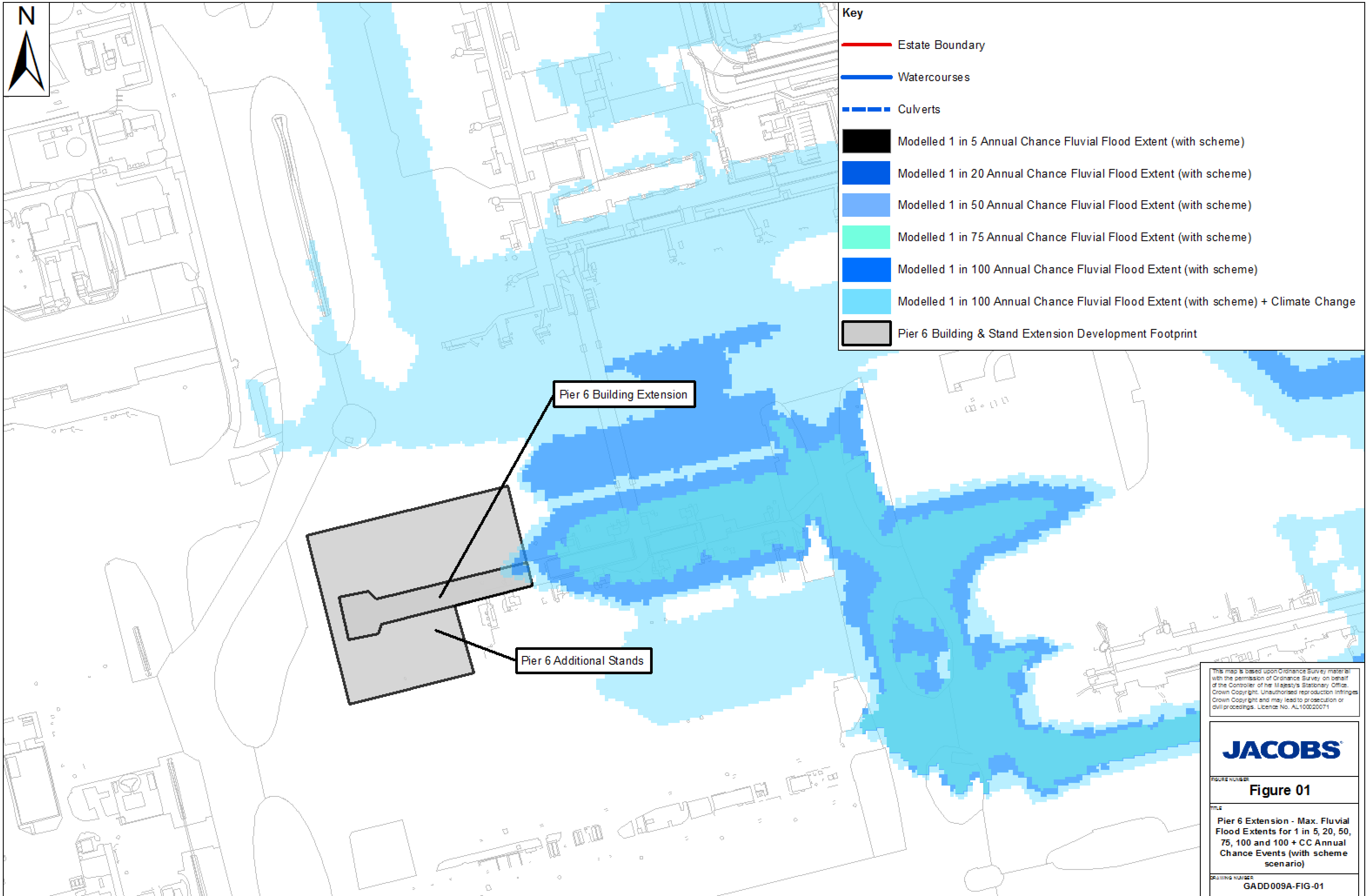
- flow modulated - PRV closes and reduces pressure during periods of low flow, such as at night, but open up increasing pressure during periods of high flow demand, such as fire hydrants being opened in an emergency;
- modulated by critical node/s in network ("closed loop") – key pressure monitors are installed at key points in the network, for which a target minimum pressure is set. The critical nodes transmit (typically by GSM) their respective pressures to the PRV, which then adjusts up or down, to meet the target pressures at the critical nodes.

Protection measures are also introduced so that the fail-safe positions for PRVs are acceptable for the water supply operations.

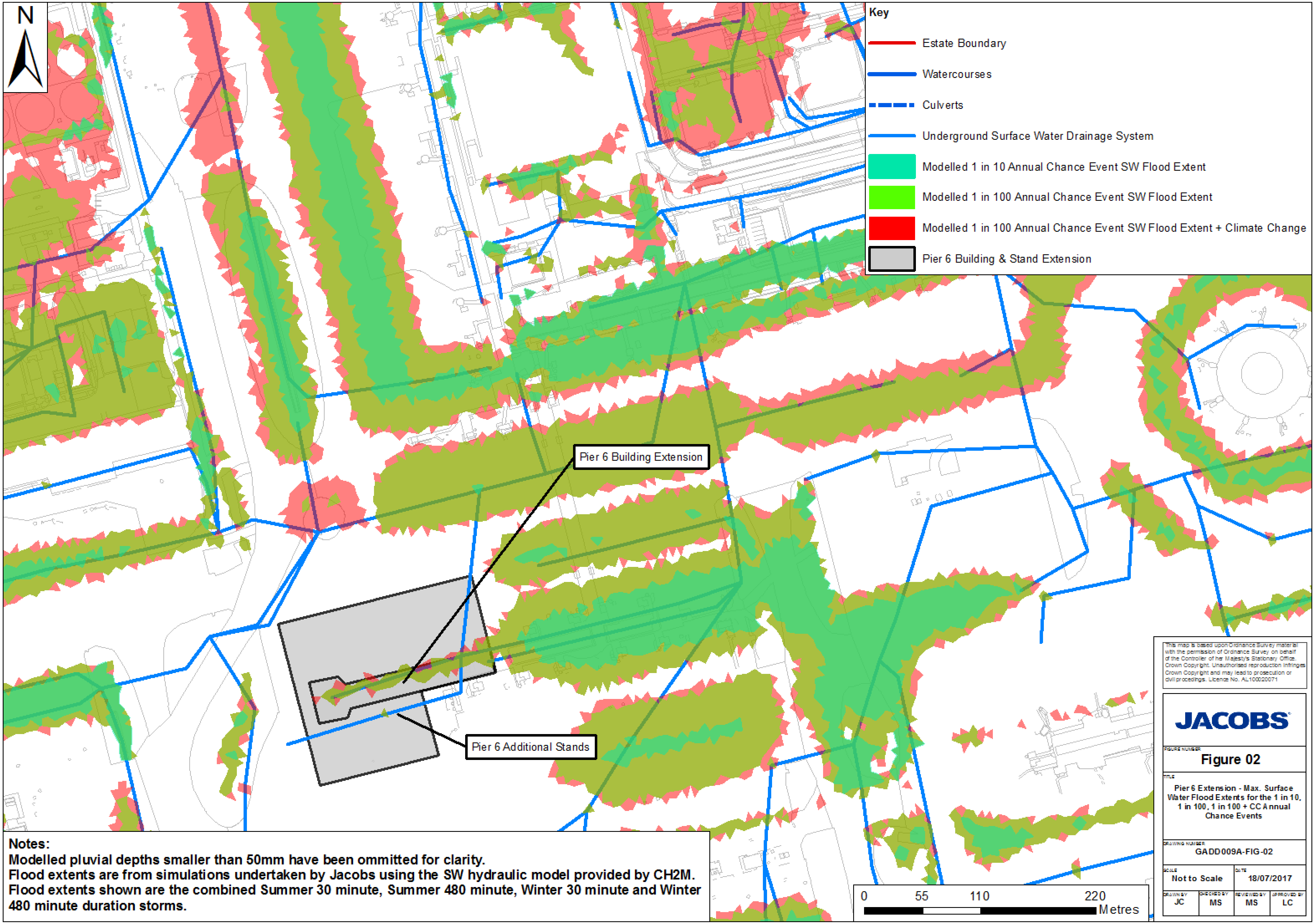
Buildings which have pressure requirements for sprinklers can be provided with their own booster pump systems, rather than pressurise an underground network of pipes to unnecessarily high pressures, and exacerbating leakage.

Pressure management is extremely effective in saving on leakage, but it has to be continuously monitored and, where economic to do so, backed up with "find and fix" leakage techniques.

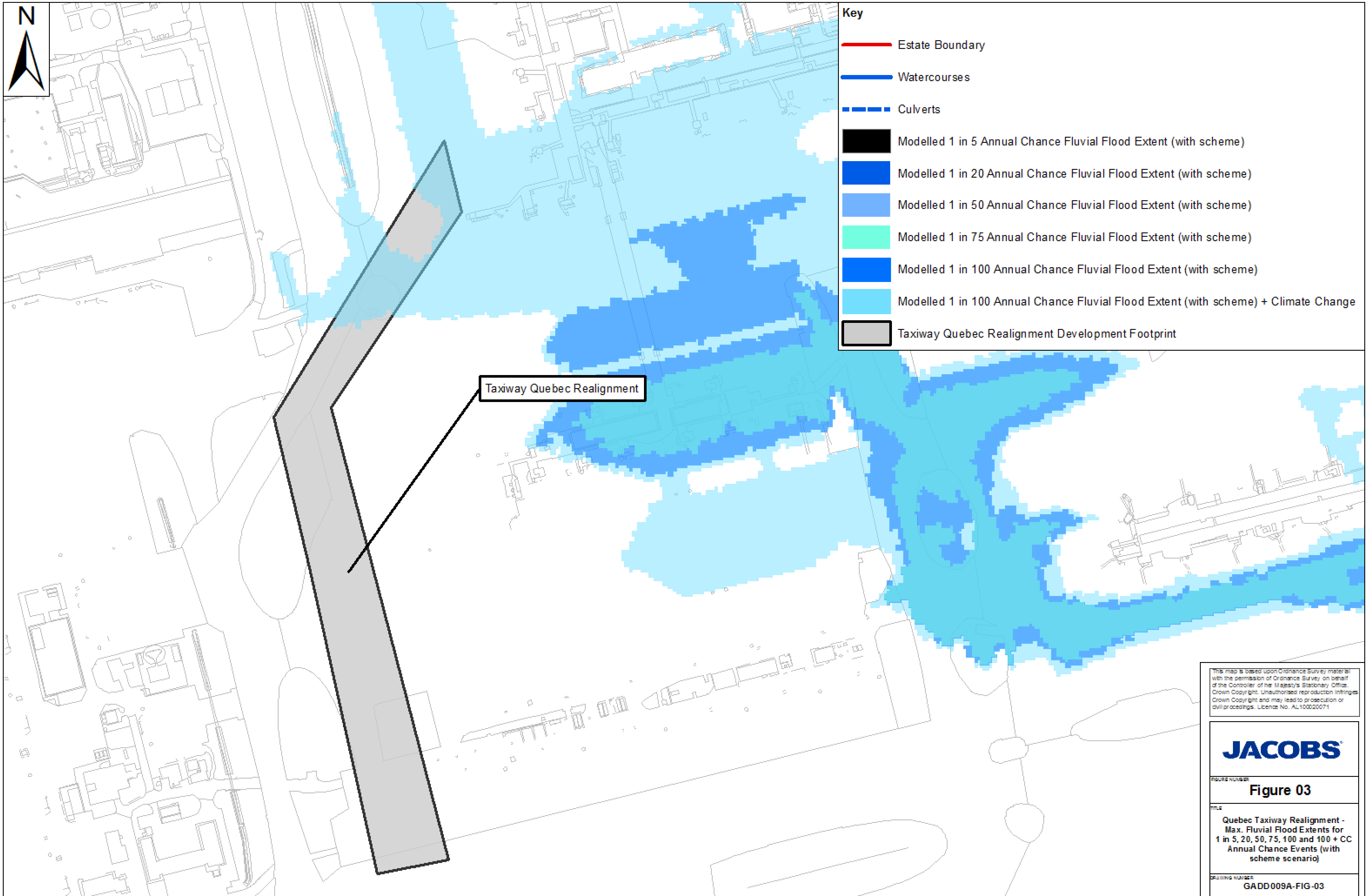
Appendix F. Flood Risk Figures



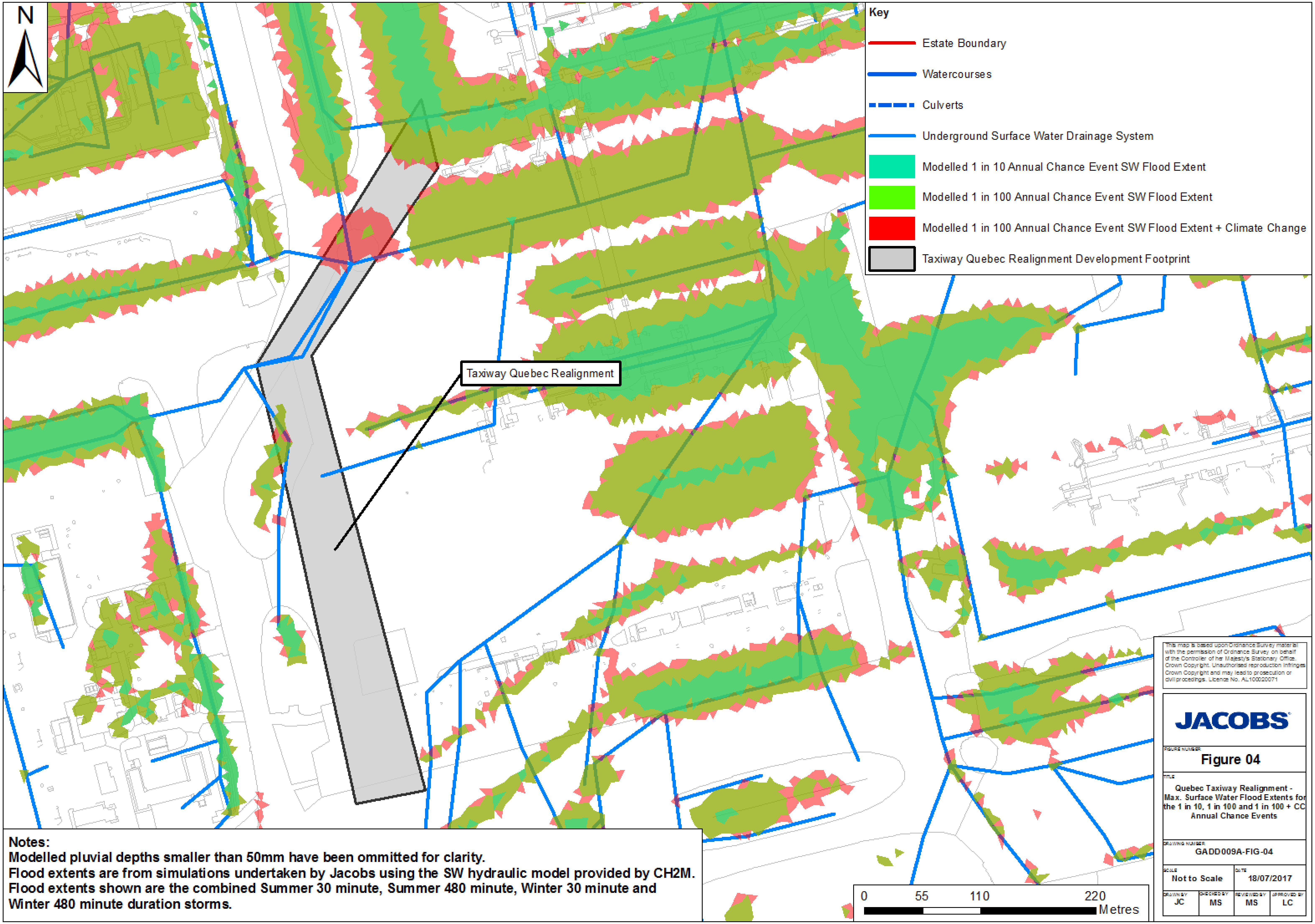
Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.



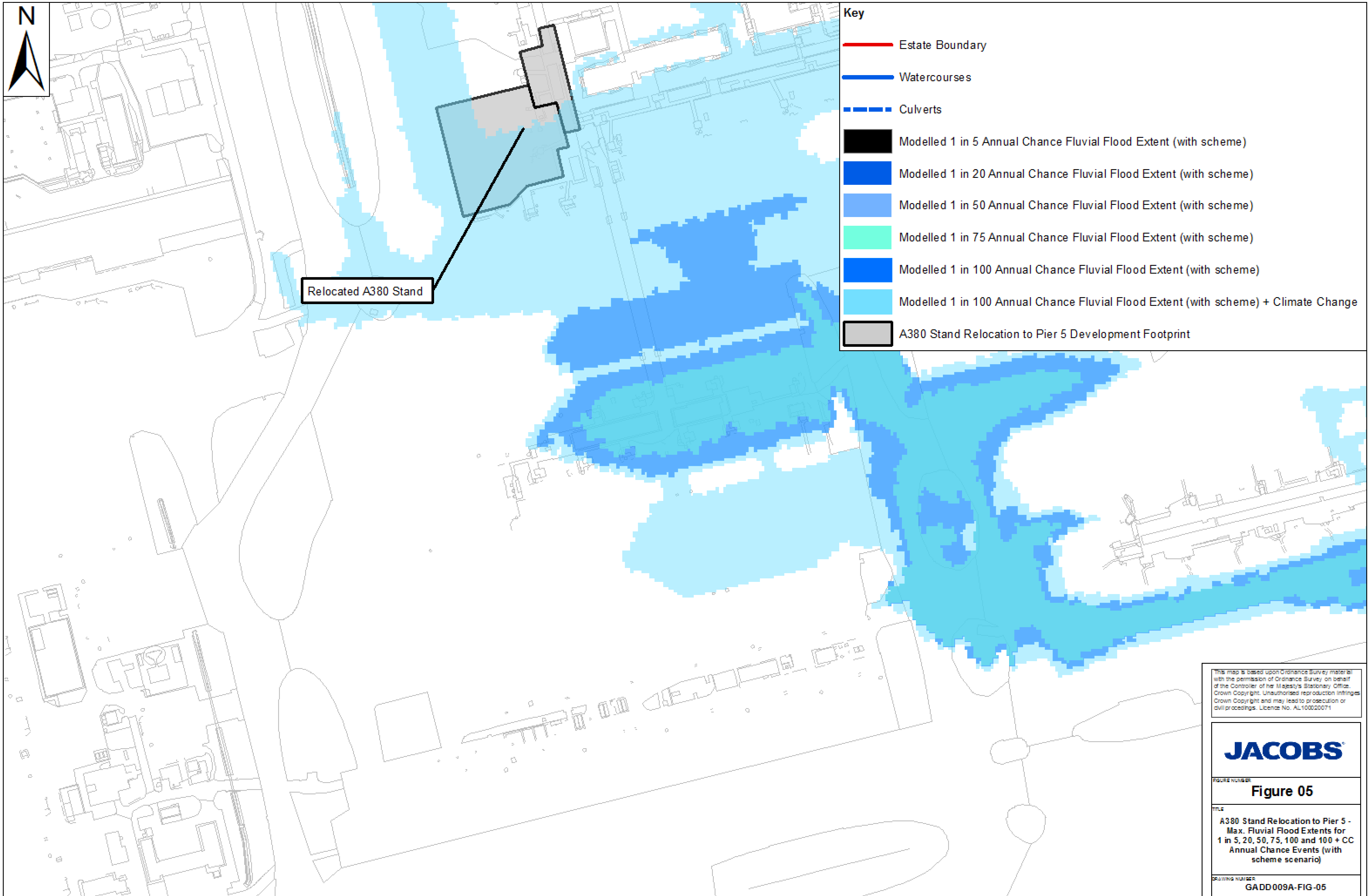
Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.



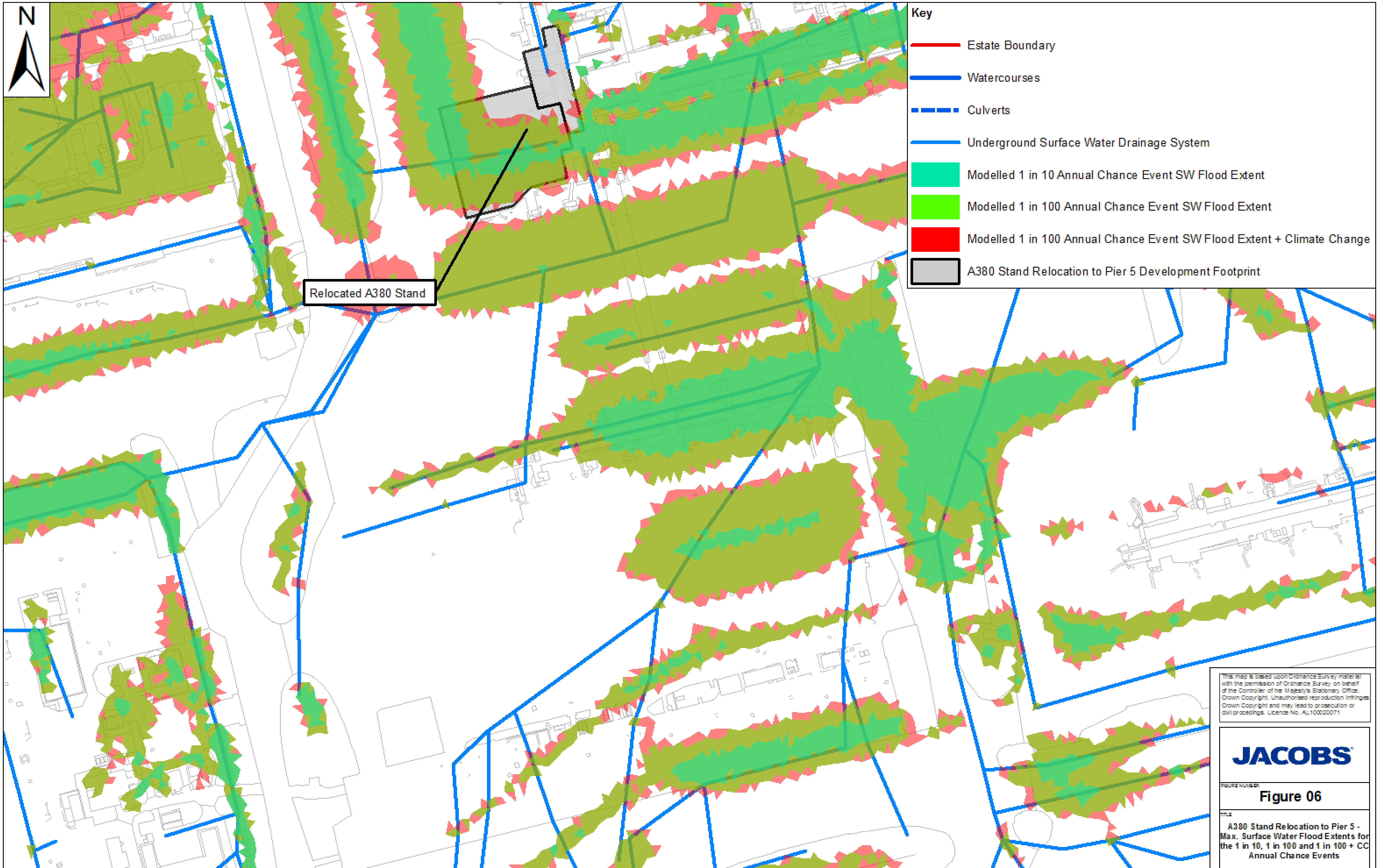
Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

FIGURE NUMBER	**Figure 05**
TITLE	A380 Stand Relocation to Pier 5 - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)
DRAWING NUMBER	GADD009A-FIG-05
SCALE	Not to Scale
DATE	17/07/2017
DRAWN BY	JC
CHECKED BY	MS
REVIEWED BY	MS
APPROVED BY	LC



Notes:

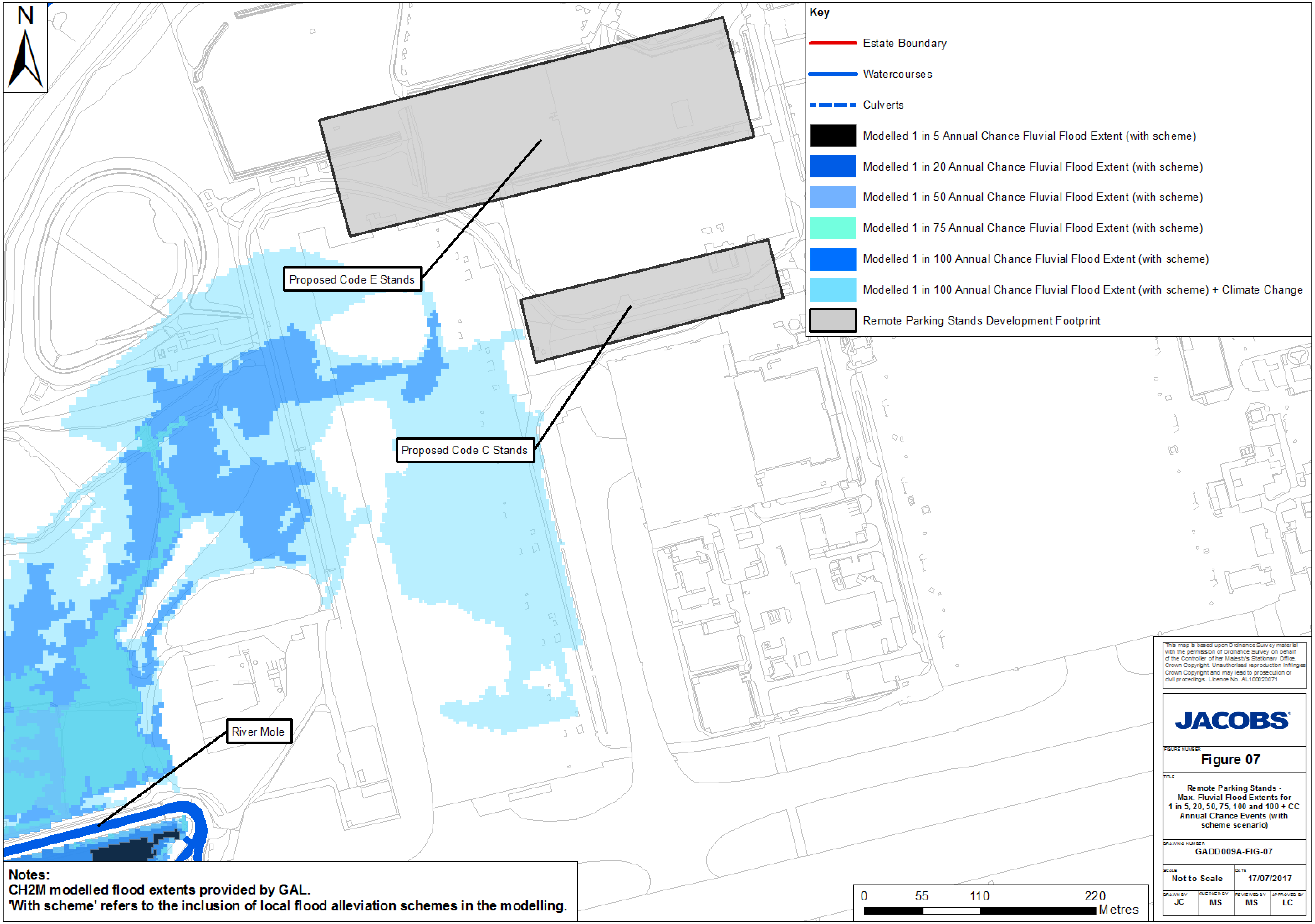
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.

Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.

Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

FIGURE NUMBER	**Figure 06**
TITLE	A380 Stand Relocation to Pier 5 - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events
DRAWING NUMBER	GADD009A-FIG-06
SCALE	Not to Scale
DATE	18/07/2017
DRAWN BY	JC
CHECKED BY	MS
REVIEWED BY	MS
APPROVED BY	LC



JACOBS

FIGURE NUMBER: Figure 07

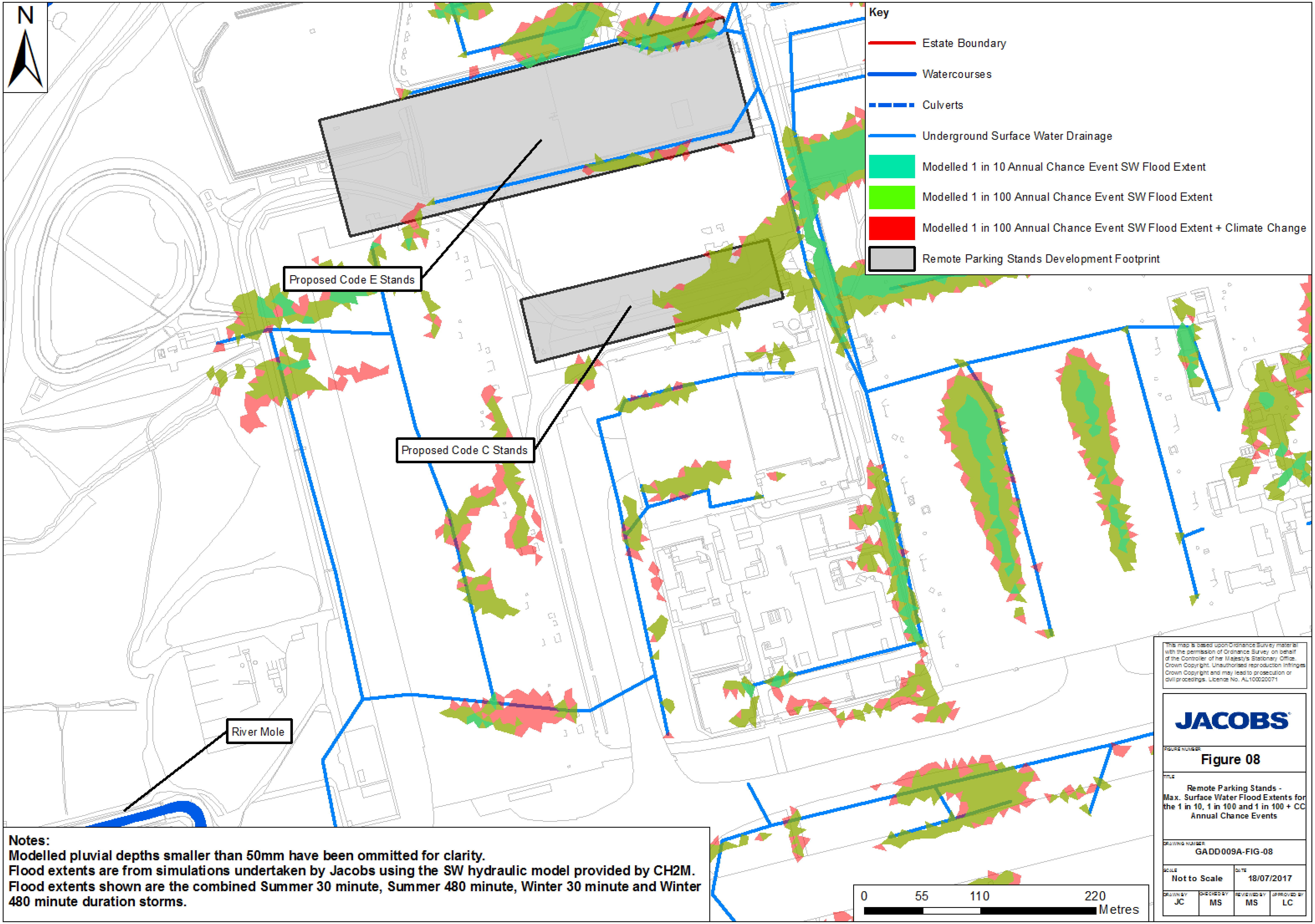
TITLE: Remote Parking Stands - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)

DRAWING NUMBER: GADD009A-FIG-07

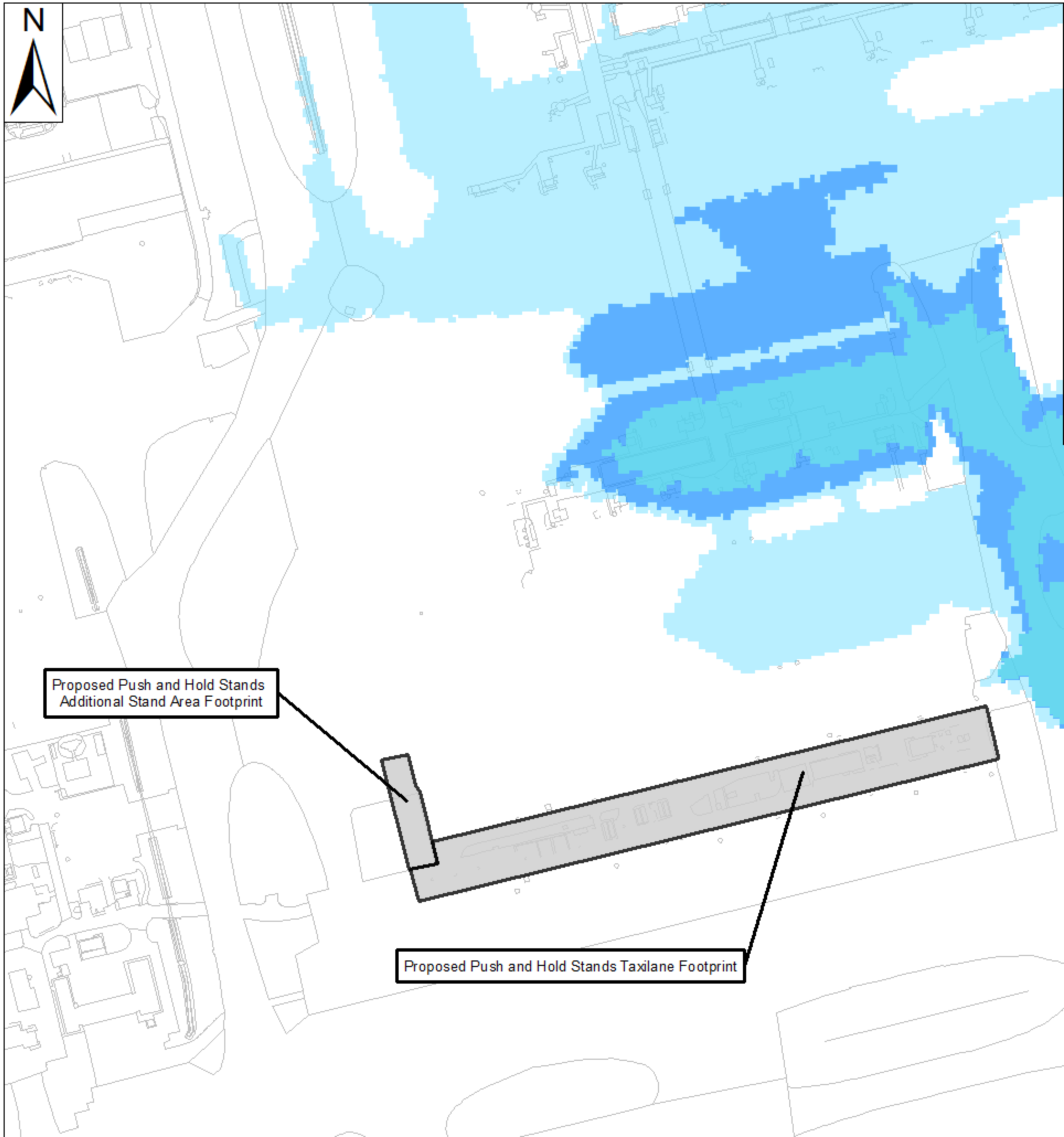
SCALE	DATE
Not to Scale	17/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC

Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.



Key

- Estate Boundary
- Watercourses
- Culverts
- Modelled 1 in 5 Annual Chance Fluvial Flood Extent (with scheme)
- Modelled 1 in 20 Annual Chance Fluvial Flood Extent (with scheme)
- Modelled 1 in 50 Annual Chance Fluvial Flood Extent (with scheme)
- Modelled 1 in 75 Annual Chance Fluvial Flood Extent (with scheme)
- Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme)
- Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme) + Climate Change
- Push and Hold Stands Development Footprint

Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

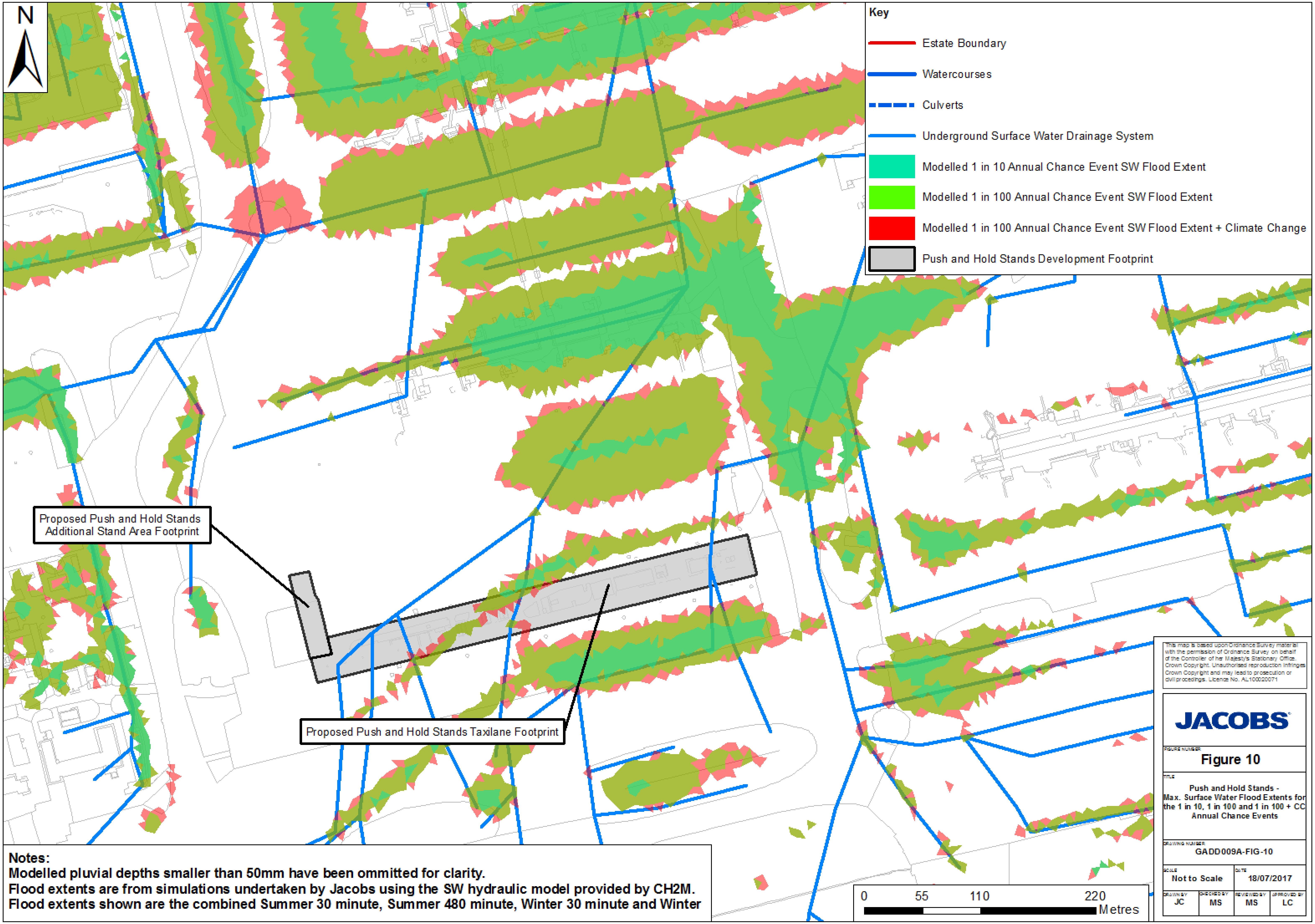
JACOBS

FIGURE NUMBER
Figure 09

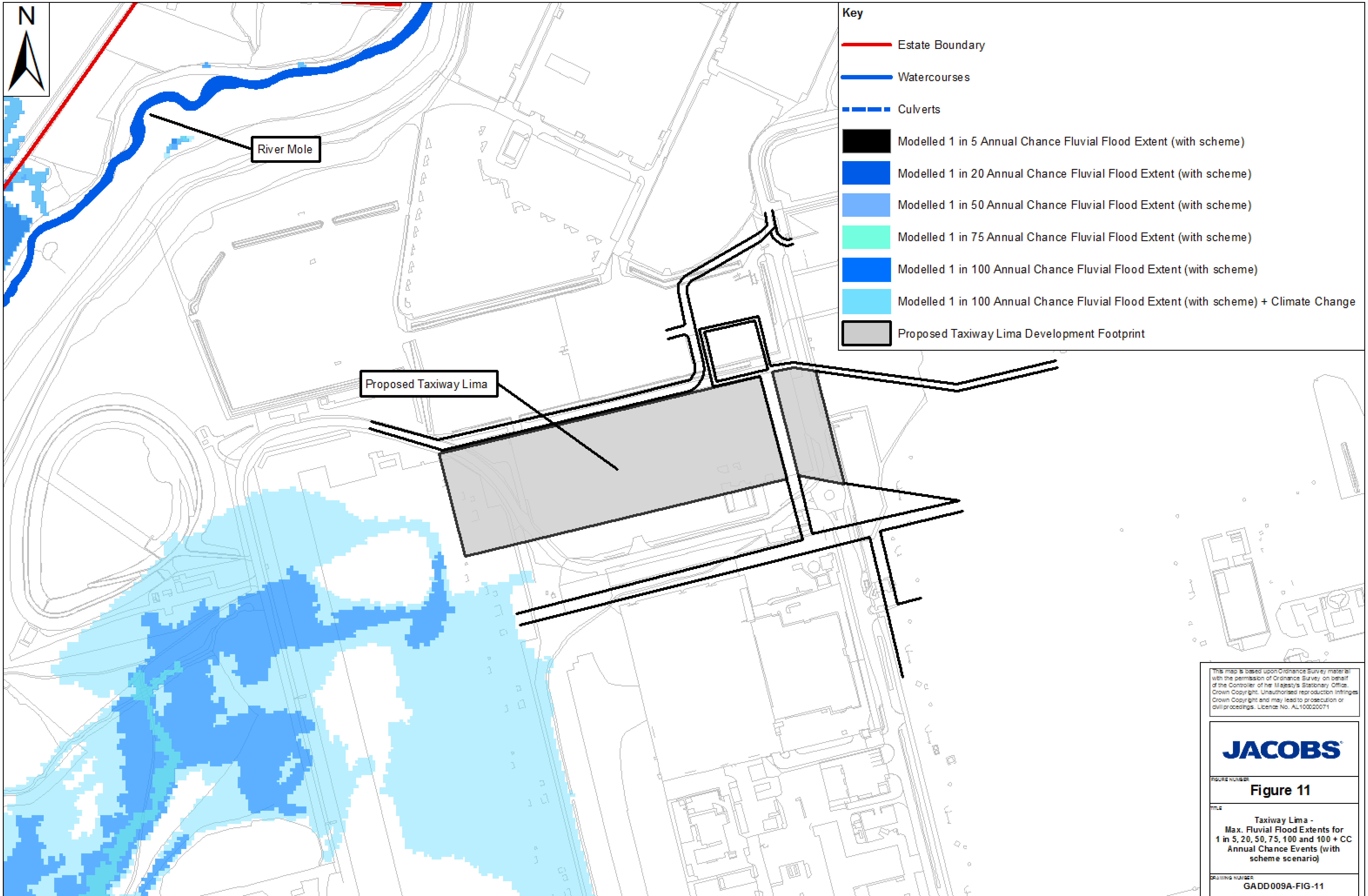
TITLE
Push and Hold Stands - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)

DRAWING NUMBER
GADD009A-FIG-09

SCALE		DATE	
Not to Scale		17/07/2017	
DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

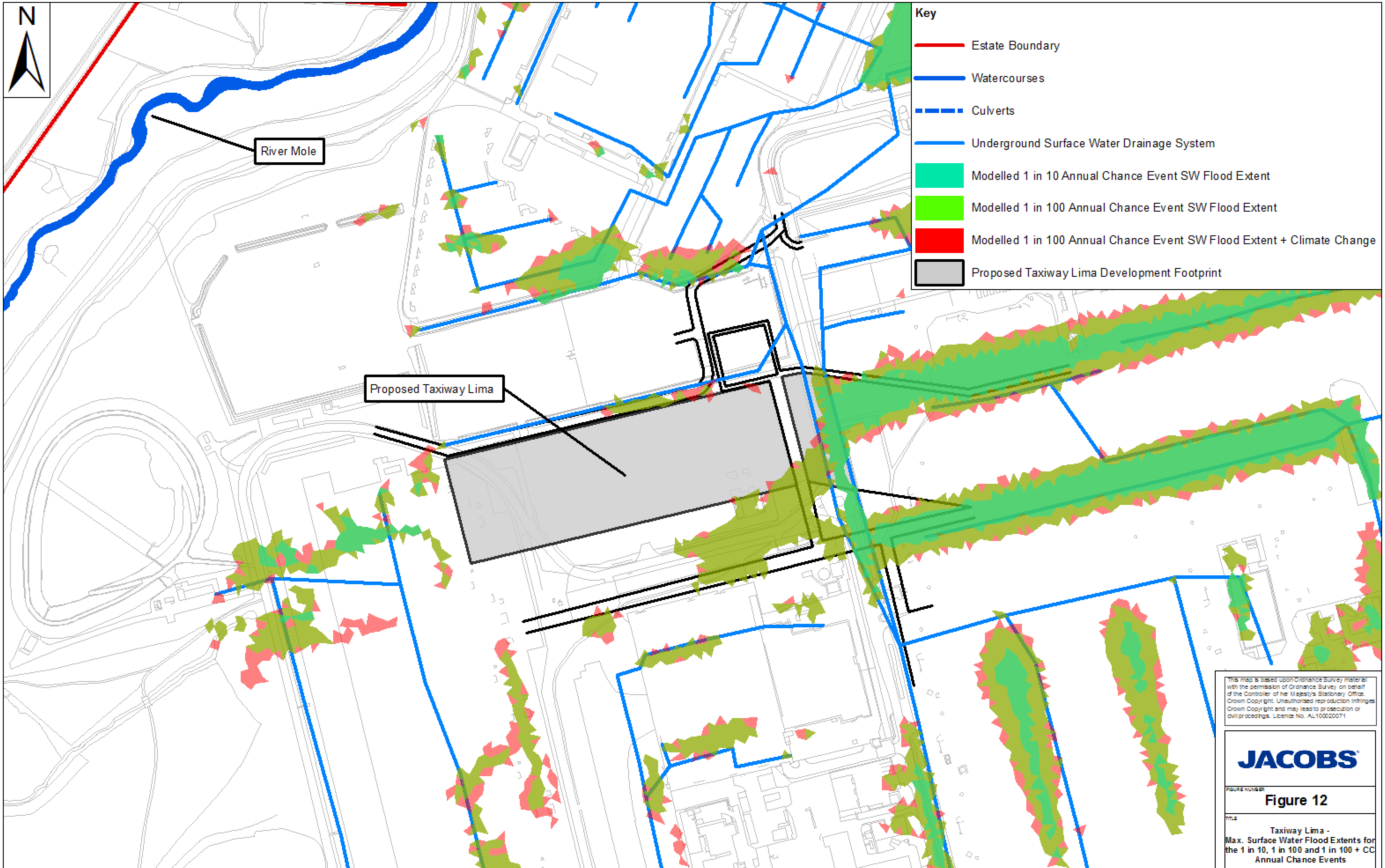
FIGURE NUMBER: **Figure 11**

TITLE: **Taxiway Lima - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)**

DRAWING NUMBER: **GADD009A-FIG-11**

SCALE	DATE
Not to Scale	17/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

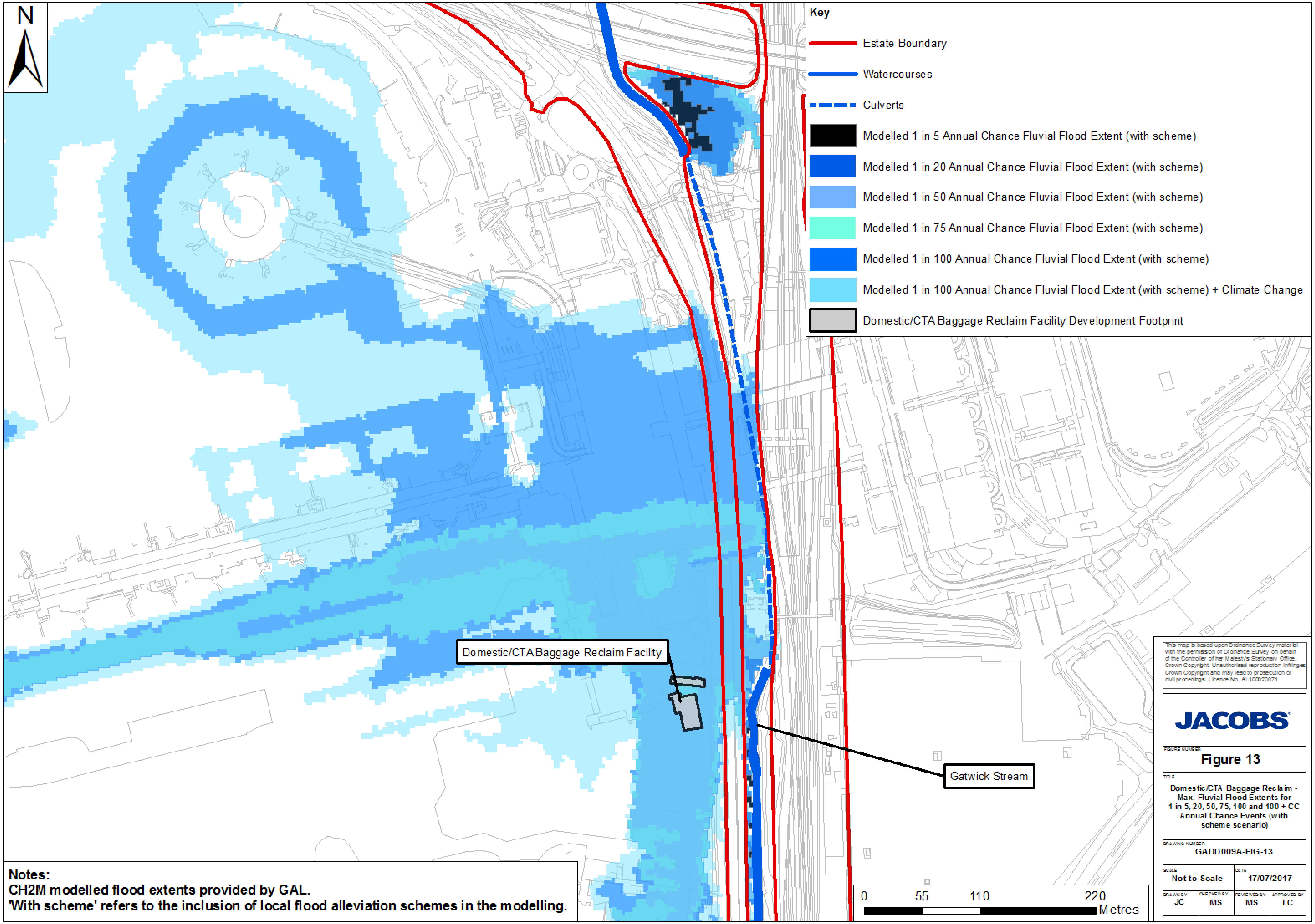
FIGURE NUMBER: Figure 12

TITLE: Taxiway Lima - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER: GADD009A-FIG-12

SCALE: Not to Scale | DATE: 18/07/2017

DRAWN BY: JC | CHECKED BY: MS | REVIEWED BY: MS | APPROVED BY: LC


N
Key
Estate Boundary
Watercourses
Culverts
Modelled 1 in 5 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 20 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 50 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 75 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme) + Climate Change
Domestic/CTA Baggage Reclaim Facility Development Footprint
Domestic/CTA Baggage Reclaim Facility
Gatwick Stream
0
55
110
220
Metres
Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.
This map is based upon Ordnance Survey material with the permission of Ordnance Survey on behalf of the Controller of her Majesty's Stationary Office. Crown Copyright. Unauthorised reproduction infringes Crown Copyright and may lead to prosecution or civil procedings. Licence No. AL100020071
JACOBS
FIGURE NUMBER
Figure 13
TITLE
Domestic/CTA Baggage Reclaim - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)
DRAWING NUMBER
GADD009A-FIG-13
SCALE
Not to Scale
DATE
17/07/2017
DRAWN BY
JC
CHECKED BY
MS
REVIEWED BY
MS
APPROVED BY
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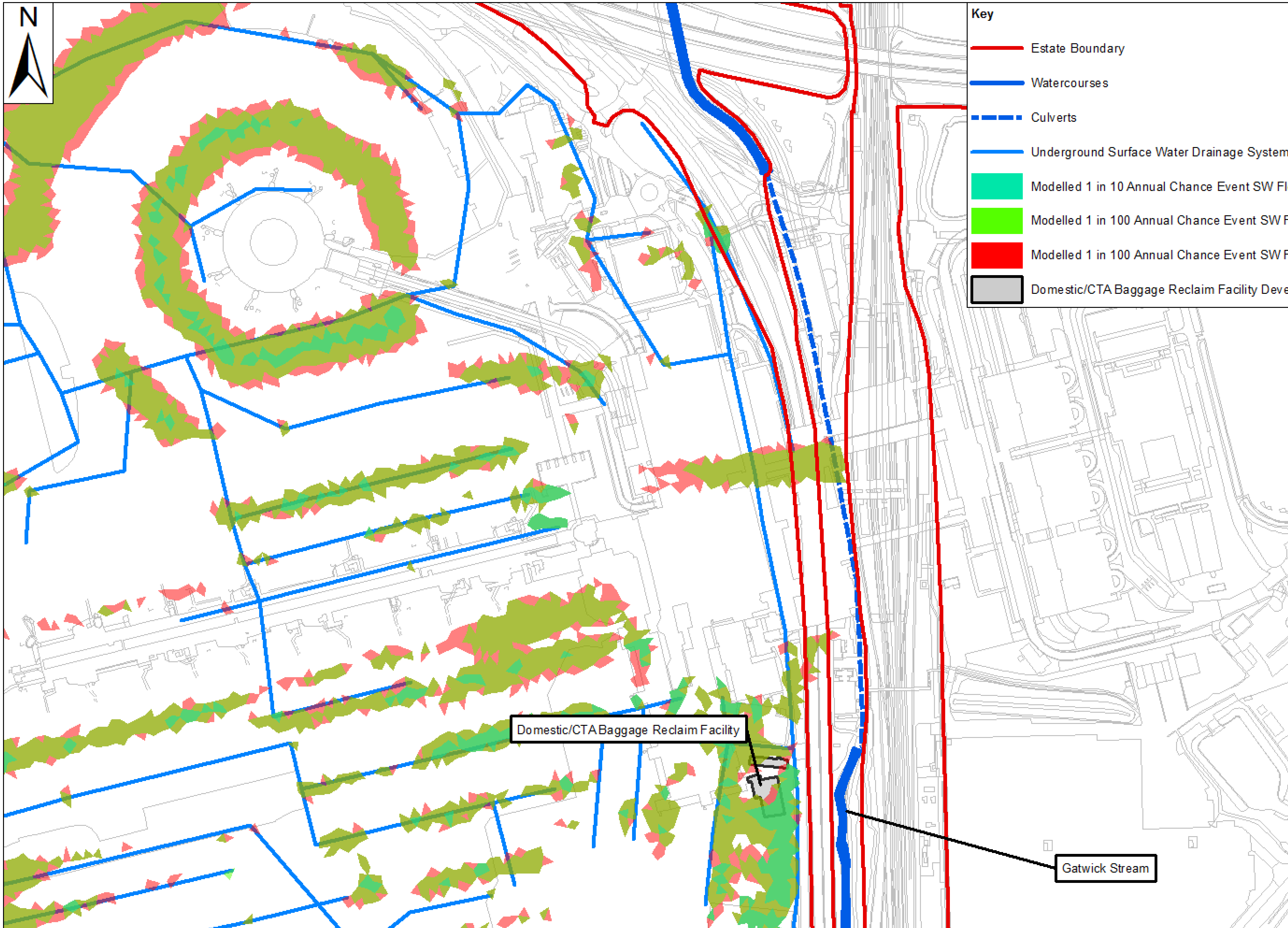


Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

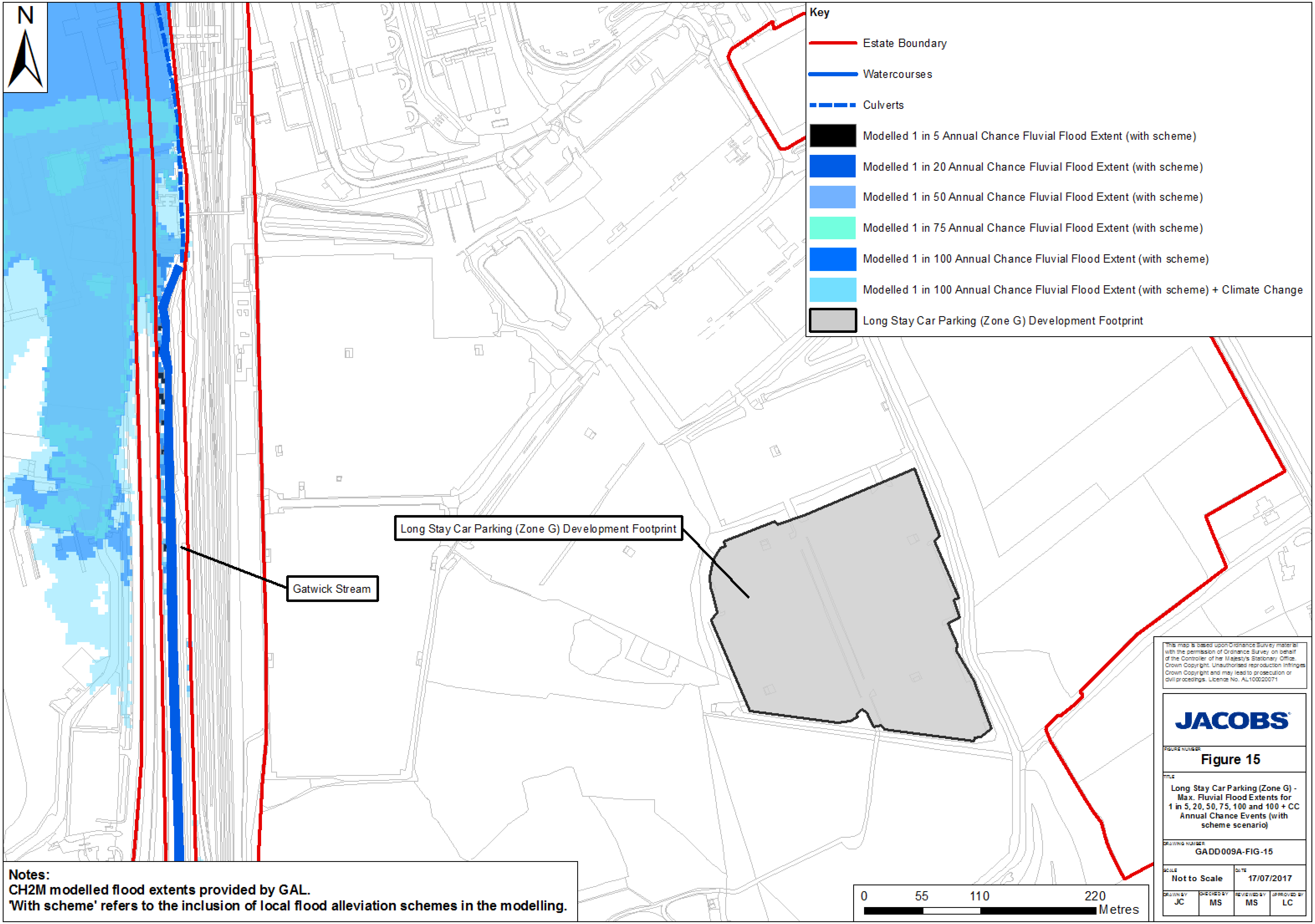
FIGURE NUMBER
Figure 14

TITLE
Domestic/CTA Baggage Reclaim - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER
GADD009A-FIG-14

