2. Water Quality

2.1 Introduction

This section presents further analysis of the impact of proposed growth on water quality in the receiving waters, following the recommendations in the Outline report (a summary of key issues identified in this report are provided in Table 2.1 below). Following discussions with the Environment Agency and the Borough Council of King's Lynn and West Norfolk, new information on planned housing numbers, provided in November 2010, has been used for the assessment.

Table 2.1 Summary of Water Quality Issues Considered in the Detailed Phase Work

Task	Key issues
1) Flood Relief Channel Analysis	Downham Market WwTW discharges into the Flood Relief Channel that carries water from the Cut Off Channel and Ely Ouse to the Tidal Ouse and Tail End Sluice. Additional flow from the works, associated with the planned housing growth, has the potential to increase nutrient levels in the Channel. Increased industrial abstraction from the Channel is predicted, associated with the Palm Papers industrial plant, which may change patterns of flow. These combined impacts may exacerbate eutrophication of the Flood Relief Channel and therefore affect the ecological status.
2) Other Inland Waters	Growth at the smaller inland works may have an impact on downstream water quality in the smaller rivers that flow toward the Ely Ouse, the Wash and North Norfolk Coast and in particular, may impact on achieving Water Framework Directive targets.
3) Bathing Waters	Previous studies have identified potential problems with compliance with the new Bathing Water Directive standards at Heacham and Hunstanton. Anglian Water has carried out a number of studies on impacts of Heacham WwTW on Bathing Water compliance including coastal modelling studies.

2.2 Housing Growth

Housing growth data for the period 2001 – 2009 and an estimate of the growth from 2009 – 2025 was provided by the Borough Council King's Lynn and West Norfolk. From this information a calculation was made of the growth predicted to 2031[1] based on continued growth at the same annual rate. The growth data provided covered the main towns, key service centres, rural villages and smaller villages. These numbers were mapped onto the sewage catchment areas to determine the growth in number of houses associated with each WwTW. Of these, a small number lay outside any WwTW catchment boundaries and were, therefore, assumed to be treated by septic tanks and non AWS treatment works. It is the case for some of the settlements that the area where growth is expected to take place is covered by different WwTW catchments. In these cases the growth numbers provided were split between the WwTW catchments. For example the growth number given for Methwold (36) is provided for Methwold and Northwold together, so has been split to have 18 homes at each of these locations. Table 2.2

[1] It is noted that the growth data provided for 2009 – 2025 represent the anticipated growth numbers but this could be subject to change once assessments are complete (Pers. Comms, King's Lynn & West Norfolk Borough Council).

provides a summary of the predicted growth at the WwTWs. Settlements with planned growth that are outside the WwTW catchments are not included in the table.

Table 2.2 Predicted Change in Housing Numbers at Each WwTW

WwTW	Settlements within WwTW Catchment	Housing Growth 2001 - 2009	Assumed Housing Growth 2009 - 2025
Burnham Market	Brancaster, Brancaster Staithe, Burnham Deepdale, Burnham Market, Burnham Overy Staithe, Burnham Thorpe, North Creake, Burnham Norton, Burnham Overy Town, South Creake	170	80
Downham Market	Downham Market, Stow Bridge, Wimbotsham, Crimplesham, Salters Lode, Ryston	2403	358
Fordham	Hilgay, Denver, Fordham, Ten Mile Bank	107	24
Grimston	Gayton, Grimston, Pott Row, Roydon, Congham	138	36
Harpley	Great Massingham, Harpley, Little Massingham	66	44
East Winch	East Winch, West Bilney	19	8
Stoke Ferry	Stoke Ferry, Wereham, Wretton	157	36
Shouldham	Shouldham	20	8
Sculthorpe	Syderstone	50	8
East Rudham	East Rudham, West Rudham	26	36
Southery-Mill Drove	Southery	63	8
Marham	Marham	44	36
Feltwell	Feltwell	157	18
Fincham	Fincham	22	8
Barton Bendish	Barton Bendish	7	0
Gayton	Gayton Thorpe	0	0
Ingoldisthorpe	Dersingham, Ingoldisthorpe	118	44
Heacham	Docking, Heacham, Hunstanton, Old Hunstanton, Snettisham, Sedgeford, Thornham, Bircham Newton, Fring, Holme Next The Sea, Titchwell	936	346
Middleton	Middleton	47	8
King's Lynn	King's Lynn, North Wootton, South Wootton. West Winch, Clenchwarton, Terrington St Clement, Castle Rising, Setchey, Tilney All Saints, Hay Green, North Runcton, Tilney High End	3226	4644

Table 2.2 (continued) Predicted Change in Housing Numbers at Each WwTW

WwTW	Settlements within WwTW Catchment	Housing Growth 2001 - 2009	Assumed Housing Growth 2009 - 2025
West Walton	Emneth, Walsoken, Outwell, Terrington St John, Tilney St Lawrence/St Johns Highway, Upwell, West Walton, St Johns Fen End/Tilney Fen End, Three Holes, Walpole St Andrew, Lakesend, Walpole Highway, Walpole Marsh	729	560
Watlington	Watlington, Runcton Holme, Wiggenhall St Mary Magdalen, Tilney cum Islington, Wiggenhall St Mary The Virgin	290	44
Methwold Hythe	Methwold, Brookville, Methwold Hythe	62	18
West Acre	Castle Acre	29	36

An associated Dry Weather Flow (DWF, assumed increase in effluent flow to the treatment works) was then calculated for these, based on the following assumptions:

- A household occupancy rate of 2.1 as used in Phase 1 (this is understood to be an average figure between currently higher rates forecast decreasing rates to 2031);
- A wastewater consumption rate (per capita consumption or pcc rate) of 144 l/day per person, as used in Phase 1, representative of the whole Borough throughout the calculation period;
- A fixed infiltration rate of 25% of consumption has been assumed to remain constant and representative in all WwTW catchments (used in Phase 1).

2.3 Impact of Growth on Wastewater Flows and Compliance with Consents

Summary information on the current effluent flows from the WwTWs in the Borough, based on existing or planned consent conditions is provided in Table 2.3 (information for all of the WwTWs in the Borough is provided in Table 2.4). Estimated effluent flows that would result from planned housing growth are also presented in Table 2.3. For WwTWs for which there is sufficient headroom in the flow consent to accommodate the growth, the consented flow would not need to change. However, for the treatment works shown below in Table 2.3, the consented flow is predicted to be exceeded and would therefore need to be revised upward.

For eight of the WwTWs (shown in grey below), current measured flows have been found to exceed the current consented DWF. Consequently, revised flow consents have been presented in AWS's PR09 submission based on current measured flows. These revised consents are to accommodate flows from existing development only.

Further increases in DWF as a result of growth/ new development at these works would result in exceedance of these revised flow consents as they are based on the measured DWF.

At three additional WwTWs; Stoke Ferry, Southery and Feltwell, the existing consented DWF would also be exceeded as a result of growth.

Table 2.3 WwTWs Predicted to Exceed the Consented DWF as a Result of Growth

WwTW	Baseline Consented DWF m3/day*	2031 DWF to Accommodate Growth m3/day
Burnham Market*	838	912
Fincham*	143	151
Grimston*	1295	1341
Harpley*	325	361
Heacham*	5968	6328
Middleton*	307	320
Watlington*	1343	1422
West Walton	14421	14850
Stoke Ferry	282	307
Southery Mill Drove	215	222
Feltwell	470	493

* revised consented flow as presented in AWS's PR09 submission

In addition, Shouldham WwTW and East Winch WwTW will be operating at the allocated flow consent, following planned growth.

None of these WwTWs listed above and in Table 2.3 have an impact on inland Habitats Directive sites as indicated by the Outline WCS. However, East Rudham and Sculthorpe both discharge indirectly to a conservation site (the River Wensum) covered by Habitats Directive. Any planned development in this area may require Appropriate Assessment. Under Review of Consent Phosphate standards have been set for these works at the limit of conventional technology (1mg/l) and thus any increase in flow may lead to adverse impact on the designated site.

Table 2.4 shows estimated average effluent load for Phosphorus, BOD and Ammonia from the WwTWs at the current consented flows and effluent quality[2]. For those works that would exceed the consented flow as a result of growth (shown in grey) the indicative effluent quality consents to achieve load standstill are also shown.

At West Walton WwTW the calculated increase in flow is based on estimated growth within the Borough of King's Lynn and West Norfolk, and not Fenland. A full assessment of the impacts of growth at this treatment works will

[2] Calculated so that the 95% value for effluent quality is at the consented value. Estimated loads derived using SIMCAT.

be carried out as part of the East Cambridgeshire and Fenland Water Cycle Study and will, therefore, not be considered further here.

A number of WwTWs discharge into IDB drains as indicated in Table 2.4. At Southery Mill Drove and Middleton WwTWs the consented flow would be exceeded and any change in the flow consent at these works would need permission from the Internal Drainage Board.

Table 2.4 Changes in Effluent Loads and Estimated Change in Consent to Achieve Load Standstill

WwTW	Receiving Water	Consents (mg/l or m3/day)			No. Homes planned (2009? - 2031)	Estimated Mean and Standard Deviation Flow (Ml/d)		Estimated Mean and Standard Deviation Flow (2031) (Ml/d)		Load Prior to Growth(kg/day)			Load after Growth - 2031 (kg/day)			% Change			Indicative Consent to ensure Load Standstill (mg/l)	
		BOD	Amm	Flow (DWF)		Mean	SD	Mean	SD	BOD	Amm	P	BOD	Amm	P	BOD	Amm	P	BOD	Amm
Burnham Market	River Burn	25	10	838	196	1.09	0.33	1.19	0.36	11.1	3.93	6.26	12.1	4.29	6.83	9.01	9.16	9.11	22.7	9.1
Fordham	Cut off Channel	20		490	59	0.64		0.64								No change	No change	No change		
Grimston	Gaywood River	20	10	1295	121	1.68	0.51	1.74	0.52	16.4	6.11	8.25	17	6.32	8.55	3.66	3.44	3.64	19.3	9.7
Harpley	Babingley River	15		325	94	0.42	0.13	0.47	0.14	2.17	2.14	2.37	2.42	2.38	2.65	11.52	11.21	11.81	13.3	0.0
East Winch	Mintlyn Stream	19		159	21	0.21		0.21								No change	No change	No change		
Stoke Ferry	River Wissey	13	10	282	130	0.37	0.11	0.41	0.12	2.21	1.67	2.38	2.44	1.85	2.64	10.41	10.78	10.92	11.6	8.9
Shouldham	Polver Drain (cutoff and renew channel)	20	10	170	21	0.22		0.22								No change	No change	No change		
Sculthorpe	River Tat	No Consent Data			37	0.186		0.186								No change	No change	No change		
East Rudham	River Wensum	15	5	160	62	0.21		0.21								No change	No change	No change		
Southery-Mill Drove	White bridge drain (IDB) (River great Ouse)	30	10	215	43	0.28	0.08	0.29	0.09	4.26	1.39	1.58	4.43	1.45	1.64	3.99	4.32	3.80	28.8	9.6
Marham	Fourteen foot drain(River Nar)				72	0.89		0.89								No change	No change	*No change*		
Feltwell	Cut off channel	15	9	470	105	0.61	0.19	0.64	0.19	5.57	2.15	4.94	5.83	2.25	5.19	4.67	4.65	5.06	14.3	8.6
Fincham	Lode Dyke	25		143	22	0.19	0.06	0.20	0.06	2.26	1.41	0.92	2.37	1.48	0.965	4.87	4.96	5.23	23.8	0.0
Barton Bendish	Trib of River Wissey	40		50	4	0.07		0.07								No change	No change	No change		
Ingoldisthorpe	The Ingol	15	5	1400	121	1.82	0.55		0.55							No change	No change	No change		
Heacham	Heacham River	13	5	5968	952	7.76		8.23		40.65	15.2		43.11	16.12		6.05	6.05		12.2	4.7
Middleton	River Nar	25		307	35	0.40	0.12	0.42	0.12	6.04	0.21	2.05	6.33	0.22	2.15	4.8	4.8	4.9	23.8	0.0
Kings Lynn	tidal	50		21600	7969	28.080		28.1								No change	No change	No change		

Table 2.4 (continued) Changes in Effluent Loads and Estimated Change in Consent to Achieve Load Standstill

WwTW	Receiving Water	Consents (mg/l or m3/day)			No. Homes planned (2009? - 2031)	Estimated Mean and Standard Deviation Flow (Ml/d)		Estimated Mean and Standard Deviation Flow (2031) (Ml/d)		Load Prior to Growth(kg/day)			Load after Growth - 2031 (kg/day)			% Change			Indicative Consent to ensure Load Standstill (mg/l)	
		BOD	Amm	Flow (DWF)		Mean	SD	Mean	SD	BOD	Amm	P	BOD	Amm	P	BOD	Amm	P	BOD	Amm
West Walton	tidal	40	20	14421	1134*	18.75		19.30		309.33	136.86		318.53	140.92		2.97	2.97	2.97	38.8	19.4
Watlington	tidal	39		1343	209	1.75		1.85		28.14			29.75			5.71		*5.71*	36.8	0.0
Castle acre	ground (soakaway)	15	5	150	64	0.20		0.21		1.21	0.36		1.31	0.39		8.72	8.72	8.72	13.7	4.6
Methwold hythe	soakaway				65															

Italics - These are not within SIMCAT so are assessed separately
*This does not include growth in the area covered by Fenland District Council

2.4 Impacts of Growth on Receiving Waters

Further analysis has been carried out of impacts of planned growth on receiving water quality using a model of the Flood Relief Channel (for growth at Downham Market) and the Environment Agency's SIMCAT and RQP tools (for the inland waters). The impacts of the increased discharges on tidal waters have been assessed on the basis that they can be protected by achieving load standstill, following guidance from the Environment Agency.

