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CONTENTS

1 Introduction

Atkins were commissioned to carry out a Development Impact Assessment on behalf of Scottish Water (SW) and the Ayrshire Joint Structure Plan and Transportation Committee (AJSPTC). This study was commenced in June 2005, with a target completion of the end of September 2005. The Development Impact Assessment was required to be carried out upon the Meadowhead and Stevenston drainage catchments.

The aims of the overall study are as follows:

- To quantify the hydraulic impact that the extensive housing developments planned for the catchments would have on the individual drainage systems.

- To develop a strategic improvement strategy in order to maintain the existing sewer system performance following connection of proposed development. This needs to be undertaken to scope the extent of works required (which may be undertaken as part of wider strategic solutions by Scottish Water) to mitigate any impact on the performance of the sewerage system directly attributable to future development.

This interim report provides details of the process that has been undertaken to produce hydraulic models that are representative of the future system and also describes, in detail, the hydraulic analysis that has been undertaken on the sewer systems and ancillaries within the Meadowhead and Stevenston catchments. An initial overview of potential strategic solutions is also presented prior to the Optioneering phase of this study. It is anticipated that the optioneering phase and reporting will be undertaken during September 2005.

1.1 Catchment Description

The Meadowhead catchment is situated approximately 35 km south west of Glasgow and comprises of a number of towns and outlying villages. The larger towns in the catchment are Annick Water, Ayr, Barassie, Irvine, Kilmarnock, Prestwick, and Troon. Also contained within the catchment are the small towns and villages of Crosshouse/ Knockentiber, Dundonald, Springside, Dreghorn, Darvel, Newmilns, Hurlford, Galston, Mossblown, Tarbolton, Monkton, Symington, Drybridge and Gatehead.

The Stevenston catchment is situated to the north west of Irvine. The catchment is comprised of the residential areas of Beith, Kilbirnie, Dalry, Kilwinning, Stevenston, West Kilbride, Ardrossan and Saltcoats.

The Meadowhead and Stevenston sewerage systems are comprised of a mixture of combined sewerage in the older areas of the catchments, with separate and partially separate sewerage in the newer areas. Many of the older residential areas in close proximity to the coast are entirely combined as historically all foul and surface waters would be discharged direct to sea.

The Meadowhead catchment drains a population of approximately 210,000 people, with all foul and combined flows discharged to the Meadowhead WWTW. It covers an area of 7,400 ha. The residential areas along the River Irvine from the east (from Darvel, through Kilmarnock and down to Dundonald) are drained directly to the WWTW by gravity, via the Irvine Valley Trunk Sewer (IVTS). Historically, the IVTS is under capacity, with numerous CSOs discharging to the River Irvine under storm conditions. Downstream of Kilmarnock, on the IVTS, is the Gatehead Tank and CSO, which discharges a significant amount of combined sewage to the River Irvine and is a known problem by SEPA and SW.

The towns of Troon, Prestwick, Irvine and Ayr all discharge to Meadowhead WWTW via terminal pumping stations. Generally, there are also CSOs which are known to discharge significant amounts of combined sewage at each of these terminal pumping stations. At Meadowhead WWTW there is a CSO located between the primary treatment and secondary (PFI) treatment plants.

The Stevenston catchment drains a population of approximately 80,000 people, with all foul and combined flows discharged to the Stevenston WWTW. The areal extent of the Stevenston catchment is less than Meadowhead, encompassing approximately 1,600 ha. Flows in this drainage area are conveyed via a combination of gravity and pumped systems. The main trunk sewer in the catchment is the Garnock Valley Trunk Sewer (GVTS).

The CSO discharges within the Meadowhead and Stevenston catchments are perceived by SW and SEPA as being the main drivers for capital investment. There are a total of 126 CSOs believed to exist within the Meadowhead catchment and 41 CSOs within the Stevenston catchment. Many of these generally discharge to local water courses or the River Irvine, but the perceived main impact is the effect on bathing beach and coastal water quality along the Ayrshire coast. There are instances of flooding within the Meadowhead and Stevenston catchment, though flooding is not perceived by SW to be a major investment driver.

2 Methodology

The methodology undertaken for this study was agreed at project start up. Between 2002 and 2004 SW undertook a series of investment planning studies to assess the impact of CSO discharges in the Meadowhead and Stevenston catchments on the water quality of the bathing beaches along the Ayrshire coast. As part of these studies individual hydraulic models of the various contributing catchments were joined to form single macro models of the Meadowhead and Stevenston drainage areas. The individual catchment hydraulic models were generally constructed as part of SW Drainage Area Plan process and were constructed based on SW DAP Specifications and other industry standards and guidelines. These models have been used for the purposes of the AJSP development impact assessment.

The tasks completed up to this point can be broadly summarised as follows:

1. Data capture – Collection of relevant housing development data
2. Hydraulic model selection – Existing system
3. Hydraulic model update – Future system
4. Hydraulic performance/flooding analysis
5. CSO/Overflow analysis – Time Series Rainfall (TSR) analysis
6. CSO/Overflow analysis – Formula A analysis
7. Summary – Notional strategic options

A more detailed discussion of each one of these steps is provided in the following sections of this report.

An interim meeting with SW and the AJSPT was held at the end of July to discuss the modelling process and model predictions following the initial analysis. Initial thoughts as to the scope of potential strategic solutions were also discussed.

2.1 Work Process and Results

This section of the report provides details of the modelling process and also contains the results of the various model analyses undertaken up to the interim meeting at the end of July.

2.1.1 Data capture

The AJSPTC provided development data for the Ayrshire region. This data was categorised as “effective” and “non effective” development. “Effective” development was defined as committed residential sites that were likely to occur prior to the year 2011. “Non effective” housing development was defined as development which would proceed beyond the year 2011.

The single source of data that represented the effective development was provided in the form of the Housing Land Supply Audit 2004-2011. This data was useful for two main purposes; firstly to ensure that the existing system hydraulic models were up to date with recent developments and secondly to update the hydraulic models with future development data so that they were representative of future system conditions. Three sources of non effective developments were provided and these originated from NAC Urban Capacity Study (North Ayrshire Council), EAC Urban Capacity Study (East Ayrshire Council) and SAC Urban Capacity Study (South Ayrshire Council).

Finally, two other sources of development data were provided, namely Greenfield housing development sites and details relating to two proposed development areas to the east of Kilmarnock.