SCALE	DATE
Not to Scale	18/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



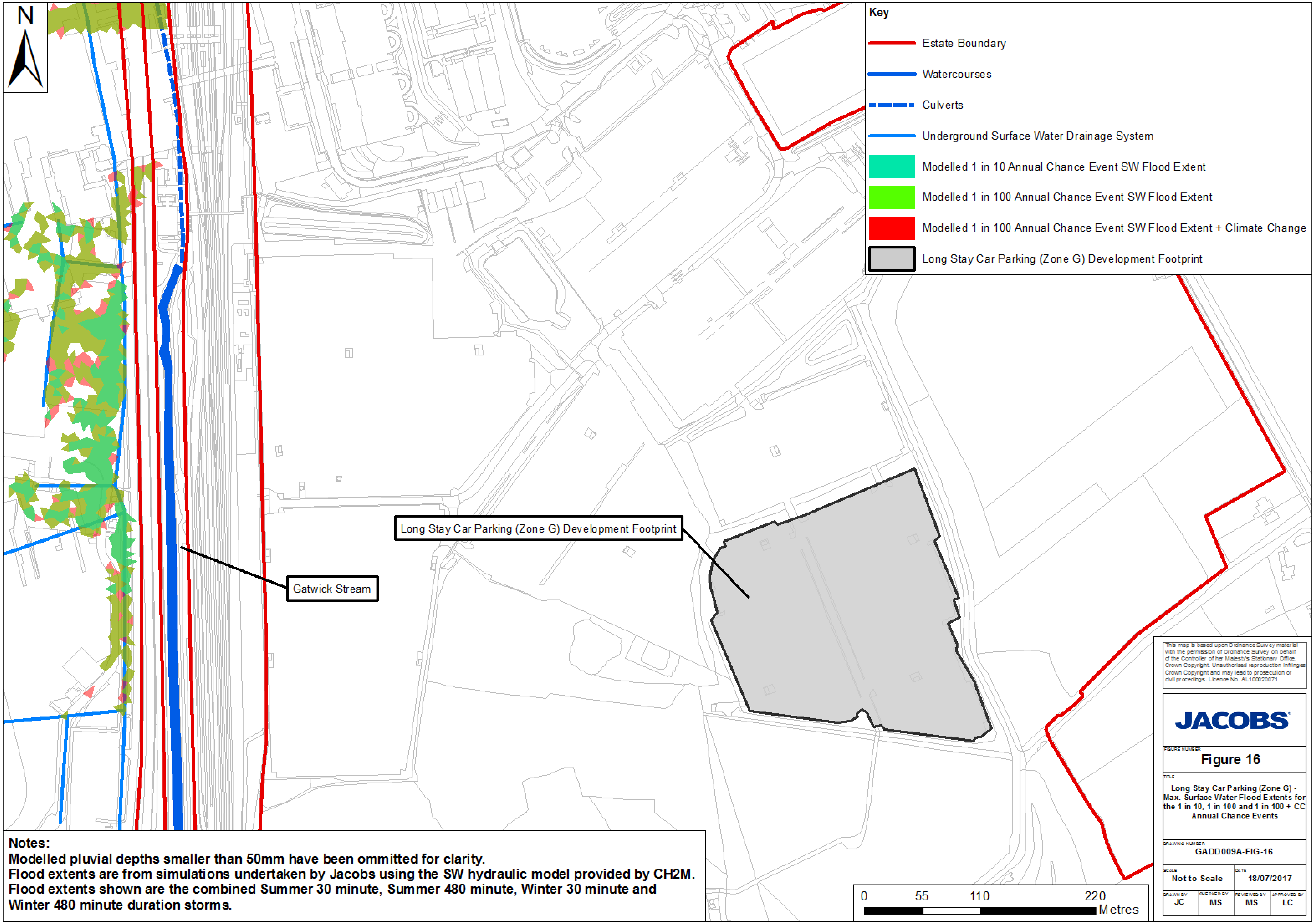
Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

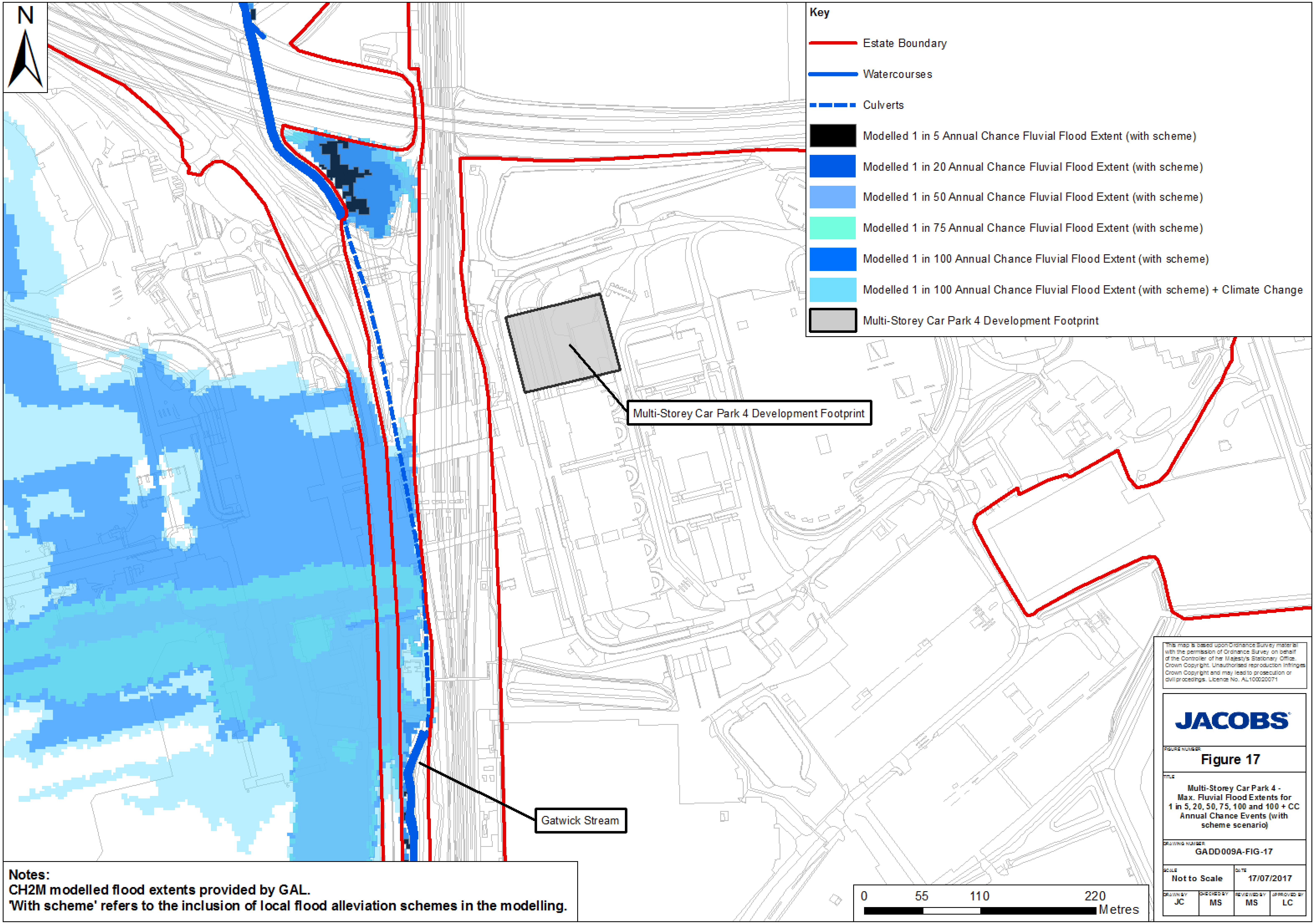
FIGURE NUMBER
Figure 15

TITLE
Long Stay Car Parking (Zone G) - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)

DRAWING NUMBER			
GADD009A-FIG-15			
SCALE: Not to Scale		DATE: 17/07/2017	
DRAWN BY: JC	CHECKED BY: MS	REVIEWED BY: MS	APPROVED BY: LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

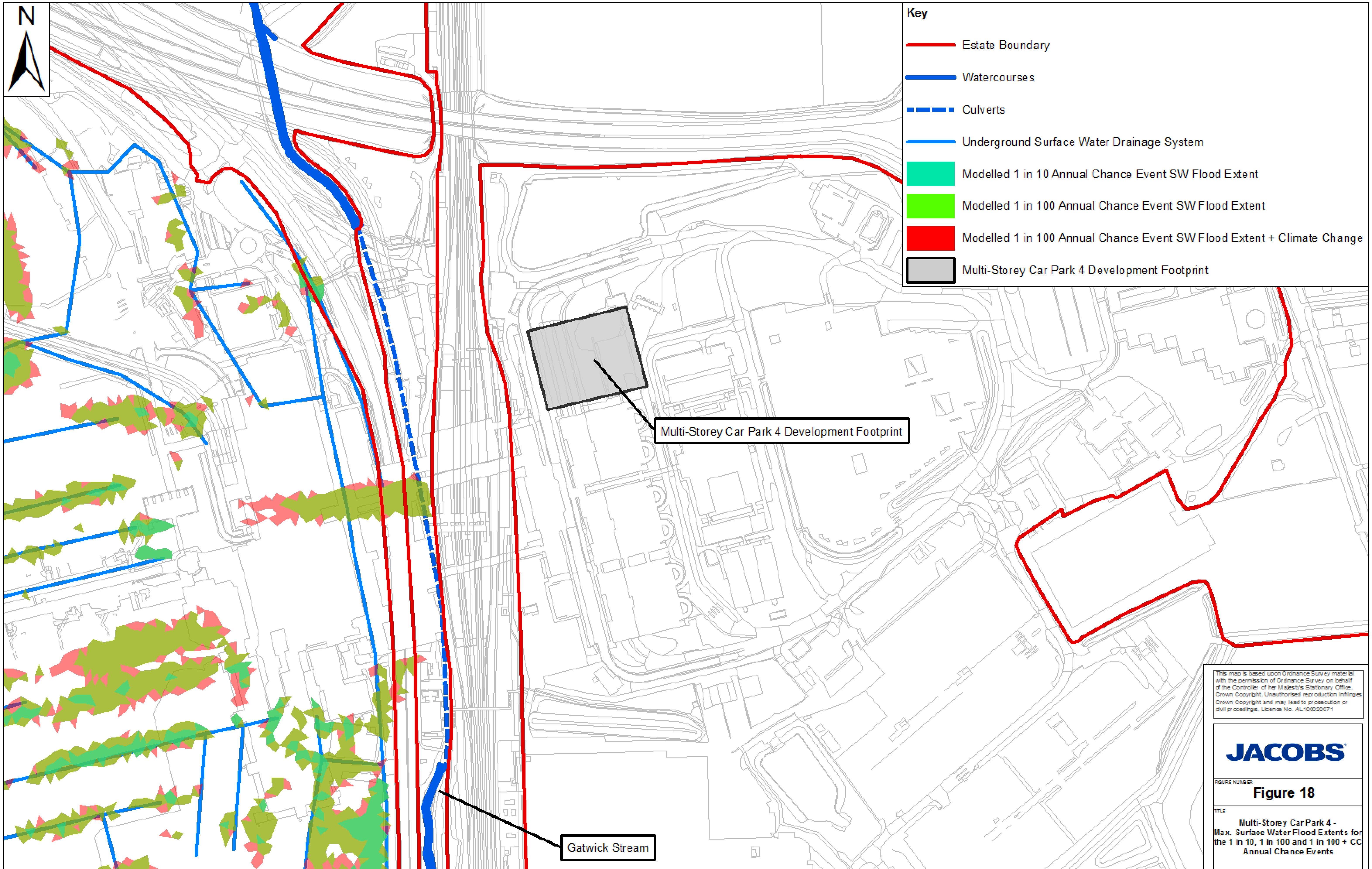
FIGURE NUMBER
Figure 17

TITLE
Multi-Storey Car Park 4 - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)

DRAWING NUMBER
GADD009A-FIG-17

SCALE	DATE
Not to Scale	17/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

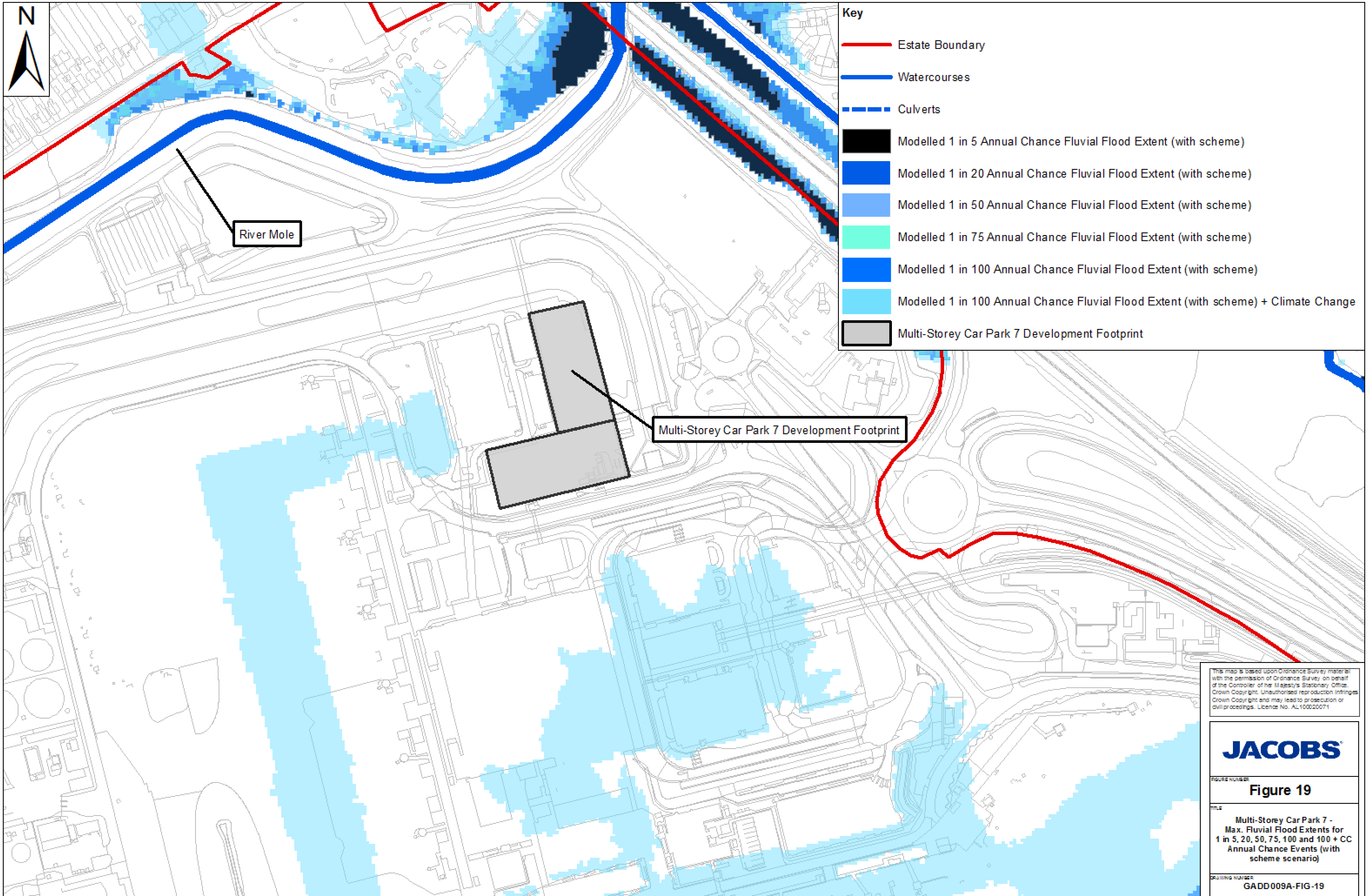
FIGURE NUMBER
Figure 18

TITLE
Multi-Storey Car Park 4 - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER
GADD009A-FIG-18

SCALE	DATE
Not to Scale	18/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

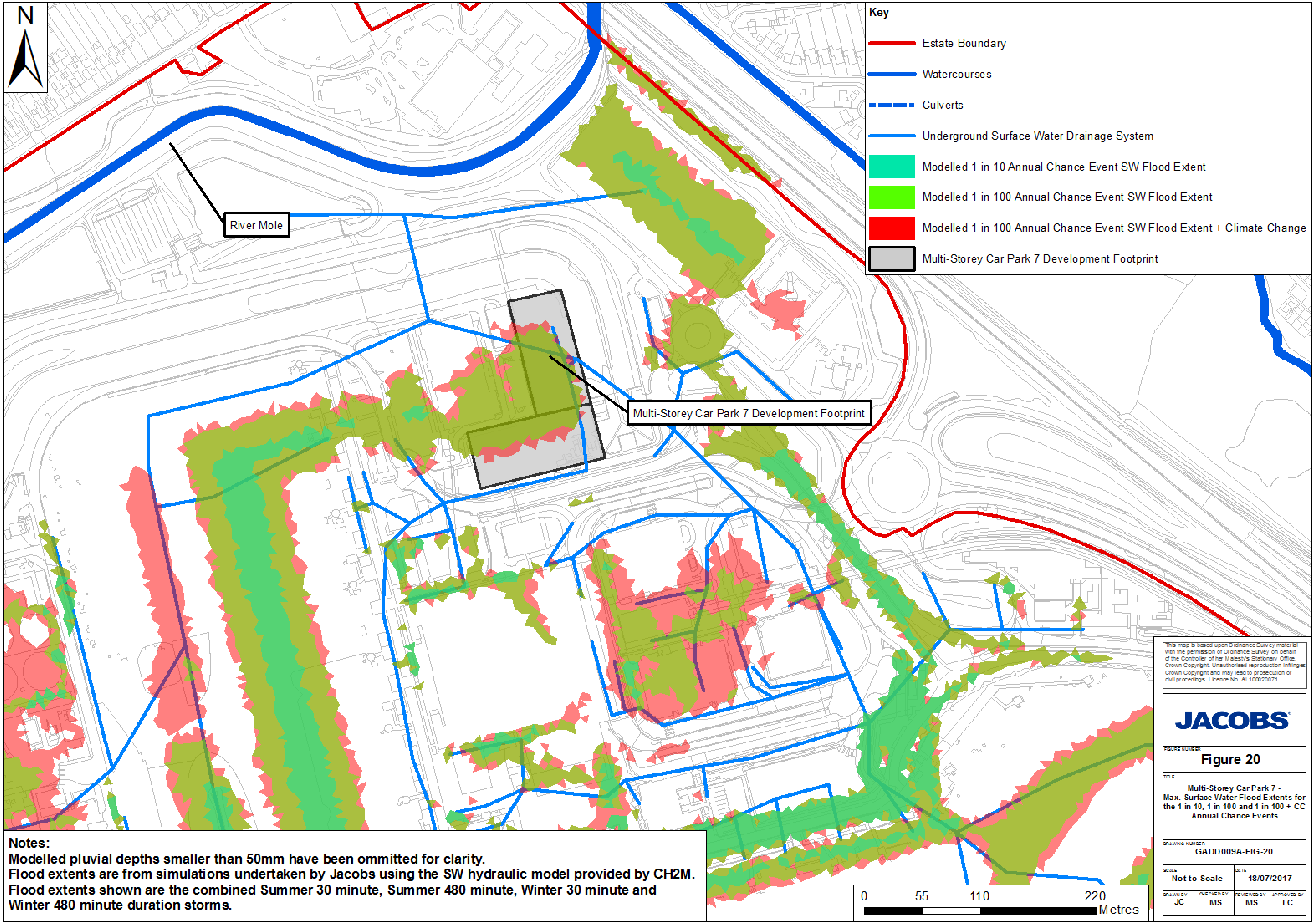
Figure Number: **Figure 19**

Title: **Multi-Storey Car Park 7 - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)**

Drawing Number: GADD009A-FIG-19

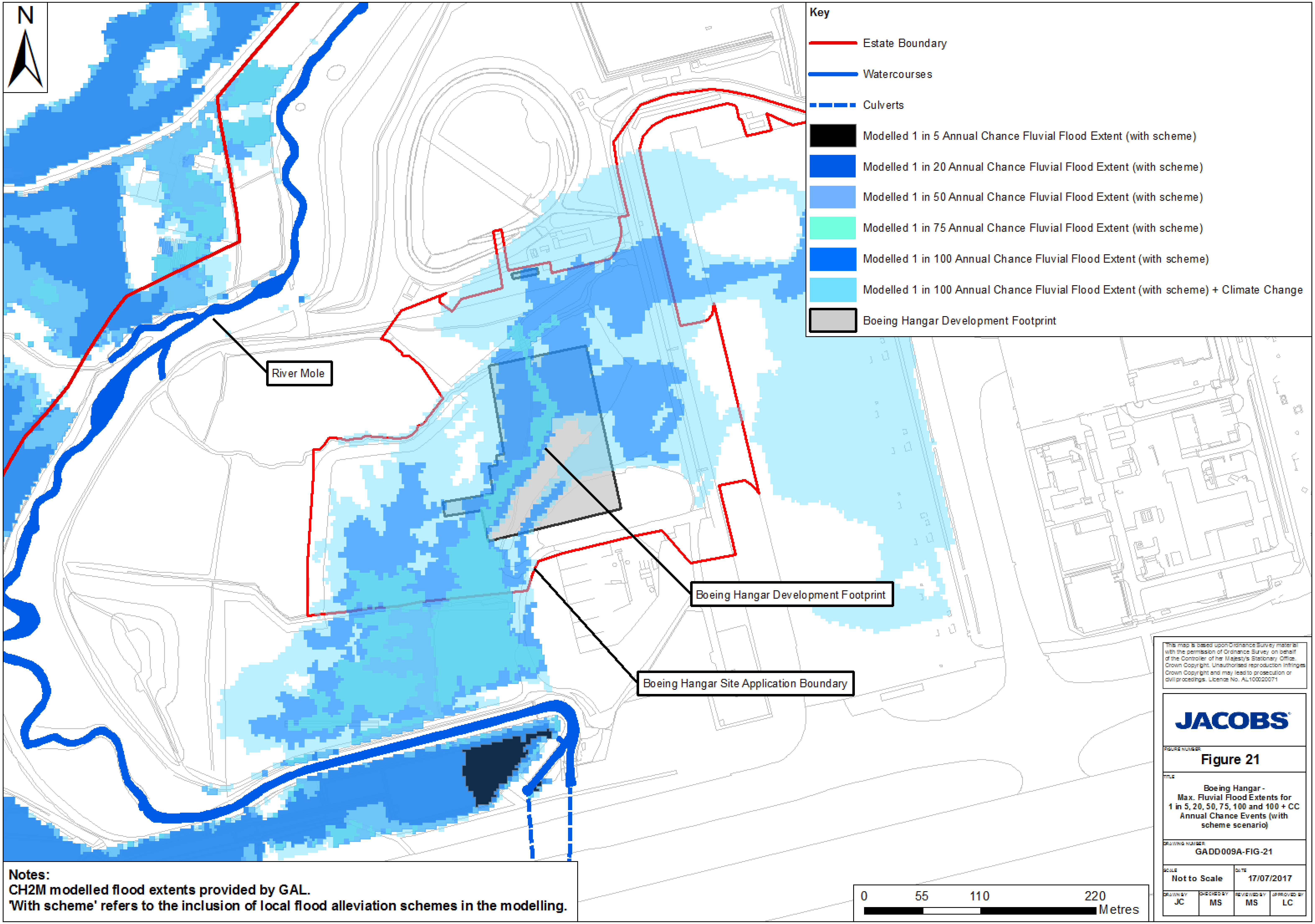
Scale	Date
Not to Scale	17/07/2017

Drawn by	Checked by	Reviewed by	Approved by
JC	MS	MS	LC



Notes:

Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.


N
Key
Estate Boundary
Watercourses
Culverts
Modelled 1 in 5 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 20 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 50 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 75 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme) + Climate Change
Boeing Hangar Development Footprint
River Mole
Boeing Hangar Development Footprint
Boeing Hangar Site Application Boundary
Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.
0 55 110 220
Metres
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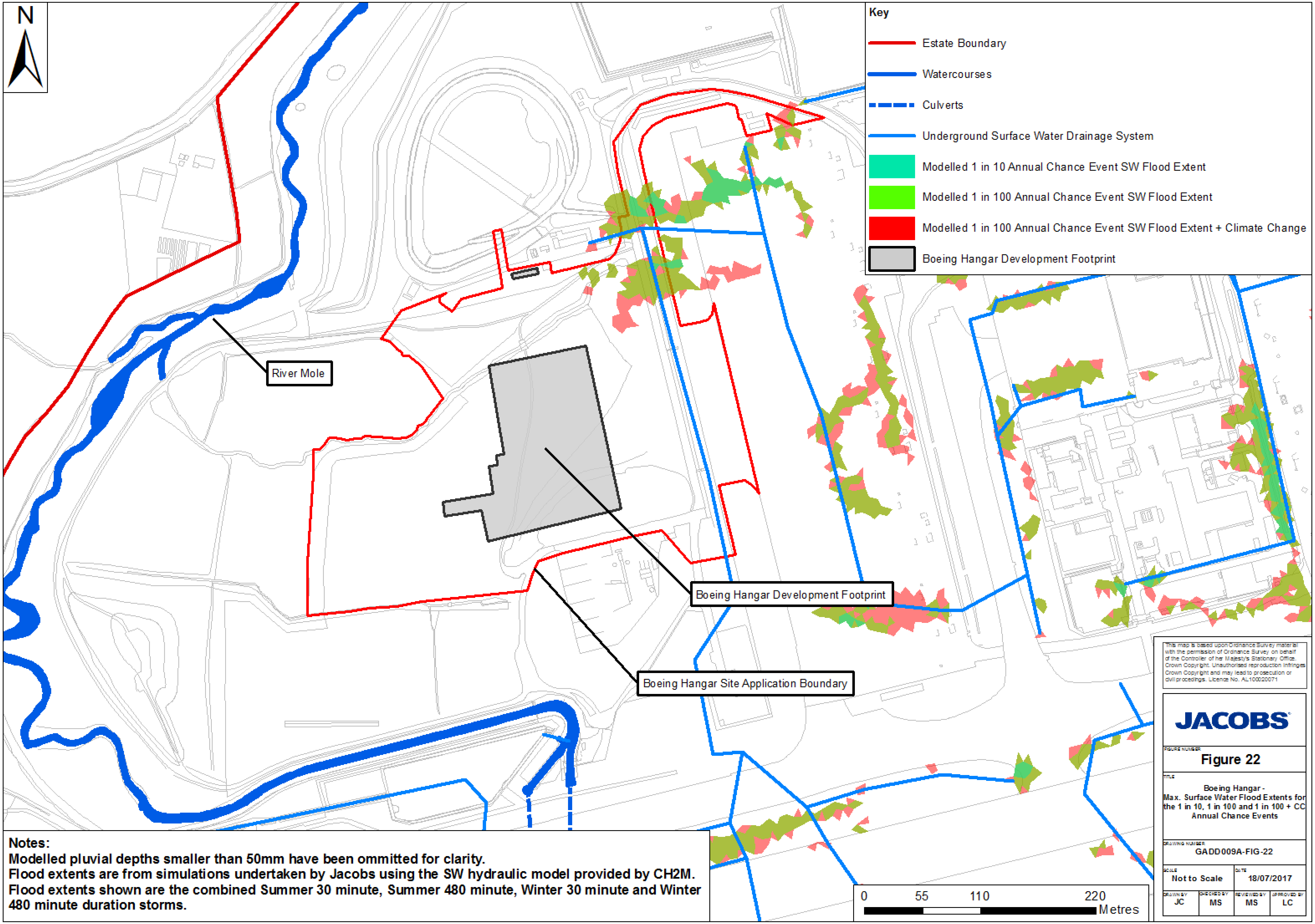
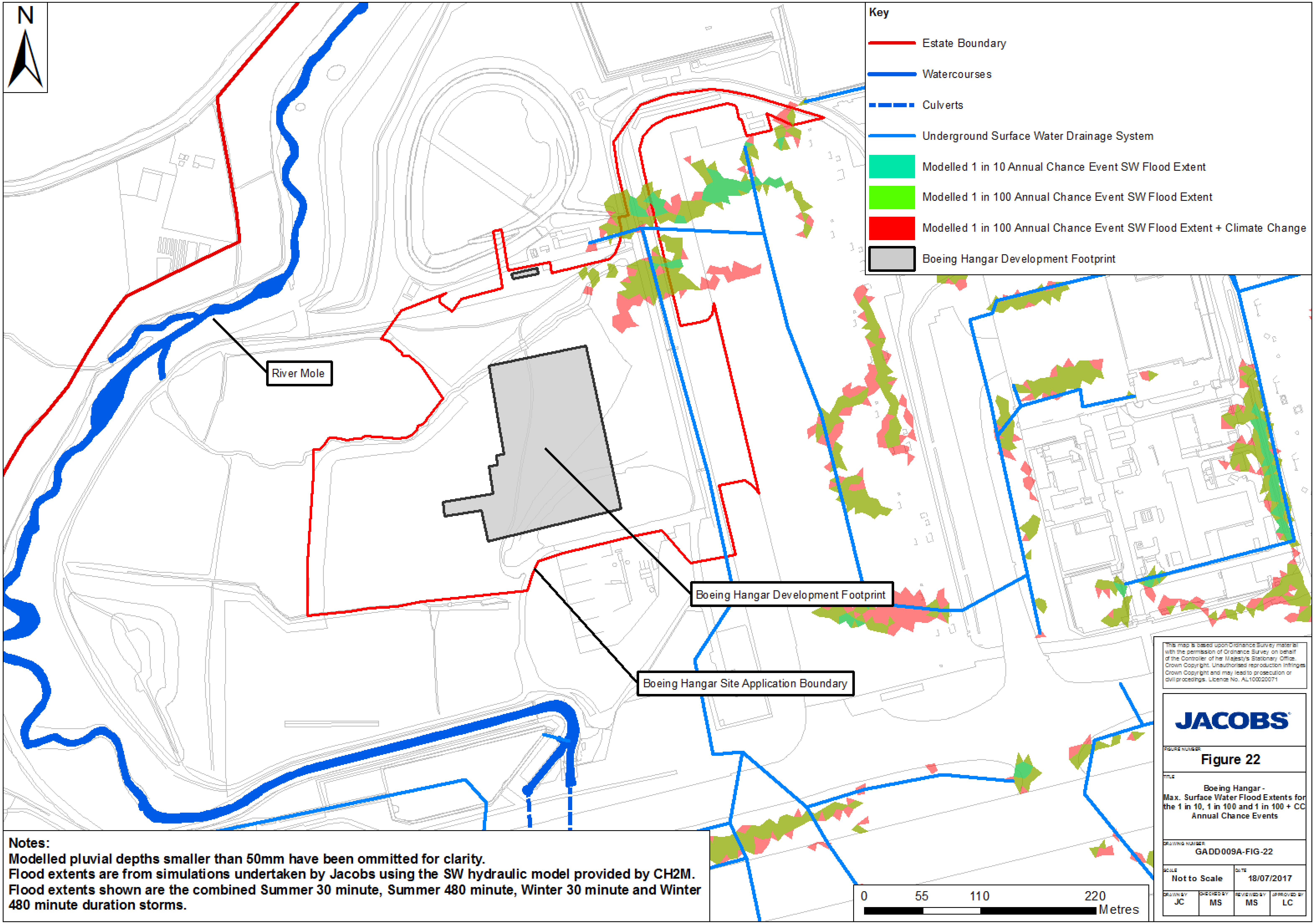
JACOBS
FIGURE NUMBER
Figure 21
TITLE
Boeing Hangar - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)
DRAWING NUMBER
GADD009A-FIG-21
SCALE
Not to Scale
DATE
17/07/2017
DRAWN BY
JC
CHECKED BY
MS
REVIEWED BY
MS
APPROVED BY
LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

FIGURE NUMBER	Figure 22
TITLE	Boeing Hangar - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events
DRAWING NUMBER	GADD009A-FIG-22
SCALE	Not to Scale
DATE	18/07/2017
DRAWN BY	JC
CHECKED BY	MS
REVIEWED BY	MS
APPROVED BY	LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