2.4.1 Flood Relief Channel Model Set Up

Model Build

A bespoke water quality model was developed to simulate water quality in the Flood Relief Channel based on a previous model that Entec developed on the adjoining Cut Off Channel. The Flood Relief Channel tank model consists of 20 tanks defined by cross section data provided by the Environment Agency covering the channel between Denver and Tails End Sluice in King's Lynn (Figure 2.1). The model consists of a series of mixed tank reactors that represent water quality processes in sub divisions of the channel. The model simulates flow, Orthophosphate, Nitrate, Ammonia, BOD, Dissolved Oxygen and Chlorophyll-a and was set up to run for the period 1996 to 2008 to cover a range of hydrological conditions.

Cross Sections

Each model tank is bounded by measured cross sections provided by the Environment Agency (e.g. Figure 2.2). Bed levels between the cross sections were interpolated to estimate the volume of each tank. The total volume of the Channel is estimated to be approximately 4,060,000m^3.

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Figure 2.1 Location of Flood Relief Channel and Key Features

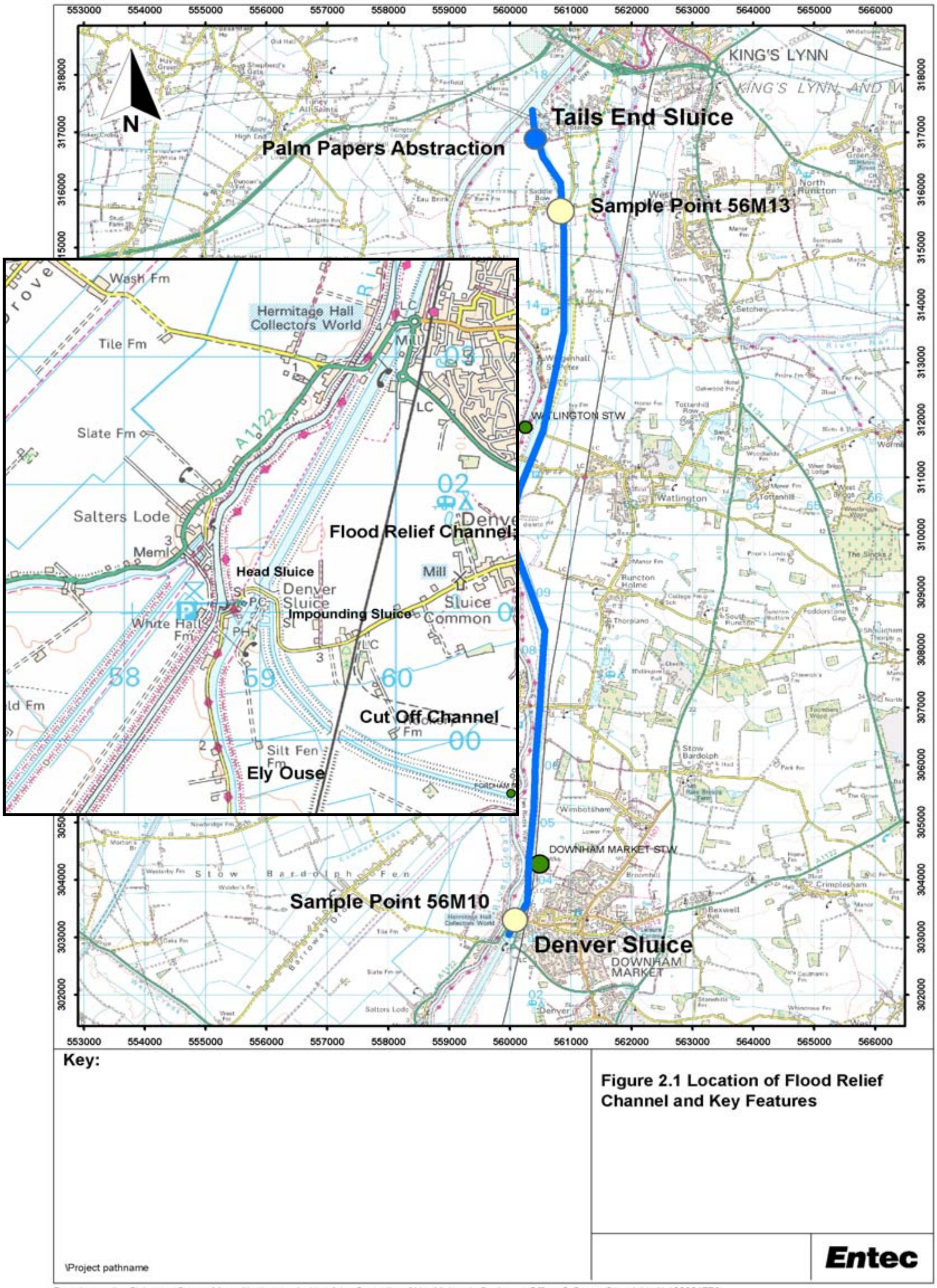
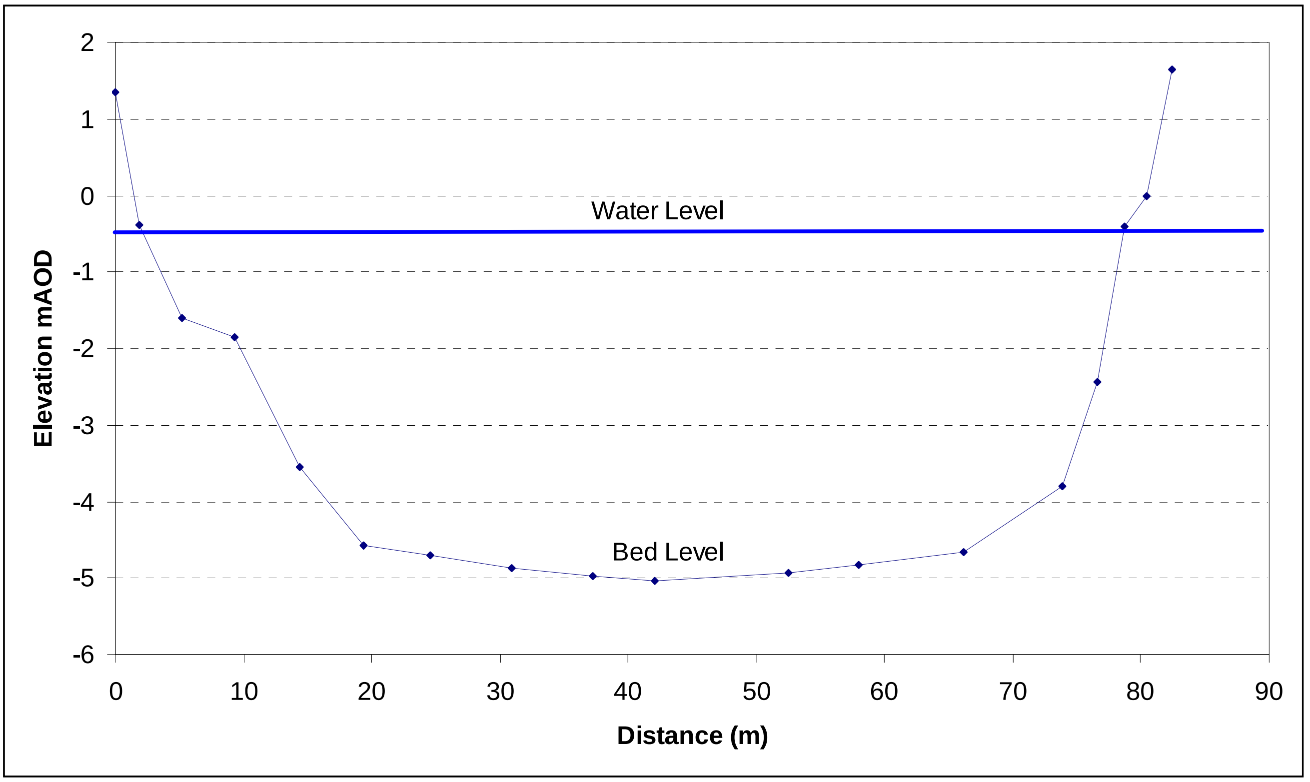


Figure 2.2 Example of Channel Cross Section

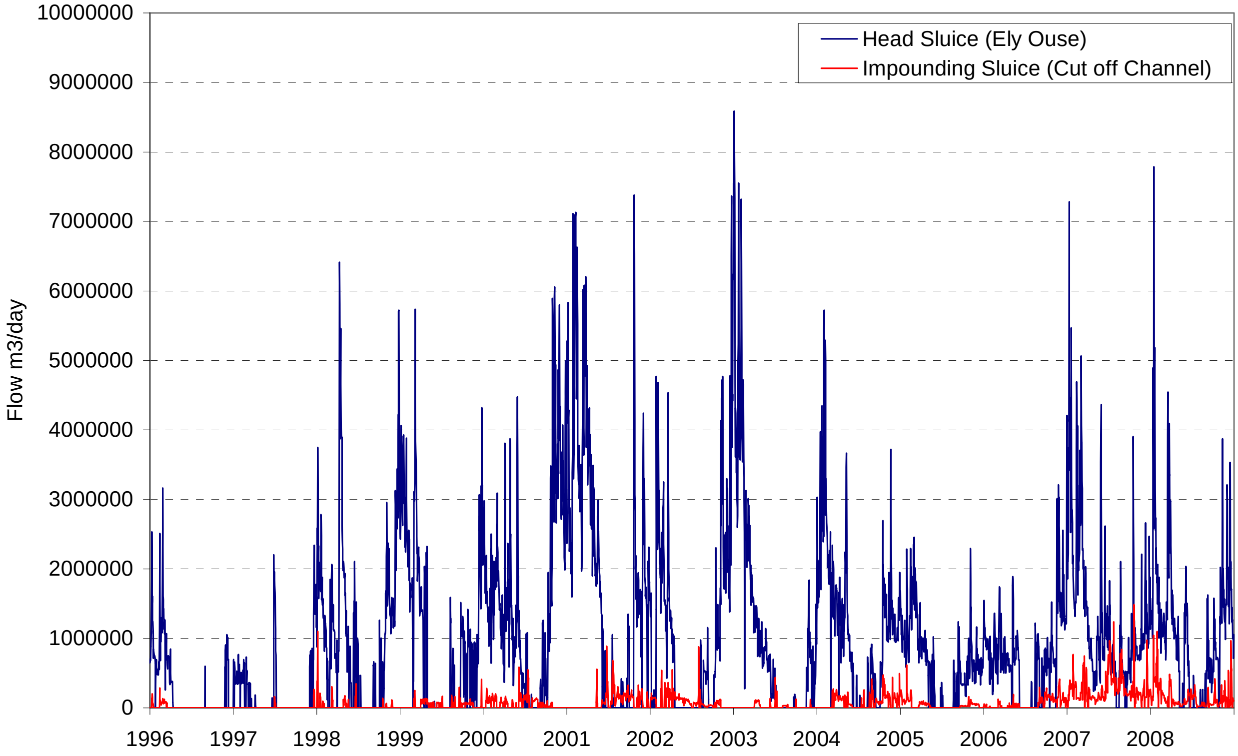


Hydrological Inputs

The following hydrological data were provided as inputs to the models.

- ***Rainfall and potential evaporation.*** The rainfall and potential evaporation series were input as time series data of direct rainfall to and evaporation from the channel;
- ***Inflows from the Ely Ouse and Cut Off Channel.*** The Environment Agency provided a record of the daily flow through the Impounding Sluice from the Cut Off Channel and Head Sluice from the Ten Mile River (Ely Ouse). Figure 2.3 shows the inflows from these rivers into the channel;
- ***Groundwater inflows.*** Groundwater inflows to the channel were assumed to occur at a similar rate to the lower end of the Cut Off Channel, which were estimated in the previous study based on output from the Environment Agency's Regional Groundwater Model.

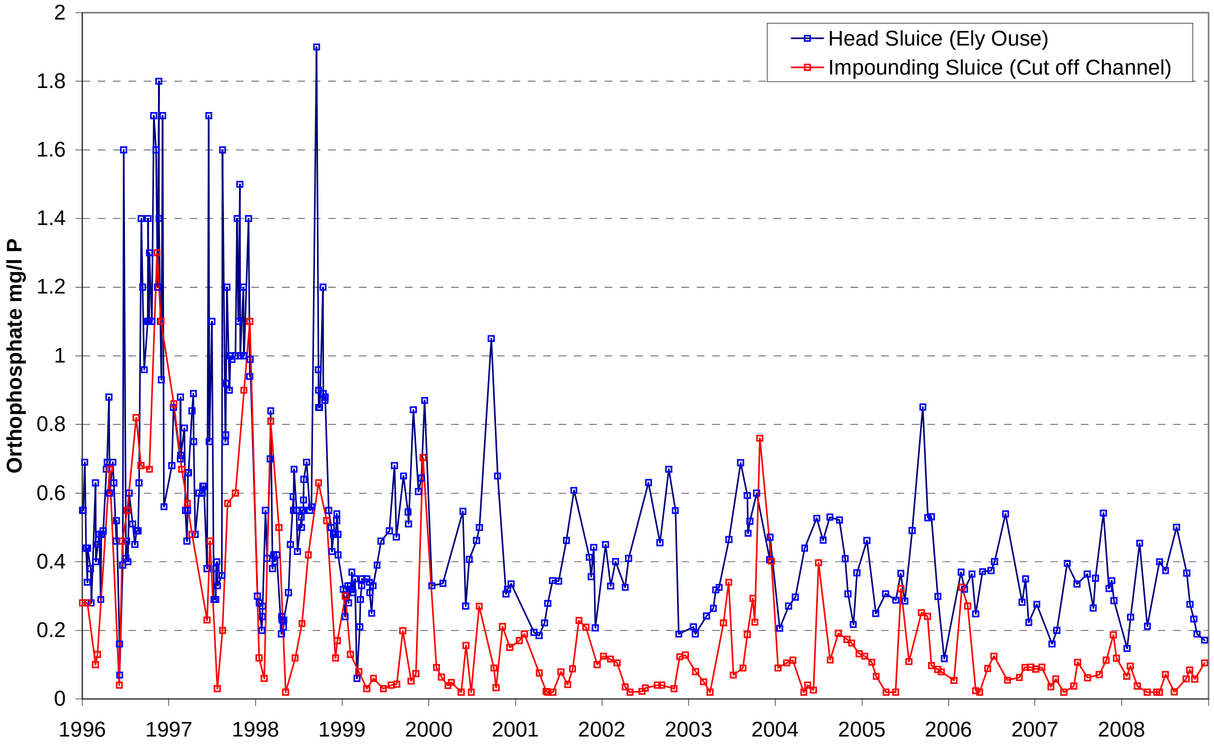
Figure 2.3 Flow into the Flood Relief Channel at Denver



Water Quality of Inflows

Observed water quality data in the Ely Ouse at Denver (sample point 51M01) and Cut Off Channel (sample point 56M08) were provided by the Environment Agency (Figure 2.4 shows Orthophosphate data). Monthly values were applied based on model calibration values from the Cut Off Channel model. No information is available for water quality in the groundwater inflows.