Scottish Water also provided an approved design for an off-line foul attenuation tank, which is to be constructed in the Moorfield area of Kilmarnock. The tank is required to alleviate the overloaded IVTS and to deal with the additional flows that will be introduced from the nearby Moorfield development, such that this development does not increase existing spill volume and frequency at the Gatehead Tank. The attenuation tank will provide approximately 1,030m³ of storage. No other significant committed capital schemes were identified by SW for inclusion within the future system model.

2.1.2 Hydraulic model selection – Existing system

To allow the Meadowhead and Stevenston sewer system performance to be benchmarked it was necessary to carry out analysis on the existing sewer system performance. Therefore hydraulic models were required that were representative of the existing system networks.

The most recent study completed for the Meadowhead catchment was the Meadowhead Q&SIII UID Investment Review. This work was undertaken on behalf of Scottish Water, and used hydraulic models to identify likely capital investment required to ensure Scottish Water's assets complied with various legislative drivers. The hydraulic model utilised for this study had been updated with recent developments up to the year 2004. Therefore, it was considered that this hydraulic model would be representative of the Meadowhead existing system and would therefore be fit for the purpose of the study.

The model used for the earlier Meadowhead Q&SIII UID Investment Review was obtained from the 'Meadowhead Bathing Beach Study' which was completed in 2004 for SW by Atkins. As part of this study, the most up to date DAP models were combined to form a macro model representing the sewerage system draining to Meadowhead WWTW.

Two models had been presented as part of this earlier study for Meadowhead and these included a summer model and a winter model, with the winter model containing elevated infiltration levels. It was considered prudent to utilise the winter model for design storm scenarios as it was perceived that this would produce the worst case performance in terms of CSO spill volumes and flood volumes.

The current available version of the Stevenston macro model was issued by BiWater in January 2004, following the production of a number of interim macro models. This January 2004 version has been used to generate the sewer hydraulic outputs used in the now completed Ayrshire Coast Bathing Beach Study and subsequently this AJSTPC Development Impact Assessment.

Subsequently, the Stevenston macro model was audited in summer 2004, and a number of issues identified that required model changes or expressed model limitations. It is understood that a number of changes prescribed by the audit report have been implemented by BiWater to the Stevenston macro model. However, the most up to date Stevenston macro model has not been used for this study, as it has yet to be reissued by BiWater.

The key features of the Meadowhead and Stevenston models are summarised as follows:

Meadowhead:

- Catchment Area: 7,400ha
- Population: 209,000
- Modelled overflows: 124
- Terminal pumping stations: 5

Stevenston:

- Catchment Area: 1,592ha
- Population: 80,357
- Modelled overflows: 41
- Terminal pumping stations: 4

Tables 1 and 2 summarise the various DAP models used to construct the macro models. These figures have been extracted from the "Ayrshire Coast Sewer Model – Macro Model User Manual" (report ref 5003462/63/DG/39) submitted to SW in November 2004.

Model Name	Catchment Area Names	Model Status	No of Modelled Nodes	Modelled Population	Source
Annick Water	Annick Water	Verified as DAP Phase 2	1,695	17,719	Hyder
Ayr	Ayr	Verified as DAP Phase 2	5,291	50,399	Atkins
Dundonald	Dundonald, Drybridge	Verified as DAP Phase 2	285	2,359	Ewans
Irvine	Irvine Town, Waterside Septic Tank	Verified as DAP phase 2	851	22,748	Hyder
Kilmarnock and Upper Irvine	Darvel, Newmilns, Galston, Hurlford & Crookedholm, Fenwick, Kilmarnock, Gatehead, Kilmaurs, Crosshouse / Knockentiber	Verified as DAP Phase 2	5,250	62,121	Atkins
Lower Irvine	Irvine Valley Trunk Sewer	Verified as DAP Phase 2	1,309	6,716	Atkins
Prestwick	Prestwick, Symington, St. Quivox, Auchincruvie, Mossblown, Tarbolton, Monkton	Verified as DAP Phase 2	2,155	25,110	Atkins
Springside & Part of Dreghorn	Springside, Dreghorn	Verified as DAP Phase 2	175	2,830	Ewans
Troon	Troon, Barassie	Calibrated model / Catchment upstream of Marrs CSO verified	949	18,424	Ewans

Table 1 – Meadowhead Individual Catchment Models

It is important to note that as part of this User Manual, extracts from the DAP reports are presented to highlight model limitations and verification issues within the individual DAP models. The model limitations are too numerous to list here, though it is recommended that future users of the model or potential scheme designers consult this User Manual so as to be familiar with any limitations and how these influence the degree of confidence in model predictions.

The Ayrshire Coast Sewer Model - Macro Model User Manual also highlights that the macro model has never been verified as a single model. The individual DAP models were verified, but no subsequent verification has been undertaken for parts of the system where interactions between individual DAP models occurs, especially the IVTS, GVTS and Meadowhead and Stevenston WWTW. This should be considered a significant issue, which results in a lower level of confidence in the model predictions in areas of the system which interact and have not been verified against flow survey data.

Model Name	Catchment Area Names	Model Status	No of Nodes in Models	Modelled Population	Source
Beith	Beith	Verified as DAP Phase 2 Model	330	6,923	BiWater
Kilbirnie	Kilbirnie	Verified as DAP Phase 2 Model	330	8,970	BiWater
Dalry	Dalry	Verified as DAP Phase 2 Model	356	6,259	BiWater
Kilwinning	Kilwinning	Verified as DAP Phase 2 Model	867	16,459	BiWater
Stevenston	Stevenston	Verified as DAP Phase 2 Model	640	11,988	BiWater
West Kilbride	West Kilbride	Verified as DAP Phase 2 Model	508	5,147	BiWater
Ardrossan	Ardrossan	Verified as DAP Phase 2 Model	299	8,970	BiWater
Saltcoats	Saltcoats	Verified as DAP Phase 2 Model	904	15,200	BiWater

Table 2 – Stevenston Individual Catchment Models

2.1.3 Hydraulic model update – Future system

The existing system Stevenston and Meadowhead hydraulic models were used as a basis for the future system hydraulic models. The primary model amendments that were made to form the future system models was the addition of the housing development data that was collected in the data capture process.

Due to the large geographical extent of the housing development data it was necessary to select the development sites that would be likely to connect into the Meadowhead and Stevenston sewer systems, as it was obvious that there were a number of developments that would fall outside of these catchment boundaries. Such development may drain to other towns or villages not connected to the Meadowhead or Stevenston WWTW, or may be constructed with their own small scale sewage treatment works or septic tanks. Therefore, it was assumed that all developments that were within a 2km distance of the existing drainage catchment boundary would connect into the sewer system.