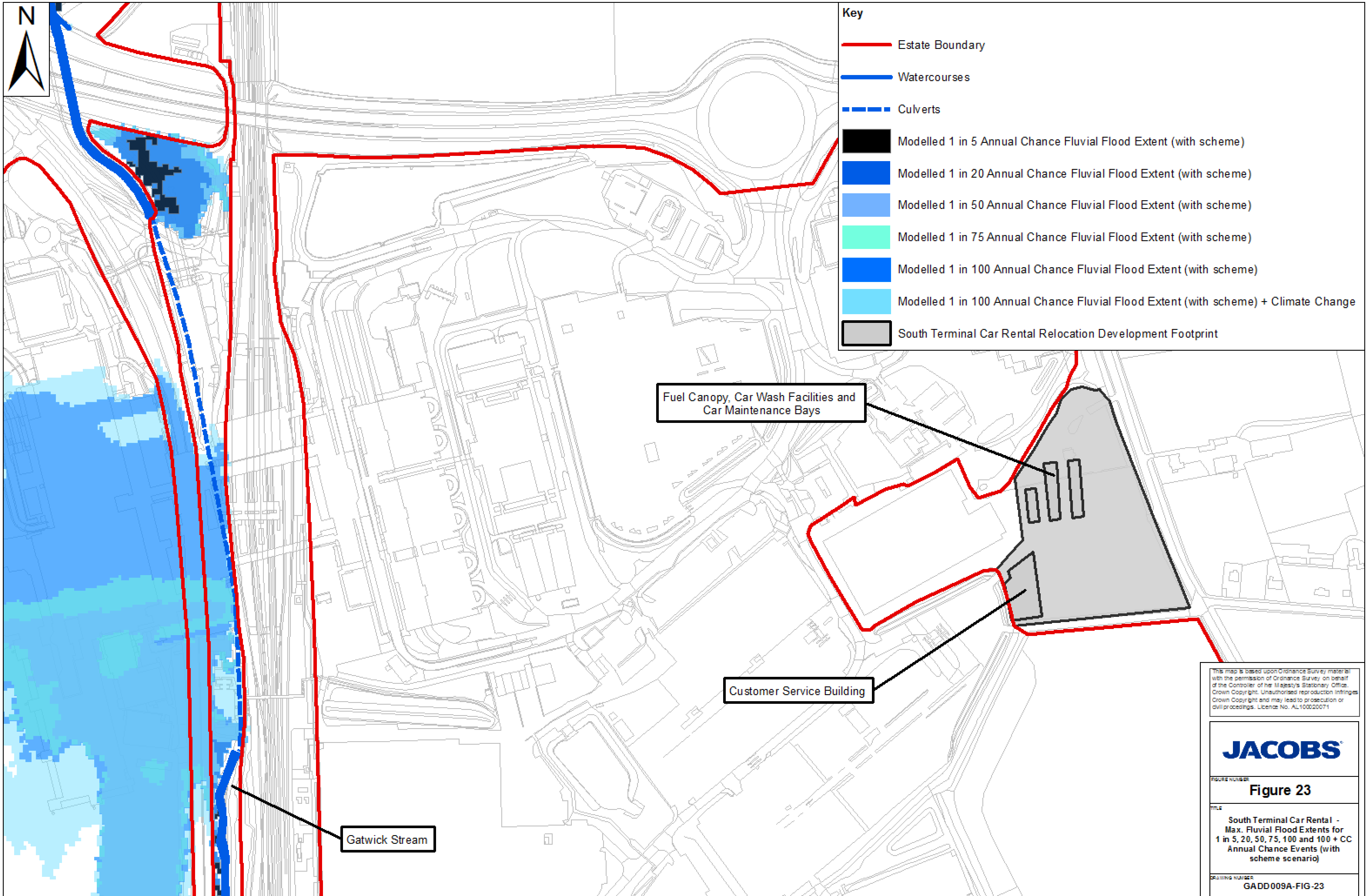
FIGURE NUMBER
Figure 22

TITLE
Boeing Hangar -
Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER
GADD009A-FIG-22

SCALE	DATE
Not to Scale	18/07/2017

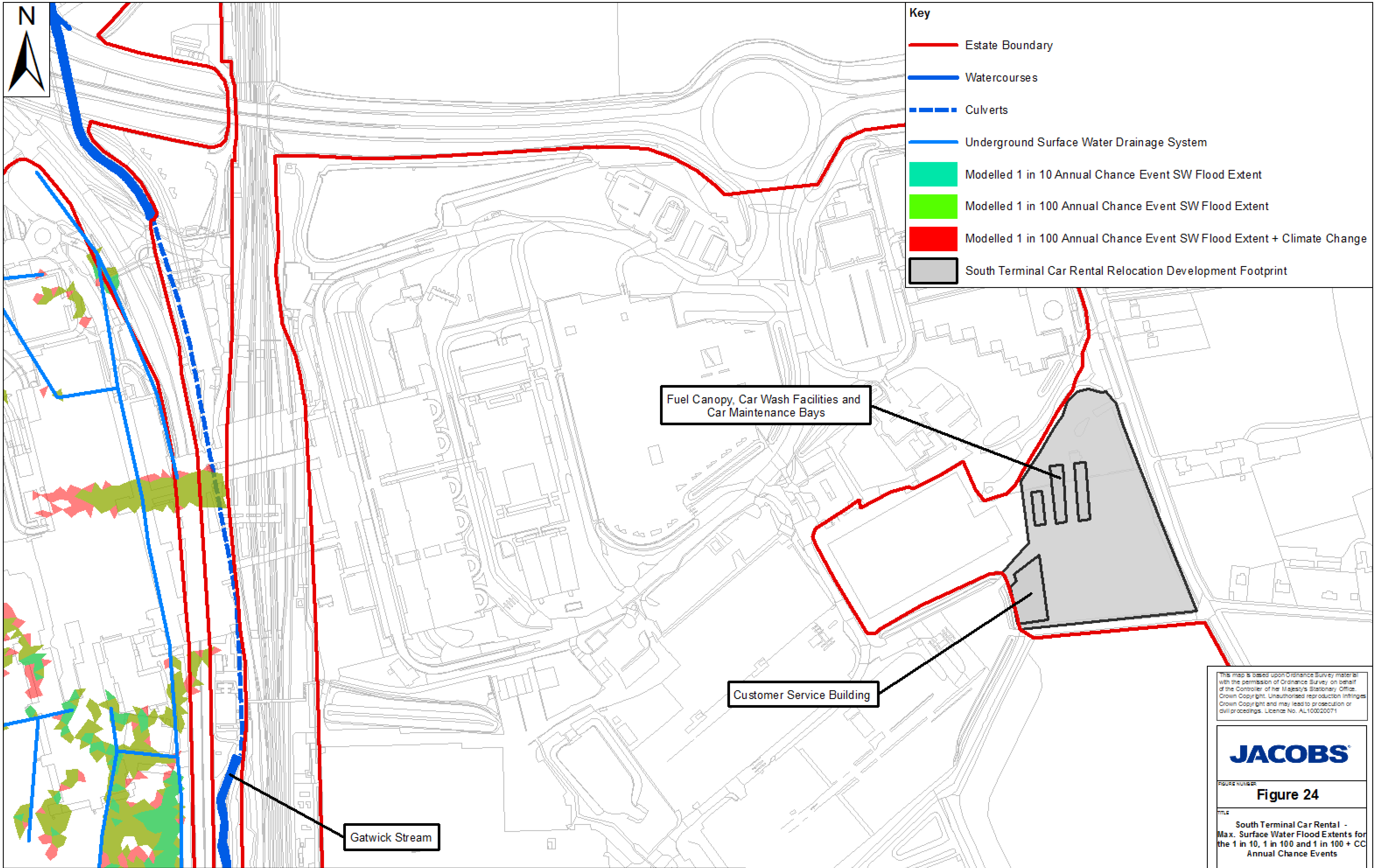
DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.

JACOBS

FIGURE NUMBER	**Figure 23**
TITLE	South Terminal Car Rental - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)
DRAWING NUMBER	GADD009A-FIG-23
SCALE	Not to Scale
DATE	17/07/2017
DRAWN BY	JC
CHECKED BY	MS
REVIEWED BY	MS
APPROVED BY	LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

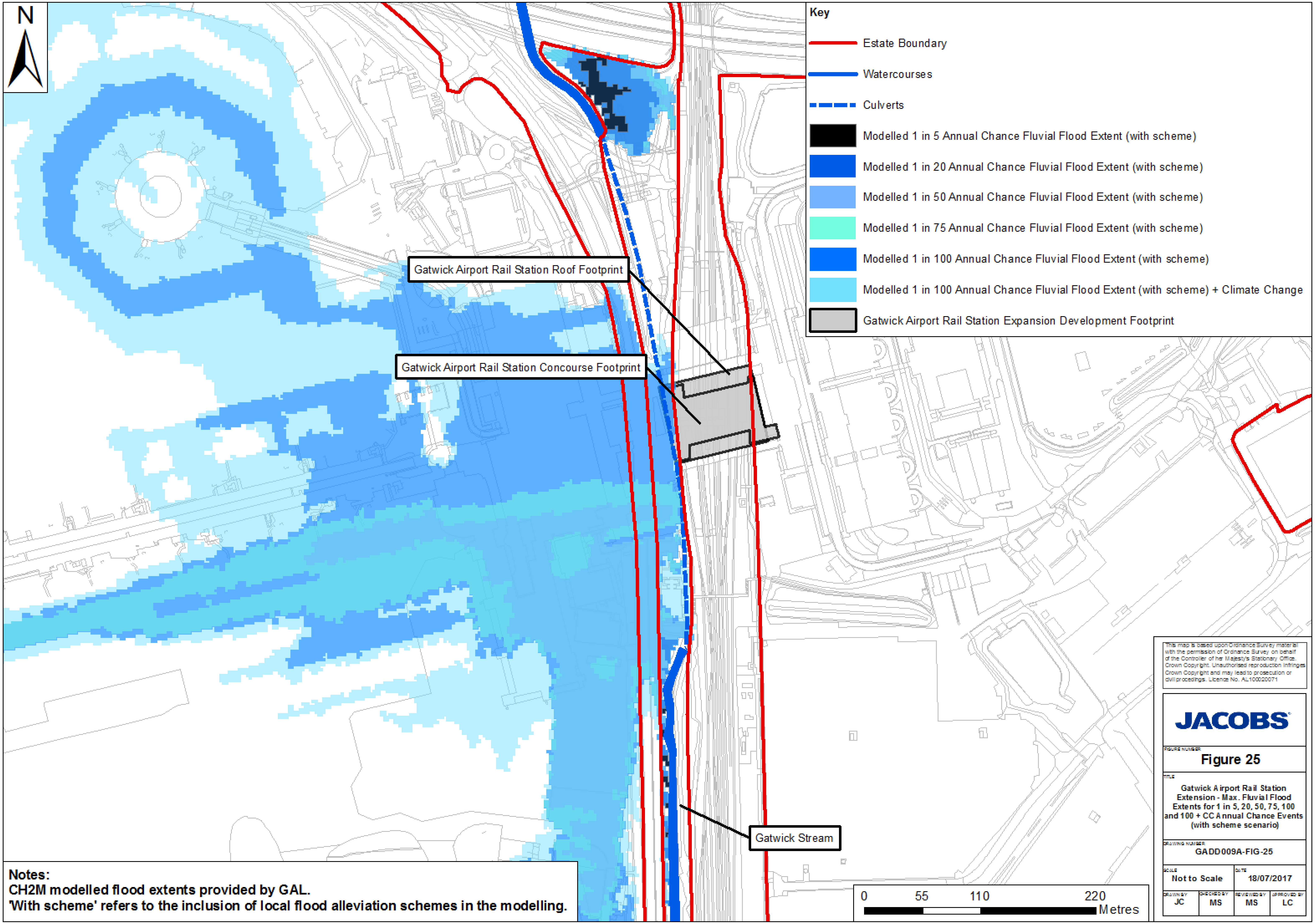
FIGURE NUMBER
Figure 24

TITLE
South Terminal Car Rental - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER
GADD009A-FIG-24

SCALE	DATE
Not to Scale	18/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC



N
Key
Estate Boundary
Watercourses
Culverts
Modelled 1 in 5 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 20 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 50 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 75 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme)
Modelled 1 in 100 Annual Chance Fluvial Flood Extent (with scheme) + Climate Change
Gatwick Airport Rail Station Expansion Development Footprint
Gatwick Airport Rail Station Roof Footprint
Gatwick Airport Rail Station Concourse Footprint
Gatwick Stream
0 55 110 220
Metres
Notes:
CH2M modelled flood extents provided by GAL.
'With scheme' refers to the inclusion of local flood alleviation schemes in the modelling.
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JACOBS
FIGURE NUMBER
Figure 25
TITLE
Gatwick Airport Rail Station Extension - Max. Fluvial Flood Extents for 1 in 5, 20, 50, 75, 100 and 100 + CC Annual Chance Events (with scheme scenario)
DRAWING NUMBER
GADD009A-FIG-25
SCALE
Not to Scale
DATE
18/07/2017
DRAWN BY
JC
CHECKED BY
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MS
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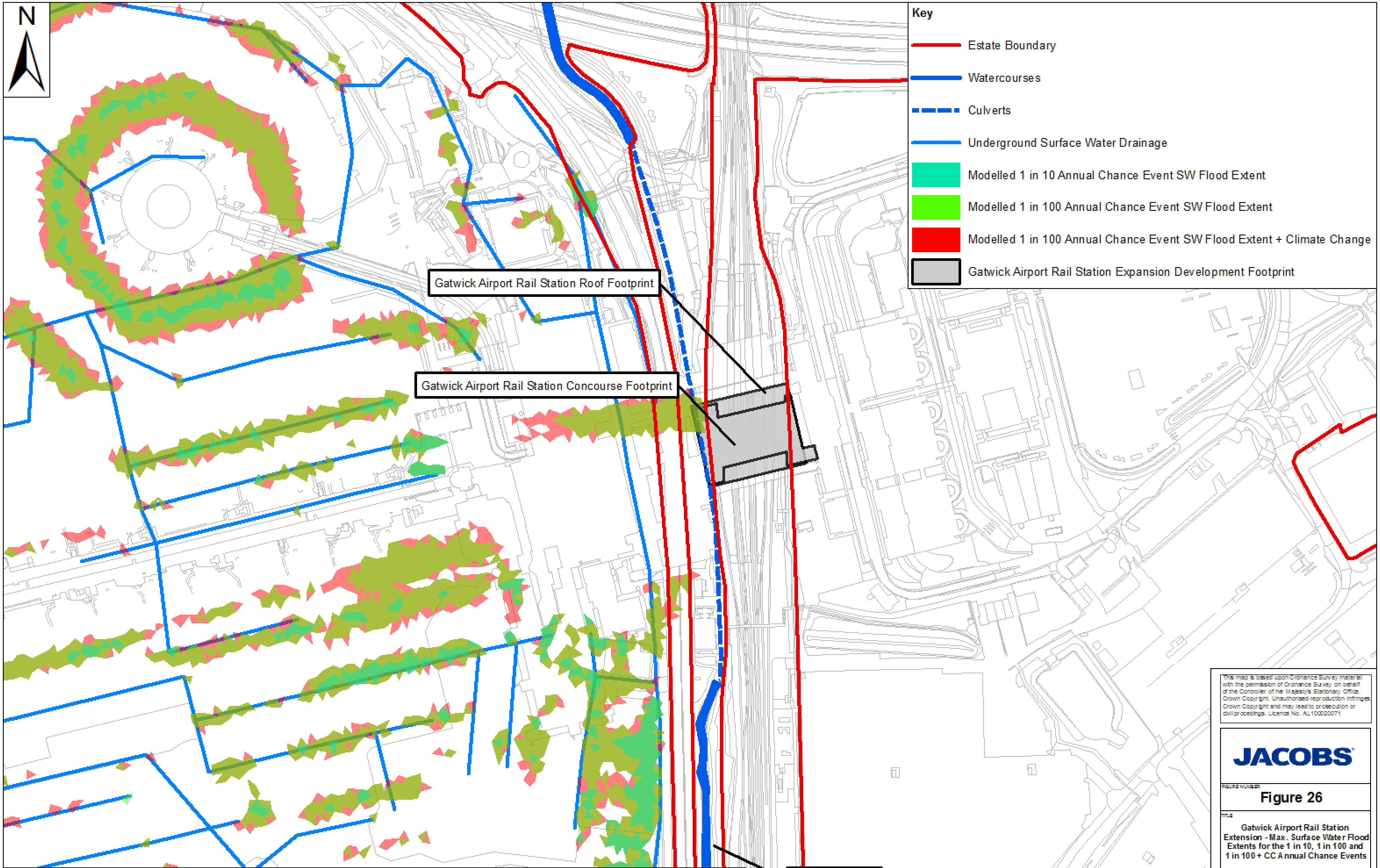
LC



Notes:
Modelled pluvial depths smaller than 50mm have been ommitted for clarity.
Flood extents are from simulations undertaken by Jacobs using the SW hydraulic model provided by CH2M.
Flood extents shown are the combined Summer 30 minute, Summer 480 minute, Winter 30 minute and Winter 480 minute duration storms.

JACOBS

FIGURE NUMBER
Figure 26

TITLE
Gatwick Airport Rail Station Extension - Max. Surface Water Flood Extents for the 1 in 10, 1 in 100 and 1 in 100 + CC Annual Chance Events

DRAWING NUMBER
GADD009A-FIG-26

SCALE	DATE
Not to Scale	18/07/2017

DRAWN BY	CHECKED BY	REVIEWED BY	APPROVED BY
JC	MS	MS	LC

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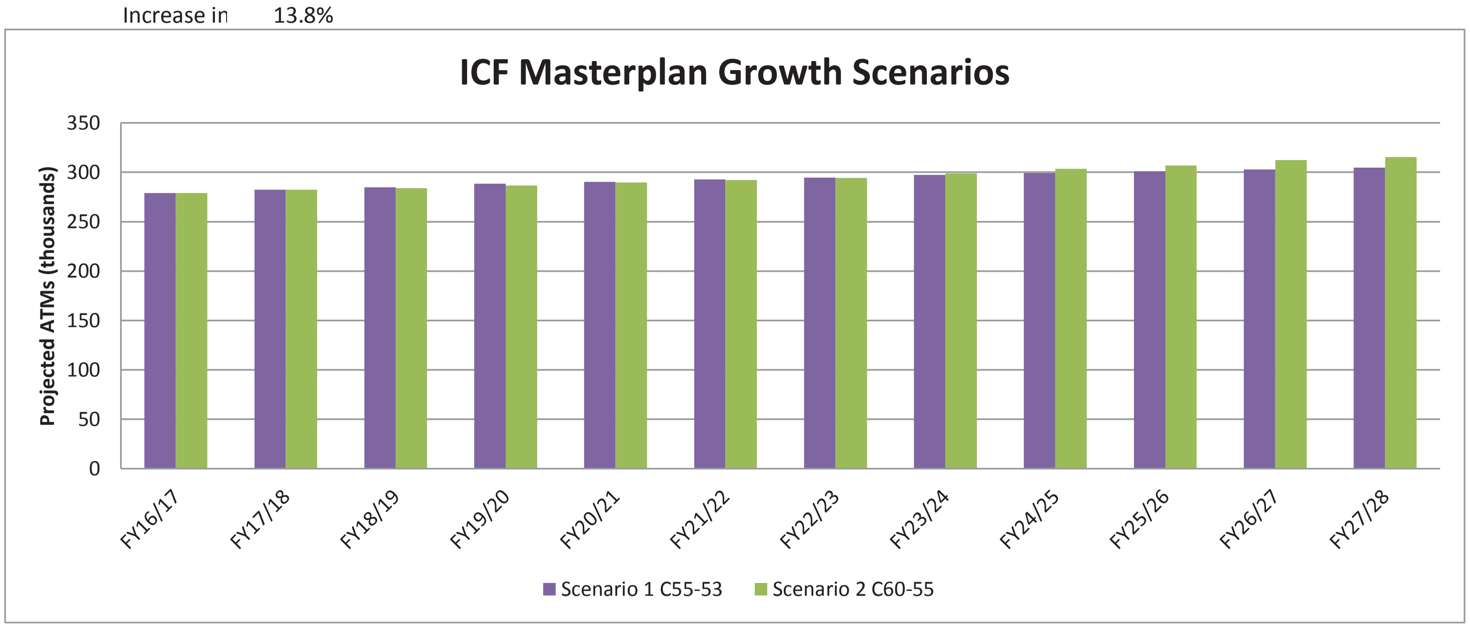
Appendix G. Calculation of Future Water Quality

		Base	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up
Scenario 1 C55-53		FY16/17	FY17/18	FY18/19	FY19/20	FY20/21	FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	FY26/27	FY27/28	FY28/29
ATMs (k)	Domestic	32	33	33	33	33	33	31	31	31	31	31	31	31
	Short Haul	222	222	223	225	225	228	231	233	234	235	236	237	239
	Long Haul	24	28	29	30	32	32	33	34	35	36	36	37	37
	Total	**279**	**282**	**285**	**288**	**290**	**293**	**295**	**297**	**299**	**301**	**303**	**305**	**306**
	Increase per year		1.012563	1.008614	1.012868	1.006804	1.008313	1.006276	1.009394	1.005945	1.006399	1.006004	1.005547	1.005496
		Increase in	9.8%											

		Base	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up	Bottom up
Scenario 2 C60-55		FY16/17	FY17/18	FY18/19	FY19/20	FY20/21	FY21/22	FY22/23	FY23/24	FY24/25	FY25/26	FY26/27	FY27/28	FY28/29
ATMs (k)	Domestic	32.4	33.1	33.1	33.2	33.2	33.2	31.2	31.2	31.3	31.3	31.3	31.3	31.3
	Short Haul	222.2	221.7	222.2	223.3	224.2	225.2	227.2	230.4	233.6	235.4	238.7	241.3	242.5
	Long Haul	24.3	27.5	28.5	30.1	32.3	33.8	35.9	37.3	38.7	40.1	42.2	42.9	43.5
	Total	**278.9**	**282.4**	**283.9**	**286.6**	**289.7**	**292.1**	**294.3**	**299.0**	**303.6**	**306.7**	**312.2**	**315.5**	**317.3**
	Increase per year		1.012563	1.005478	1.009659	1.010597	1.008478	1.007262	1.016067	1.015527	1.010275	1.017864	1.010494	1.005698
		Increase in	13.8%											

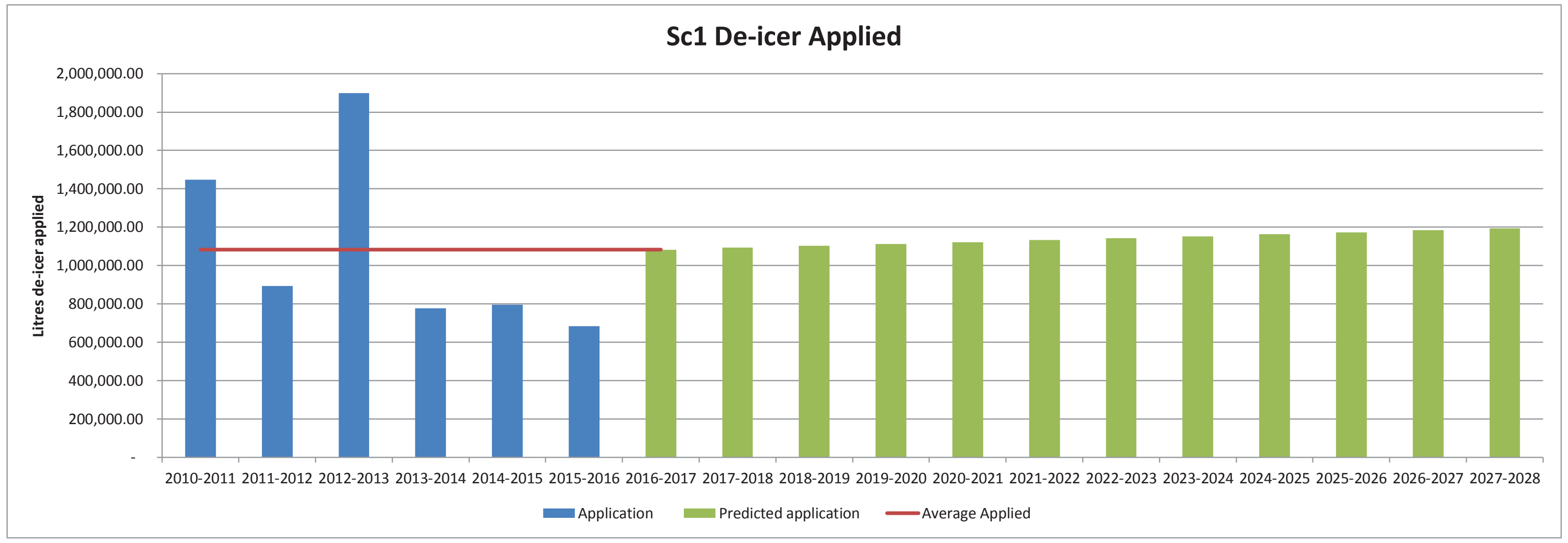


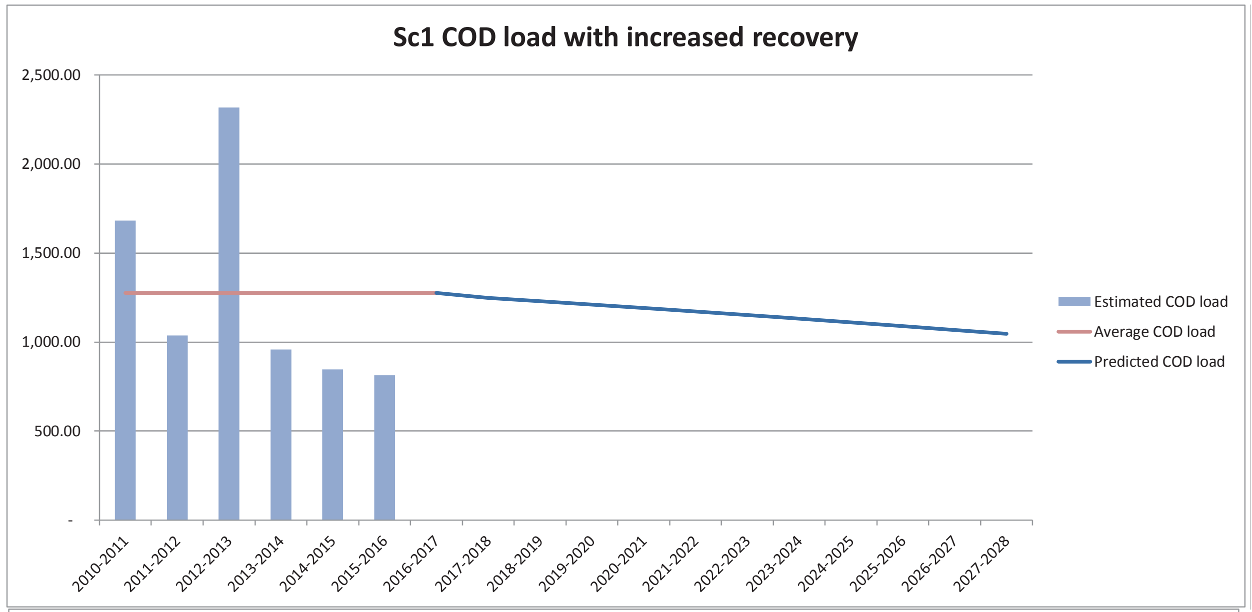
		Without Improvement			With Improvement			
Title	New floor area (m2)	Additional Consumption - Gas (kWh)	Additional Consumption - Elec (kWh)	Total (kWh)	Improvement factor	Additional Consumption - Gas (kWh)	Additional Consumption - Elec (kWh)	Total (kWh)
ESOS / Energy efficiency savings		-2,000	-12,500	-14,500	0%	-2,000	-12,500	-14,500
Boeing Hanger	17,393		4,429,192	4,429,192	25%		3,321,894	3,321,894
Pier 6 extension	15,000	1,173,986	5,162,290	6,336,276	25%	880,489	3,871,718	4,752,207
Pier 6 - A380 Stand	885	69,265	304,575	373,840	25%	51,949	228,431	280,380
CTA/ Domestic facility	470	250,016	278,023	528,039	25%	187,512	208,517	396,029
Railway Station expansion	5,158	Unknown	Unknown	Unknown	25%	Unknown	Unknown	Unknown
MSCP 7	84,735		5,908,001	5,908,001	25%		4,431,001	4,431,001
MSCP 4	27,300		975,751	975,751	25%		731,813	731,813
Long stay decking phase 1	40,180		87,957	87,957	25%		65,967	65,967
Remote aircraft parking - Additions	11 stands		1,021,604	1,021,604	0%		1,021,604	1,021,604
Push & Hold / De-icing stands								
Lima taxiway								
Total	**191,121**	**1,491,267**	**18,154,894**	**19,646,161**		**1,117,951**	**13,868,446**	**14,986,397**