Figure 2.4 Ortho Phosphate Concentrations in the Ely Ouse and Cut Off Channel at Denver



Calibration

Observed and simulated water quality at two monitoring stations in the Flood Relief Channel is shown in Figures 2.5 and 2.6.

Figure 2.5 Comparison of Observed and Simulated Water Quality at Sample Point 56M10

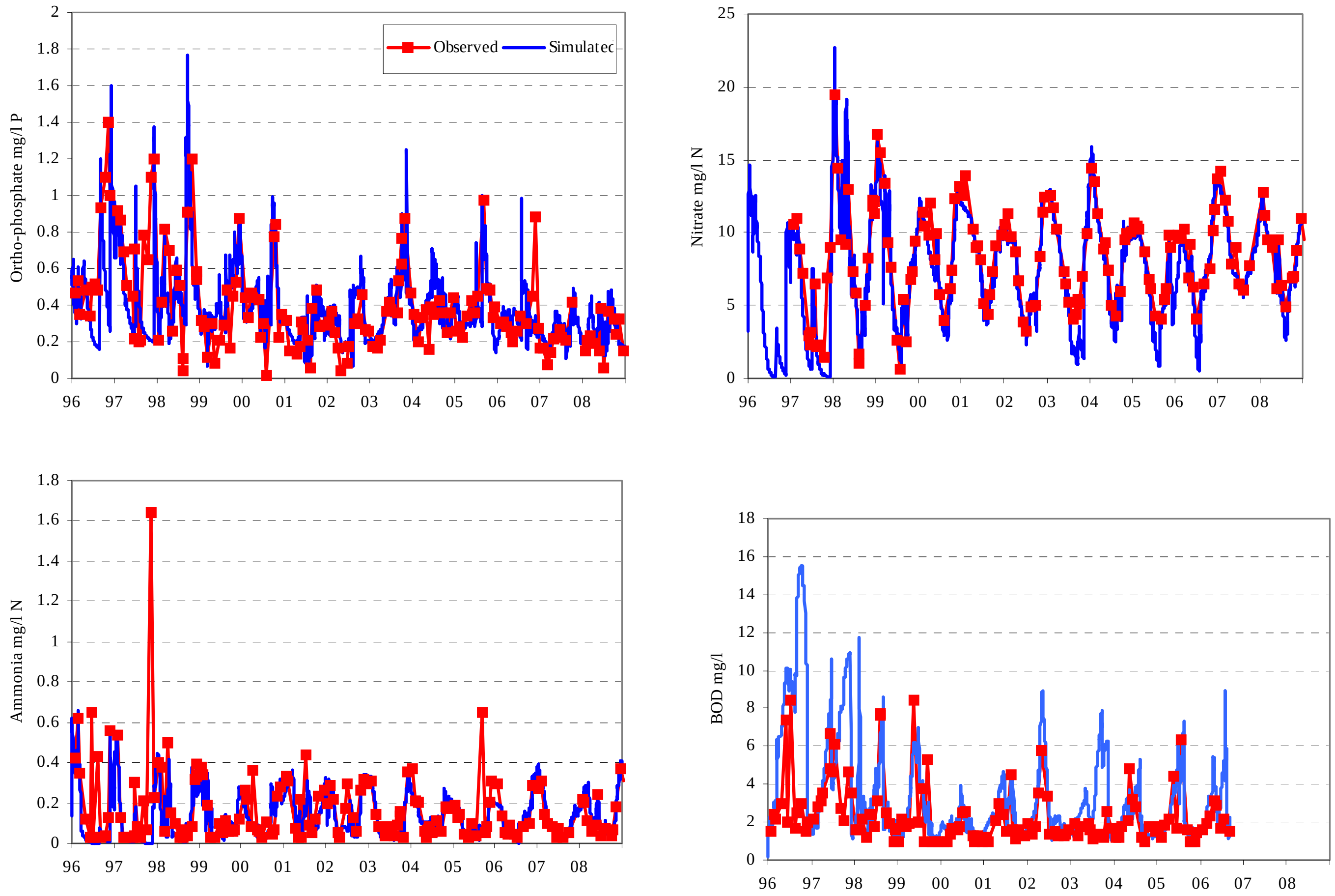
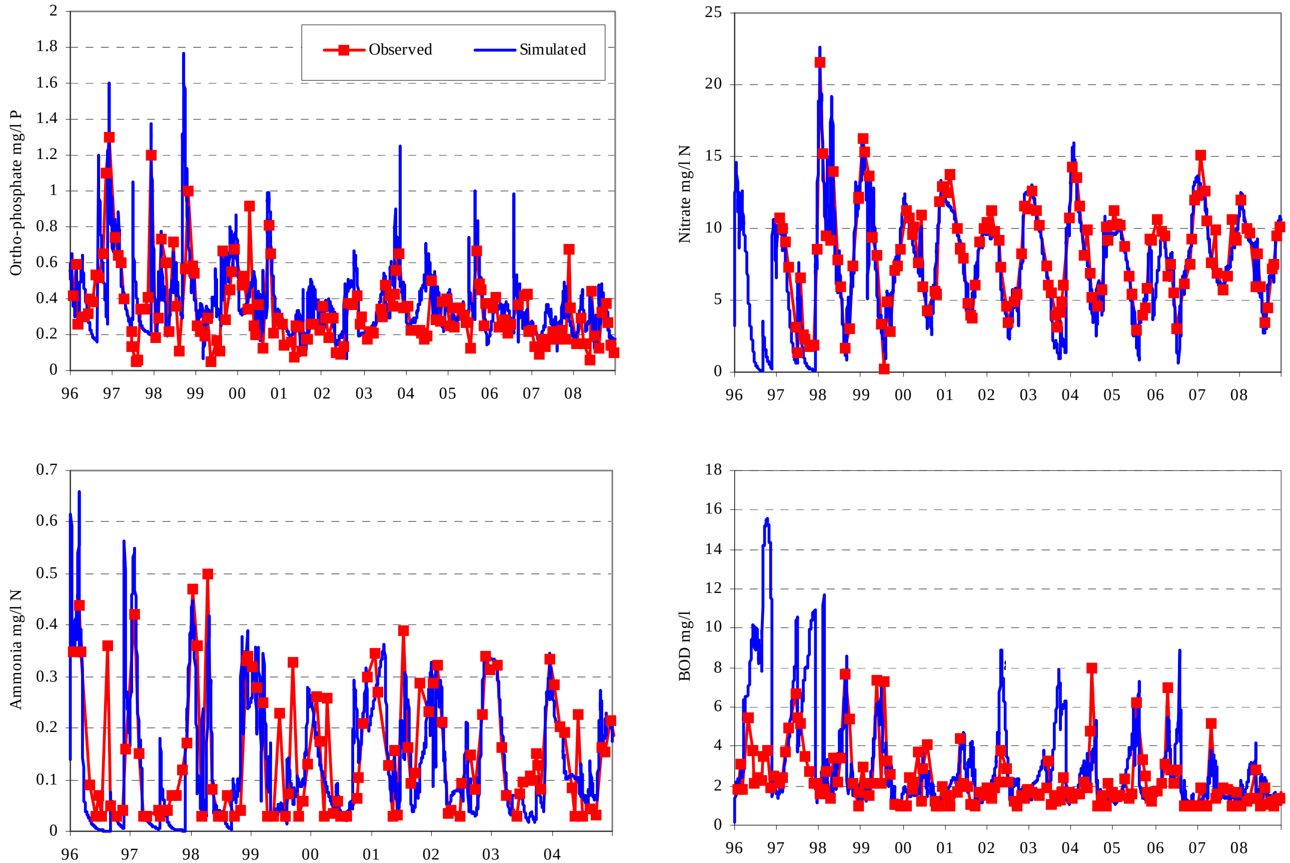


Figure 2.6 Comparison of Observed and Simulated Water Quality at Sample Point 56M13



2.4.2 Impact of Increased Wastewater Flows at Downham Market Sewage Works on Water Quality in the Flood Relief Channel

Using the bespoke model, a scenario was run to assess the impact of increasing wastewater flow inputs to the Flood Relief Channel and abstracting water for Palm Paper:

- The flow from Downham Market WwTW was increased to account for an additional 1,626 households (projected growth between 2008 and 2026). An occupancy rate of 2.1 and per capita use of water of 144l/day were assumed to calculate the increase in DWF;
- A daily abstraction of 18,000m^3/day by Palm Papers from the northern end of the Flood Relief Channel (based on estimated rates of abstraction provided by RPC Brown Consulting Hydrologist Ltd).

A comparison of simulated water quality between baseline (i.e. present day) and 2031conditions is shown in Figures 2.7 and 2.8. With the exception of a slight increase in peak Phosphorus concentrations, associated with increased flows from Downham Market WwTW, the changes in water quality are marginal. Inputs of Phosphorus, Ammonia and BOD upstream from the Ely Ouse and Cut Off Channel are far greater than inputs from the sewage works when flow is passing through Head Sluice and the Impounding Sluice. During periods when there is no flow through the sluices the impact of the increased Phosphorus loads is reduced by natural settling and adsorption processes. Phosphorus concentrations are generally well above the Water Framework Directive target for Good Chemical Status of 0.12mg/l. Ammonia concentrations are below the WFD target of 0.6mg/l and BOD concentrations increase above the WFD target of 5mg/l during most summers. Control of pollution upstream of the Borough would be required before WFD targets for Good Chemical Status could be met in the Channel.

Figure 2.7 Comparison of Simulated Baseline and 2031 Water Quality at Sample Point 56M10