Development data was applied to the hydraulic models by drawing a region around the development site within the modelling software and then allocating it to a modelled manhole. These regions are referred to as subcatchments. Each subcatchment was allocated a unique subcatchment reference following a naming convention of RES_DEV[sequential number] for the Meadowhead model and fut_res_[identifier] for the Stevenston model. This naming convention ensured that an auditable trail was formed so that all additional populations could be easily identifiable from the existing population within the hydraulic model.

It is highlighted that discussions were not held with individual developers regarding the details of each site, because very few of the identified sites have details developed as yet. As a result, no information was available with regards to the connectivity of the planned developments to the existing sewerage system. Ttherefore this had to be assumed based upon the proximity of the development site to the sewer system and the size of development. For example, the larger housing developments were assumed to connect further down the sewer system to avoid an early onset of flooding that would be introduced by connecting such large flows to a small diameter sewer at the head of a system. Furthermore, a large development may be required to drain in a number of different directions due to topography or downstream sewer capacity but it was not possible to consider this in any detail as part of this study.

The housing capacity of each development site was included in each of the six sets of housing development data provided for this study. This capacity data was subsequently multiplied by a residency ratio to calculate a population for each subcatchment.

Available housing capacity was determined based on information provided by the AJSPT, and whether development was "effective" or "non-effective". At the instruction of the AJSPT, 100% of the housing capacity for the effective development was applied to the model with a high residency ratio of 2.3. 50% of the housing capacity for the non effective development was applied to the model, with a lower residency ratio of 1.925. The modelling parameters for the various housing developments are summarised in Table 3.

Source of development data	Capacity modelled	Residency ratio
Housing Land Supply 2004 - 2011	100%	2.3
NAC Urban capacity study	50%	1.925
EAC Urban capacity study	50%	1.925
SAC Urban capacity study	50%	1.925
Greenfield development	100%	1.925
Kilmarnock East developments	100%	1.925

Table 3: Population calculation parameters

To allow a foul flow to be generated from the modelled populations a consumption figure of 165l/head/per day was applied to the models. Time varying profiles were then created to allow this flow to be applied in different concentrations throughout the day. This time varying profile is referred to as a diurnal profile. Due to the very large number of individual diurnal profiles within the Meadowhead catchment, the diurnal profile to be applied to the future development for the Meadowhead catchment was created by compiling the various existing diurnal profiles that had been utilised for the modelled catchment. This was undertaken by calculating average flow multiplying factors to create a typical profile. This new diurnal profile is shown in Figure 1.

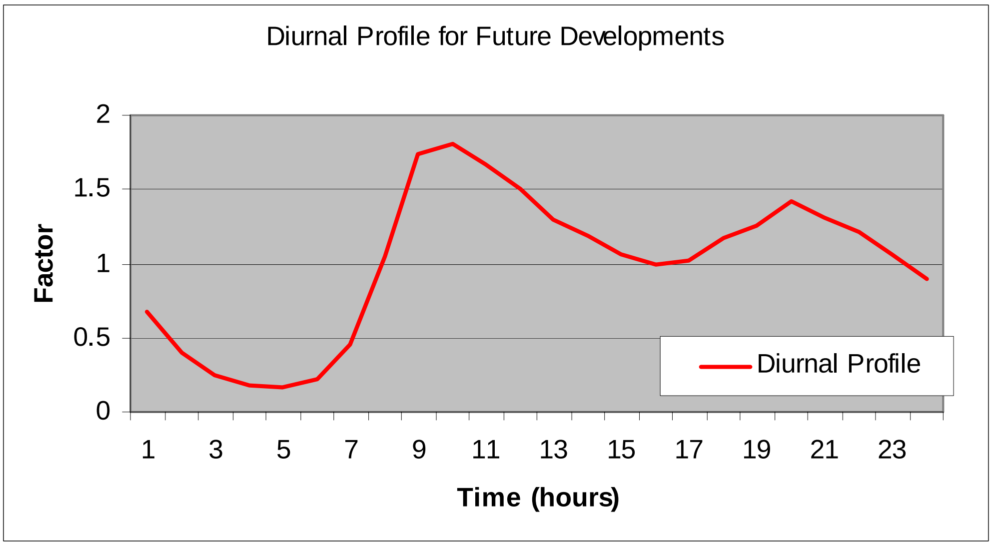


Figure 1: Diurnal Profile for the Meadowhead Catchment Applied to Future Development

The diurnal profile for future development in the Stevenston catchment was applied by assigning the existing diurnal profile from the local catchment. Modelling of the Stevenston catchment is more simplistic in comparison with the Meadowhead model, in that one diurnal profile has applied globally across each of the eight township catchments. Hence the profile for future development used the same profile as is used to model existing foul flow for all development within the Stevenston catchment boundary.

Following the Scottish Water project brief, it was specified that an allowance should be made for infiltration into the sewer system. Infiltration is defined as the seepage of ground water into the sewer system via pipe joints and pipe defects. The infiltration flow was allowed for by applying 40% of the population based flow as a constant baseflow. This baseflow was applied to all future development subcatchments.

A summary of the additional flows applied to the Stevenston and Meadowhead future system models is given as follows.

Meadowhead:

Future population	258,094 (increase of 48,940)
Additional population average flow	93.5l/s
Additional infiltration flow	37.3l/s

Stevenston;

Future population	100,364 (increase of 20,007)
Additional population average flow	38.2l/s
Additional infiltration flow	15.2/s

The final change that was made to the Meadowhead model was the addition of the off line storage tank to the Irvine Valley Trunk Sewer in the vicinity of Moorfield, Kilmarnock. The tank consists of a 204m long precast concrete box culvert, 4.2m wide by 1.2m high. Flows spill into the tank via a high level overflow and are then returned to the trunk sewer as the levels subside following rainfall. No other future committed capital schemes were identified by SW for inclusion into the model.

It is highlighted that in 2003 as part of the Ayrshire Coast Sewer Model Study, the individual DAP models were updated with recent improvement schemes undertaken by SW, so most recent changes to the sewer system are included within the model.

No changes in configuration of operating regime were known at either the Stevenston or Meadowhead WWTW. As a result, no further changes were required to be made to the model in these areas.