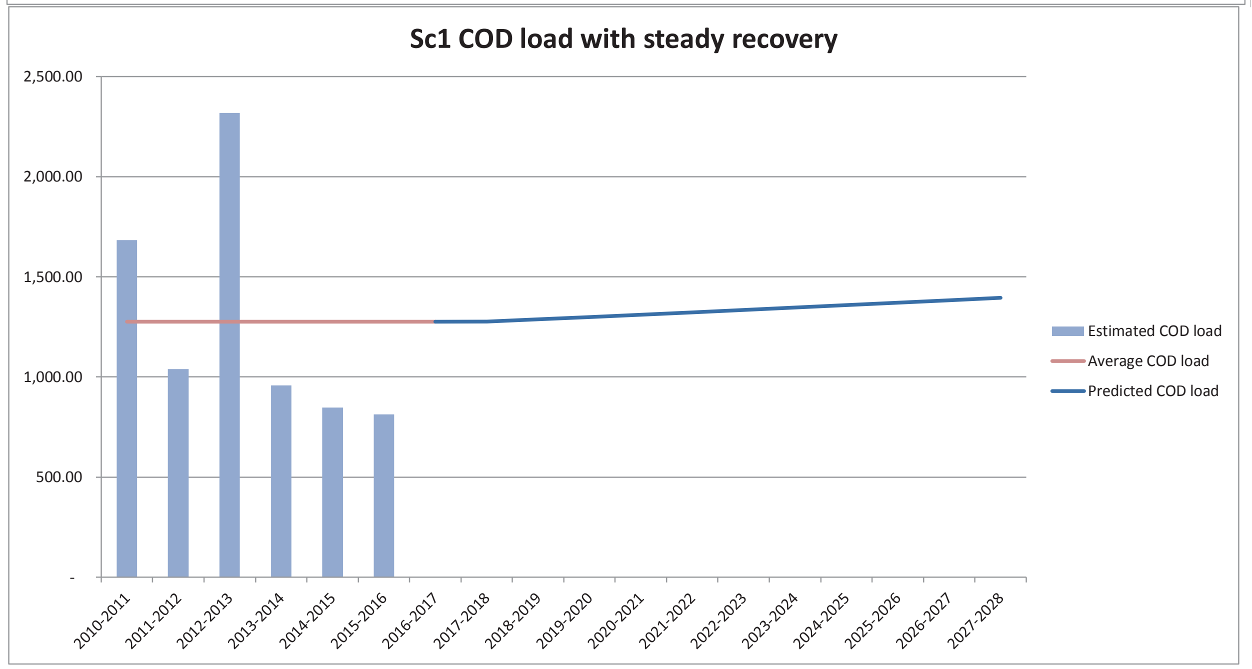
Sc1

C55-53

Aircraft De-icer	Application	Recovery	Unrecovered	Average Applied	Average Unrecovered	Estimated Baseline	Assumin 1.46 kg o2/l Estimated COD load	tonnes o2 /yr Average COD load	Aircraft numbers Per year increase	Recovery Rate	Based on average applied Predicted application	Based on average applied - steady recovery rates Predicted unrecovered	Based on average applied - increased recovery rates Predicted unrecovered	Based on baseline applied Predicted application	Assuming steady recovery rates (tonnes O2/yr) Predicted COD load based on average applied	Future COD load based on baseline applied	Including increase in recovery rates Predicted COD load based on average applied	Future COD load based on baseline applied
2010-2011	1,447,190.00	295,000.00	1,152,190.00	1,083,022.67	873,755.33	600,000.00	1,682.20	1,275.68		0.20								
2011-2012	894,494.00	183,500.00	710,994.00	1,083,022.67	873,755.33	600,000.00	1,038.05	1,275.68		0.21								
2012-2013	1,898,563.00	311,404.00	1,587,159.00	1,083,022.67	873,755.33	600,000.00	2,317.25	1,275.68		0.16								
2013-2014	776,811.00	120,600.00	656,211.00	1,083,022.67	873,755.33	600,000.00	958.07	1,275.68		0.16								
2014-2015	796,667.00	217,100.00	579,567.00	1,083,022.67	873,755.33	600,000.00	846.17	1,275.68		0.27								
2015-2016	684,411.00	128,000.00	556,411.00	1,083,022.67	873,755.33	600,000.00	812.36	1,275.68	1.00	0.19								
2016-2017				1,083,022.67	873,755.33	600,000.00		1,275.68	1.00	0.20	1,083,022.67	866,418.13	866,418.13	600,000.00	1,275.68	700.80	1,275.68	876.00
2017-2018									1.01	0.22	1,092,706.89	874,165.51	854,298.12	605,365.11	1,276.28	707.07	1,247.28	867.76
2018-2019									1.01	0.24	1,102,477.71	881,982.17	841,892.07	610,778.19	1,287.69	713.39	1,229.16	859.31
2019-2020									1.01	0.25	1,112,335.91	889,868.72	829,195.86	616,239.68	1,299.21	719.77	1,210.63	850.63
2020-2021									1.01	0.27	1,122,282.25	897,825.80	816,205.27	621,750.00	1,310.83	726.20	1,191.66	841.74
2021-2022									1.01	0.29	1,132,317.53	905,854.02	802,916.06	627,309.60	1,322.55	732.70	1,172.26	832.61
2022-2023									1.01	0.31	1,142,442.54	913,954.03	789,323.94	632,918.91	1,334.37	739.25	1,152.41	823.25
2023-2024									1.01	0.33	1,152,658.09	922,126.47	775,424.53	638,578.38	1,346.30	745.86	1,132.12	813.66
2024-2025									1.01	0.35	1,162,964.99	930,371.99	761,213.45	644,288.45	1,358.34	752.53	1,111.37	803.84
2025-2026									1.01	0.36	1,173,364.05	938,691.24	746,686.21	650,049.58	1,370.49	759.26	1,090.16	793.77
2026-2027									1.01	0.38	1,183,856.09	947,084.87	731,838.31	655,862.22	1,382.74	766.05	1,068.48	783.46
2027-2028									1.01	0.40	1,194,441.96	955,553.56	716,665.17	661,726.85	1,395.11	772.90	1,046.33	772.90
INCREASE											111,419.29	89,135.43		61,726.85	119.43	72.10	- 229.35	- 103.10
															9%	10%	-18%	-12% % change

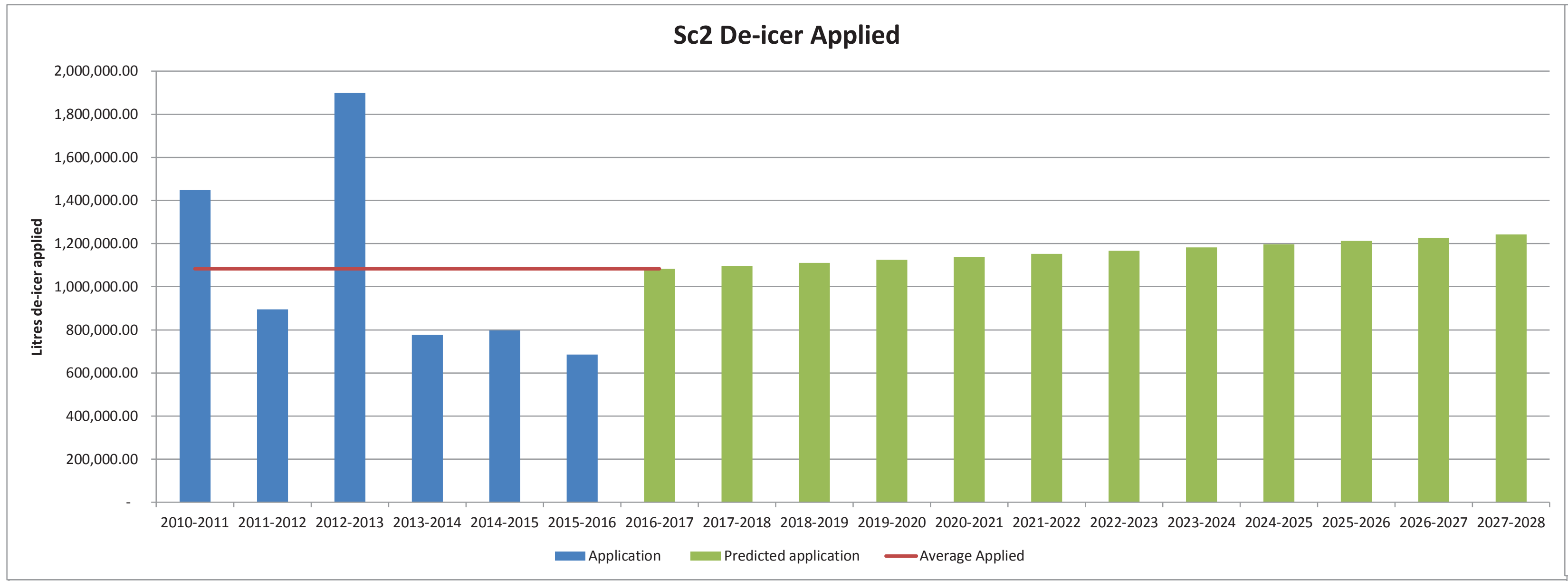

Sc1 De-icer Applied
Litres de-icer applied
2,000,000.00
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Application
Predicted application
Average Applied

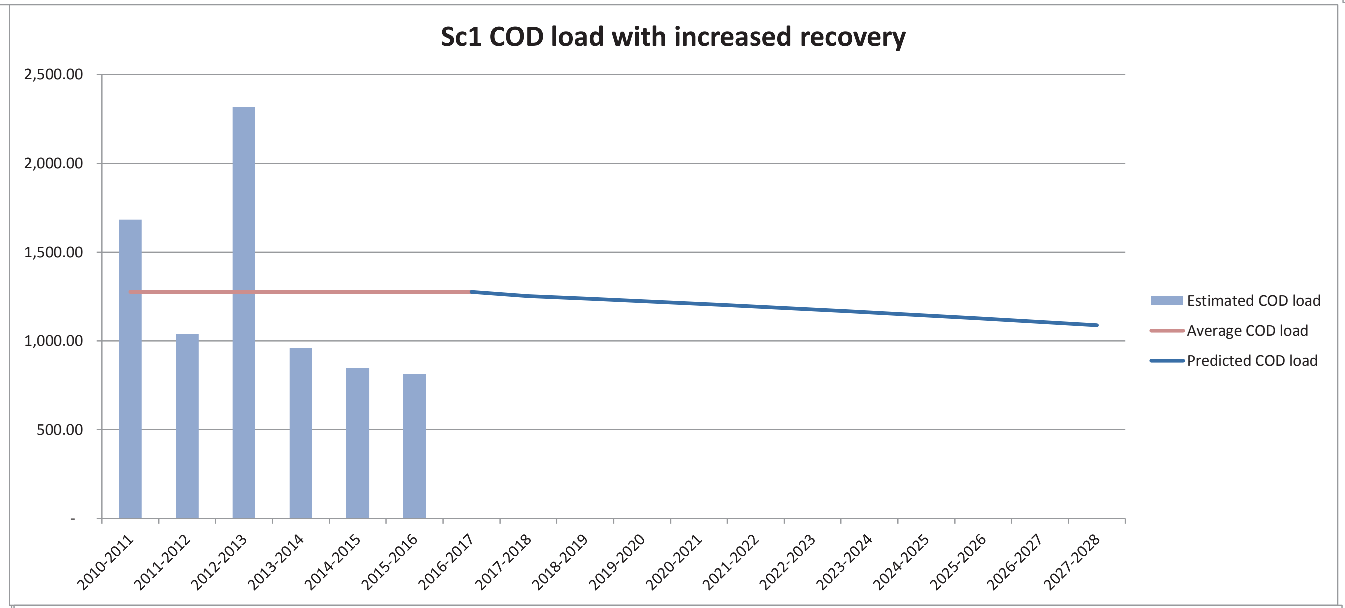

Sc1 COD load with increased recovery
2,500.00
2,000.00
1,500.00
1,000.00
500.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Estimated COD load
Average COD load
Predicted COD load

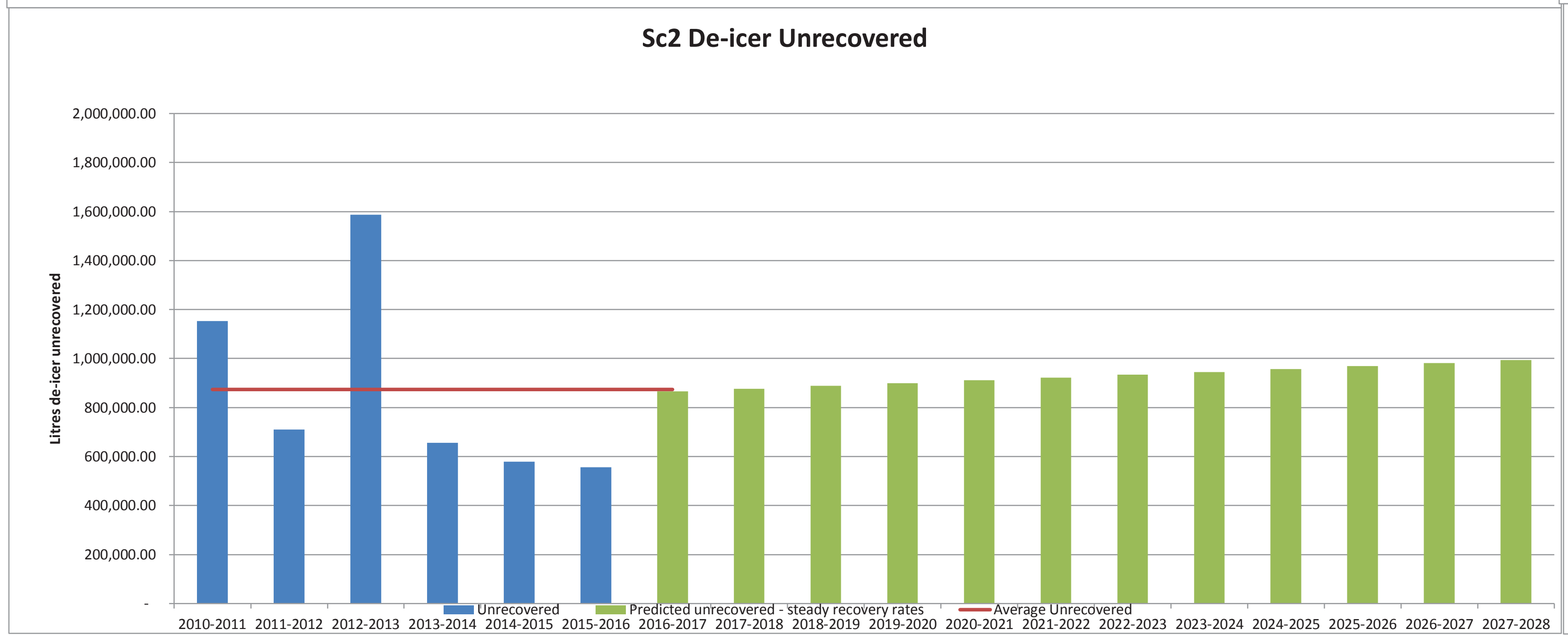

Sc1 COD load with steady recovery
2,500.00
2,000.00
1,500.00
1,000.00
500.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Estimated COD load
Average COD load
Predicted COD load

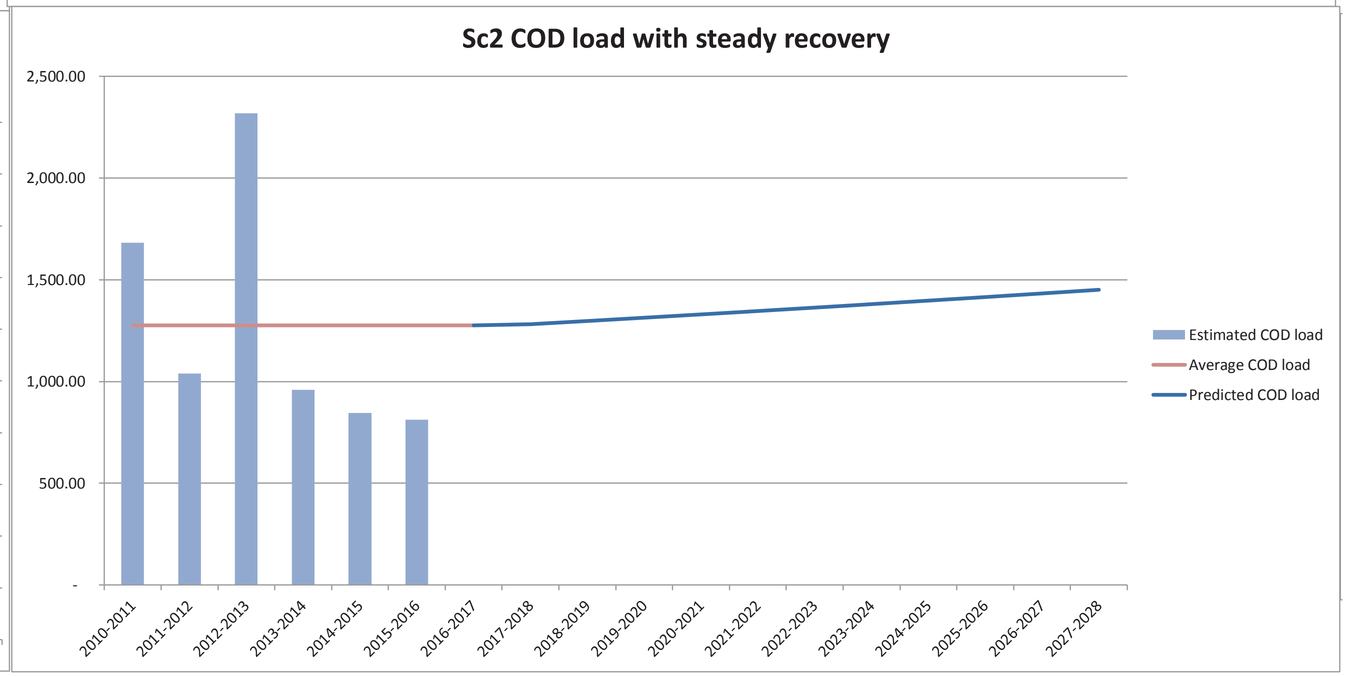
Sc2
C60-55

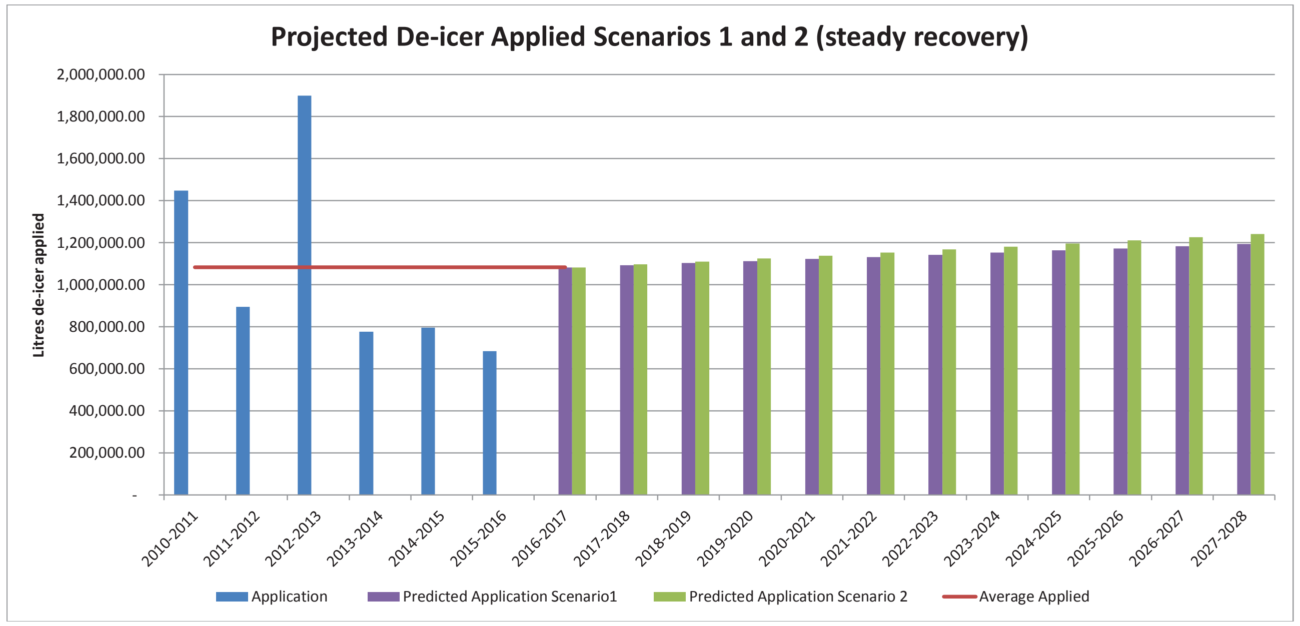
Aircraft De-icer	Application	Recovery	Unrecovered	Average Applied	Average Unrecovered	Estimated Baseline	Assuming 1.46 kg o2/l Estimated COD load	tonne O2/yr Average COD load	From Aircraft numbers Per year increase	Recovery Rate	Based on average applied Predicted application	Based on average applied unrecovered - steady recovery	Based on average applied unrecovered - increasing recovery	Based on baseline applied Predicted application	ASSUMING A COD LOAD OF 1.460 kg o2/l Assuming steady recovery rates: Predicted COD load based on average applied	Future COD load based on baseline applied	ASSUMING A COD LOAD OF 1.460 kg o2/l Also including increase in recovery rates: Predicted COD load based on average applied	Future COD load based on baseline applied	
2010-2011	1,447,190.00	295,000.00	1,152,190.00	1,083,022.67	873,755.33	600,000.00	1,682.20	1,275.68		0.20									
2011-2012	894,494.00	183,500.00	710,994.00	1,083,022.67	873,755.33	600,000.00	1,038.05	1,275.68		0.21									
2012-2013	1,898,563.00	311,404.00	1,587,159.00	1,083,022.67	873,755.33	600,000.00	2,317.25	1,275.68		0.16									
2013-2014	776,811.00	120,600.00	656,211.00	1,083,022.67	873,755.33	600,000.00	958.07	1,275.68		0.16									
2014-2015	796,667.00	217,100.00	579,567.00	1,083,022.67	873,755.33	600,000.00	846.17	1,275.68		0.27									
2015-2016	684,411.00	128,000.00	556,411.00	1,083,022.67	873,755.33	600,000.00	812.36	1,275.68	1.00	0.19									
2016-2017				1,083,022.67	873,755.33	600,000.00		1,275.68	1.00	0.20	1,083,022.67	866,418.13	866,418.13	600,000.00	1,275.68	700.80	1,275.68	876.00	
2017-2018									1.01	0.22	1,096,598.85	877,279.08	857,340.92	607,521.27	1,280.83	709.58	1,251.72	870.85	
2018-2019									1.01	0.24	1,110,345.22	888,276.18	847,899.99	615,136.83	1,296.88	718.48	1,237.93	865.44	
2019-2020									1.01	0.25	1,124,263.91	899,411.13	838,087.64	622,847.85	1,313.14	727.49	1,223.61	859.76	
2020-2021									1.01	0.27	1,138,357.07	910,685.66	827,896.05	630,655.54	1,329.60	736.61	1,208.73	853.79	
2021-2022									1.01	0.29	1,152,626.90	922,101.52	817,317.26	638,561.09	1,346.27	745.84	1,193.28	847.54	
2022-2023									1.01	0.31	1,167,075.60	933,660.48	806,343.15	646,565.75	1,363.14	755.19	1,177.26	841.01	
2023-2024									1.01	0.33	1,181,705.43	945,364.35	794,965.47	654,670.75	1,380.23	764.66	1,160.65	834.17	
2024-2025									1.01	0.35	1,196,518.65	957,214.92	783,175.84	662,877.35	1,397.53	774.24	1,143.44	827.03	
2025-2026									1.01	0.36	1,211,517.56	969,214.05	770,965.72	671,186.82	1,415.05	783.95	1,125.61	819.58	
2026-2027									1.01	0.38	1,226,704.49	981,363.59	758,326.41	679,600.45	1,432.79	793.77	1,107.16	811.81	
2027-2028									1.01	0.40	1,242,081.79	993,665.43	745,249.08	688,119.55	1,450.75	803.72	1,088.06	803.72	
INCREASE											159,059	127,247	- 121,169	88,120	175	103	- 188	- 72	tonnes O2
															14%	15%	-15%	-8%	% change


Sc2 De-icer Applied
Litres de-icer applied
2,000,000.00
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Application
Predicted application
Average Applied

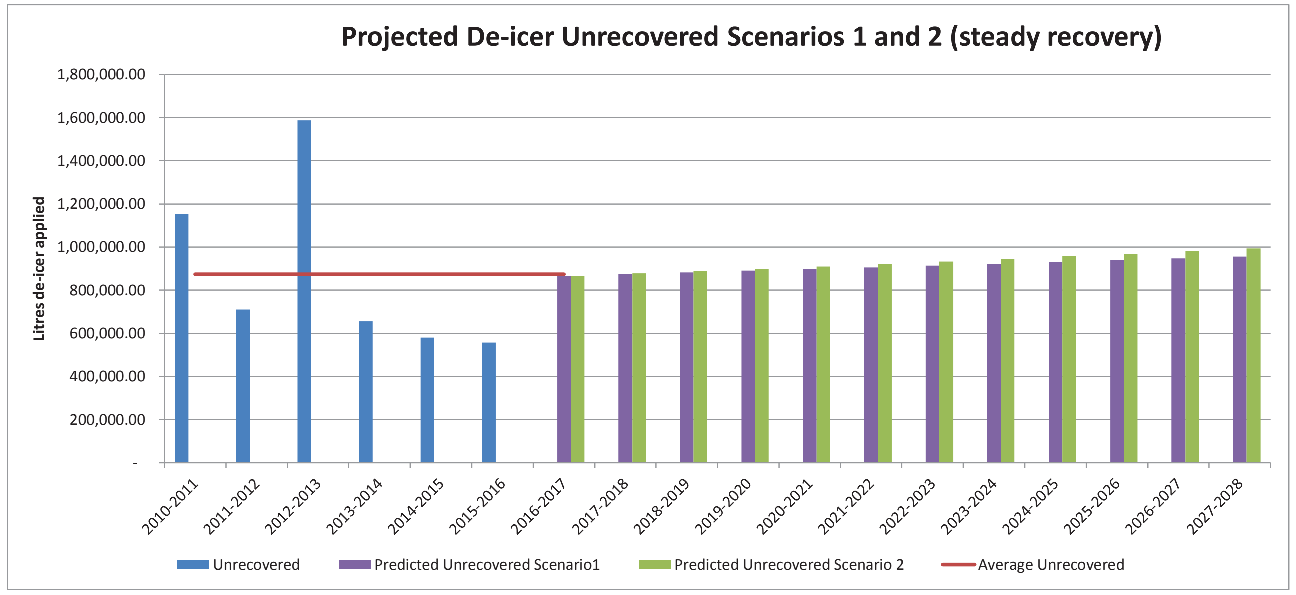

Sc1 COD load with increased recovery
2,500.00
2,000.00
1,500.00
1,000.00
500.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Estimated COD load
Average COD load
Predicted COD load


Sc2 De-icer Unrecovered
Litres de-icer unrecovered
2,000,000.00
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Unrecovered
Predicted unrecovered - steady recovery rates
Average Unrecovered

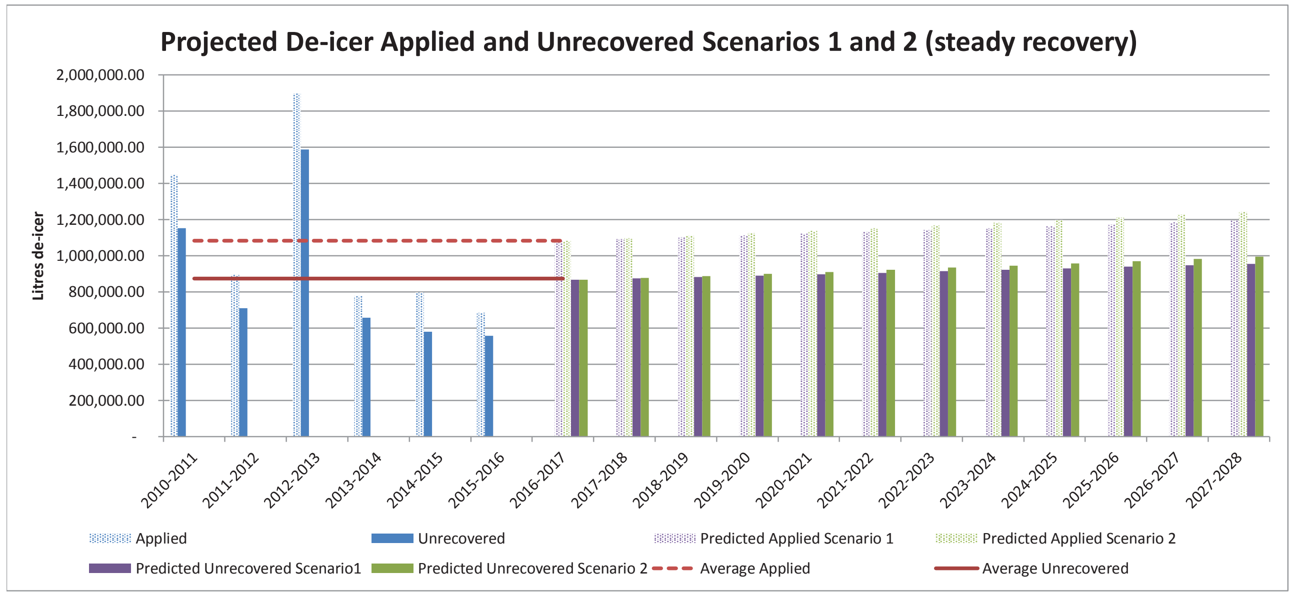

Sc2 COD load with steady recovery
2,500.00
2,000.00
1,500.00
1,000.00
500.00
-
2010-2011 2011-2012 2012-2013 2013-2014 2014-2015 2015-2016 2016-2017 2017-2018 2018-2019 2019-2020 2020-2021 2021-2022 2022-2023 2023-2024 2024-2025 2025-2026 2026-2027 2027-2028
Estimated COD load
Average COD load
Predicted COD load



Projected De-icer Applied Scenarios 1 and 2 (steady recovery)
Litres de-icer applied
2,000,000.00
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
2022-2023
2023-2024
2024-2025
2025-2026
2026-2027
2027-2028
Application
Predicted Application Scenario1
Predicted Application Scenario 2
Average Applied



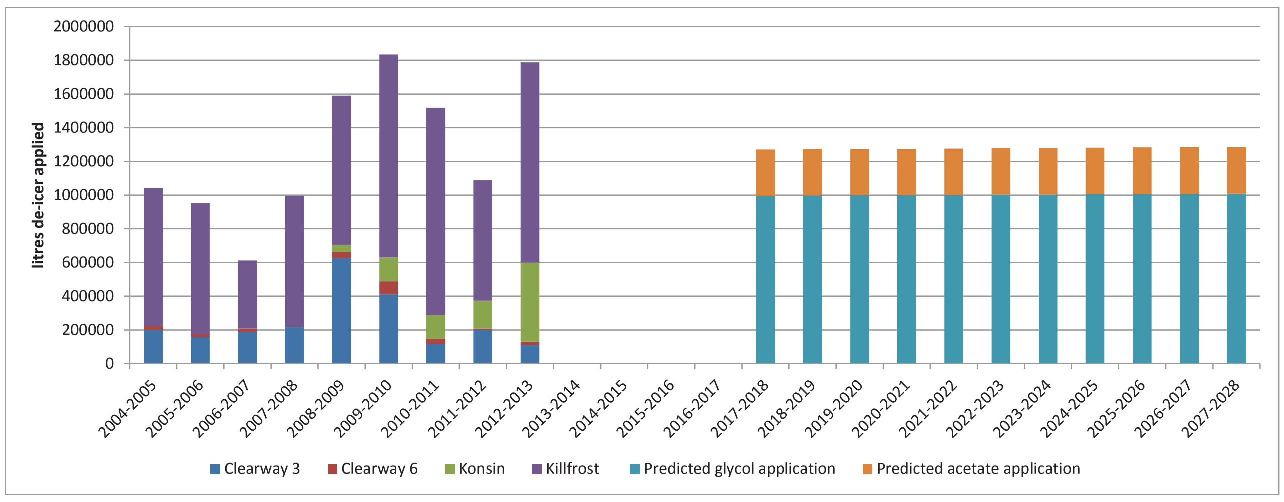
Projected De-icer Unrecovered Scenarios 1 and 2 (steady recovery)
Litres de-icer applied
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
2022-2023
2023-2024
2024-2025
2025-2026
2026-2027
2027-2028
Unrecovered
Predicted Unrecovered Scenario1
Predicted Unrecovered Scenario 2
Average Unrecovered