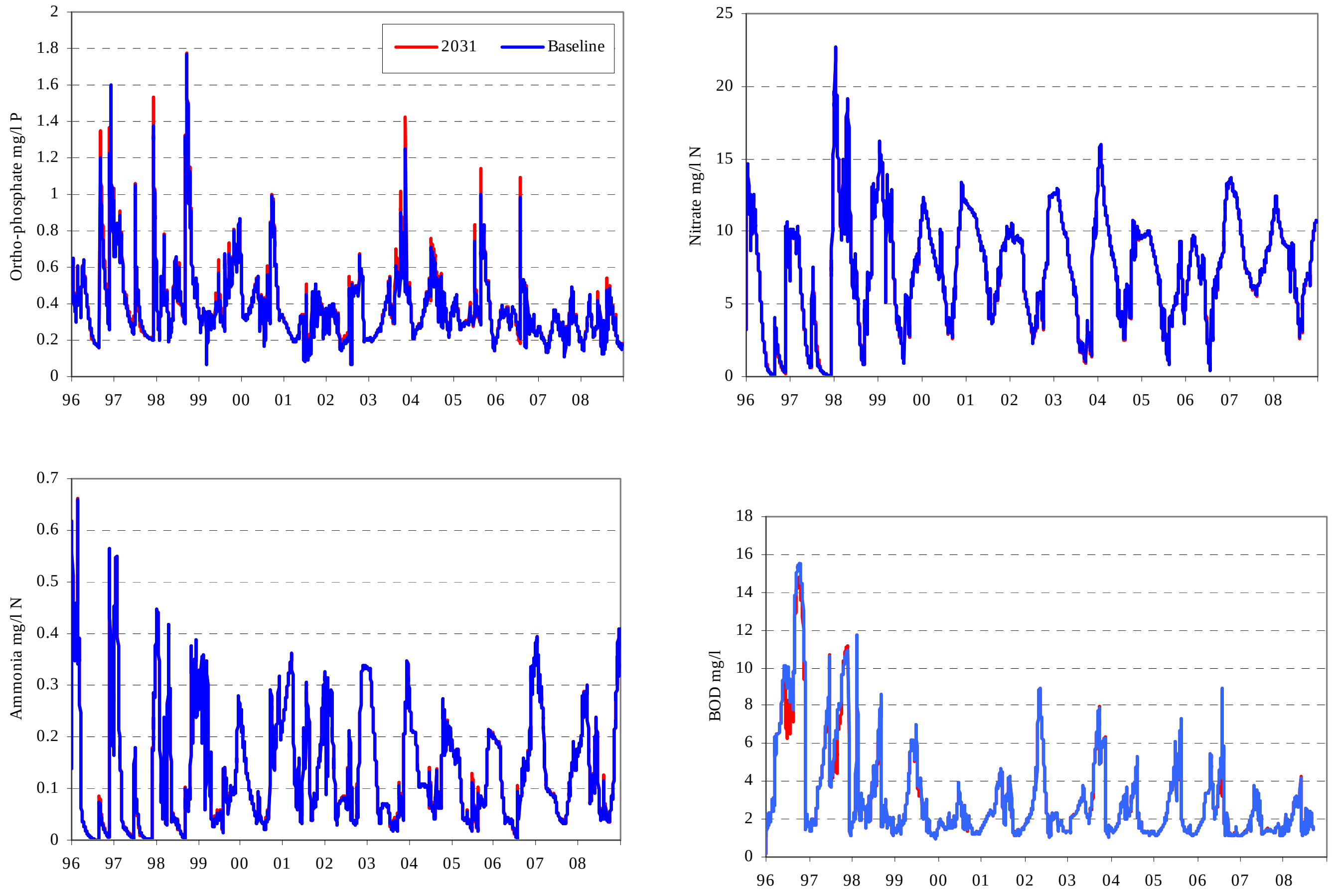
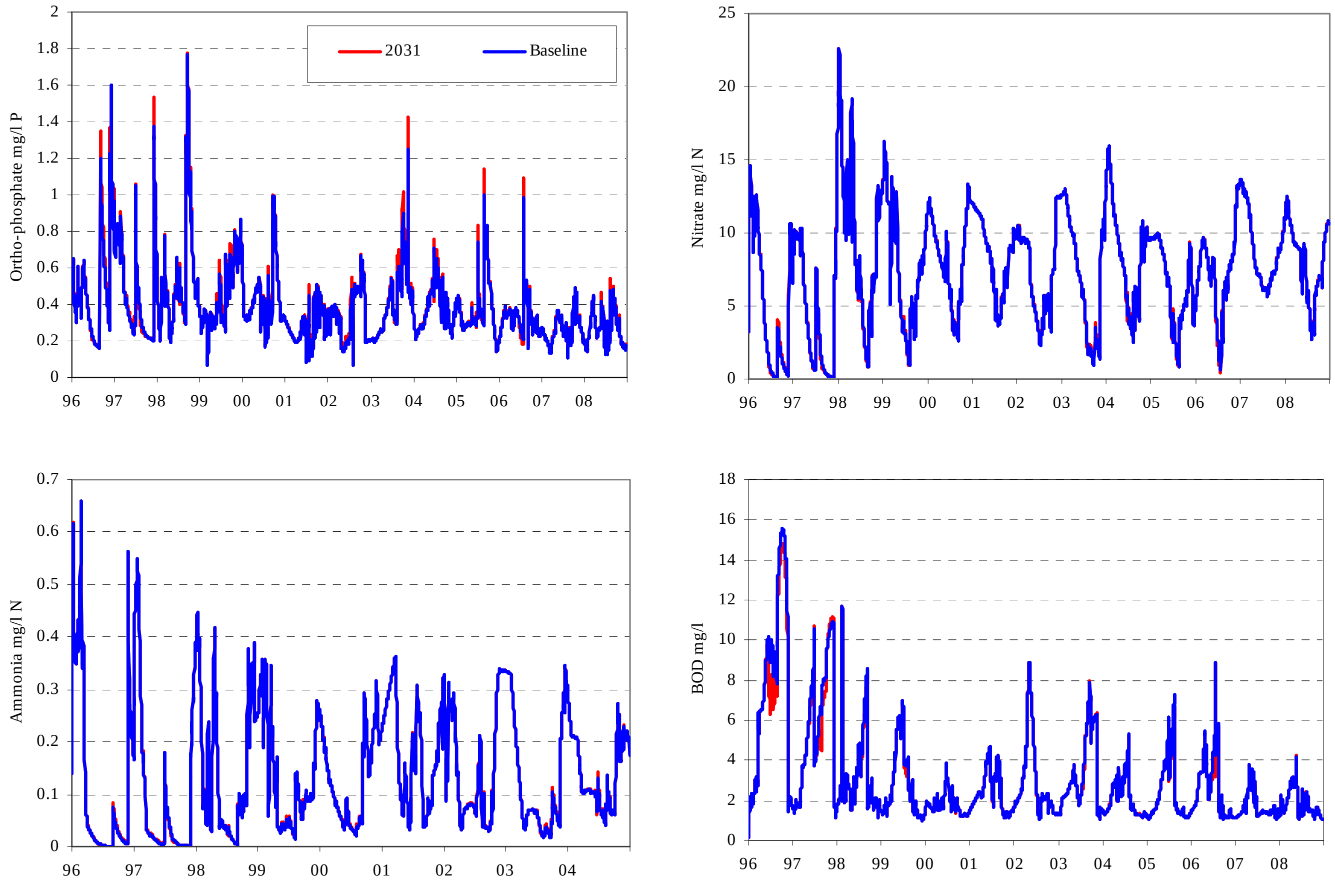


Figure 2.8 Comparison of Simulated Baseline and 2031 Water Quality at Sample Point 56M13



2.4.3 Impact of Increased Wastewater Flows on Inland Waters (SIMCAT)

The impact of increased wastewater flows at the smaller inland works in the Borough due to housing growth was assessed using National SIMCAT models (Wash and Anglian); the main water quality modelling tool used by the Environment Agency. In some cases, the wastewater discharges enter drains and are, therefore, not represented in the SIMCAT models. For these WwTWs other methods were used, if available, as described below, or the assessment was based on achieving load standstill (as shown in Table 2.4). The SIMCAT analysis was carried out in the following phases:

- Check on model structure and calibration;
- Assessment of impact of increase effluent flows on downstream water quality with regard to deterioration;
- Identification of indicative consents to prevent deterioration;
- Assessment of impact of increased effluent flows on meeting WFD targets.

Calibration

An initial check on the model structure was carried out followed by a calibration phase. Calibration was undertaken for the river reaches where the WwTWs were located and a distance downstream. Calibration plots alongside the model structure are shown in Figures 2.9 to 2.13 for WwTWs with growth reaching or exceeding flow consents (as indicated in Table 2.4).

Assessment of the Impact of Growth with Regards to Deterioration

An assessment was undertaken using SIMCAT of the impact of increases in flow associated with growth on water quality downstream of the WwTWs. The assessment is based on a comparison of river quality immediately downstream of the WwTW and at the WFD assessment point. Effluent flows were set to current consented flows and predicted flows after growth whilst effluent concentrations were set to values required to achieve the current consent. Table 2.5 shows simulated concentrations before and after growth and also compares the predicted WFD status based on the standards shown in Table 2.6.

Table 2.5 Estimated Impact of Growth on Downstream Water Quality and Compliance with WFD Standards Before and After Planned Growth

WwTW	Current WFD Status (provided by EA)			Phosphorus (Annual Average) mg/l				BOD 90%ile (mg/l)				Ammonia 90%ile (mg/l)				Change in status Y/N	New consent required to avoid deterioration within class (current consent in brackets)		
	P	BOD	Amm	Downstream		WFD Point		Downstream		WFD Point		Downstream		WFD Point			P	BOD	Amm
				B	A	B	A	B	A	B	A	B	A	B	A				
WwTW modelled using SIMCAT (showing compliance with WFD standards).																			
Burnham Market*	M	H	H	0.28	0.3	0.24	0.26	2.55	2.61	2.41	2.46	0.42	0.45	0.34	0.37	Y	5	24 (25)	9 (10)
Fincham	H	H	H	0.2	0.21	0.06	0.06	1.94	1.97	1.4	1.41	0.44	0.45	0.09	0.09	N		25 (25)	
Grimston	P	H	H	2.79	2.84	1.26	1.29	10.41	10.54	6.14	6.27	3.86	3.9	1.9	1.94	N	4.5	19 (20)	9.5 (10)
Harpley	H	H	H	0.18	0.2	0.07	0.08	1.73	1.79	1.42	1.44	0.33	0.37	0.1	0.11	N	4.5	14 (15)	10 (10)
Stoke Ferry	G	H	H	0.21	0.21	0.21	0.21	1.51	1.51	1.51	1.52	0.1	0.1	0.1	0.1	N		13 (13)	10 (10)
Heacham	NA	NA	NA	4.76	6.13	NA	NA	6.08	6.12	NA	NA	2.88	2.95	NA	NA	NA		12 (13)	4.5 (5)

Table 2.5 (continued) Estimated Impact of Growth on Downstream Water Quality and Compliance with WFD Standards Before and After Planned Growth

WwTW	Current WFD Status (provided by EA)			Phosphorus (Annual Average) mg/l				BOD 90%ile (mg/l)				Ammonia 90%ile (mg/l)				Change in status Y/N	New consent required to avoid deterioration within class (current consent in brackets)		
	P	BOD	Amm	Downstream		WFD Point		Downstream		WFD Point		Downstream		WFD Point			P	BOD	Amm
				B	A	B	A	B	A	B	A	B	A	B	A				
WwTWs discharging to tidal waters, drains or local watercourses – load standstill used for assessment (see Table 2.4)																			
Watlington	NA	NA	NA													NA		36 (40)	
West Walton	NA	NA	NA													NA		38 (40)	19
Southery	NA	NA	NA													NA		27 (30)	9.5 (10)
Middleton	NA	NA	NA													NA		23 (25)	
WwTWs discharging to Cut Off Channel																			
Feltwell (north flow)	M	H	H	0.39	0.39			6.3	6.3			0.17	0.17			NA		15 (15)	9 (9)
Feltwell (south flow)	M	H	H	0.34	0.35			5.59	5.59			0.28	0.27					15	8 (9)

B = Before Growth, A = After Growth. No WFD Compliance Point Available for Heacham.

Table 2.6 Water Framework Directive Water Quality Standards (Standard for Salmonid Rivers shown in Brackets)

WFD Status	Ammonia 90%ile (mg/l)	BOD 90%ile (mg/l)	SRP AA (mg/l)
HIGH (H)	0.3	4 (3)	0.05
GOOD (G)	0.6	5 (4)	0.12
MODERATE (M)	1.1	6.5 (6)	0.25
POOR (P)	2.5	9 (7.5)	1.0

The SIMCAT output indicates that the changes in water quality as a result of growth are small. Apart from downstream of Burnham Market, no change in WFD status occurs as a result of growth, either immediately downstream of the WwTW or at the WFD compliance point. Introducing a Phosphorus consent at Burnham Market of 5mg/l P would prevent this deterioration in status.

Although the model results indicate that growth will not affect the WFD status in most works, a slight increase in concentration of certain elements is observed. Further analysis was carried out using SIMCAT to estimate how much the consents would need to be tightened to prevent any increases and deterioration within the WFD class (it was assumed that consents would be tightened in intervals of 0.5 mg/l rather than smaller changes following the normal practices of the Environment Agency).

At Fincham and Stoke Ferry, the analysis indicates that there would be no deterioration in water quality at the compliance point as a result of growth[3] so no tightening of the consent would be required. At Burnham Market, Grimston and Harpley small reductions in the consent would be required to avoid deterioration within the status class.

For the WwTWs discharging to tidal waters or drains, it was not possible to model impact of growth using simple water quality planning tools such as SIMCAT because the downstream flow and mixing patterns are complex (e.g. in IDB drains flow may occur in both directions or may be close to zero for periods of the year). Consequently, in agreement with the Environment Agency, the assessment is based on achievement of load standstill (Table 2.4).

For Feltwell WwTW, an existing bespoke model of the Cut-Off Channel, developed by Entec for assessment of modifications to the Ely Ouse Transfer Scheme the period 1996-2004, was used to provide flow information to input to the Environment Agencies RQP tool. Flow in the Cut Off Channel can occur in both directions depending on operation of the transfers from the channel to the River Stour. Separate assessments using the RQP tool were, therefore, carried out for periods when flow occurs north to south and periods when flow occurs south to north (upstream water quality was based on observed data to the north - 56M08 or south - 56M06 of the discharge point depending on the direction of flow). Although the outputs are not directly comparable to annual standards, the

[3] SIMCAT and RQP reports to 2 decimal places.

analysis provides an indication of the impact of growth. In both cases the changes in downstream water quality were small.

In conclusion, therefore, the increased effluent flows associated with growth are estimated to either result in no change in WFD status or require a small tightening of the water quality consents to prevent deterioration. Deterioration within the status class would also be prevented by a small tightening of the water quality consents. Compliance with these tightened water quality consents could be achieved using current treatment processes and are, therefore, unlikely to require significant investment in new infrastructure by Anglian Water.

In practice the consent conditions applied will be dependent upon the measured flows and observed water quality both within the river and discharge at the time of the consent review. Following negotiations between AWS and the Environment Agency, new consent limits would be set that ensure regulatory requirements are met. At this stage, however, the analysis presented above indicates that environmental impacts of wastewater discharges are unlikely to constitute a constraint on growth or present timing issues for development. However, future WFD measures may require improvements to any or all WwTWs in the area and it is, therefore, important that adequate space is available at the works to allow for improved treatment.

2.4.4 Assessment of the Impact of Growth with Regards to the Achievement of Good Status

For those works in which the WFD chemical status after growth would be worse than Good (listed in Table 2.7 below), further analysis was carried out using the Environment Agency's RQP tool to determine the impact of growth on the achievement of Good status. Following guidance from the Environment Agency, upstream water quality was set to the middle of Good status (i.e. 0.0875 mg/l for P) and downstream quality compared with and without growth. Upstream flows were based on output from the SIMCAT models or, in the case of Feltwell, the Cut Off Channel model as described above. The RQP tool was used to calculate the consent required to achieve Good status immediately downstream of the discharge point before and after growth.