2.1.4 Hydraulic performance/flooding analysis

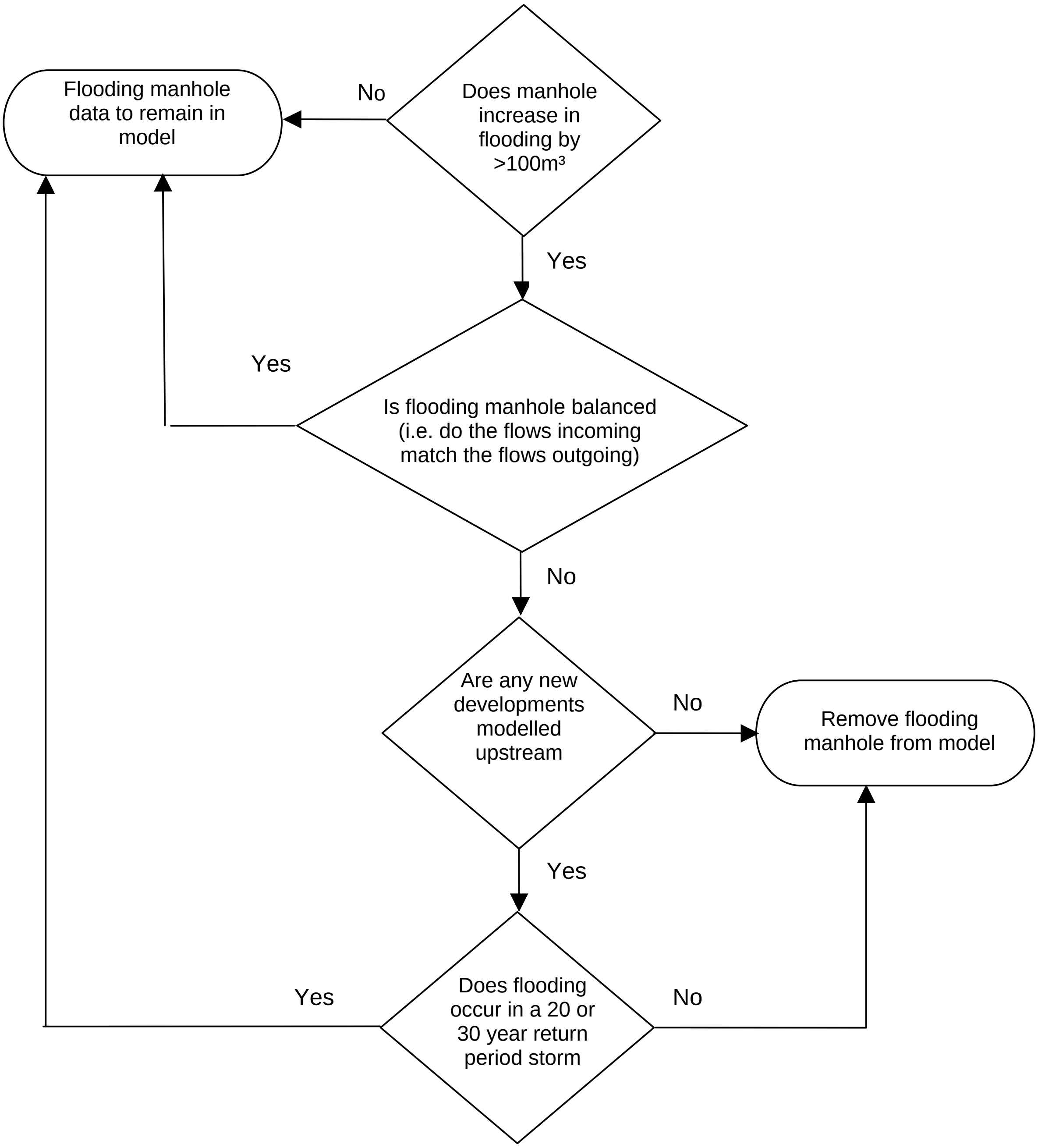
The existing system and future system hydraulic models for both Meadowhead and Stevenston were simulated with a number of design storms, which included 1, 2, 5, 10, 20 and 30 year return periods for durations of 30, 60, 120, 180 and 360 minutes. For strategic purposes it was agreed with Scottish Water that the flooding analysis would initially only be carried out for a 10 year return period to identify key changes in the thresholds of flooding.

The model predicted changes in flooding throughout the catchment, with some of the changes in flood volume appearing extremely large (in the order of 1,000m3). On review of the model simulation results further, it became evident that both the existing and future system hydraulic models for Stevenston and Meadowhead became unstable in parts under certain design storm conditions. The nature and location of these instabilities is unpredictable, and attempts were made to change the model around the location of instabilities and repeat the simulations. However, in each case, the instabilities re-appeared in a different location. As a result, it was not possible to remove all instabilities in terms of model flooding.

An example of these instabilities was where new flooding manholes were predicted in the future system model for the 10 year return period event that were not predicted in the existing system model for the same storm, even though no additional flows had been added upstream. These flooding manholes were confirmed as erroneous by reviewing the results from the larger 20 year return period model simulations where it was found that no flooding was predicted (due to the instabilities not occurring). Unfortunately these model instabilities are a result of a combination of modelling software limitations and the complexity of the macro models. The macro models have been constructing utilising numerous models from numerous sources, and whilst attempts were made to standardise the models, conflicts in some parameters may cause instabilities. Furthermore, the instabilities may exist simply because of issues in the base SW DAP model.

It is also highlighted that the macro model, and many of the DAP models, have been constructed to investigate CSO performance, rather than flooding. Similarly, the performance of the individual DAP models has generally been verified against relatively low return period storm events. As a result, the model performance and reliability is generally better for the low return period storms (i.e. representative of events that trigger CSO spills) than the more extreme high return period events (that generally cause flooding).

In an effort to utilise the results from the model simulations for flooding, a filtering process was undertaken to remove some of the erroneous flood volumes, caused by instabilities, from the model prediction data set. This was carried out using a procedure that is summarised in the following flow chart:



With the major model instabilities removed the results of the flooding analysis were re-assessed and these are summarised in Table 4 for Meadowhead and Table 5 for Stevenston. The data presented is in terms of total flood volume within the local area specified.