Projected De-icer Applied and Unrecovered Scenarios 1 and 2 (steady recovery)
Litres de-icer
2,000,000.00
1,800,000.00
1,600,000.00
1,400,000.00
1,200,000.00
1,000,000.00
800,000.00
600,000.00
400,000.00
200,000.00
-
2010-2011
2011-2012
2012-2013
2013-2014
2014-2015
2015-2016
2016-2017
2017-2018
2018-2019
2019-2020
2020-2021
2021-2022
2022-2023
2023-2024
2024-2025
2025-2026
2026-2027
2027-2028
Applied
Unrecovered
Predicted Applied Scenario 1
Predicted Applied Scenario 2
Predicted Unrecovered Scenario1
Predicted Unrecovered Scenario 2
Average Applied
Average Unrecovered

Current Ha	410	ha
Future Incr	5.4	ha
% increase	1%	

	K-acetate-based	Na-acetate-based	Ethylene glycol-based	Propylene glycol-based	K-acetate-based	Average Application		
	Actual application (l/yr)				Actual			
	Clearway 3	Clearway 6	Konsin	Killfrost	ECO2	Average Total	Average glycol based	Average acetate based
2004-2005	200000	23000	0	820000	0	1269222	995444	273777.7778
2005-2006	158000	17000	0	776000	0	1269222	995444	273777.7778
2006-2007	186000	23000	0	404000	0	1269222	995444	273777.7778
2007-2008	215000	2000	0	780000	0	1269222	995444	273777.7778
2008-2009	629000	33000	44000	885000	0	1269222	995444	273777.7778
2009-2010	411000	78000	142000	1203000	0	1269222	995444	273777.7778
2010-2011	116000	33000	138000	1232000	0	1269222	995444	273777.7778
2011-2012	200000	8000	166000	713000	0	1269222	995444	273777.7778
2012-2013	109000	23000	467000	1189000	0	1269222	995444	273777.7778
2013-2014						1269222	995444	273777.7778
2014-2015						1269222	995444	273777.7778
2015-2016	0	0	0	0	280282	1269222	995444	273777.7778
2016-2017	0	0	506	0	433678	1269222	995444	273777.7778
2017-2018								
2018-2019								
2019-2020								
2020-2021								
2021-2022								
2022-2023								
2023-2024								
2024-2025								
2025-2026								
2026-2027								
2027-2028								
INCREASE								
% change								

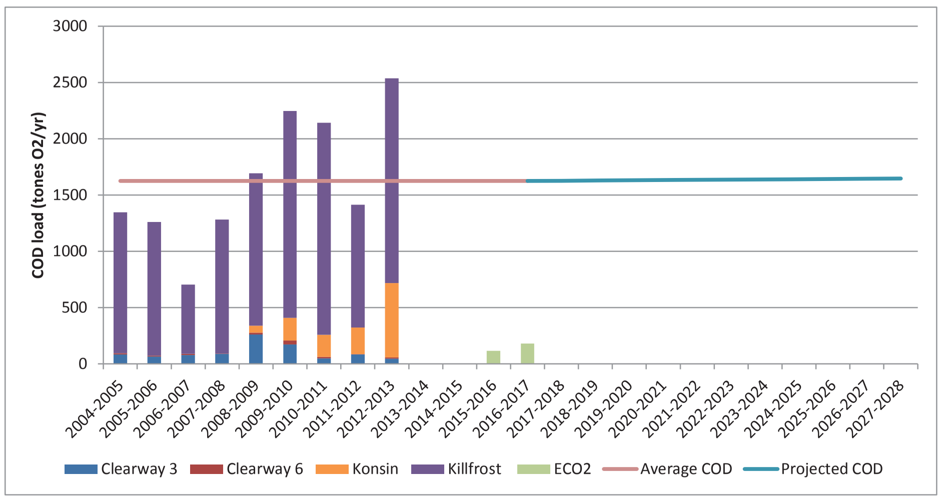


	Clearway 3	Clearway 6	Konsin	Killfrost	Safegrip ECO2
COD	320 mg O2 / g	561mg O2/g	1290 mg O2/g	1390 mg O2/g	Assume 320
density	1.3g/cm3	800kg/m3	1.1g/cm3	1.1g/mL	1.40g/cm3
COD(kg O2/L)	0.416	0.4488	1.419	1.529	0.416

Application increase assuming no change in de-icer, but

Approx COD (tonne O2/yr)

Hardstanding increase per year	Predicted glycol application	Predicted acetate application		Clearway 3	Clearway 6	Konsin	Killfrost	Safegrip ECO2	Average	Total
				83.2	10	0	1253.78		1625	1347
				65.728	8	0	1186.504		1625	1260
				77.376	10	0	617.716		1625	705
				89.44	1	0	1192.62		1625	1283
				261.664	15	62.436	1353.165		1625	1692
				170.976	35	201.498	1839.387		1625	2247
				48.256	15	195.822	1883.728		1625	2143
				83.2	4	235.554	1090.177		1625	1413
				45.344	10	662.673	1817.981		1625	2536
									1625	
									1625	
				0	0	0	0	117	1625	117
				0	0	0.718014	0	180	1625	181
1.001197339	996636.3291	274106								
1.001197339	997829.6409	274434								
1.001197339	999024.3815	274762								
1.001197339	1000220.553	275091								
1.001197339	1001418.156	275421								
1.001197339	1002617.193	275751								
1.001197339	1003817.666	276081								
1.001197339	1005019.576	276411								
1.001197339	1006222.926	276742								
1.001197339	1007427.716	277074								
1.001197339	1008633.949	277405								
	11997.61959	**3300**								
	1%	1%								



Scenario 1				Scenario 2					Scenario 3				
COD load assuming no change in de-icer and increase in				COD load assuming glycol to ECO2 de-icer change, but no hardstanding change					COD load assuming glycol to ECO2 de-icer change and				
Predicted glycol COD	Predicted acetate COD	Hardstanding increase per year	Predicted total COD	Predicted glycol COD	Predicted acetate COD	Predicted ECO2 COD	ECO2 % glycol replacement per year	Predicted total COD	Predicted glycol COD	Predicted acetate COD	Predicted ECO2 COD	Predicted total COD	
1510	115	1.001197339	1625	1510	115	0	0	1625	1510	115		1625	
1512	115	1.001197339	1627	1057	115	124	0.3	1296	1059	115	124	1298	
1514	115	1.001197339	1629	423	115	248	0.6	786	424	115	249	788	
1516	115	1.001197339	1631	21	115	393	0.95	529	21	115	394	530	
1518	115	1.001197339	1633	0	115	414	1	529	0	115	415	530	
1519	115	1.001197339	1635	0	115	414	1	529	0	115	415	530	
1521	116	1.001197339	1637	0	115	414	1	529	0	116	415	530	
1523	116	1.001197339	1639	0	115	414	1	529	0	116	415	530	
1525	116	1.001197339	1641	0	115	414	1	529	0	116	415	530	
1527	116	1.001197339	1643	0	115	414	1	529	0	116	415	531	
1529	116	1.001197339	1645	0	115	414	1	529	0	116	415	531	
1530	116	1.001197339	1647	0	115	414	1	529	0	116	415	531	
	22					-1096				-1094			tonnes O2
			1%					-67%				-67%	

Current COD load (tonnes O2/yr)	
Aircraft de-icer COD load	1,276
Pavement de-icer COD load	1,625
Total de-icer COD load	2,901

Scenario1 C55-53

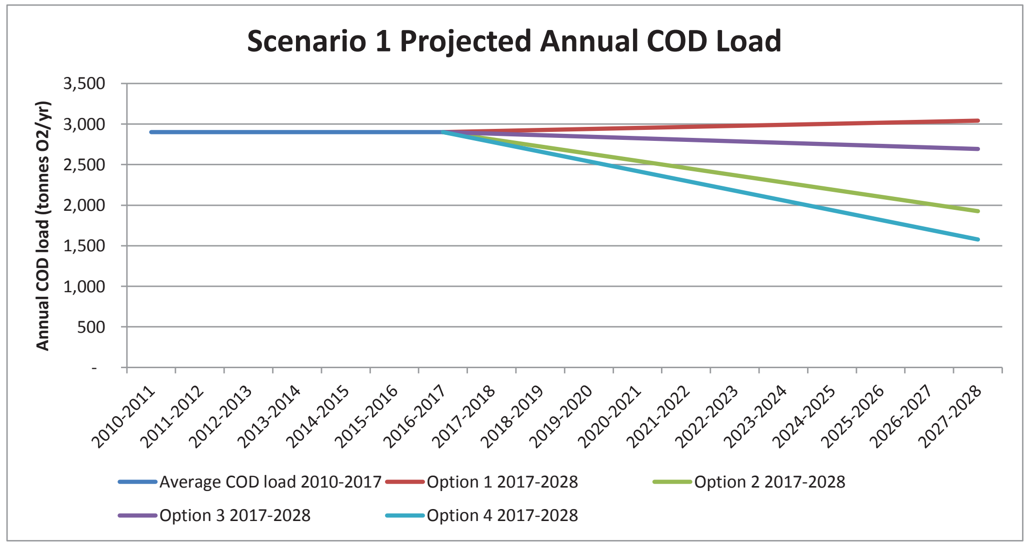
Future COD load (tonnes O2/yr)	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc1 (baseline)	3,042	1,926
Increase in recovery rate	2,693	1,577

% change from current	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc1 (baseline)	105%	66%
Increase in recovery rate	93%	54%

Future COD load (tonnes O2/yr)	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc1 (baseline)	- 141	975
Increase in recovery rate	208	1,324

decrease	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc1 (baseline)	-5%	34%
Increase in recovery rate	7%	46%

Scenario 1 (tonnes O2/yr)	Average COD lo	Option 1 2017-:	Option 2 201	Option 3 2017-2028	Option 4 2017-2028
2010-2011	2,901				
2011-2012					
2012-2013					
2013-2014					
2014-2015					
2015-2016					
2016-2017	2,901	2,901	2,901	2,901	2,901
2017-2018					
2018-2019					
2019-2020					
2020-2021					
2021-2022					
2022-2023					
2023-2024					
2024-2025					
2025-2026					
2026-2027					
2027-2028		3,042	1,926	2,693	1,577



Appendix H. Qualitative Appraisal of Water Quality Management Measures

Current COD load (tonnes O2/yr)	
Aircraft de-icer COD load	1,276
Pavement de-icer COD load	1,625
Total de-icer COD load	2,901

Scenario2 C60-55

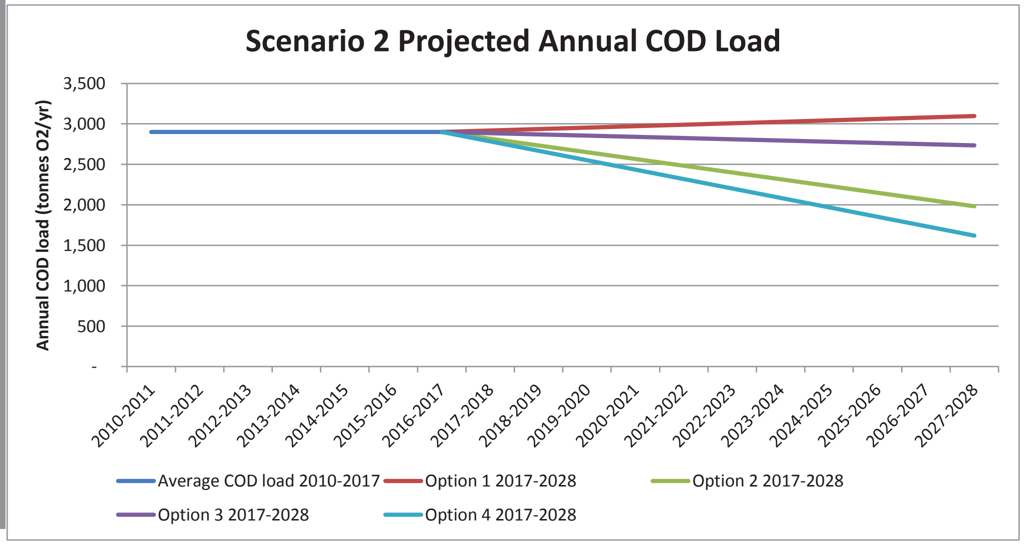
Future COD load (tonnes O2/yr)	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc2 (baseline)	3,097	1,982
Increase in recovery rate	2,735	1,619

% change from current	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc2 (baseline)	107%	74%
Increase in recovery rate	94%	60%

Future COD load (tonnes O2/yr)	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc2 (baseline)	- 197	919
Increase in recovery rate	166	1,282

decrease	Increase in hardstanding (baseline)	Change of de-icer
Increase in aircraft numbers Sc1 (baseline)	-7%	32%
Increase in recovery rate	6%	44%

Scenario 2 (tonnes O2/yr)	Average COD l	Option 1 2	Option 2 2	Option 3 2017-2028	Option 4 2017-2028
2010-2011	2,901				
2011-2012					
2012-2013					
2013-2014					
2014-2015					
2015-2016					
2016-2017	2,901	2,901	2,901	2,901	2,901
2017-2018					
2018-2019					
2019-2020					
2020-2021					
2021-2022					
2022-2023					
2023-2024					
2024-2025					
2025-2026					
2026-2027					
2027-2028		3,097	1,982	2,735	1,619



GAL - Water Quality Management Strategy - De-Icing Fluids Management Strategy

The aim is to produce a high level option review for enhancing the quality of local watercourses.
The timescale 2017 to 2028
Current Situation - Key Points
Average use of de-icer to aircraft - approx 1,083,000 litres per year with 209,000 litres per year recovery (approx. 20% and steady)
Average use of de-icer to pavement - average from 2007/08 to 2013/14 is approx. 1.4m litres per year and no recovery.
Current water quality issues - BOD >10mg/l in stream numbers over years. Since 2010 an average of 28 days/yr (170 total and 77 max in one year) have had discharges above 10mg/l/
Growth in ATMs - between 10%-14% depending on growth scenario
Growth in hardstanding area - 5.4Ha of paving airside (1% increase). Note, this is "new" hardstanding on greenfield

Options Table - potential strategies to further reduce COD load to surface water drainage system and nearby surface water courses

Scenario	More Explanation	Cost	Timescales	Land Take	Environmental Impact	Potential Benefits	Potential Issues	Comments	Recommendations
Do Nothing	Continue as present with no further mitigation.	No infrastructure costs, but increased cost of treatment in Crawley STW. Trade waste agreement expires 2018/2019. Currently costs £100-150k/yr. Future costs may be up to £400-500k/yr.	N/A	None.	Significant Negative - Due to 10% increase of ATMs, Approx. 10% more hard surfacing. This will have a negative impact on volume of BOD discharged and likelihood of exceedance of voluntary and permitted BOD/COD limits	None - due to 2019 cost hike for water disposal.	Large increase in cost from 2019. Increasing likelihood of compliance limit exceedances which may lead to fines and possible prosecution resulting in financial costs, potential clean-up requirement/mitigation being imposed and reputational damage.	Negative reputational effects. New trade waste agreement may be different.	Look into likely cost profiles for glycol disposal going forward to 2028.
Less De-Icer Usage	Apply de-icer at a specific area of apron to airplanes or certain areas of taxiway.	Initial cost of infrastructure/equipment for de-icer application in specific areas. Increased de-icing cost with different systems? However, saving in de-icer usage.	Likely 6 months to 1 year due to any existing contractual commitments and equipment purchase.	Possible small land take if new equipment / stands for application required.	Minor /Significant positive reduction of COD/BOD and less treatment required.	Reduction in pollution due to decreased usage. Potential to recover more de-icer if applied to specific areas making it easier to recover.	Could lead to longer turnaround if application to planes is due to more taxiing or potential queuing of aircraft to receive de-icing at specific locations. Airlines likely to have their own de-icing procedures and possibly products. Application to specific taxiways could result in Health and Safety and operational efficiency risks, particularly in the event of sudden severe weather.	Significantly less de-icer usage unlikely - already using less de-icer than previous years. Greater recovery more likely to be possible.	Clarify current pavement de-icing regime with GAL. Review potential modifications to technique and regime (where it's applied)? Where does this drain to? Could this have implications for limiting the amount of water to be treated?
Less Polluting De-Icer Usage	Since 2015, Gatwick has changed to de-icer products with lower pollution potential (reduction in COD and BOD).	Potential greater cost of new products. Konsin - £1.10/l, Eco2 - £1.29/l. Existing stocks of some de icers e.g. Clearway 6.	Use up existing stocks, new contracts; ongoing.	None or small.	Significant Positive - 3-4x decrease in COD load with different de-icer formulation (from about 1,600mg/l to 350mg/l).	Significant decrease in treatment level/type/volume required to discharge de-icer. The benefit will increase after 2019 due to increased water treatment charges.	Current de-icer purchasing agreement. Layout of water storage may need some consideration.	This could result in a 3 to 4x decrease in COD load depending on the product used. Early results from 2015/2016 show that significant reduciton in COD loading has been achieved. For info COD:BOD ratio (5-day) - 2:1.	Find out more details on the products currently being used together with plans for future usage of each.
More Water Storage Onsite	Construction of a further pollution or water storage lagoon to reduce BOD loading of discharge to stream to less than 10mg/l more frequently.	High cost - broadly proportional to the size of pond required. Note costs may be offset anyway by requirement for further water storage.	2-4 yrs. Considerable planning, design, construction and testing required to implement solution.	Variable but quite significant, say 2-5 Ha? Constrained by operations. Constrained by topography. Possibly in SW of site? Near FTG?	Minor Positive - Both in terms of water quality. Additional minor positive in terms of flooding as more storage leading to greater control on discharge, providing less 'peaky' flow. Holding and segregating 'polluted' runoff so discharge of more water when less polluted. Then more intensive treatment?	Flood storage and additional water efficiency benefits. More storage leading to greater control on discharge, providing less 'peaky' flow. Holding and segregating 'polluted' runoff so discharge of more water when less polluted. Opportunity to use 'clean' water for fire fighting.	Relatively costly. System needs to be gravity fed? New pipes crossing runway or taxiway would be difficult to implement?	Possible firefighting storage location to remove that water load from pond D, thus increasing storage of polluted waters. May also work in combination with treatment or other solutions.	Discuss feasible on-site locations with GAL and then evaluate the feasibility further.
More de-icer recovery Onsite	More active recovery of de-icer. Either of plane run-off or from sweeper fluid. Potentially using a second sweeper vehicle.	Low to moderate cost. May need new sweepers, interceptors or recovery equipment. Balance against potential reduction in Southern Water treatment plant bill.	6 months to 2 years depending on solution.	Relatively low - Possibly more land if logistics requires more standing time?	Potentially significant positive impact. But note no reduction in usage and technical/practical limitations in additional recovery.	Possible cross-benefits with water storage and attenuation.	Could lead to longer turnaround if application to planes is due to more taxiing or potential queuing of aircraft to receive de-icing at specific locations. Airlines likely to have their own de-icing procedures and possibly products.	Greater recovery possible. New contractor currently in place who apparently is recovering 23% of de-icer as opposed to previous average 20% of de-icer.	Review latest figures on de-icer recovery. Look into the feasibility of greater recovery of de-icer from sweeper fluid?
More treatment Onsite	Use a water pre-treatment system onsite to mitigate effects of de-icer. The solution considered was an aerated reed bed.	Moderate to high. This is dependant upon intensity of treatment required and effluent volume. Higher energy = higher costs (both capital and operational).	Potential licensing as well as planning and development cycle - 3-5yrs?	Trade-off between energy, land take and treatment efficiency - higher energy = more intense treatment = less land take. Reed bed treatment has relatively large footprint. There are likely to be constraints on location and possibly may not be undertaken onsite.	Minor/Significant Positive - This is dependant on whether discharge is direct to river or to Treatment Works.	More control on effluent discharge. Significant saving in water disposal costs, particularly after 2019.	Technical issues 'Feeding' of reed bed prior to winter period to increase rate of treatment in cold weather. May need on-site specialist or service agreement?	Pre-treatment of run-off before pond D to increase amount of water flowing from pond D to stream, rather than into lower D. Downstream reed-bed option would need consideration of additional land purchase by Gatwick.	Review the proposals for currently dealing with water treatment and integrate these into this options appraisal. Review the feasibility of a "near source" treatment system which could recover/separate de-icer, possibly with re-use such as membrane filtration/reverse osmosis?
More Treatment Offsite	Addition of pre-treatment for Discharge from pollution lagoon to Crawley STW.	Current agreement expires 2018/2019. Currently 100-150k/yr with 40% discount. Future costs may be up to 400-500k/yr based on current position. Costs offset partly against above although additional treatment would likely be higher, as would likely include an element of operational costs as well as capital costs. Lastly land purchase costs.	Estimated 4-7 yrs to include negotiations with Southern Water, planning and construction. May be other based upon AMP cycle.	Offsite so no land-take as pumped off-site - possible gravity-fed space at STW (i.e. downstream of lagoons).	None assuming that the water treated is the foul effluent only and no impact on discharge to stream.	No impacts to GAL in terms of land usage. If addition to Southern Water then operation will be their responsibility. If GAL, then they will have greater control on the treatment process and more able to make adjustments.	Potential cost of purchasing land. Requirements for specialists in GAL if GAL run treatment plant. If STW run treatment plant then GAL will only have an indirect control on costs via contract agreements.	Potentially a number of options to consider here. GAL or Southern Water to run system. Suitable area of land needs to be identified.	As above.

Appendix I. Compliance with Planning Policy

Table I1: Emerging/Draft National Planning Policy

	Document Reference (Policy Number, Paragraph Number)	Policy Summary (See hyperlink for further elaboration on Policy requirements)	Recommendations for the development of the Masterplan
THE HORIZON: THE FUTURE OF UK AVIATION – A CALL FOR EVIDENCE ON A NEW STRATEGY (JULY 2017)			
	The Horizon: The Future of UK Aviation - A call for Evidence on a New Strategy Paragraph 2.2: Proposed Aims and Objectives.	This emerging strategy is not a planning policy document as such and does not have any specific policy or objective for, flood or water quality. However overall the aim of this strategy is "*to achieve a safe, secure and sustainable aviation sector that meets the needs of consumers and of a global, outward-looking Britain*". The strategy will have the following six objectives: *• help the aviation industry work for its customers;* *• ensure a safe and secure way to travel;* *• build a global and connected Britain;* *• encourage competitive markets;* *• support growth while tackling environmental impacts; and* *• develop innovation, technology and skills.*	Future development at Gatwick would comply with national and local policy. The Masterplan should take into account the high level aims and objectives identified within this strategy.
	Chapter 7: Support Growth While Tackling Environmental Impacts, Paragraph 7.2: Context.	The strategy identifies that *"Government and industry have a vital role in ensuring that the aviation sector grows in a sustainable way"*. This includes taking in to account environmental impacts and the mitigation proposed associated with airport expansion.	
DRAFT AIRPORTS NATIONAL POLICY STATEMENT (NPS): NEW RUNWAY CAPACITY AND INFRASTRCTURE AT AIRPORTS IN THE SOUTH EAST OF ENGLAND (FEBRUARY 2017)			
Water use and wastewater management	Draft Airports National Policy Statement Chapter 5: Specific Impacts and Requirements, Paragraph 5.126-5.136	This strategy provides the primary basis for decision making on development consent applications for additional airport capacity for the Heathrow Northwest Runway but is also "important and relevant" for any applications for terminal capacity in London and the Southeast. **Resource and Waste Management** It is identified that as part of the assessment for waste management "*the applicant should set out the arrangements that are proposed for managing any waste produced in the application for development consent. The arrangements described should include information on the proposed waste recovery and disposal system for all waste generated by the development. The applicant should seek to minimise the volume of waste sent for disposal unless it can be demonstrated that the best alternative is the best overall environmental, social and economic outcome when considered over the whole lifetime of the project*". As part of the mitigation for waste management it is identified within this strategy that *"The applicant should set out a comprehensive suite of mitigations to eliminate or significantly reduce the risk of adverse impacts associated with resource and waste management"*.	The Masterplan should have regard to assessment for waste management under its specific section on the management of water, how it is managed today and in the medium and long term. It is not thought that the document introduces any new policy approaches in the field of water use and waste water management as it is derived from existing policy statements.
Flood risk and surface water management	Paragraphs 5.137 – 5.160	**Flood Risk** The strategy identified that there is the potential for airport expansion to result in increased risk from climate change effects, particularly to increased surface water runoff rate and pressure on potable water supply. There may also be effects on groundwater. The strategy states that "*The applicant should provide a flood risk assessment. This should identify and assess the risks of all forms of flooding to and from the preferred scheme, and demonstrate how these flood risks will be managed, taking climate change into account"*.	In terms of flood risk the Masterplan should take into account that development would be expected to comply with the Sequential and Exception Tests which will be demonstrated via planning applications. While this would aim to ensure development was within the areas of lowest flood risk, airport operations, and the location of existing facilities may require such developments to be located in areas of higher risk. In such circumstances the application will demonstrate that it is safe for users over its lifetime and will not

	Document Reference (Policy Number, Paragraph Number)	Policy Summary (See hyperlink for further elaboration on Policy requirements)	Recommendations for the development of the Masterplan
		The strategy goes on to state that *"Where the preferred scheme may be affected by, or may add to, flood risk, the applicant is advised to seek early pre-application discussions with the Environment Agency, and, where relevant, other flood risk management bodies such as lead local flood authorities, Internal Drainage Boards, sewerage undertakers, highways authorities and reservoir owners and operators.* For local flood risk (surface water, groundwater and ordinary watercourse flooding), "*local flood risk management strategies and surface water management plans provide useful sources of information for consideration in a flood risk assessment".* Furthermore, as stated within the strategy "*when assessing the potential impacts of climate change on airports which can be wider than flooding impacts, such as implications from heat and water availability and the potential adaptation strategies for them, the applicant should take into account the latest UK Climate Change Risk Assessment, the latest set of UK Climate Projections, and other relevant sources of climate change evidence".*	exacerbate flood risk to other parties.
Water Quality		**Water Quality and Resources** Airport infrastructure projects can have adverse effects on the water environment, including groundwater, inland surface water and transitional waters. It is therefore considered that as part of any application for the expansion of an airport *"the applicant should make sufficiently early contact with the relevant regulators, including the Environment Agency, for abstraction*	The Masterplan should demonstrate how, as part of the development application, it would impact upon current water quality and (if required) the mitigation proposed to ensure no deleterious impact on then current water quality.

	Document Reference (Policy Number, Paragraph Number)	Policy Summary (See hyperlink for further elaboration on Policy requirements)	Recommendations for the development of the Masterplan
		licensing and environmental permitting, and with the water supply company likely to supply the water. Where the proposed development is subject to an environmental impact assessment and the development is likely to have significant adverse effects on the water environment, the applicant should ascertain the existing status of, and carry out an assessment of, the impacts of the proposed project on water quality, water resources and physical characteristics as part of the environmental statement". Furthermore "*The applicant should assess the effects on the surrounding water and wastewater treatment network in cooperation with the relevant water and sewerage undertaker(s). It should also address any future water infrastructure requirements of the preferred scheme, including for supplies and sewerage treatment, and the effects on the surrounding water and wastewater treatment network. This assessment would be based on the additional wastewater flows which would need to be treated at sewage treatment works and should be developed through liaison with the relevant water and sewerage undertaker(s)".*	

Emerging Plans within Crawley Borough Council

There are currently no emerging plans or planning guidance for Crawley Borough Council. The new Local Plan, Crawley 2030 was adopted in December 2015 and therefore the policies and objectives are still currently relevant. Relevant Supplementary Planning Guidance is up to date. We note that the Council are currently consulting on Affordable Housing SPD, but do not consider this to be relevant. The Local Development Scheme (LDS) for the period 2015-2018 does refer to a Planning and Climate Change SPD (which was adopted in October 2016) and an update of the Gatwick Airport SPD beginning in 2017, but there is no evidence of any steps having been taken on this and we understand a new Local Development Scheme will begin in September 2017. GAL will need to monitor progress with this LDS, or engage with the Council to help shape their plans.

Emerging Local Plans in Surrounding Areas

The emerging Local Plans in the surrounding districts as identified in Table 2 are also relevant to the wider assessment of future development particular as they are referred to on pages 2 and 3 of the S.106 agreement[7]. Surrey County Council, West Sussex County Council and Horsham District Council do not currently have any emerging plans relevant to the assessment of this masterplan topic area. There are no emerging Strategic Flood Risk Assessments (SFRA) associated with the development of the emerging plans.

Table I2: Emerging/Recently Adopted Local Plans in Surrounding Areas

District Council	Plan/Policy/Guidance	Summary of Plan/Policy/Guidance	Recommendations for the development of the Masterplan
East Sussex County Council	County Councils only have a statutory function for Waste and Minerals Planning. These plans are not directly relevant to the consideration of water resources although they would need considering as part a wider master planning exercise.	N/A	The Masterplan should take into consideration of recently adopted Replacement Waste Local Plan (2017) Replacement Waste Local Plan No updates on Strategic Flood Risk Management Assessments.
Mole Valley District Council	The Future Mole Valley Local Plan.	No document available.	There is currently no document available. However, the Masterplan should take into consideration the development of the Future Mole Valley Local Plan and the timeline for its adoption. It is identified in the Local Development Scheme (2016) that the new local plan is set for adoption in Autumn 2018. No updates on Strategic Flood Risk Management Assessments.
Reigate and Banstead District Council	The Development Management Plan – Part 2 of the Local Plan.	Section 4: Climate Change Resilience and Flooding Policy SC9: *"Direct development away from areas at risk of flooding, and ensure all developments are safe from flood risk and do not increase flood risk elsewhere or result in a reduction in water quality".* The draft Development Management Plan identifies proposed policy CCF2 which states "*Sites within flood zones 2 and 3, sites within flood zone 1 which are greater than 1 hectare in area and sites with critical drainage problems will be required to:*	The Masterplan should take into consideration the development of Part 2 to the Local Plan Policies SC9 and CCF2. Development Management Plan - Part 2 of Local Plan No updates on Strategic Flood Risk Management Assessments.