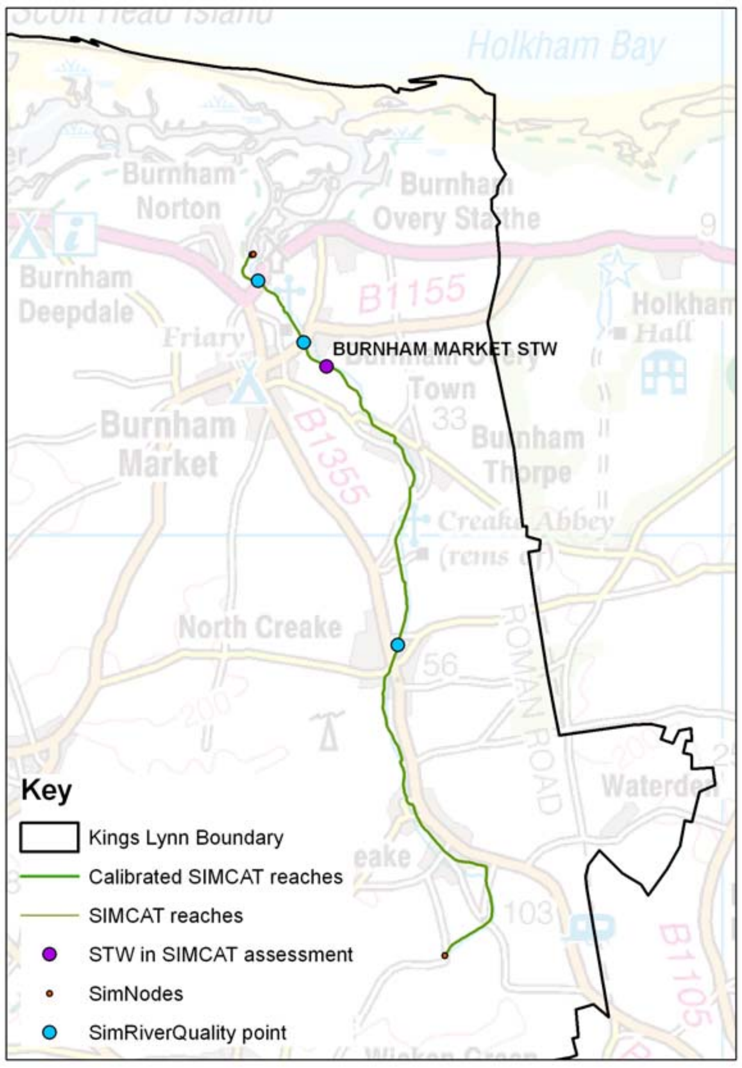
Table 2.7 compares simulated downstream quality before and after growth and shows whether growth would result in a change of downstream WFD status. The effluent quality consent required to achieve Good Chemical Status before and after growth is also presented. At Grimston and Burnham Market WwTWs, Good Chemical Status could only be achieved if a very tight quality consent were set, beyond the limits of Best Available Technology (1 mg/l) reflecting the low level of dilution in the receiving water at these works. In practice, therefore, growth is likely to have little impact on the capacity to achieve Good Chemical Status downstream because it is not achievable within current technology and cost/ benefit constraints. At Feltwell WwTW, the consent required to achieve Good chemical status would be tighter after growth although this would be achieved in both cases by setting a Phosphorus consent of 1mg/l. Generally the Environment Agency sets Phosphorus consents at the 1mg/l or 2mg/l level so growth is unlikely to change the consent if a decision were taken to further protect this water body. At Heacham WwTW, the downstream flows in the short stretch of river before the tidal limit, consist of greater than 99% effluent flow so achieving the WFD targets for Good Status downstream would require the effluent quality to be close to the WFD targets. This would be well beyond the limit of Best Available Technology for Phosphorus, Ammonia and BOD.

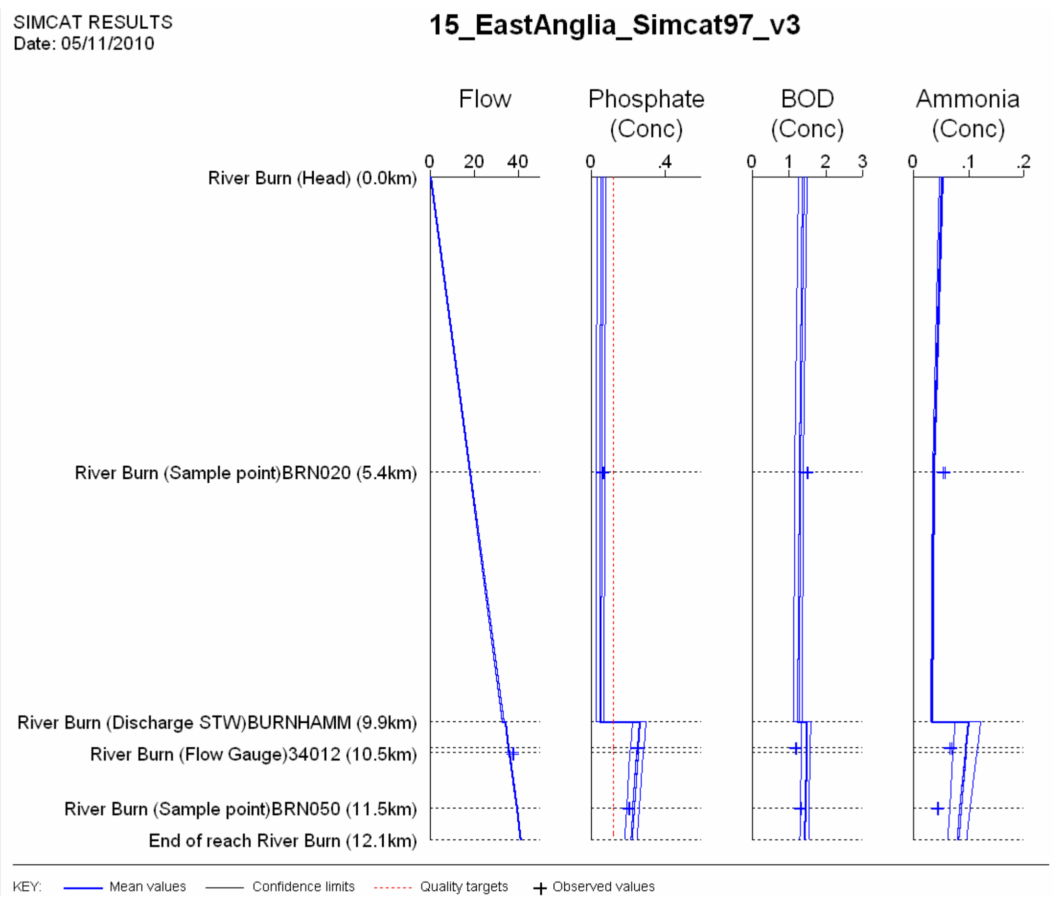
Table 2.7 Impact of Growth on the Achievement of Good Chemical Status for Phosphorus based on Good Status Upstream Water Quality

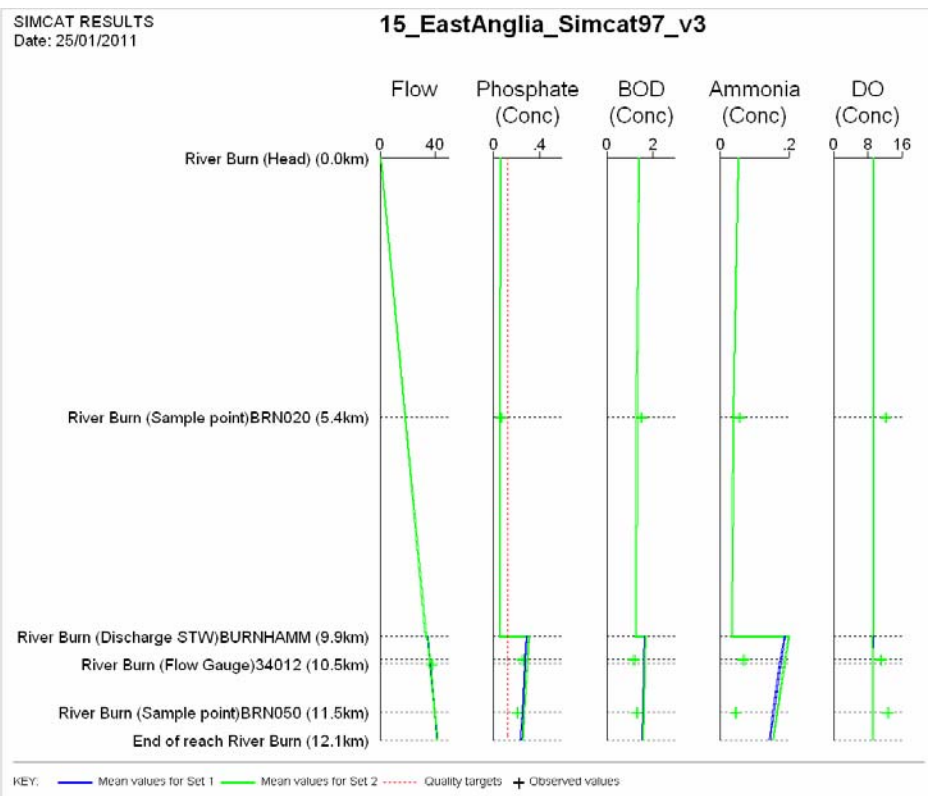
WwTW	Downstream Quality (mg/l)		Change on Status (Y/N)	Consent to achieve Good Status	
	Before Growth	After Growth	N	Before	After
Burham Market	0.53	0.57	N	0.51	0.48
Grimston	3.59	3.57	N	0.16	0.16
Feltwell (north flow)	0.23	0.24	N	1.78	1.88
Feltwell (south flow)	0.26	0.27	N	1.5	1.58

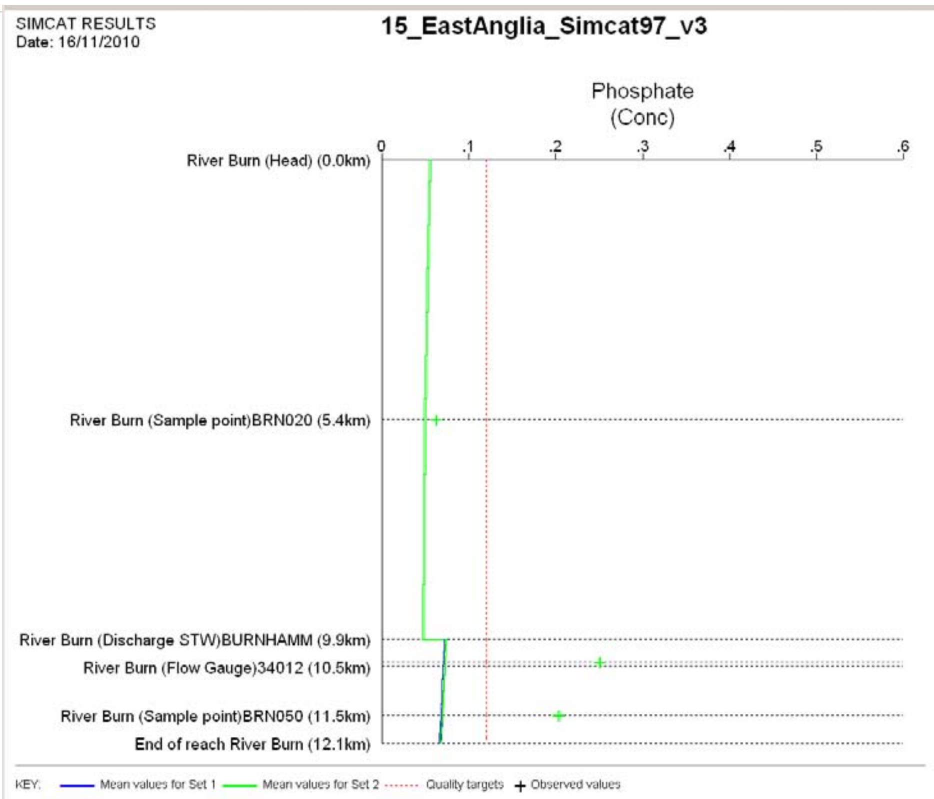
Further SIMCAT runs were carried out for effluent Phosphorus concentrations set at the Best Available Technology (BAT) limit of 1mg/l P to determine where growth would make it more difficult to achieve good chemical quality under these conditions. This provides an indication of the potential to achieve Good status by consenting at a catchment level, taking into account the limitations of conventional treatment. Graphical results for the growth and BAT scenarios are presented in Figures 2.9 to 2.13 indicate only a marginal impact of additional flow associated with growth on the achievement of Good chemical status for Phosphorus.