Plan No.	Catchment	Existing Flood Volume (m³)	Future Flood Volume (m³)	Flood Volume increase (m³)
Plan 1M (Area 13)	South Ayr	3821	4623	802
Plan 1L (Area 12)	North Ayr	3333	3808	475
Plan 1K (Area 11)	Tarbolton, Mossblown, Auchincruive	6716	7160	444
Plan 1C (Area 3)	Kilmarnock	9536	9914	378
Plan 1G (Area 7)	Irvine, Annick Water	5789	6050	261
Plan 1A (Area 1)	Newmilns/Darvel	2303	2497	194
Plan 1I (Area 9)	Symington	1184	1267	83
Plan 1J (Area 10)	Monkton, Prestwick	5709	5788	79
Plan 1D (Area 4)	Fenwick	374	448	74
Plan 1B (Area 2)	Hurlford, Galston	4423	4479	59
Plan 1H (Area 8)	Troon	242	281	39
Plan 1E (Area 5)	Kilmaurs, Crosshouse, Gatehead	1256	1279	23
Plan 1F (Area 6)	Springside, Dreghorn, Drybridge, Dundonald	291	300	9

Table 4: Meadowhead flood analysis Results (10 year return period)

The flooding manholes where flooding is predicted to increase under future system conditions are shown on Plan 1A to Plan 1M, as indicated in Table 4. With the flood volume increase ranked in order of size, it can be seen that the greatest increase in flood volumes were predicted in north and south Ayr. This equates to an increase in flood volume of between 14% and 21% for these two areas. There is no obvious pattern to the increase in flooding across Ayr, other than it is quite a generalised phenomenon, occurring wherever development is proposed, indicating the existing system is currently close to the threshold for flooding. Fenwick and Troon are also predicted to increase in total flood volume by between 16% and 20%. In contrast, flooding is predicted to only increase by less than 10% in the other Meadowhead areas.

Plan No.	Catchment	Existing Flood Volume (m³)	Future Flood Volume (m³)	Flood Volume increase (m³)
Plan 2F (Area 6)	Kilbirnie, Beith	2832	3668	836
Plan 2B (Area 2)	Ardrossan, Saltcoats	801	1330	529
Plan 2A (Area 1)	West Kilbride	413	723	310
Plan 2C (Area 3)	Kilwinning	351	501	150
Plan 2E (Area 5)	Dalry	961	1046	85
Plan 2D (Area 4)	Stevenston	1793	1849	56

Table 5: Stevenston flood analysis Results (10 year return period)

The manholes where flooding was predicted to increase under future system conditions within the Stevenston catchment are shown on Plan 2A to Plan 2F as indicated by Table 3. The largest increase in flood volumes were predicted to occur in Kilbirnie and Beith. There is an increase in flooding of 22% in this instance with the majority of the flooding occurring in Beith.

Incidentally there is also a concentration of future population areas applied to this area of the model with a combined additional total population of 435. The main carrier sewer is 375mm in size and it is likely that this part of the sewer system is reaching capacity resulting in the additional flooding being predicted.

The Stevenston model audit report indicated that there were uncertainties with the way that the manhole flood types and flood cones have been modelled across the catchment. It is unclear from the response to the audit report, whether this issue has been addressed. As a result, less confidence can be placed in predicted flood volumes for the Stevenston catchment.

The same approach to remove predicted flooding due to instabilities used within the Meadowhead model was undertaken within the Stevenston model.

It must be highlighted that the results of the flood analysis should be treated with some degree of caution due to the model instabilities that were identified within each of the models. This issue was discussed at the interim meeting at the end of July and it was highlighted that the model appears to be unstable in terms of flooding and that flooding is perceived to not be a major deficiency driver by SW within the catchments. As a result, it was agreed that less importance would be given to the impact on flooding in shaping the extent of any strategic solutions.

It was highlighted that the strategic solutions would be better developed based on the impacts at the known key deficiencies within the catchment (such as the CSOs). Furthermore, as shown on the various plans, many of the flooding impacts are located relatively high up the catchment and local or medium scale solutions would be more appropriate, rather than the strategic solutions that are the focus of this study. It is likely that any downstream strategic solutions developed based on the key CSO deficiencies, especially along trunk sewers, would help alleviate the impact of some of the more upstream flooding impacts due to the provision of increased capacity downstream.

Whilst this approach to strategic optioneering is acceptable for this initial high level study, it is strongly recommended that should any large scale strategic solution be developed in the future then consideration be given to also providing capacity within the solution for any additional flows from these upstream flooding locations, should these also be addressed in the future. If this is not considered, the strategic solution may be under designed should a number of localised upstream flooding schemes be undertaken that have not been considered at this stage. This additional analysis would be best undertaken at a more advanced design stage when the scope of the strategic solution has been confirmed, rather than at this high level planning stage.

2.1.5 CSO/Overflow analysis – TSR Analysis

2.1.5.1 Modelling of CSO Spill Frequency and Volume

2.1.5.1.1 Time Series Rainfall Analysis

The Meadowhead catchment contains a total of 124 modelled overflows (with two known overflows not modelled) and Stevenston a total of 41 modelled overflows. Two separate approaches were taken to assess the impact that the developments would have on the performance of the overflows. Firstly, the model was simulated with a year of stochastically generated synthetic rainfall data (calibrated against historical daily total data from Prestwick), which is referred to as time series rainfall (TSR). Using this data the overflow annual spill frequency and total annual spill volume at each CSO within the study area was determined. Furthermore, this data was analysed to produce the bathing season spill frequency and volume. Bathing seasons are identified as June to September inclusive.

The TSR approach is an industry standard methodology for assessing the relative deficiency status of a CSO. It differs from the flooding analysis in that it is based on rainfall of a much lower return period (i.e. generally less than 1 year in this case), as most CSOs would be expected to spill significantly during the large return periods utilised for the flooding analysis.

SEPA regularly identify deficient CSOs based on a combination of the frequency which they spill and the volume that they spill, as this governs the frequency and severity of polluting incidents to the watercourse. The bathing season statistics are frequently used in addition to the annual statistics for sewerage systems located close to the coast due to the impact of sewage discharges on bathing beaches at the time of most frequent visits and activities by people.

It was agreed with SW that the TSR assessment would be based on a typical single year of stochastically generated rainfall. This rainfall data had previously been generated as part of the Prestwick DAP study and it was considered acceptable to apply this data across the whole of the Meadowhead and Stevenston catchments for this high level review.

2.1.5.1.2 Formula A Analysis

The second approach to assess the CSO performance was to calculate the minimum theoretical flow that each overflow should be passing forward at the time that spill occurs. This theoretical flow is referred to within the water industry as the Formula A value and is simply calculated based upon the population, infiltration and trade flow contributions upstream of the overflow. The Formula A is often equivalent to approximately 6 x DWF, and it is considered good practice for a CSO to pass this flow at the time of discharging to a water course. SEPA frequently use the performance of the CSO against Formula A as a means of identifying deficient CSOs.