[7] S.106 agreement agreed between Gatwick Airport Limited, West Sussex County Council and Crawley Borough Council dated 15th December, 2015 doc ref GAT/7/BS

District Council	Plan/Policy/Guidance	Summary of Plan/Policy/Guidance	Recommendations for the development of the Masterplan
		A) Satisfy sequential test and where necessary the exceptions test; and *B) Demonstrate through a site-specific flood risk assessment (appropriate to the scale of development) and flood risk management plan.* *In addition to complying with other relevant DMP policies all development proposals in areas of flood risk will be expected to:* *A) Be designed so that the most vulnerable uses are located in areas of lowest flood risk within the site.* *B) Incorporate appropriate flood plain compensation, surface water attenuation, flood storage and flood resilient design features, which would not increase flood risk elsewhere or reduce the quality of attenuated surface water prior to it entering the watercourse downstream.* *C) Make an appropriate allowance for the effects of climate change representative of the nature and scale of development proposals and the national sensitivity ranges for rainfall intensity and peak river flows.* *D) Provide for safe access and egress in the event of flooding.* *E) Be designed to ensure the safe management and mitigation of residual risk.* *F) Maintain the free passage of surface water along the natural flow paths where possible.* *G) Incorporate a sustainable drainage system – including appropriate arrangements for its ongoing maintenance for the lifetime of the development - unless it*	

District Council	Plan/Policy/Guidance	Summary of Plan/Policy/Guidance	Recommendations for the development of the Masterplan
		can be demonstrated to be inappropriate. For all major development (including that outside flood risk areas), sustainable urban drainage systems should be provided unless demonstrated to be inappropriate.	
Tandridge District Council	Emerging Tandridge Local Plan - Consultation on sites.	No document available.	There is currently no document available. However, the Masterplan should take into consideration the development of the Emerging Tandridge Local Plan when published. The submission of a draft local plan is scheduled for 2018 within the Local Development Scheme document (June 2017). The proposed date for adoption is scheduled for 2019 in accordance with the Local Development Scheme document. Emerging Tandridge Local Plan
Mid Sussex District Council	Mid Sussex District Plan 2014-2031- Pre Submissions document.	Within the emerging local district plan it is identified that "*the Gatwick airport has ambitious plans for growth and development, utilising the existing runway and terminals, to support up to 45 million passengers by 2021. The Council within mid Sussex District will work with partners across the Gatwick Diamond area, through the Gatwick Diamond Initiative, to encourage sustainable economic growth to support this expansion. This will include supporting Gatwick as an economic and transport hub, and seeking to improve access to and from the airport by a range of modes of transport.*"	The Masterplan should take into consideration the development of the Mid Sussex District Plan when adopted (2017, according to the Local Development Scheme). It is understood that this plan is currently at examination. Pre-Submissions Draft Mid Sussex District Plan 2014-2031 No updates on 2015 Strategic Flood Risk Management Assessments.

Water Masterplan 2020 & 2028 Forecast - Full backing report

Other Emerging and/or changing legislation

BREEAM

The Masterplan should be aware of the updates to BREEAM's standards. As a key part of the update process, all technical issues will be reviewed to ensure they continue to deliver value and are up to date with recent developments within the industry, best practice standards, regulation & policy. There is currently no document available to identify the proposed changes. These are likely to be launched in Spring 2018.

Climate Change Predictions

The Masterplan should be aware of the expected updates to climate change predictions following the Paris Climate Change Agreement in December 2015. The UKCP (UK Climate Predictions) 18 project is to build upon the UKCP09 project which will further help decision-makers assess the full range of risks from the changing climate and advise how we can adapt. The upgrades to climate change predictions will focus on future climate scenarios such as temperature and precipitation over land and are therefore considered relevant to the Masterplan. Planning requirements have previously been driven by the requirements of the Environment Agency who last update their guidance in 2016, the publication of UKCP18 may result in a further update.

Appendix J. Potential Flood Risk Mitigation Measures

Proposed Development Number	Proposed Development	Development Works	Surface Water Drainage Catchment	Fluvial Flood Risk						Surface Water Flood Risk			Potential Flooding Description		Existing Permeable Areas Loss	Potential Flood Mitigation Options		Recommendations
				Storm Return Period						Storm Return Period								
				5yr	20yr	50yr	75yr	100yr	100yr+20% CC	10yr	100yr	100yr+20% CC	Fluvial	Surface Water		Fluvial	Surface Water	
															(m²)			
1	Pier 6 Extension	Pier 6 is located south-west of the North Terminal building. The objective of the Pier 6 project is to increase the level of pier service in the North Terminal as well as providing a consolidated operations zone for Gatwick's largest carrier, easyJet. The Pier 6 project will deliver 7 new full Code C stands immediately west of the current pier. It will also make modifications to Stand 103, allowing the stand to accommodate up to an A320 aircraft, giving a total of 17 pier served stands (a net gain of 6 stands). The extension is currently expected to be be complete in Spring 2022. In order to make way for the Pier 6 extension the current A380 stand (Stand 110 at Pier 6) will be relocated to Pier 5 (described in further detail further along in this table). Modifications will be made to the Quebec taxiway to facilitate the A380's reaching it's new stand. The Pier 6 building western extension will be 3 storeys with a total footprint of approx. 15,000m^2 (building outline footprint of approx. 5000m^2). The extension is assumed to require a new substation. The 7 new stands will require approx. 20,000m^2 of concrete. However, the existing site is already paved so there will be no net increase in paved area. The Quebec taxiway will require 6,000m^2 of additional/replacement concrete. Stand 103 substation generators will be relocated to allow the stand to be brought into service.	Pond D	N	N	N	N	Y	Y	N	Y	Y	The majority of the existing Pier 6 building is located within the 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change fluvial flood extents from the Gatwick Stream.The 1 in 75 annual chance fluvial flood extent does however fall short of the proposed Pier 6 building extension by approx.30 metres to the east. With regards to the 1 in 100 annual chance and 1 in 100 annual chance plus climate change events the fluvial flood extents encroach on the eastern end of the proposed Pier 6 building extension. The flood extent within the proposed building footprint is quite small but nonetheless the proposed Pier 6 building footprint would likely displace this fluvial flooding into the adjacent Pier 6 stands if not mitigated for.	The existing Pier 6 building is almost fully located within the 1 in 10 annual chance surface water flood extent. It appears that the surface water flooding is from the existing slot drains located adjacent to the northern and southern faces of the Pier 6 building which likely drain the existing Pier 6 stands of surface water.The Pier 6 building extension is located outside the the 1 in 10 annual surface water flood extent. The proposed Pier 6 building extension is subject to encroachment of potential surface water flood extents from the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. This appears to be originating from an existing slot drain (Google aerial imagery) serving the existing stands. The proposed Pier 6 building footprint is located over this slot drain and so the slot drain would likely be removed and repositioned as part of the propsoed development. It is unlikley the flood risk from such a large storm event could be completely designed out (i.e. slot drainage slots only have a certain capacity to accept runoff). However, any potential flooding could be accounted for in the design of the proposed Pier 6 building/stands to minimise operational impacts.	Development area already fully paved. No net gain in paved area.	(1) Introduce a hard flood defence (e.g. flood wall) along the left-hand bank of the Gatwick Stream to retain the flow in channel and prevent flooding of the airfield.This would be an expensive option but would offer the best fluvial flood protection to the airfield. (2) Employ bank raising along the Gatwick Stream to contain the water in channel and prevent it flooding the airfield. If the options to provide a flood wall or bank raising along the Gatwick Stream are not pursued then the following less expensive mitigation options could be considered: (3) For the existing Pier 6 building its resilience to fluvial flooding could be assessed and if any low floor level thresholds, critical assets (e.g. electrical equipment) are idenitifed these coud be raised above fluvial flood water levels to increase flood resilience. Demountable flood defences could also be employed where appropriate (e.g. doorways) in the event of a flood event to limit flood inundation of the building interior. An assessment to identify potential underground flowpaths (e.g. cable trenches, etc.) would need to be undertaken to assess the viability of demountable flood defences. (4) Although there is limited encroachment of fluvial flood extents to the proposed Pier 6 building footprint the proposed structure could nonetheless be designed with added resilience to fluvial flooding (e.g. increased floor level thresholds, placement of critical assets above fluvial flood water levels, etc.)	**Existing Pier 6 Building & Stands Surface Water Drainage:** (1) The surface flooding could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at Pier 6. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at Pier 6; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the surface water drainage system collection area at the ground surface has a fixed capacity to accept rainfall runoff. To mitigate inundation of the Pier 6 building with surface water building floor thresholds could be raised, move critical assets above floodwater levels and employ demountable defences where approriate (e.g. doorways, etc.); (3) For large return period and long duration events (i.e. lower rainfall intensity but sustained rainfall) if the existing surface water drainage system has insufficient attenuation to contain large volumes of surface water runoff (i.e. resulting in surcharging the drainage system and flooding the airfield) then an option may be to retrofit the drainage system and employ increased attenuation storage on the drainage system (e.g. offline underground attenuation storage tank) thereby reducing the risk of surface water surcharging the drainage system and flooding the airfield ground surface. **Proposed Pier 6 Building Extension & Stands Surface Water Drainage:** (4) Where practicable an exercise could be undertaken to identify areas that can be installed as permeable as opposed to being paved within the proposed Pier 6 development. This will reduce the volume of surface water runoff draining to the proposed drainage system thereby reducing the surface water flood risk and the extent of any potential surface water flooding; (5) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the surface water drainage system collection area at the ground surface will have a fixed capacity to accept rainfall runoff. Surface water modelling of the proposed drainage system should be undertaken to assess the movement of the surface water that evades the drainage system at the ground surface such that design measures can be employed. For example the ground can be profiled to fall certain directions away from less critical areas to eventually drain into the drainage system, etc); (6) For large return period and long duration storm events (i.e. lower rainfall intensity but sustained rainfall) attenuation storage can	(1) Once outline/detailed design is commenced on the proposed Pier 6 building extension and associated stands a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and proivde effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Potentially a project could be undertaken to identify redundant pavement across the airfield to reduce the hydraulic loading on the drainage system which could improve drainage locally at Pier 6; (4) The footprint of the proposed Pier 6 development is crossed by existing surface water sewers. Consideration should therefore be given to re-routing these sewers around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewers should be assessed to confirm, that they can withstand the additional loading, but the development could have an impact on the ability of GAL to maintain these sewers.
2	Re-aligned Quebec Taxiway	There is limited information available on the proposed Taxiway Quebec realignment at present. There is only a single reference on the Pier 6 Extension presentation slides which states that a realignment of Quebec Taxiway is proposed and shows reduced grassed areas relative to Google aerial imagery for the location.	Pond D	N	N	N	N	N	Y	Y	Y	Y	The proposed QuebecTaxiway realignment corridor is not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, and 1 in 100 annual chance events from the Gatwick Stream. However, the fluvial flood extents for the 1 in 100 annual chance plus climate change storm event encroach on a small portion of the the Quebec Taxiway corridor just south-west of the proposed tie-in point with the proposed relocated A380 stand at Pier 5 (i.e. existing Stands 254 and 255 at the southern end of Pier 5).	The surface water flood extents for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events encroach on a small portion of the proposed Quebec Taxiway realignment corridor. The prime area affected is at the tie-in location to the proposed A380 stand on Pier 5 (i.e. existing Stands 254 and 255 at the southern end of Pier 5).	5333	(1) Introduce a hard flood defence (e.g. flood wall) along the left-hand bank of the Gatwick Stream to retain the flow in channel and prevent flooding of the airfield.This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Instead of a hard flood defence employ bank raising along the Gatwick Stream to contain the water in channel and prevent it flooding the airfield. This would offer a similar level of protection as the hard flood defence in Point (1). If the options to provide a flood wall or bank raising along the Gatwick Stream are not pursued then the following less expensive mitigation options could be considered: (3) Although there is limited encroachment of the 1 in 100 annual chance plus climate change fluvial flood extents to the proposed Pier 5 building addition footprint the proposed structure could nonetheless be designed with added resilience to fluvial flooding (e.g. increased floor level thresholds, placement of critical assets above fluvial flood water levels, etc.); (4) Demountable flood defences could also be stored on site and employed where appropriate (e.g. doorways) in the event of a flood event to limit flood inundation of the building interior. This would be a last resort mitigation measure in the event of a major flood event. An assessment to identify potential underground flowpaths (e.g. cable	**Existing Quebec Taxiway Surface Water Drainage:** (1) The surface flooding could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally on Quebec Taxiway. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally on the affected Quebec Taxiway; (2) For large return period and long duration events (i.e. lower rainfall intensity but sustained rainfall) if the exisitng surface water drainage system has insufficient attenuation to contain large volumes of surface water runoff (i.e. resulting in surcharging the drainage system and flooding the airfield) then an option may be to retrofit the drainage system and employ increased attenuation storage on the drainage system (e.g. offline underground attenuation storage tank or oversized carrier drains/slot drains) thereby reducing the risk of surface water surcharging the drainage system and flooding the airfield ground surface.	(1) Once outline/detailed design is commenced on the proposed Quebec Taxiway a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and proivde effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Given that existing permeable area will be lost as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the drainage system which could improve drainage locally; (4) The footprint of the proposed Quebec Taxiway development is crossed by existing surface water sewers. Consideration should therefore be given to re-routing these sewers around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewers should be assessed to confirm, that they can withstand the additional loading.
3	A380 Relocation to Pier 5	Pier 5 is located directly west of the North Terminal Building. Due to the proposed expansion of the Pier 6 stands west and associated extension of the Pier 6 building the A380 stand (Stand 110 on Pier 6) will be relocated to Pier 5. The location is the approximate area covered by exisitng Stands 554 and 555 on the southern end of Pier 5. The new stands are to serve all Code E and Code F models currently available and on order. The number of Code C stands should not be reduced from the existing provision (currently 6 Code C stands between Stands 551 and 559).	Pond D	N	N	N	N	N	Y	Y	Y	Y	The re-located A380 stand and the additon to the Pier 5 building to accommodate the re-located A380 stand are not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance and 1 in 100 annual chance events from the Gatwick Stream. Fluvial flood extents for the 1 in 100 annual chance event plus 20% climate change uplift factor for the Gatwick Stream do encroach on the majority of the proposed re-located A380 stand and the southern portion of the Pier 5 building addition.	Surface water flood extents for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift encroach on the proposed re-located A380 stand boundary and the southern end of the addition to the Pier 5 building. The surface water flood extent for the 1 in 10 annual chance storm event takes up just under a quarter (by eye) of the proposed A380 stand footprint and is concentrated around the alignment of the existing surface water slot drains serving Stands 554 and 555. The surface water flood extents for the 1 in 100 annual chance and the 1 in 100 annual chance plus climate change uplift events are much more extensive, encroaching on the majority of the proposed A380 stand footprint. This is likely due to the fact that the existing slot drainage throats are slender openings with a limited capacity to collect runoff. The 1 in 100 annual chance and 1 and 100 annual chance plus climate change uplift events are very large rainfall events and hence large surface water flood extents result.	Development area already fully paved. No net gain in paved area.	(1) Introduce a hard flood defence (e.g. flood wall) along the left-hand bank of the Gatwick Stream to retain the flow in channel and prevent flooding of the airfield.This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Instead of a hard flood defence (e.g. flood wall)employ bank raising along the Gatwick Stream to contain the water in channel and prevent it flooding the airfield. This would offer a similar level of protection as the hard flood defence in Point (1). If the options to provide a flood wall or bank raising along the Gatwick Stream are not pursued then the following less expensive mitigation options could be considered: (3) Outside the measures quoted in points (1) and (2) above it is quite limited as to what can be done in the middle of an airport taxiway to mitigate fluvial flooding. However, an exercise could be undertaken to assess the feasability of profiling the taxiway pavement such that any potential fluvial flood water for the 1 in 100 annual chance plus climate change uplift event can be directed to a less critical location on the airfield. There are nearby grassed areas located adjacent to Quebec Taxiway which could be used a sacraficial flood storage locations	**Existing Stands 554 & 555 (i.e. proposed A380 Stand) & Pier 5 Additional Building Surface Water Drainage:** (1) The surface flooding could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at the proposed A380 Stand location. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at the A380 Stand location; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the surface water drainage system collection area at the ground surface has a fixed capacity to accept rainfall runoff. To mitigate inundation of the Pier 5 building addition with surface water building floor thresholds could be raised, move critical assets above floodwater levels, etc. Surface water ponding on the stands could also be mitigated through the provision of attenuation storage in the drainage system to contain additional flood water; (3) For large return period and long duration events (i.e. lower rainfall intensity but sustained rainfall) if the exisitng surface water drainage system has insufficient attenuation to contain large volumes of surface water runoff (i.e. resulting in surcharging the drainage system and flooding the airfield) then an option may be to retrofit the drainage system and employ increased attenuation storage on the drainage system (e.g. offline underground attenuation storage tank) thereby reducing the risk of surface water surcharging the drainage system and flooding the airfield ground surface; (4) Demountable flood defences could also be stored on site and employed where appropriate on the Pier 5 additional building (e.g. doorways) in the event of a flood event to limit flood inundation of the building interior. This would be a last resort mitigation	(1) Once outline/detailed design is commenced on the proposed A380 Stand re-location a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and proivde effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Given that existing permeable area will be lost as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the drainage system which could improve drainage locally; (4) The footprint of the proposed A380 Stand Re-location development is crossed by existing surface water sewers. Consideration should therefore be given to re-routing these sewers around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewers should be assessed to confirm, that they can withstand the additional loading, but the development could have an impact on the ability of GAL to maintain these sewers.
4	Remote Parking Stands	The GAL presentation titled "Gatwick Airport Master Plan Production Workshop" (presented 4th May 2017) presents two options (i.e. Option 1 and 2) for the remote parking stands. GAL have stated to take Option 2 forward for this Masterplan flood risk assessment. The selection of Option 1 or 2 depends on the timing of the proposed Lima Taxiway (discussed further below) and timing of requirement. GAL have taken high level assumptions that 6 proposed Code C stands will be required to the south side of the proposed Lima Taxiway. Approx 15,000m^2 of concrete will be required. The Code C stands development will result in the loss of existing permeable areas and replacement with the aforementioned concrete paving. GAL have taken high level assumptions that 5 proposed Code E stands will be required to the north side of the proposed Lima Taxiway. Approx 25,000m^2 of concrete will be required. The Code E stands development location is currently a car parking facility which is primarily paved. However, there will be a loss of small pockets of existing permeable areas and replacement with the aforementioned concrete paving. Assumed that new substations are required to support the proposed Code C and Code E stands.	Pond M/Pond D - Code C Stands (Primarily Pond M but a portion development boundary straddling Pond D catchment) Dog Kennel Pond - Code E Stands	N	N	N	N	N	N	Y	Y	Y	Proposed Code C Stands (south of proposed Lima Taxiway): The proposed Code C stands are not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change events from the River Mole. However, fluvial flood extents for the 1 in 100 year plus climate change event get within 5m immediately west of Code C stands development. Proposed Code E Stands (north of proposed Lima Taxiway): The proposed Code E stands are not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change events from the River Mole. However, fluvial flood extents for the 1 in 100 annual chance plus climate change event get within 25m immediately south-west of Code E stands development.	(i) Proposed Code C Stands (south of proposed Lima Taxiway): There appears to be no encroachment of surface water flood extents for the 1 in 10 annual chance event on the proposed Code C stands development footprint. The flood extents (which appear to originate from the existing stand surface water drainage on Lima Taxiway) are approx. 40 metres west of the proposed development footprint. Flood extents do encroach on the proposed Code C stands development footprint from the east for the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. These flood extents appear to originate from the existing slot drain systems serving the aircraft stands on Lima Taxiway to the east. No surface water flooding is shown from the existing car park surface water drainage system within the development boundary. It is likely that this car park surface water drainge system may not have been modelled. It is recommended that the existing surface water drainage system is modelled for the aforementioned design events to gain a representative picture of surface water flooding to the Code C stands development footprint. (ii) Proposed Code E Stands (north of proposed Lima Taxiway): Flood extents encroach on the proposed Code E stands footprint in the north-east corner and along the southern boundary for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. These flood extents appear to originate from the surface water drainage systems serving the existing car parks located immediately north and within the development footprint. However, no surface water flooding is shown from the majority of the existing car park surface water drainage system within the development boundary. It is likely that this car park surface water drainge system may not have been modelled completely. It is recommended that the existing car park surface water drainage system is modelled for the aforementioned design events to gain a representative picture of surface water flooding to the Code E	Code C Stands = 6510 Code E Stands = 12120 **Note:** Polygon area of 25,000m^2 quoted in the GAL presentation titled "Gatwick Airport Master Plan Production Workshop" does not match area of the polygon illustrated in the presentation of approx. 45,615 m^2. The existing grassed area in the 45,615 m^2 polyon is 12,210m^2 but is not necessarily the area that could be lost.	Based on the CH2M fluvial modelling there are no flood extents present on the proposed Remote Parking Stands (Code C and Code E) and so no mitigation is recommeded within the development footprint itself. However, the nearby taxiway, namely Taxiway Sierra to the south is inundated with flood water from the 1 in 100 annual chance event and the 1 in 100 annual chance plus climate change event which could restrict accessability (depending on flood depths) to the proposed Taxiway Lima and therefore the proposed Code C and Code E stands during a major storm event. Given that it's open airfield at this location the options available are limited to the following: (1) Introduce a hard flood defence (e.g. flood walls) along the banks of the River Mole just downstream of the existing culvert under the runway to retain the flow in channel and prevent flooding of the airfield. This would prevent the flood extents encroaching on the aforementioned taxiway. This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Employ bank raising along the River Mole to contain the water in channel and prevent it flooding the airfield. This would prevent the flood extents encroaching on Taxiway Sierra. This would offer similar protection to the aforementioned flood wall option; (3) An alternative to the aforementioned flood wall and bank raising options is to provide flood bunds just south of the proposed Boeing Hangar site application boundary (see Boeing Hangar entry further along in this table) and along the western boundary of the aggregate grading facility to the north-east of River Mole. This would contain the floodwaters in a reduced flooplain and avoid encroachment of the fluvial flood waters onto Taxiway Sierra.	(1) The surface flooding from Taxiway Lima encroaching on the proposed Code C stands could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at Taxiway Lima. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at Taxiway Lima and preventing flood extents encroaching on the proposed Code C Stands development footprint. This also applies similarly to the proposed Code E stands for which surface water flood extents encroach from the adjacent car park faciltiy to the north; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the surface water drainage system collection area at the ground surface has a fixed capacity to accept rainfall runoff. Surface water ponding on the stands could be mitigated through the provision of attenuation storage in the drainage system to contain additional flood water; (3) For large return period and long duration storm events (i.e. lower rainfall intensity but sustained rainfall) attenuation storage can be provided within the proposed drainage systems for the Code C and Code E stands to mitigate water surcharging the drainage system and encroching on the proposed stands. The attenuation provision can be an underground attenuation tank or oversized carrier drains/slot drains with a flow control device to limit the dischagre rate.	(1) Once outline/detailed design is commenced on the proposed Remote Parking Stands development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Existing car parks are located within the proposed Code C and Code E stands development footprints. It does not appear that the existing car park surface water drainage systems have been modelled by CH2M. It is recommended that the existing car park surface water drainage system is modelled to understand the existing surface water flood risk and to determine the allowable discharge rates for the proposed developments (i.e. there are pockets of permeable area within the development boundary); (4) Given that existing permeable area will be lost as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the airport drainage system which could improve drainage locally.; (5) With regards to the new substations required to support the proposed Code C and Code E stands a study must be undertaken to ensure these are located in an area of no flood risk. If this is not feasible then mitigation measures should be put in place to ensure flood resilience (e,g, raising critical equipment above floodwater levels, ensuring accessability to substations even during a flood event, etc.).
5	Push & Hold Stands	Push and Hold Stands will be for aircraft that are ready to push back but for whom there is not an immediately available runway slot to tie up stands and resources. Push and hold stands offer the opportunity to improve on-time performance, and maintain capacity. Departing aircraft can push back from stand, taxi to a hold point, close to the runway, and be ready to respond when a slot becomes available. According to GAL the current 130/140 stands are ideally located for push and hold operations. They are en-route to the runway from Piers 3, 4, 5, and 6 and are very close to the runway. The current 130/140 stands are located immedaitely south of Pier 6 and its associated stands. According to GAL the push and hold stands will be delivered in three phases – the first phase, for Summer 2019 will comprise 3 additional new stands at the western end. The existing stands are assumed to remain as is. However, the existing roadway, buildings and grassed areas in between the two sets of stands will require removal and replacement with a taxilane. The aforementioned grassed areas will be replaced with approx 1500m^2 of concrete. The total space will be approx. 86,000m^2. Approximately half of the stands will be equipped for de-icing operations in winter, with appropriate drainage and contaminant recovery systems.	Pond D	N	N	N	N	N	N	Y	Y	Y	The proposed Push and Hold stands are not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change events from the Gatwick Stream. However, fluvial flood extents for the 1 in 100 annual chance plus climate change storm event get within 15m immediately north-east of the Push and Hold stands proposed taxilane development.	Existing 130/140 Stands to remain in operation as part of Push & Hold Stands development: The existing 130 and 140 stands are subject to the encroachment of surface water flood extents for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. The 140 stands in particular are subject to significant surface water flood extents for the aforementioned flood events with a large portion of the stand area (eastern half) inundated with surface water from the "back-of-stand" slot drain. Push & Hold Stands - Proposed Taxilane: The 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift flood extents from an existing slot drain serving the 130/140 stands crosses diagonally through the proposed footprint of the Push and Hold Stands taxilane. A small flood extent for the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift also encroaches on the proposed taxilane boundary from the existing surface water slot drain serving the 140 Stands located south of the proposed taxilane footprint. Push & Hold Stands - Proposed Additional Stand Area: The proposed additional stand area footprint is located immediately outside the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift flood extents from an existing slot drain serving the 130/140 stands. The extremity of the flood extents just touch the boundary of the additional area footprint boundary	5968	Based on the CH2M fluvial modelling there are no flood extents present on the proposed Push and Hold stands footprint and so no mitigation is recommeded within the development footprint itself. However, the nearby taxiways, namely Taxiway Kilo to the north in addition to Taxiway Papa and Taxiway November to the east are inundated with flood water from the 1 in 75 annual chance event up to the 1 in 100 annual chance plus climate change event which could restrict accessability (depending on flood depths) to the proposed Push and Hold Stands during a major storm event. Given that it's open airfield at this location the options available are limited to the following: (1) Introduce a hard flood defence (e.g. flood wall) along the left-hand bank of the Gatwick Stream to retain the flow in channel and prevent flooding of the airfield. This would prevent the flood extents encroaching on the aforementioned taxiways. This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Employ bank raising along the Gatwick Stream to contain the water in channel and prevent it flooding the airfield. This would prevent the flood extents encroaching on the aforementioned taxiways. This would offer similar protection to the aforementioned flood wall.	(1) The surface flooding at the existing 130/140 stands could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the surface water drainage system collection area at the ground surface has a fixed capacity to accept rainfall runoff. Surface water ponding on the stands could be mitigated through the provision of attenuation storage in the drainage system to contain additional flood water; (3) For large return period and long duration events (i.e. lower rainfall intensity but sustained rainfall) if the existing surface water drainage system has insufficient attenuation to contain large volumes of surface water runoff (i.e. resulting in surcharging the drainage system and flooding the airfield) then an option may be to retrofit the drainage system as part of the proposed Push and Hold Stands development and employ increased attenuation storage on the drainage system (e.g. offline underground attenuation storage tank, replace drainage system with larger capacity system, etc.) thereby reducing the risk of surface water surcharging the drainage system and flooding the airfield ground surface.	(1) Once outline/detailed design is commenced on the proposed Push and Hold Stands a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and proivde effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Given that existing permeable area will be lost as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the drainage system which could improve drainage locally; (4) The footprint of the proposed Push and Hold Stands development is crossed by existing surface water sewers. Consideration should therefore be given to re-routing these sewers around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewers should be assessed to confirm, that they can withstand the additional loading, but the development could have an impact on the ability of GAL to maintain these sewers.
6	Lima Taxiway	This project will extend the existing Lima Taxiway to link Tango and Uniform Taxiways together at their northern ends. This will ease congestion on the Juliet taxiway, improve the efficiency of routings, and facilitate the creation of a north/south split of the airfield for the tower controllers to improve capacity. Space is being safeguarded to the south of the Lima Taxiway for the provision of 6 proposed Code C stands and to the north for the provision of 5 proposed Code E stands, if and when required (previously described under "Remote Parking Stands"). According to GAL the project will comprise of 62,000m^2 of concrete. The proposed Lima Taxiway developmnet location is currently a car parking facility which is primarily paved. However, there will be a loss of small pockets of existing permeable areas and replacement with the aforementioned concrete paving. This project is currently programmed to commence in 2020 and be complete in 2022. The project will include the relocation of 4 substations.	Pond D	N	N	N	N	N	N	Y	Y	Y	The proposed Lima Taxiway footprint is not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change events from the River Mole. However, the fluvial flood extents for the 1 in 100 annual chance plus climate change event get within approx. 20m to the east and 30m to the south of the proposed development footprint on Taxiway Union. This potential flooding of Taxiway Union could limit access to the proposed Lima Taxiway depending on the flood depths.	Flood extents encroach on the proposed Lima Taxiway development footprint from the east for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. The flood extents only affect a small portion of the development footprint in the east. These flood extents appear to originate from the existing slot drain systems serving the aircraft stands on Lima Taxiway to the east of the proposed development. No surface water flooding is shown from the existing car park surface water drainage system within the development boundary. However, it is likely that this car park surface water drainge system may not have been modelled. It is recommended that the existing car park surface water drainage system is modelled for the aforementioned design events to gain a representative picture of surface water flooding within proposed Lima Taxiway development footprint.	3045	Based on the CH2M fluvial modelling there are no flood extents present on the proposed Taxiway Lima footprint and so no mitigation is recommeded within the development footprint itself. However, the nearby taxiway, namely Taxiway Sierra to the south is inundated with flood water from the 1 in 100 annual chance event and the 1 in 100 annual chance plus climate change uplift storm event which could restrict accessability (depending on flood depths) to the proposed Taxiway Lima during a major storm event. Given that it's open airfield at this location the options available are limited to the following: (1) Introduce a hard flood defence (e.g. flood walls) along the banks of the River Mole just downstream of the existing culvert under the runway to retain the flow in channel and prevent flooding of the airfield. This would prevent the flood extents encroaching on the aforementioned taxiway; (2) Employ bank raising along the River Mole to contain the water in channel and prevent it flooding the airfield. This would prevent the flood extents encroaching on Taxiway Sierra. This would offer similar protection to the aforementioned flood wall; (3) An alternative to the aforementioned flood wall and bank raising options is to provide flood bunds just south of the proposed Boeing Hangar site application boundary (see Boeing Hangar entry further along in this table) and along the western boundary of the aggregate grading facility to the north-east of River Mole. This would contain the floodwaters in a reduced flooplain and avoid encroachment	(1) The surface flooding from the existing Taxiway Lima to the east encroaching on the proposed Taxiway Lima could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at Taxiway Lima. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at Taxiway Lima and preventing flood extents encroaching on the proposed Taxiway Lima development footprint; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the proposed surface water drainage system collection areas at the ground surface will have a fixed capacity to accept rainfall runoff. Surface water modelling of the proposed drainage systems should be undertaken to assess the movement of the surface water that evades the drainage system at the ground surface such that design measures can be employed. For example the ground can be profiled to fall certain directions away from less critical areas to eventually drain into the drainage system, etc). Also, potential surface water ponding on the stands could be mitigated through the provision of attenuation storage in the drainage system to contain additional flood water; (3) For large return period and long duration storm events (i.e. lower rainfall intensity but sustained rainfall) attenuation storage can be provided within the proposed drainage systems for the proposed Taxiway Lima to mitigate surface water surcharging the proposed drainage system and encroching on the proposed development. The attenuation provision can be an underground attenuation tank or oversized carrier drains/slot drains with a flow control device to limit the dischagre rate.	(1) Once outline/detailed design is commenced on the proposed Lima Taxiway development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) An existing car park is located within the proposed Lima Taxiway development footprint. It does not appear that the existing car park surface water drainage system has been modelled by CH2M. It is recommended that the existing car park surface water drainage system is modelled to understand the existing surface water flood risk and to determine the allowable discharge rates for the proposed Lima Taxiway development (i.e. there are pockets of permeable area within the development boundary); (4) Given that existing permeable area will be lost as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the drainage system which could improve drainage locally; (5) With regards to the relocation of 4 existing substations a study must be undertaken to ensure these are relocated to an area of no flood risk. If this is not feasible then mitigation measures should be put in place to ensure flood resilience (e,g, raising critical equipment above floodwater levels, ensuring accessability to substations even during a flood event,