Figure 2.9 Model Structure, Calibration Plots and Assessment of the Impact of Growth at Consented and BAT Levels for Burnham Market WwTw







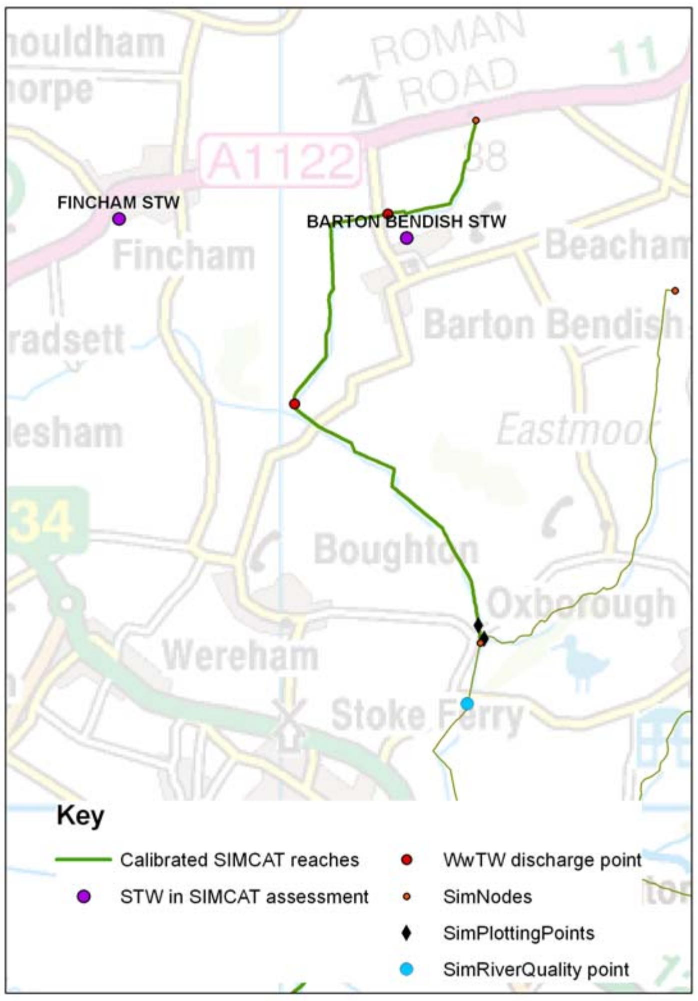


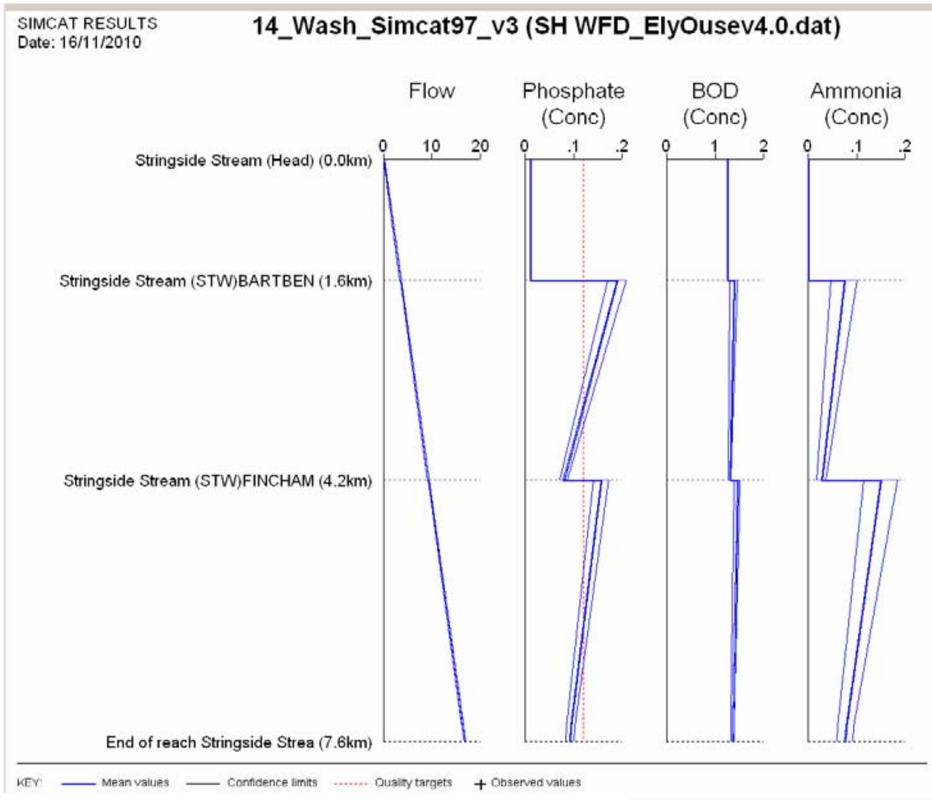
Blue Line – Consent Scenario results
Green line – Growth Scenario results

Impact of Growth on WwTW Discharge

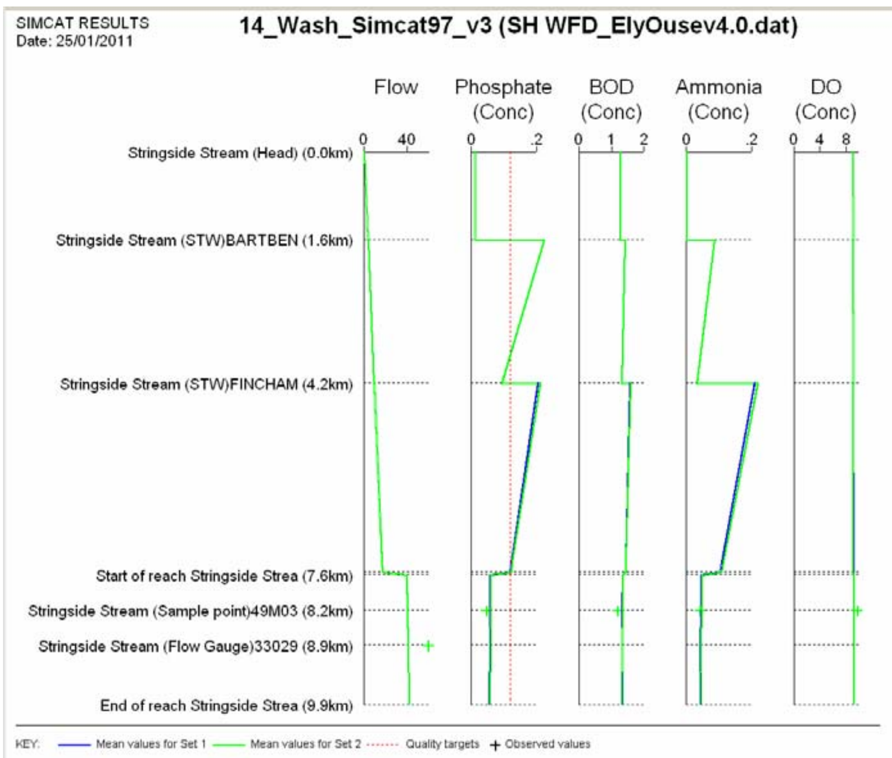
Impact of Growth with WwTW P BAT

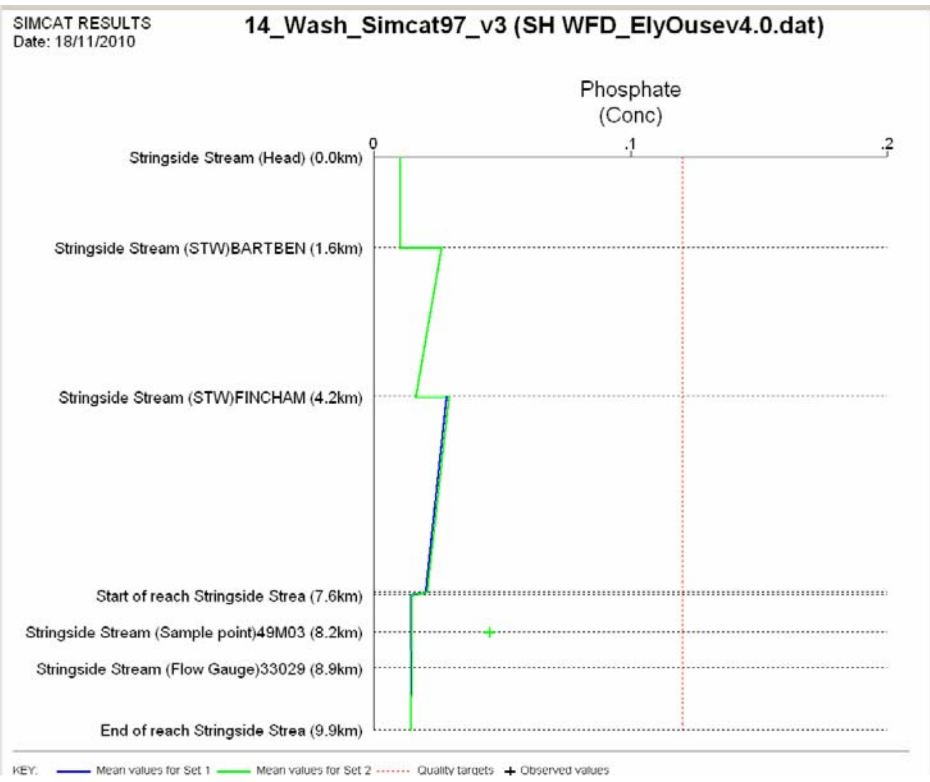
Figure 2.10 Model Structure, Calibration Plots and Assessment of the Impact of Growth at Consented and BAT Levels for Fincham WwTW





Calibration



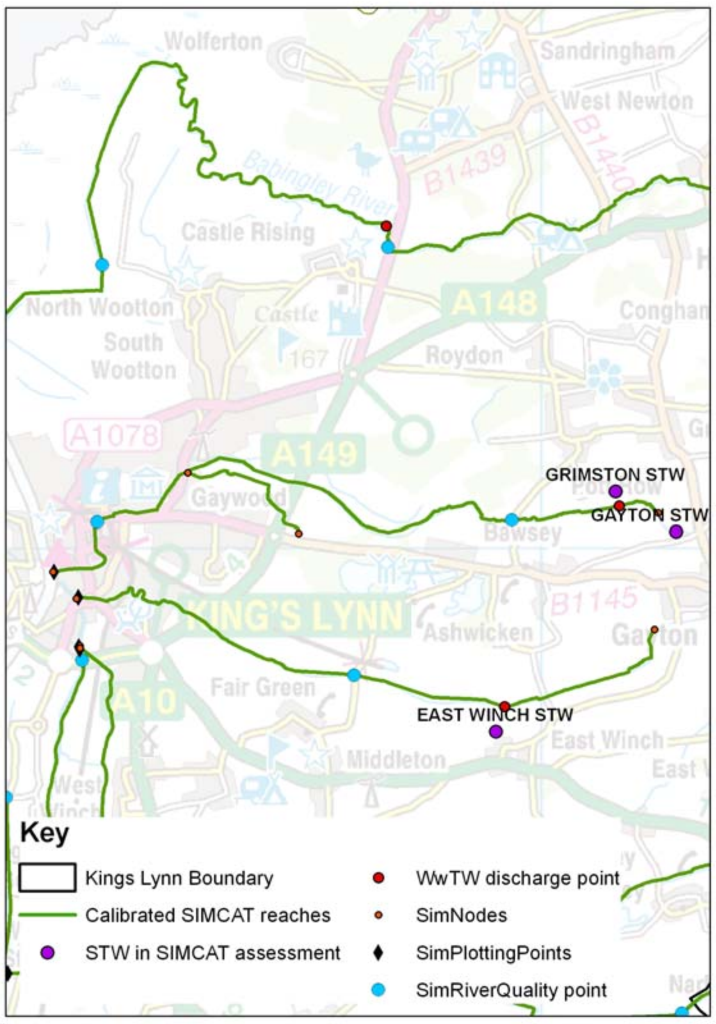


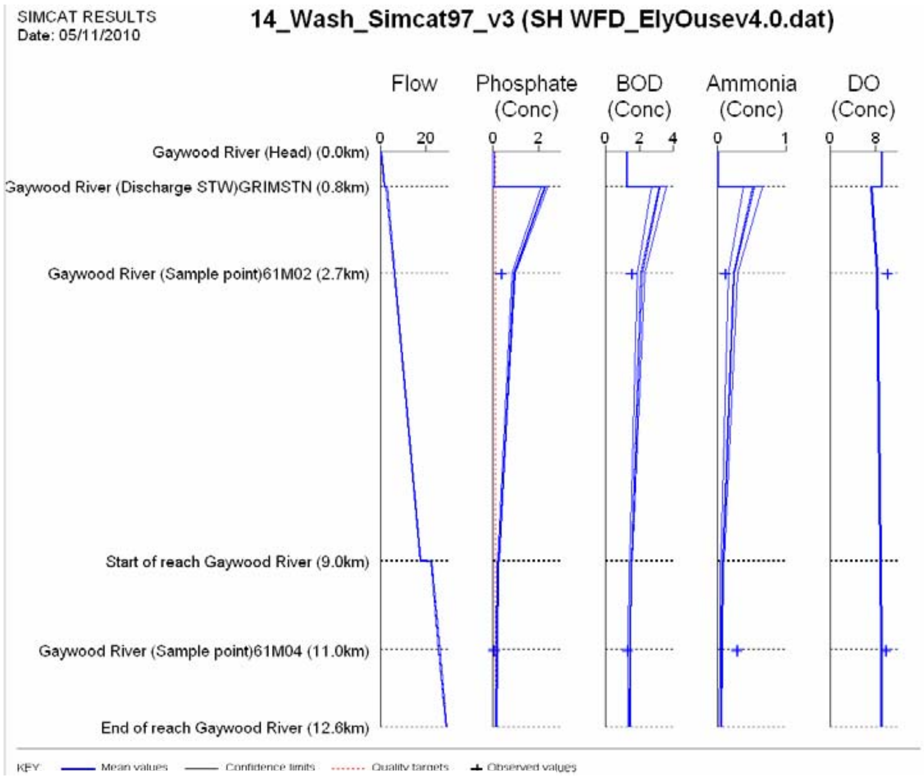
Blue Line – Consent Scenario results
Green line – Growth Scenario results

Impact of Growth on WwTW Discharge

Impact of Growth with WwTW P BAT

Figure 2.11 Model Structure, Calibration Plots and Assessment of the Impact of Growth at Consented and BAT Levels for Grimston WwTW