Obviously, by increasing the population upstream of a CSO through development, the amount of flow required to be passed forward during a spill (Formula A) also increases, due to its relationship with the upstream population. It is possible that a number of existing CSOs are currently at the borderline of satisfactorily passing the required Formula A, yet an increase in population upstream through future development would act to cause the CSO to not pass future Formula A, and thus be considered deficient.

The Formula A values have been calculated for the Meadowhead and Stevenston existing system and future system hydraulic models.

2.1.5.2 Implications of Rainfall Data Used

The Ayrshire Coast Sewer Model - Macro Model User Manual goes into significant detail relating to the application of appropriate TSR data across such large catchments as Meadowhead and Stevenston. In this case, a single profile stochastically generated synthetic series (calibrated against historical daily data) was utilised due to the lack of adequate detailed historic data for direct input into the model. Ideally, for catchments this size true historic data covering a number of years (more than 20) should be utilised. Furthermore, the historic data should be obtained from a number of sites across the catchment to account for any spatial variability in rainfall. By applying a single typical year as a single profile (as is the case in this study), model limitations are introduced by the fact that a typical year is not truly representative of a long series of rainfall and that there is no consideration of spatial variability in the rainfall. For example, it would not rain across the whole catchment at the same time in reality as is represented in this model. In reality, spatial variability in rainfall acts to cause rainfall, and thus CSO operation, to occur at different times across different parts of the catchment.

As a result, the approach used in this study is limited, but that is due to two main issues. Firstly, earlier studies have identified that there is not an adequate series of detailed rainfall data from an adequate number of sites in either catchment. SEPA started collecting 15 minute data from nine sites within Meadowhead in 2000, but this still only results in a four year series. Secondly, due to the tight timescales required to undertake this study, it would not be possible to simulate the model with four years of data (or 20 years). It took two full weeks of simulation time to undertake the existing system simulation for a single year, thus simulating the four year series on the existing, future and strategic options systems within the required timescale was considered impractical.

2.1.5.3 Results of CSO Assessment

The spill frequency and spill volume analysis carried out on the overflows within the Meadowhead catchment are summarised in Table 6 and Table 7, and those for the Stevenston catchment are presented in Tables 8 and 9. Tables 6 and 8 display the annual performance and Tables 7 and 9 display the bathing season performance.

The TSR analysis carried out on the overflows within the Meadowhead catchment predicted that the total annual spill frequency of the all the overflows combined would increase from 4,323 times per year to 4,656 times per year, equating to an increase of 8%. As a consequence, the total annual spill volume for all CSOs is predicted to increase from 8,662,061m³ to 9,936,758m³, equating to an increase of 15%. Table 7 summarises the performance of the overflows for the bathing season period. The total overflow spill frequency for this period increased from 1,396 times to 1,530 times, equating to an increase of 10%. The spill volumes for this period are predicted to also increase from 2,749,468m³ to 3,035,798m³.

A total of 54 CSOs within the Meadowhead catchment are predicted to increase in total annual spill volume by 25m3 or more, and 47 predicted to increase in predicted bathing season volume by 25m3 or more.

The spill volume increase of the individual overflows is displayed on Plan 3. It can be seen from Plan 3 that the largest increases in overflow spill volumes are focussed to the overflows in the following locations:

- Irvine Valley Trunk Sewer (Upper Towns)
- Irvine Valley Trunk Sewer (Kilmarnock)
- Irvine Valley Trunk Sewer & Gatehead Tank (Lower Irvine Reach)
- Trunk sewers in Irvine Town and Terminal PS
- Terminal PS at Prestwick & Ayr
- Meadowhead WWTW

It is not surprising that the CSOs that appear to be affected the most by the proposed development are those located in downstream locations, such as along the IVTS and at terminal pumping stations. This is clearly shown on Plan 3 where there is a large number of CSOs predicted to increase in spill volume by more than 25m3 along the IVTS from Darvel to Meadowhead WWTW.

Four CSOs are predicted to increase in annual spill volume by greater than 100,000m3, and these are the Scott Ellis Tanks at Kilmarnock, the Gatehead Tank on the IVS, the Meadowhead WWTW CSO and the Ayr PS CSO. These results are not surprising as previous studies have suggested these are the largest spilling CSOs within the catchment, and SEPA have historically perceived each discharge location as being problematic.

Of the other key CSOs predicted to increase in annual spill volume by more than 5,000m3, four are located within Irvine Town (14 West Road CSO, Goldfields CSO, Williamfield CSO and River Weir Overflow), four are on or in close proximity to the IVS (11 Furnace Court CSO, IVS South of Nethercraig CSO, Holmes Road CSO, and former Darvel STW CSO), one is located within Prestwick and one in Ayr.