Proposed Development Number	Proposed Development	Development Works	Surface Water Drainage Catchment	Fluvial Flood Risk – Storm Return Period 5yr	20yr	50yr	75yr	100yr	100yr+20% CC	Surface Water Flood Risk – Storm Return Period 10yr	100yr	100yr+20% CC	Potential Flooding Description – Fluvial	Potential Flooding Description – Surface Water	Existing Permeable Areas Loss (m²)	Potential Flood Mitigation Options – Fluvial	Potential Flood Mitigation Options – Surface Water	Recommendations
7	Domestic/CTA Baggage Reclaim (South Terminal)	The proposed Domestic/CTA Baggage Reclaim will be located immediately to the south-east corner of Pier 1 on the South Terminal. The development provides a new baggage reclaim hall & VCC at level 10. A separate exit leading to the Pier 1 corridor to link back to the South Terminal is proposed. The airside road will require realignment and the perimeter fence to east repositioned to accomodate the new development.The proposed CTA Baggage Reclaim building will have a footprint of 470m² according to the GAL presentation titled "Gatwick Airport Master Plan Production Workshop" from the 4th May 2017.	Pond D	N	N	Y	Y	Y	Y	Y	Y	Y	The proposed Domestic/CTA Baggage Reclaim building footprint is not impacted by fluvial flood extents for the 1 in 5 annual chance and 1 in 20 annual chance events from the Gatwick Stream. However, fluvial flood extents for the 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events encroach on the proposed Domestic/CTA Baggage Reclaim building footprint completely surrounding the proposed development.	Surface water flood extents for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events encroach on the proposed Domestic / CTA Baggage Reclaim building footprint.The surface water flooding originates from the existing surface water drainage system that serves a portion of the airfield in the east in the vicinity of the proposed Domestic / CTA Baggage Reclaim facility.	Google aerial imagery from 2017 indicates that this site is presently a paved/brownfield site. The GIS World Imagery basemap illustrates the presence of a building. However, it is understood that this basemap is outdated and the building has been demolished recently.	(1) Introduce a hard flood defence (e.g. flood wall) along the left-hand bank of the Gatwick Stream to retain the flow in channel and prevent flooding of the airfield.This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Instead of a flood wall employ bank raising along the Gatwick Stream to contain the water in channel and prevent it flooding the airfield. This would offer a similar level of protection as the hard flood defence in Point (1). If the options to provide a flood wall or bank raising along the Gatwick Stream are not pursued then the following less expensive mitigation options could be considered: (3) The propsoed CTA Baggage Reclaim building could be designed with added resilience to fluvial flooding (e.g. increased floor level thresholds, placement of critical assets above fluvial flood water levels, etc.). Accessability to the Domestic / CTA Baggage Reclaim facility would have to be looked into in the event of a major fluvial flood event; (4) Demountable flood defences could also be stored on site and employed where appropriate (e.g. doorways) in the event of a flood event to limit flood inundation of the building interior. This would be a last resort mitigation measure in the event of a major flood event. An assessment to identify potential underground flowpaths (e.g. cable	(1) The surface flooding from the existing airfield and buildings drainage encroaching on the proposed CTA could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at the CTA site. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at the CTA site and preventing flood extents encroaching on the proposed CTA Baggage Reclaim development footprint; (2) For large return period and short duration storm events (i.e. high rainfall intensity) there will be an increased risk of surface water flooding as the proposed surface water drainage system collection areas at the ground surface will have a fixed capacity to accept rainfall runoff. Surface water modelling of the proposed drainage systems should be undertaken to assess the movement of the surface water that evades the drainage system at the ground surface such that design measures can be employed and to assess the feasibility of providing storage elsewhere to mitigate flood risk from the surface water drainage system. For example the ground can be profiled to fall certain directions away from less critical areas to eventually drain into the drainage system after the storm event has passed, etc); (3) For large return period and long duration storm events (i.e. lower rainfall intensity but sustained rainfall) attenuation storage can be provided within the proposed building and road drainage systems for the proposed CTA Baggage Reclaim development to mitigate surface water surcharging the proposed drainage system and encroching on the proposed development. The attenuation provision can be an underground attenuation tank or oversized carrier drains/slot drains with a flow control device to limit the dischagre rate.	(1) Once outline/detailed design is commenced on the proposed CTA Baggage Reclaim building a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and proivde effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) Potentially a project could be undertaken to identify redundant pavement across the airfield to reduce the hydraulic loading on the drainage system which could improve drainage locally at the proposed development location.
8	Long Stay Car Parking	The existing Long Stay Car Parking facilities are located east of the A23 and railway line. GAL propose to provide decked car parking facilities for long-stay car parking as it offers the potential to increase the number of long-stay spaces within the existing car park footprint. Phase 1 of this development is planned for the South Terminal car parking zones in 2018. Phase 1 in 2017/18 will comprise of: (i) The provision of 1,123 decked spaces (net gain of 981 self-parking spaces) in Zone G of the South Terminal long stay parking. (ii) Existing passenger bus operations are assumed to continue without change.	Pond G	-	-	-	-	-	-	-	-	-	The proposed long-stay car parking facility footprint within the existing Zone G is located outside the main airfield. The car park appears to be outside the flood extents of the Gatwick Stream for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and the 1 in 100 annual chance plus climate change uplift events. However, looking at Google maps it appears that there may be a series of drainage ditches/small watercourse which may not have been modelled yet. If not it is recommended that these drainage dithces are assessed to understand the existing flood risk to the Zone G car parking facility.	The proposed long-stay car parking facility footprint within the existing Zone G cap park is located outside the main airfield. It doesn't appear that a surface water drainage model has been built for the existing Zone G car park and the adjacent car parks surface water drainage systems. It is recommended that this is undertaken to gain an understanding of the existing surface water flood risk to the Zone G car park and to understand the allowable discharge rates for the proposed development.	Google aerial imagery of the development area (i.e. existing car park) shows that its currently fully paved. No net gain in paved area. **Note**: Also, no increase in paved area to be drained as the majority of the decked levels, with the exception of the top-most deck, will remain dry being sheltered by the deck levels above and the building façade.	Based on the CH2M fluvial modelling there are no flood extents from the nearby Gatwick Stream present on the proposed decked long-stay car parking site (i.e. existing Zone G) and so no mitigation is recommeded within the development footprint itself. However, according to Google aerial imagery there are potentially some local drainage ditches nearby which may not have been modelled as they are a distance outside the main airfield. It is recommneded that these are verified and if so modelled to assess the potential flood risk and determine if any flood protection measures are required.	(1) It does not appear that the existing surface water drainage system serving this existing car parking site has been developed due to the lack of flood extents for large return period storm events such as the 1 in 100 annual chance event plus climate change uplift. It is therefore recommended that a surface water drainage model of the existing car park surface water drainage system is developed to understand the existing flood risk and to facilitate the determination of the allowable discharge rate for the proposed decked long-stay car park development; (2) When designing the surface water drainage system the proposed long stay multi-storey car park development the discharge rate must not exceed the existing site runoff rate; (3) Pollution control measures will be required as vehicles will be stationary on the top deck of the facility which will be exposed to rainfall which could wash engine oils, petroleum, lubricants, etc. off the ground surface and into the drainage system. The lower decks will also require pollution control measures due to wet cars entering the facility and wind blown rain.	(1) Once outline/detailed design is commenced on the proposed Long Stay Car Park development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) The proposed long stay car park development is located outside the main airfield and therefore fluvial flood modelling undertaken by CH2M. It is recommended that any minor watercourses/drains are identified and if found to be present are modelled to understand fluvial flood risk to the proposed long stay car park development; (4) The proposed long stay development is located outside the main airfield and therefore outside the scope of the surface water drainage flood modelling undertaken by CH2M. It is recommended that the existing car park surface water drainage system is modelled to understand the existing surface water flood risk and to determine the allowable discharge rate for the proposed long stay car park
9	Multi-Storey Car Park 4	This project would create approximately 1,200 spaces in a multi-storey car parking structure on the site of a current high-sided vehicle car park adjacent to the other South Terminal multi-storey car parks. No firm development plans have been seen by Jacobs to inform this high level flood risk assessment. Only a broad-brush boundary has been provided as shown in the GAL presentation titled "Gatwick Airport Master Plan Production Workshop" dated 4th May 2017. Based on this broad-brush boundary there will be a loss of small pockets of existing permeable areas and replacement with paved surfacing. GAL Assumptions include: (i) 1,200 spaces (11.5m² per space); (ii) 5 storeys (6 floors); (iii) No requirement for flood attenuation in South Terminal.	Pond F	N	N	N	N	N	N	-	-	-	The proposed Multi-Storey Car Park 4 facility boundary polygon is located outside the main airfield. The car park appears to be outside the flood extents of the Gatwick Stream for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and the 1 in 100 annual chance plus climate change uplift events. However, looking at Google maps aerial imagery it appears that there may be a series of drainage ditches/small watercourse which may not have been modelled yet. If not it is recommended that these drainage dithces are assessed to understand the existing flood risk within and around the proposed Multi-Storey Car Park facility boundary polygon.	The proposed Multi-Storey Car Park 4 facility boudary polygon is located outside the main airfield. There is an existing car parking facility located within the boundary polygon for MSCP 4. It doesn't appear that a surface water drainage model has been built for the existing car park surface water drainage system. It is recommended that this is undertaken to gain an understanding of the existing surface water flood risk and to understand the allowable discharge rates for the proposed development.	2018 **Note:** the MSCP4 polygon is only a loose boundary and not a fixed development footprint. Therefore, it is potentially subject to change.	Based on the CH2M fluvial modelling there are no flood extents from the nearby Gatwick Stream present on the proposed multi-storey car park 4 site boundary and so no mitigation is recommended within the development footprint itself. However, according to Google aerial imagery there are some local drainage ditches nearby which may not have been modelled as they are a distance outside the main airfield. It is recommended that these are modelled to assess the potential flood risk and determine if any flood protection measures are required.	(1) It does not appear that the existing surface water drainage system serving this existing car parking site has been developed due to the lack of flood extents for large return period storm events such as the 1 in 100 yannual chance event plus climate change uplift. It is therefore recommended that a surface water drainage model of the existing car park surface water drainage system is developed to understand the existing flood risk and to facilitate the determination of the allowable discharge rate for the proposed Multi-Storey Car Park 4 development; (2) When designing the surface water drainage system the proposed Multi-Storey Car Park 4 development attenuation storage must be provided to restrict the discharge rate to the existing site condition runoff rate (e.g. the existing site has a combination of permeable and paved area whereas the proposed development is likely to be completely paved with increased runoff rates). Attenuation storage could be provided in the form of an underground attenuation tank, oversized carrier drains, etc; (3) Pollution control measures will be required as vehicles will be stationary on the top deck of the facility which will be exposed to rainfall which could wash engine oils, petroleum, lubricants, etc. off the ground surface and into the drainage system. The lower decks will also require pollution control measures due to wet cars entering the facility and wind blown rain.	(1) Once outline/detailed design is commenced on the proposed MSCP 4 development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) The proposed MSCP 4 development is located outside the main airfield and therefore fluvial flood modelling undertaken by CH2M. It is recommended that any minor watercourses/drains are identified and if found to be present are modelled to understand fluvial flood risk to the proposed MSCP 4 development; (4) The proposed MSCP 4 development is located outside the main airfield and therefore outside the scope of the surface water drainage flood modelling undertaken by CH2M. It is recommended that the existing car park surface water drainage system is modelled
10	Multi-Storey Car Park 7	GAL currently assume that this project would create approximately 3,168 spaces in a multi-storey car parking structure on the site of an existing car park located north of the North Terminal building. No firm development plans have been seen by Jacobs to inform this high level flood risk assessment. Only a broad-brush boundary has been provided as shown in the GAL presentation titled "Gatwick Airport Master Plan Production Workshop" dated 4th May 2017. Based on this broad-brush boundary there will be no loss of permeable areas as the present car park site appears to be paved according to aerial imagery. GAL current assumptions: (i) 7 storeys (8 floors); (ii) 3,168 spaces (each space assumed 11.5m²); (iii) Link bridge to North Terminal = 100m x 7m with travelators; (iv) Flood attenuation tank underneath = 4,000m² / 2,900m³.	Pond D	N	N	N	N	N	N	Y	Y	Y	The proposed Multi-Storey Car Park 7 boundary polygon appears to be outside the flood extents of the Gatwick Stream for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and the 1 in 100 annual chance plus climate change uplift events.	Surface water flood extents for the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events encroach upon the proposed Multi-Storey Car Park 7 facility boudary polygon. This surface water flooding appears to originate from the existing surface water drainage system (likely to be slot drains) serving the aircraft stands at Pier 5 near the North Terminal flowing east to the MSCP 7 site. There is an existing car parking facility located within the boundary polygon for MSCP 7. It doesn't appear that a surface water drainage model has been built for the existing car park surface water drainage system. It is recommended that this is undertaken to gain an understanding of the existing surface water flood risk and to understand the allowable discharge rate for the proposed development. **Note:** surface water flood extents are shown on existing building locations. This is so as generally buildings are modelled as areas of increased roughness as opposed to the buidlings providing a complete barrier to the floodwaters. In reality water will still flow through the buildings just at a slower rate.	Google aerial imagery suggests that this development area (i.e. existing car park) is currently completely paved. No net gain in paved area. **Note:** Also, no increase in paved area to be drained as the majority of the decked levels, with the exception of the top-most deck, will remain dry being sheltered by the deck levels above and the building façade.	Based on the CH2M fluvial modelling there are no flood extents from the nearby Gatwick Stream and River Mole present on the proposed Multi-Storey Car Park 7 site boundary and so no fluvial flood mitigation is recommended for this development.	(1) It does not appear that the existing surface water drainage system serving this existing car parking site has been developed The flood extents shown appear to be from the Pier 5 vicinity to the west. It is therefore recommended that a surface water drainage model of the existing car park surface water drainage system is developed to understand the existing flood risk and to facilitate the determination of the allowable discharge rate for the proposed multi-storey car park development; (2) The surface flooding from the existing Pier 5 to the west encroaching on the proposed MSCP 7 site could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at Pier 5. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at the Pier 5 stands and preventing flood extents encroaching on the proposed MSCP 7 development footprint; (3) Discharge rates from the proposed MSCP 7 development should be similar to the existing car park given that the exposed deck at the top of the proposed MSCP 7 should have a similar area to the existing car park footprint. Attenuation storage required if betterment in the runoff rates is sought over the existing site paved area (e.g. greenfield runoff rates). The ground level deck should be considered for the placement of attenuation storage (e.g. easier accessability for maintenance, etc.); (4) Pollution control measures will be required as vehicles will be stationary on the top deck of the facility which will be exposed to rainfalll which could wash engine oils, petroleum, lubricants, etc. off the ground surface and into the drainage system. The lower decks will also require pollution control measures due to wet cars entering the facility and wind blown rain.	(1) Once outline/detailed design is commenced on the proposed MSCP 7 development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) It does not appear that the existing car park drainage within the footprint of the proposed MSCP 7 development has been modelled by CH2M. It is recommended that the existing car park surface water drainage system is modelled to understand the existing surface water flood risk and to determine the allowable discharge rate for the proposed MSCP 7 development; (4) The footprint of the proposed MSCP 7 development is crossed by a large (approximately 3m) diameter surface water sewer which conveys runoff from a large part of the airport to Pond D. Pond D is the most critical surface water drainage pond in the network and it would be advisable to avoid having such a critical asset beneath MSCP 7. Consideration should therefore be given to re-routing the sewer around the footprint of the new development, although this would require a detailed assessment of feasibility. If this is not possible then the hydraulic capacity and structural integrity of the sewer should be assessed to confirm, that it can withstand the additional loading, but the development
11	Boeing Hangar	The proposed Boeing Hangar development site application boundary is located immediately south of Pond M on a primarily greenfield site. Looking at the development drawings and google imagery the proposed development will pave over the upsteam catchment of Man's Brook and the Brook itself. The proposed development will include an aircraft hangar, paved access roads and paved service yard in front and around the proposed hangar. A new substation is proposed as part of the development (shown north of the proposed aircraft hangar). Looking at the 3D imagery for the proposed development small pockets of permeable area will be retained as landscaped areas around the proposed development site.	River Mole and / or Man's Brook (Greenfield site presently)	N	N	N	Y	Y	Y	Y	Y	Y	The proposed Boeing Hangar footprint and wider site application boundary is not impacted by fluvial flood extents for the 1 in 5 annual chance, 1 in 20 annual chance and 1 in 50 annual chance events from the nearby River Mole. Fluvial flood extents for the 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change events from the River Mole encroach on the proposed Boeing Hangar footprint and the wider site application boundary. The River Mole is located a short distance south of the proposed development and so the fluvial flood extents flow in a south to north direction across the proposed development site and ending up on Taxiway Union. The 1 in 100 annual chance plus climate change uplift flood extents cover a large majority of the proposed development application site boundary. It is noted that a small watercourse known as Man's Brook flows through the site. There appear to be no flood extents from Man's Brook up to and including the 1 in 100 annual chance plus climate change uplift event. This appears an unlikely scenario and it may be that the watercourse has not been modelled. If not then it is recommended that the watercourse is modelledto gain a fully informed understanding of fluvial flood risk to the proposed Boeing Hangar development.	The proposed Boeing Hangar development site is primarily greenfield and so it is assumed that there is no formal surface water drainage system in place from which surface water flooding can occur. The greenfield site likely drains to the nearby Man's Brook. Surface water flood extents for the 1 in 10 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift encroach on a small portion of the north-east corner of the site application boundary. This surface water flooding appears to originate from the existing surface water drainage system serving the aircraft stands on the nearby Taxiway Union to the east. Based on the proposed development plans for the Boeing Hangar development (Drawing No. 777-D5A-00-XX-DR-A-010-0002 developed by Mott McDonald) a proposed access road would be subjected to this potential surface water flooding.	The potential permeable area that could be lost has not been determined for the Boeing hangar development. Without the proposed development technical drawings in CAD (PDF drawings are available and have been used in this assessment) one cannot accurately assess the loss of permeable area.	Based on the CH2M fluvial modelling fluvial flood extents for the 1 in 75 annual chance, 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events extend from south to north from the River Mole across the proposed hangar site. To prevent this fluvial flooding encroaching on the proposed development the following flood mitigation measures could be employed: (1) Introduce a hard flood defence (e.g. flood walls) along the banks of the River Mole just downstream of the existing culvert under the runway to retain the flow in channel and prevent flooding proposed development site. This would be an expensive option but would offer the best fluvial flood protection to the airfield; (2) Employ bank raising along the River Mole to contain the water in channel and prevent it flooding the proposed development site. This would offer similar protection to the aforementioned flood wall; (3) A less expensive alternative to the aforementioned hard flood defence and bank raising options on the River Mole is to provide flood bunds immediately south of the proposed Boeing Hangar site application boundary and along the wesern boundary of the aggregate grading facility to the north-east of River Mole. This would contain the floodwaters in a reduced flooplain and avoid encroachment of the	(1) The surface flooding from Taxiway Union could be arising from the drainage system being at capacity further downstream (i.e. backing up) and preventing effective drainage locally at Taxiway Union. An exercise could be undertaken to identify redundant pavement across the airport which can be removed and returned to permeable surfacing, reducing runoff into the downstream drainage system thereby reducing backing up and potentially promoting more effective drainage locally at Taxiway Union and preventing flood extents encroaching on the proposed Boeing Hangar site application boundary; (2) A flood bund could be provided at the north-eastern boundary of the application site boundary to form a barrier against the potential surface water flood extents encroaching on the Boeing Hangar site boundary; (3) Given that the proposed hangar development will be using significant paved areas on a presently greenfield site attenuation storage will be required to facilitate the restriction of the surface water discharge rates to greenfield runoff rates. Attenuation could be provided in the form of an underground tank and/or oversized carrier drains/slot drains.	(1) It appears that fluvial flood modelling may not have been undertaken of Man's Brook (i.e. no fluvial flood extents present up to and including the 1 in 100 annual chance plus climate change uplift event from this watercourse). Only fluvial flood extents from the River Mole appear to be present. If this modelling of Man's Brook has not been undertaken then it is recommended that it is done to understand the fluvial flood risk (if any) to the proposed Boeing Hangar development from Man's Brook; (2) According to the development drawings it appears that the upstream end of Man's Brook will be paved over by the proposed Boeing Hangar development. Without site visit knowledge of this specific location we are unsure if there is a further upstream catchment to Man's Brook that needs to be culverted or routed around the proposed Boeing Hangar development. If this has not already been assessed (i.e.not clear from the present development drawings) then it is recommended that the catchment area to Man's Brook is understood and if any measures such as a culvert or re-routed channel are required to maintain the flow conveyance associated with any upstream catchment area; (3) With regards to the proposed surface water drainage system for the Boeing Hangar development a form of attenuation storage will be required (e.g. underground tank, pond, oversized carrier drains, etc.) to facilitate the restriction of the discharge rate to greenfield runoff rates since existing site is primarily greenfield. The presence of any proposed attenuation storage is not clear on the development drawings made available
12	South Terminal Car Rental Re-location	There is limited information available on the South Terminal car rental facility relocation at present. There is only a single presentation slide available (i.e. in GAL presentation titled "Gatwick Airport Master Plan Production Workshop" from 04/05/2017 - Slide 24) which presents a basic layout of the proposed car rental facility. The proposed development appears that it will be developed within the footprint of the existing Courtlands Parking facility which is enclosed by Buckingham Gate to the north and Balcombe Road to the east. The existing parking facility is primarily paved with some very small pockets of permeable areas that could potentially be lost should the proposed South Terminal car rental development go ahead (i.e. based on the basic layout in the GAL presentation it appears that the proposed car rental development will be completely paved). Based on the GAL presentation basic layout the proposed development will include the following: (i) Car maintenance bays; (ii) Car wash facilities; (iii) Fuel canopy (with 12 fuelling positions); (iv) Car rental spaces area (approx. 260 spaces); (v) Bus pick-up and drop-off area;	Unknown - Not located within a delineated pond catchment boundary. (Pond F and Pond G catchment boundaries are located immediately north and west of Car Rental location respectively though)	N	N	N	N	N	N	-	-	-	The proposed South Terminal Car Rental facility boundary polygon is located outside the main airfield to the east. The car park appears to be outside the flood extents of the Gatwick Stream for the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance, 1 in 75 annual chance, 1 in 100 annual chance and the 1 in 100 annual chance plus climate change uplift events. However, looking at Google Maps it appears that there may be a few drainage ditches which may not have been modelled yet. If not it is recommended that these drainage dithces are assessed to understand the existing flood risk to the proposed development.	The proposed South Terminal Car Rental facility boudary polygon is located outside the main airfield to the east. The proposed car rental facility site is an existing car parking facility. It doesn't appear that a surface water drainage model has been built for the existing car park surface water drainage system. It is recommended that this is undertaken to gain an understanding of the existing surface water flood risk and to understand the allowable discharge rate for the proposed development.	285	Based on the CH2M fluvial modelling there are no flood extents from the nearby Gatwick Stream present on the proposed South Terminal Car Rental facility site boundary and so no mitigation is recommended within the development footprint itself. However, according to Google aerial imagery there are some local drainage ditches nearby which may not have been modelled as they are a distance outside the main airfield. It is recommended that these are modelled to assess the potential flood risk and determine if any flood protection measures are required.	(1) It does not appear that the existing surface water drainage system serving this existing car parking site has been developed due to the lack of flood extents for large return period storm events such as the 1 in 100 annual chance event plus climate change. It is therefore recommended that a surface water drainage model of the existing car park surface water drainage system is developed to understand the existing flood risk and to facilitate the determination of the allowable discharge rate for the proposed development; (2) When designing the surface water drainage system the car rental development attenuation storage may be required to restrict the discharge rate to the existing site condition runoff rate (e.g. the existing site has small pockets of permeable and paved area whereas the proposed development is likely to be completely paved with marginally increased runoff rates). Attenuation storage could be provided in the form of an underground attenuation tank, oversized carrier drains, etc; (3) Pollution control measures will be required as a fuel canopy is proposed, car washing facilities and car maintenace bays are proposed which could release engine oils, petroleum, lubricants, etc. to the ground surface which could be washed into the drainage system during a storm event. The proposed fule station will require a full retention interceptor and a connection to the existing foul drainage system due to the potential for serious contamination.	(1) Once outline/detailed design is commenced on the proposed South Terminal Car Rental development a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) As part of the FRA/drainage strategy study it is recommended that a study is undertaken into the feasibility of attenuation storage at the proposed development site to benefit the wider drainage capacity in the downstream surface water drainage system; (3) The proposed car rental re-location development is located outside the main airfield and therefore outside the scope of the fluvial flood modelling undertaken by CH2M. It is recommended that any minor watercourses/drains are identified and if found to be present are modelled to understand fluvial flood risk to the proposed car rental facility development; (4) The proposed car rental re-location development is located outside the main airfield and therefore outside the scope of surface water drainage flood modelling undertaken by CH2M. It is recommended that the existing car park surface water drainage system is
13	Gatwick Airport Rail Station Extension	The report "Gatwick Airport Station Development - Single Option Concept Report" (Report No. 142637-COT-REP-EAR-000001) originated by the Gatwick Airport Station Development (GASD) team which describes the concept design. The proposed Gatwick Railway Station development will inlcude the introduction of a new concourse in the space between the existing GAL Northern and Southern footbridges in addition to the South Terminal Building and PTI to the west and east respectively. The proposed concourse floor plate will be elevated above track level and will likely tie into the floor level of the South Terminal building. The roof for the proposed development will span between the existing GAL Northern footbridge and the GAL Southern footbridge. The concept report has enabled the determination of approximate concourse and roof layout polygons to be generated to assess the flood risk to the proposed development.	Unknown - Not located within a delineated pond catchment boundary. (Pond F and Pond D catchment boundaries are located immediately east and west of the Railway Station complex respectively though)	N	N	N	N	Y	Y	N	Y	Y	The Gatwick Stream is culverted from approx. 100m upstream of the South Terminal building to approx. 215m downstream of the South Terminal building. The floodwaters go out of bank at the upstream culvert headwall, flow west and subsequently north across the airfield and towards the South Terminal building. The proposed rail station concourse and roof layout polygons are not encroached upon by the 1 in 5 annual chance, 1 in 20 annual chance, 1 in 50 annual chance and 1 in 75 annual chance events from the Gatwick Stream. Fluvial flood extents from the Gatwick Stream encroach on the proposed concourse and roof layout polygons for the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. However, the proposed new concourse will be above the railway track level with the proposed roof further elevated above the concourse and so should be above any potential fluvial floodwaters. **Note:** fluvial flood extents are shown on existing building locations. This is so as generally buildings are modelled as areas of increased roughness as opposed to the buidlings providing a complete barrier to the floodwaters. In reality water will still flow through the buildings just at a slower rate.	The Gatwick Airport Rail Station proposed concourse and roof footprint polygons are not encroached upon by the 1 in 10 annual chance event surface water flood extents. Surface water flood extents encroach on a small portion of the proposed concourse and roof layout polygons for the 1 in 100 annual chance and 1 in 100 annual chance plus climate change uplift events. However, the proposed new concourse will be above the railway track level with the proposed roof further elevated above the concourse and so should be above the surface water flood extents shown (i.e. flooding at ground level). **Note:** surface water flood extents are shown on existing building locations. This is so as generally buildings are modelled as areas of increased roughness as opposed to the buidlings providing a complete barrier to the floodwaters. In reality water will still flow through the buildings just at a slower rate.	3229	Based on the CH2M fluvial modelling there are minimal flood extents for the 1 in 100 annual chance and 1 in 100 annual chance event plus climate change uplift from the nearby Gatwick Stream present on the Gatwick Rail Station proposed concourse and roof polygons. However, these developments are likely to be elevated above any such fluvial extents as the concourse and roof will be elevated above track level (i.e. the fluvial flood extents will flow along ground level and potentially track level). If the potential proposed fluvial flood protection measures described previously along the Gatwick Stream (e.g. the flood wall and the bank raising) with regards to the other proposed developments the aforementioned flood extents could potetnailly be eliminated from the Gatwick Airport Rail Station proposed concourse and roof location.	(1) It does not appear that the surface water drainage system serving the existing GAL North and South footbridges and Rail Station Building has been developed due to the lack of surface water flood extents for large return period storm events such as the 1 in 100 annual chance event plus climate change. It is therefore recommended that a surface water drainage model of the existing aforementioned surface water drainage systems are developed to understand the existing flood risk; (2) When designing the proposed surface water drainage system for the proposed rail station extension roof attenuation storage will be required to restrict the discharge rate to the existing site condition runoff rate (e.g. the existing site has permeable brownfield and paved areas whereas the proposed development is likely to have a roof structure with increased runoff rates). Attenuation storage could be provided in the form of an underground attenuation tank, oversized carrier drains, etc. the feasability of which will have to be assseseed at concept design stage. The proposed roof structure could also be designed as a green roof which would limit the amount of runoff directly to the surface water drainage system (e.g. absorption and evapotraspiration).	(1) Once outline/detailed design is commenced on the proposed Rail Station expansion a detailed Flood Risk Assessment (FRA) and surface water drainage strategy will need to be developed to inform the proposed development design (i.e. mitigate flood risk and provide effective surface water drainage of the site); (2) Given that the existing permeable area (i.e. brownfield ground between and adjacent to platforms) will be sheltered by the proposed roof for the new station expansion eliminating any infiltration a surface water runoff model should be built of the existing site condition to inform the allowable discharge rate and attenuation storage requirements for the proposed development; (3) Given that existing permeable area will be sheltered (i.e. loss of infiltration, generating more runoff from proposed roof) as part of this proposed development potentially a project could be undertaken to identify redundant pavement across the airfield to balance the permeable/paved area split and to reduce the hydraulic loading on the airport drainage system which could improve drainage locally at the railway station.