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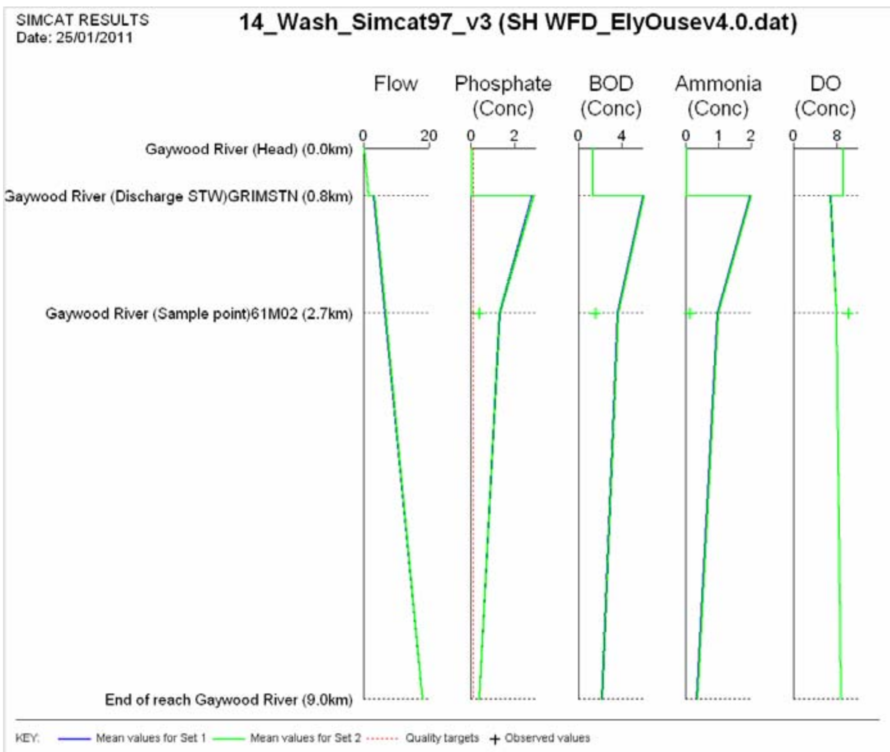
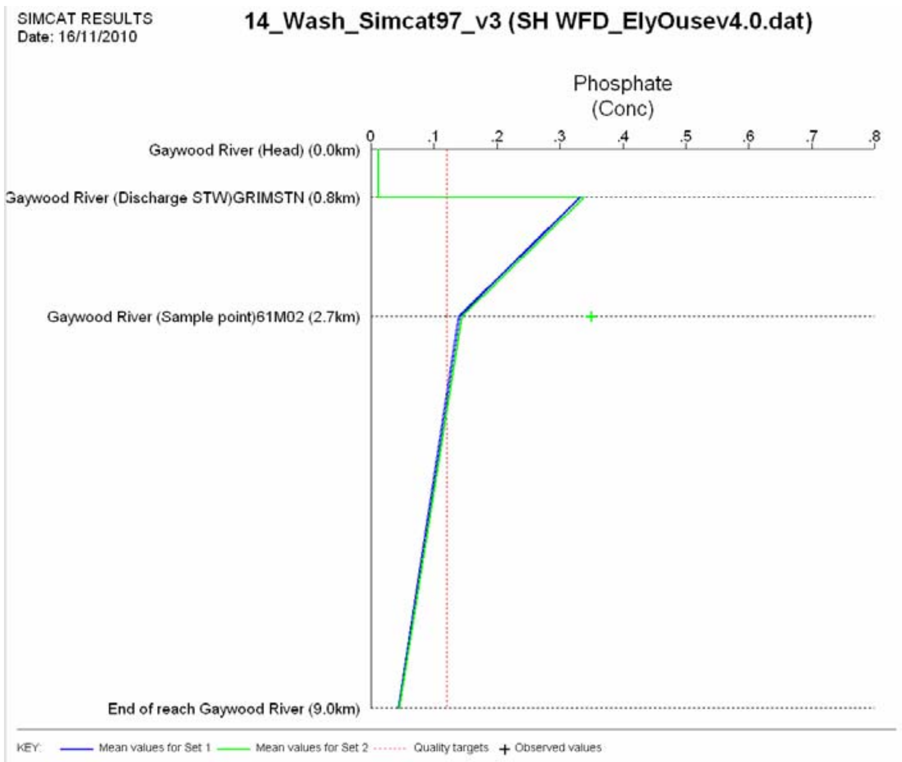


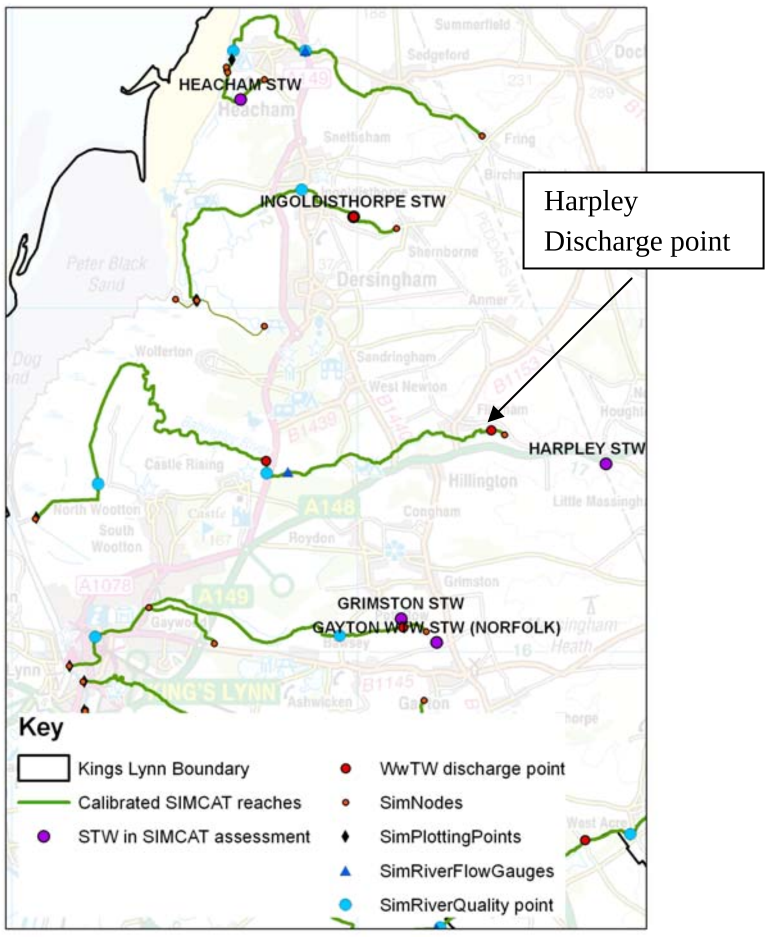


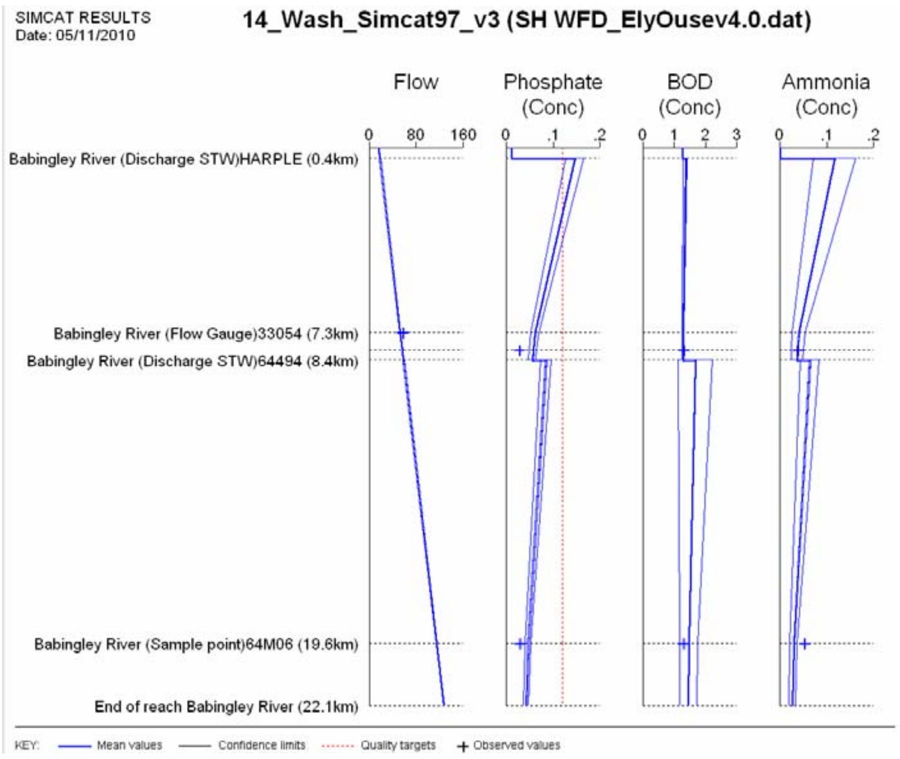
Blue Line – Consent Scenario results
Green line – Growth Scenario results

Impact of Growth on WwTW Discharge

Impact of Growth with WwTW P BAT

Figure 2.12 Model Structure, Calibration Plots and Assessment of the Impact of Growth at Consented and BAT Levels for Harpley WwTW





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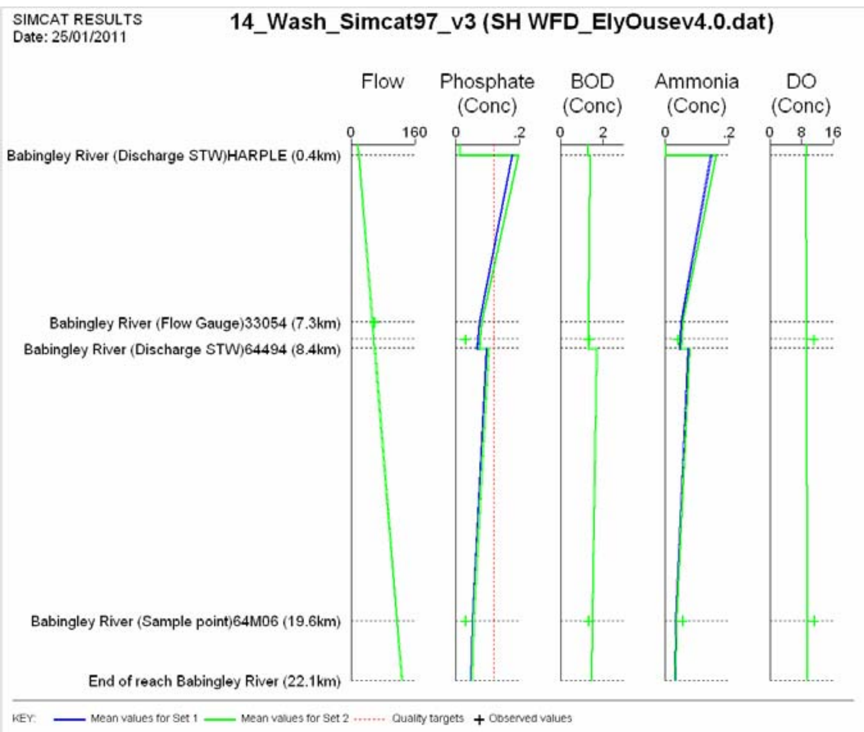
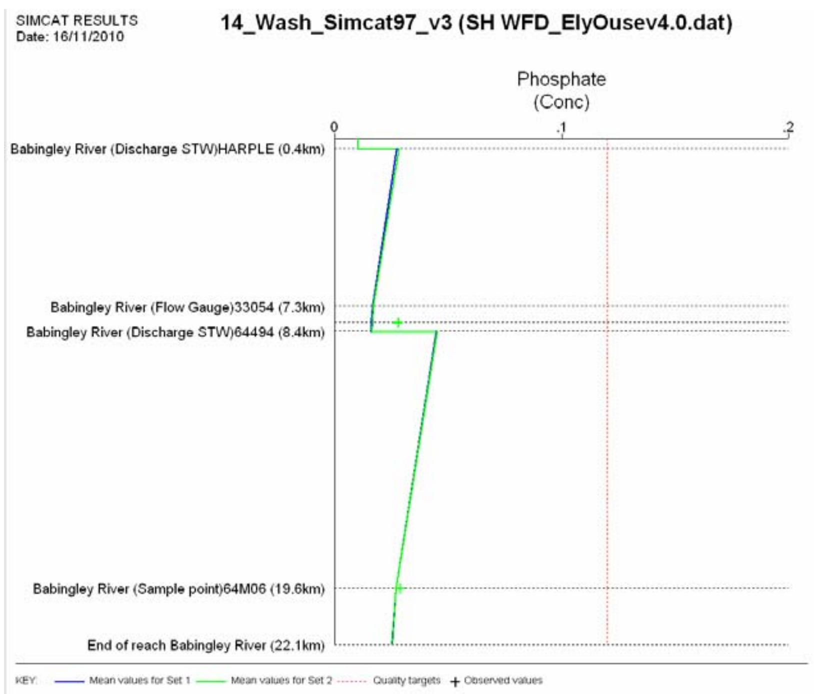