id	CSO Name / Location	Existing Annual spill volume (m³)	Existing Annual spill frequency	Future Annual spill volume (m³)	Future Annual spill frequency	Spill Volume increase (m³)
1	109 London Road, Kilmarnock	3,469	90	3,467	90	-2
2	14 Walnut Road, Kilmarnock	0	0	0	0	0
3	2 Burns Avenue, Kilmarnock	8,047	20	8,165	20	118
4	2 Maxholm Road, Kilmarnock	26,456	49	27,189	49	733
5	22 Douglas Street, Kilmarnock	24,569	28	24,498	29	-71
6	22 Holehouse Road, Kilmarnock	518	2	519	3	1
7	25 - 27 Loreny Drive, Kilmarnock	5,797	8	5,778	8	-19
8	32 Old Street, Kilmarnock	26,000	61	26,037	61	37
9	36 New Mill Road, Kilmarnock	1,133	11	1,116	11	-17
10	41 MacDonald Drive, Kilmarnock	0	0	0	0	0
11	46 Bruce Street, Kilmarnock	2,570	30	2,568	29	-2
12	51 Main Road (behind), Crookedholm, Hurlford	8,540	46	9,634	46	1,094
13	54 Bruce Street, Kilmarnock	3,065	64	3,064	64	-1
14	80 Carron Avenue, Kilmarnock	105,155	92	107,446	95	2,291
15	86 Carron Avenue, Kilmarnock	0	0	0	0	0
16	Ayrshire Metals, Cochrane St @ Victoria Roundabout	2,147	14	2,195	14	48
17	Barassie P.S., 72 Beach Road, Troon	2,865	4	3,156	5	291
18	Beach Drive NW corner of Magnum Centre, Irvine	0	0	0	0	0
19	Beach Road, Beach Park P.S., Irvine No1	6,639	25	6,642	25	3
20	Cross Keys, 142 Harbour Street, Irvine	0	0	0	0	0
21	Dean Park Pavilion, Kilmarnock	21,199	30	20,378	30	-821
22	Elvinside Farm, Galston Road, Hurlford	50,622	55	53,253	54	2,631
23	Galston Road, Hurlford Bridge, Hurlford	26,875	24	26,854	24	-21
24	Gatehead Storm Tanks, near A759	1,083,905	98	1,259,323	94	175,418
25	Gillsburn Gardens, Kilmarnock	0	0	0	0	0
26	Gottries Road Overflow, 3F Gottries Crescent, Irvine	0	0	0	0	0
27	Grassyards Road, 20 Kay Park Terrace, Kilmarnock	340	2	345	2	5
28	Green Street, Kilmarnock	3,282	29	3,349	29	67
29	Harbour Pumping Station, 1 Titchfield Cottage, Harbour Road, Troon	0	0	0	0	0
30	Holmes Road, Western Intercepting Sewer Holmes Road, Kilmarnock	239,926	80	248,483	84	8,557
31	Howard Park, Kilmarnock	53,078	67	53,154	68	76
32	Irvine 19, Williamsfields, (Sports Club); next to 64 Harbour Street, Irvine	0	0	0	0	0
33	Irvine River Weir Overflow, behind 4 Williamfield Grove	58,017	125	75,262	176	17,245
34	Kirkstyle School; near 33 Carron Avenue, Kilmarnock	834	2	835	2	1
35	Loans/Muirhead/Barassie 2, Barassie PS, Near 72 Beach Road, Barassie	0	0	0	0	0
36	Loreny P.S., 4 Umberly Road, Kilmarnock	16	1	16	1	0
37	Magnum Car Park (Side of Magnum), Irvine	0	0	0	0	0
38	Marr Screening Chamber, Troon	30,671	112	30,947	114	276
39	Meadowhead Treatment Works - Inlet Works Emergency Screen Chamber	0	0	0	0	0
40	Meadowhead Treatment Works, Irvine	677,992	93	839,313	111	161,321
41	No.11 Furnace Court (behind); Hurlford	508,873	193	604,995	202	96,122
42	No.6 Cheapside Street (behind); Kilmarnock	78,481	69	81,670	70	3,189
43	Pan Rocks Emergency Overflow, North Shore Road @ Barassie Street, Troon (140m beyond MLWM)	137,174	69	136,876	69	-298
44	Rear 75 Dean Street, Kilmarnock	9,603	35	8,395	36	-1,208
45	Rowallan Tanks;opp 136 Glasgow Road, behind Rowallen Creamery, Kilmarnock	14,584	65	15,814	65	1,230
46	Scott Ellis Siphon, where A77 crosses River Irvine, South of Linfern Avenue East, Kilmarnock	258	1	299	1	41
47	Scott Ellis Tanks, New Mill Road, South of Samson Avenue, Kilmarnock	217,837	40	627,107	217	409,270
48	Southhook P.S., Southhook Road, Kilmarnock	201	15	203	15	2
49	St Marnock Street @ St Marnock Place; Kilmarnock	861	3	867	3	6
50	West of Greenholm Street at footbridge, Kilmarnock	16,868	12	17,105	12	237
51	Williamfield Storm Overflow	236,099	113	262,802	134	26,703
52	11 Cross Street, Galston	149	7	148	8	-1
53	14 – West Road CSO, Irvine	2,275,724	157	2,375,045	157	99,321
54	2 George Street Overflow, Ayr	1,287	2	1,258	2	-29
55	9 Kilmaurs Road, Crosshouse	1,755	35	1,945	38	190
56	Annick Water, Irvine	5,604	46	5,666	48	62
57	Auchans PS EO	629	12	630	12	1
58	Ayr PS Storm Pumps, Ayr	1,203,143	16	1,358,143	17	155,000
59	Bankhead Avenue CSO	113	2	114	2	1
60	Beldevere View, Galston	136	2	139	2	3
61	Bellisle Golf Course, Ayr	19,197	24	25,391	29	6,194
62	Bourtree Hill PS EO, Annick	0	0	0	0	0
63	Breahead Screens EO	135	2	137	2	2
64	Brieryside PSEO, Prestwick	7,343	57	7,327	51	-16
65	Brown Street, Newmilns	0	0	0	0	0
66	Burns Street Overflow, Tarbolton 7108/485	2,236	25	2,239	25	3
67	Cambusdoon EO, Ayr	0	0	0	0	0
68	Campbell Place PS CSO, Annick	0	0	0	0	0
69	CSO, IVS south of Nethercraig – between Gatehead and Drybridge	125,820	75	163,728	87	37,908
70	Dalmellington Road off Annfield Burn CSO, Ayr	223	2	219	2	-4
71	Esplanade PSEO - 7119/-, Prestwick	65,417	57	66,128	57	711
72	Esplanade PSEO, Prestwick	0	0	0	0	0
73	Former Darvel STW Darvel, Kilmarnock	131,147	118	136,488	118	5,341
74	Former Galston STW (low)	40,932	86	41,895	87	963
75	Fullarton, Irvine	1,533	12	1,558	12	25
76	Garrier Bridge CSO, Springside	15,112	91	15,141	91	29
77	Girdle Toll PS EO, Annick	0	0	0	0	0
78	Goldfields CSO, Irvine	304,204	157	347,320	157	43,116
79	Greenan PS EO, Ayr	3,291	12	3,834	14	543
80	Greenside, Newmilns	1,427	26	1,434	27	7
81	Holmsbridge PS CSO, Springside	0	0	0	0	0