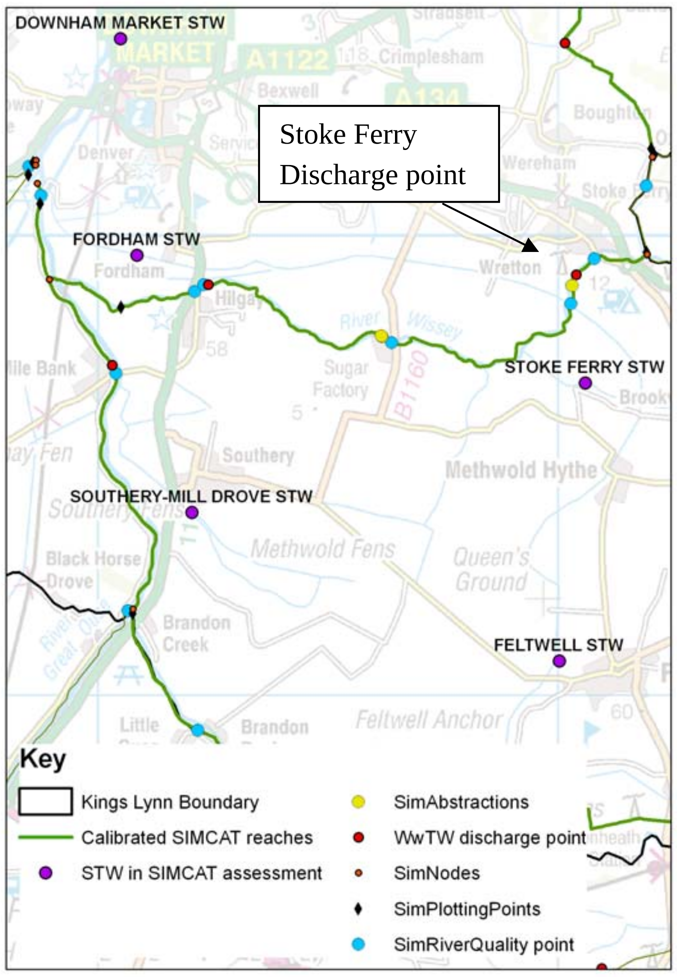


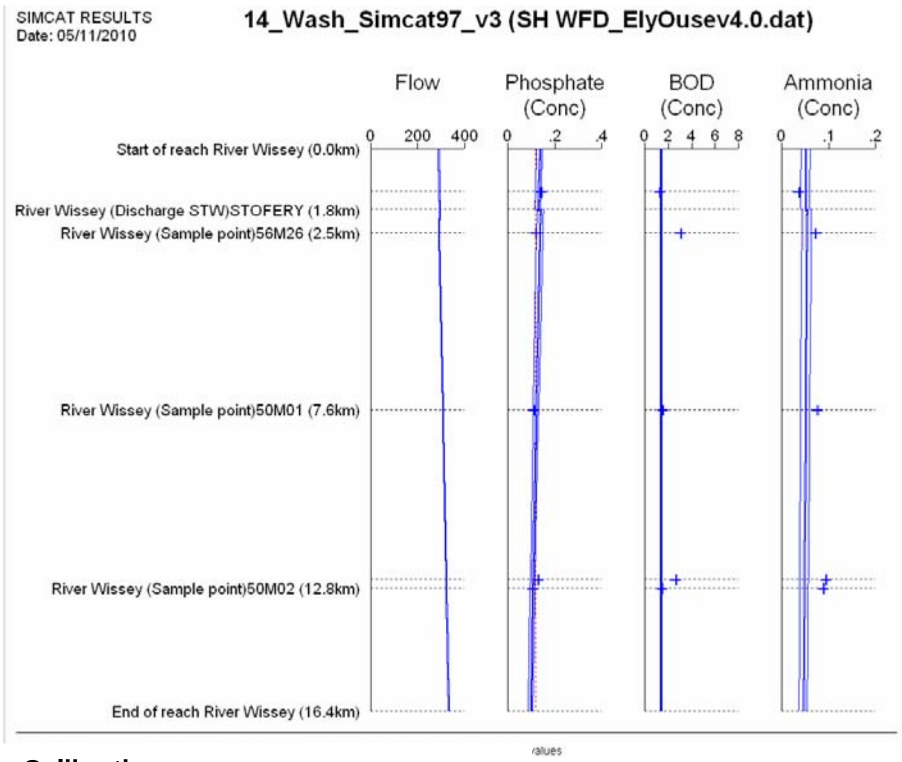
Blue Line – Consent Scenario results
Green line – Growth Scenario results

Impact of Growth on WwTW Discharge

Impact of Growth with WwTW P BAT

Figure 2.13 Model Structure, Calibration Plots and Assessment of the Impact of Growth at Consented and BAT Levels for Stoke Ferry WwTW





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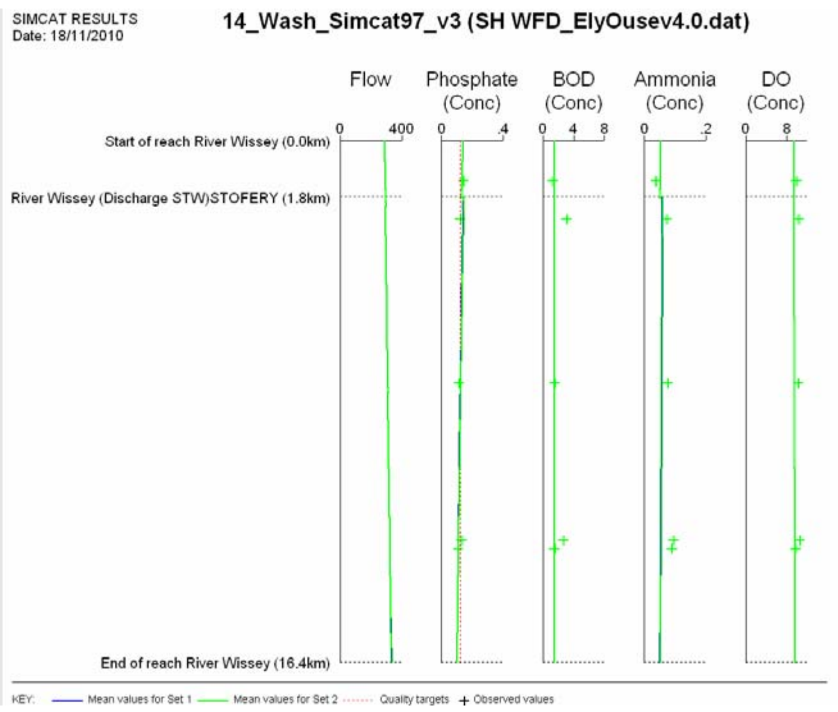

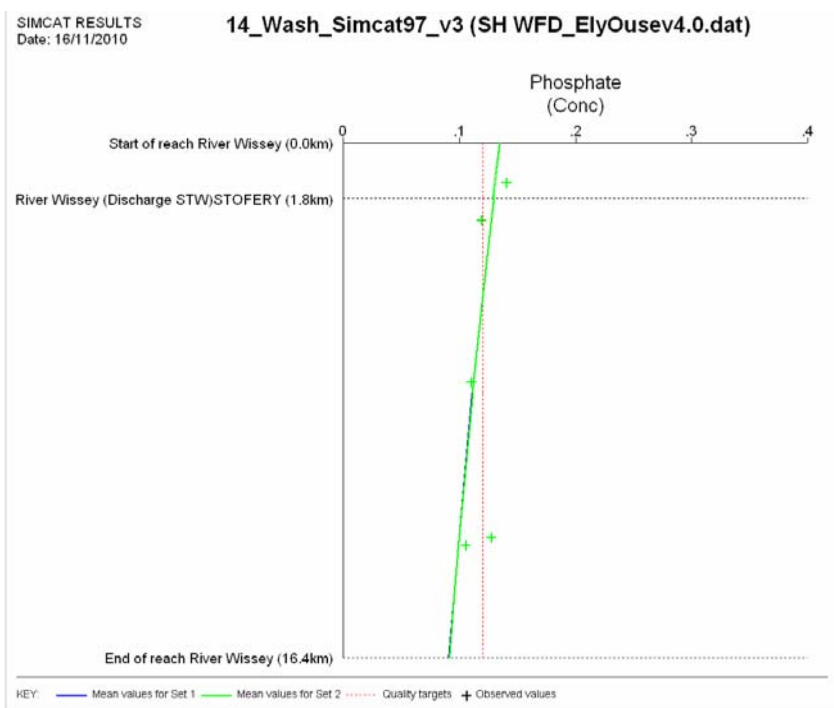

Blue Line – Consent Scenario results
Green line – Growth Scenario results

Impact of Growth on WwTW Discharge

Impact of Growth with WwTW P BAT

2.5 Bathing Waters

The Bathing Waters Directive (76/160/EEC) sets out microbiological and chemical standards to protect public health at designated bathing waters. Monitoring of bathing waters occurs throughout the bathing season, and water quality data are assessed against the obligatory and guideline standards in the Directive. The revised Bathing Waters Directive (2006/7/EC) includes tighter microbiological standards and a requirement to provide warning information about potential breaches at bathing waters. The revised Directive sets four new standards - excellent, good, sufficient and poor. Apart from certain exceptions, bathing waters must achieve a 'good' standard (which is statistically close to the former 'guideline' standard).

Overall there have been significant improvements in bathing water quality through improving water company discharges and the sewerage infrastructure and the Anglian region is no exception. These improvements have been funded through the periodic review of Anglian Water's spending, including spending on environmental investments. However, Anglian Water have identified a significant risk of non compliance with the new standards at Heacham and Hunstanton beaches and are undertaking investigations to further quantify this risk and identify the sources of coliforms within the catchment area of the beaches. A summary of the findings of the Anglian Water work is presented and reviewed below to assess whether these issues are likely to constitute a constraint to growth in the Hunstanton area.

2.5.1 Anglian Water Studies

Anglian Water uses ACMS, a coastal modelling tool, to confirm that their wastewater treatment levels are sufficient to ensure compliance under various tidal and wind conditions. They selectively use detailed risk assessment methods at hotspot bathing waters using ACMS, sewer modelling and optioneering using STORM-IMPACT (multi-variable analysis).

An Anglian Water Bathing Waters Strategy Phase 4 report was completed in October 2008. This stated that there was reasonable evidence to link the River Heacham bacterial loads to Bathing Waters compliance issues and identified the need to carry out bacterial load surveys on the river. It was noted that telemetry data from pumping stations, such as Folgate and Hunstanton South End, should be checked for erroneous data/ trends to ensure that there are no contributions from pumping station overflows. The report concluded that there was no influence on bathing waters from effluent from the King's Lynn catchment, as this does not reach the sensitive waters at Hunstanton and Heacham. The possibility of misconnections and caravan park discharges into sewers or the river could not be excluded. Overall the movement of bacteria from the River Heacham outfall is northward, as the monitoring sites south of the outfall show lower bacterial concentrations. The report emphasises that discharges from the river only occur during low water to prevent seawater ingress. The unknown parameters in the above assessment are: the contributions from caravan parks and misconnections, the background river bacterial concentrations, the river flow regime, the surface sewer overflow contributions and the reliability of telemetry data from pumping stations.

The predicted classification was 'good' for Hunstanton Main Beach and 'sufficient' for Hunstanton Beach and Heacham Beach based on 2004-2007 data, an improvement from the 2003-2006 sampling period ('sufficient' for

Hunstanton Main Beach and Hunstanton Beach, and 'poor' for Heacham Beach). The main threat at Heacham Beach was from Faecal Streptococci rather than Faecal Coliforms. It is thought that the River Heacham is driving Bathing Waters compliance issues as it appears to transfer significant bacteriological loads. In actions agreed between Anglian Water and the Environment Agency in December 2008, it was proposed that sampling (to include E.Coli and Intestinal Coli at 2-3 times per week for 3 weeks) is carried out upstream and downstream of the Heacham urban catchment to assess inputs from the urban area. In a second phase, increased sampling should be carried out if a significant increase in bacterial loads is shown downstream of the urban area; alternatively, if no effects are observed, the focus should shift to other sources such as remote point sources and land use. If the data shows that levels above the urban catchment are significant and increase significantly through the catchment, then a mixture of actions will be required. In any case an appropriate mitigation strategy should be developed to control the identified microbial sources. It is also thought that surface water sewers contribute to Bathing Waters failures. The agreed actions are to sample sediment from selected surface sewers under simulated (and real, where possible) rainfall events and to shortlist surface sewers for real-time monitoring. CCTV surveys should also be undertaken and assessed. Further, and more advanced, options include Microbial Source Tracking (MST) methods; these are to be assessed in 2010 to determine whether they can be used on statutory Bathing Waters and river samples to assist with microbial source apportionment.

Local growth around Heacham and Hunstanton may affect management of the surface water and wastewater systems but the Bathing Waters requirements are unlikely to constitute a significant constraint on growth. The projected increase in incoming DWFs to Heacham WwTW is relatively small, in the order of 4-5% (current PE served is 31,700) and other sources of bacteria are believed to be important.

2.5.2 Summary and Conclusions

Increased wastewater flows would result in exceedance of the current flow consents at 11 WwTWs in the Borough of King's Lynn. The increased flow at these works, however, is estimated to be relatively small (i.e. below 10%) and could, therefore, be offset by small reductions in the effluent quality consents. Compliance with these tightened consents could be achieved using current treatment processes and would, therefore, not require significant investment in new infrastructure by Anglian Water. Consequently, wastewater discharges are unlikely to constitute a constraint on growth or present timing issues for development. Modelling of downstream quality indicates that increased flows associated with growth would result in small changes in water quality which could be offset by a small tightening of consents.

Further analysis related to treatment works currently failing to meet downstream Good chemical status indicates that growth would make it more difficult to achieve Good status but in practice this would have little impact on consenting policy because required treatment would either be below Best Available Technology limits or require similar consents to achieve Good status before and after growth.

Consented flow would be exceeded at Southery Mill Drove and Middleton WwTWs that discharge into IDB drains. Any change in the consent at these works would need permission from the Internal Drainage Board which could, therefore, present a potential constraint on growth.