id	CSO Name / Location	Existing Annual spill volume (m³)	Existing Annual spill frequency	Future Annual spill volume (m³)	Future Annual spill frequency	Spill Volume increase (m³)
82	Holmsford Bridge CSO, Springside	2,854	26	2,857	26	3
83	Holmston PS No. 1 CSO, Ayr	0	0	0	0	0
84	Holmston PS No. 2 CSO, Ayr	115	2	118	2	3
85	Holmston Storm Tank, Ayr	16,816	4	16,849	4	33
86	Kilmarnock Road CSO, Springside	3,285	42	3,301	42	16
87	Kilmaurs PS Tank EO	36,613	107	40,447	113	3,834
88	Kilwinning Rd, Irvine	1,630	12	1,666	12	36
89	Kirkton Road, Fenwick	2,791	38	2,973	39	182
90	Lamont Drive, Irvine	3,406	31	3,404	30	-2
91	Larch CSO, Crosshouse / Knockentiber	42	1	35	2	-7
92	Loundon Road West, Newmilns	22,410	73	22,591	75	181
93	Low Green Siphon, Irvine	652	13	725	15	73
94	Mason Holms Syphon, Newmilns	2,330	29	2,343	29	13
95	McIntyre Court PSEO - 7342/-, Prestwick	0	0	0	0	0
96	Morton Park Darvel, Kilmarnock	6,221	29	6,272	30	51
97	Nelson Street syphon	1,016	9	1,023	9	7
98	Newmilns Road Pumping Station; Galston (G6)	0	0	0	0	0
99	Newton EO, Ayr	6,680	2	6,670	2	-10
100	No name, Irvine CSO	0	0	0	0	0
101	Olympic Complex CSO No1, Dundonald	20,958	55	21,252	55	294
102	Olympic Complex CSO No2, Dundonald	6,871	76	7,326	79	455
103	Pan Rock PS, Troon	124,338	84	123,452	83	-886
104	Perceton Village PS CSO, Annick	219	1	226	1	7
105	Polwarth Street, Galston	10,843	44	11,145	47	302
106	Pow Burn Storm Tanks, Prestwick	153,008	63	155,818	66	2,810
107	Pow Burn EO	2,317	4	2,375	4	58
108	Pow Burn CSO	80,639	43	81,406	43	767
109	Puddleford, Irvine	12,138	112	12,439	111	301
110	Queens Crescent, Newmilns	1,737	16	1,746	17	9
111	Red Burn PS (Kilwinning Road), rear of 19 Fairways, Irvine	2	1	2	1	0
112	Shewalton PS CSO, Annick	0	0	0	0	0
113	Sillars Meadow, Irvine	19,003	62	20,135	65	1,132
114	Smithfield Crescent Overflow, Tarbolton	3,316	31	3,335	27	19
115	St Andrews Caravan Park CSO , Prestwick	4,404	4	6,487	5	2,083
116	St Andrews PSEO - 7341/- Prestwick	34,730	26	42,725	30	7,995
117	St Quivox, Prestwick	164	7	164	7	0
118	Strath Yard, Newmilns	39,796	86	40,769	86	973
119	Tarryholme PS EO, Annick	0	0	0	0	0
120	Water of Fail CSO, Tarbolton	31,701	106	31,530	107	-171
121	Waterside Septic Tank, Irvine	107,062	157	107,275	157	213
122	Montgomery Street CSO, Irvine	0	0	0	0	0
123	Thistle PSEO, Irvine	831	27	831	28	0
124	Ayr PS EO, Ayr	0	0	0	0	0

Key

Future system performance worsened
Future system performance remains the same
Future system performance improved

Table 6: Meadowhead Annual TSR Analysis – Comparison of Existing system and Future system Overflow performance

id	CSO Name / Location	Existing Bathing season spill volume (m³)	Existing Bathing season spill frequency	Future Bathing season spill volume (m³)	Future Bathing season spill frequency	Spill Volume increase (m³)
1	109 London Road, Kilmarnock	1,887	34	1,885	34	-2
2	14 Walnut Road, Kilmarnock	0	0	0	0	0
3	2 Burns Avenue, Kilmarnock	6,328	8	6,381	8	53
4	2 Maxholm Road, Kilmarnock	13,430	16	13,692	16	262
5	22 Douglas Street, Kilmarnock	15,375	9	15,070	10	-305
6	22 Holehouse Road, Kilmarnock	518	2	518	2	0
7	25 - 27 Loreny Drive, Kilmarnock	6,122	3	6,072	3	-50
8	32 Old Street, Kilmarnock	17,912	18	17,931	18	19
9	36 New Mill Road, Kilmarnock	1,068	5	1,050	5	-18
10	41 MacDonald Drive, Kilmarnock	0	0	0	0	0
11	46 Bruce Street, Kilmarnock	1,615	12	1,614	11	-1
12	51 Main Road (behind), Crookedholm, Hurlford	4,574	13	5,033	12	459
13	54 Bruce Street, Kilmarnock	1,339	24	1,338	24	-1
14	80 Carron Avenue, Kilmarnock	31,531	26	31,915	28	384
15	86 Carron Avenue, Kilmarnock	0	0	0	0	0
16	Ayrshire Metals, Cochrane St @ Victoria Roundabout	1,534	6	1,557	6	23
17	Barassie P.S., 72 Beach Road, Troon	2,707	3	2,873	3	166
18	Beach Drive NW corner of Magnum Centre, Irvine	0	0	0	0	0
19	Beach Road, Beach Park P.S., Irvine No1	4,475	8	4,475	8	0
20	Cross Keys, 142 Harbour Street, Irvine	0	0	0	0	0
21	Dean Park Pavilion, Kilmarnock	11,527	9	11,030	9	-497
22	Elvinside Farm, Galston Road, Hurlford	15,162	13	15,647	13	485
23	Galston Road, Hurlford Bridge, Hurlford	14,134	8	14,164	8	30
24	Gatehead Storm Tanks, near A759	255,532	22	281,824	22	26292
25	Gillsburn Gardens, Kilmarnock	0	0	0	0	0
26	Gottries Road Overflow, 3F Gottries Crescent, Irvine	0	0	0	0	0
27	Grassyards Road, 20 Kay Park Terrace, Kilmarnock	340	2	345	2	5
28	Green Street, Kilmarnock	1,767	8	1,763	8	-4
29	Harbour Pumping Station, 1 Titchfield Cottage, Harbour Road, Troon	0	0	0	0	0
30	Holmes Road, Western Intercepting Sewer Holmes Road, Kilmarnock	96,817	20	98,642	21	1825
31	Howard Park, Kilmarnock	24,577	18	23,741	17	-836
32	Irvine 19, Williamsfields, (Sports Club); next to 64 Harbour Street, Irvine	0	0	0	0	0
33	Irvine River Weir Overflow, behind 4 Williamfield Grove	16,234	45	24,025	74	7791
34	Kirkstyle School; near 33 Carron Avenue, Kilmarnock	834	2	835	2	1
35	Loans/Muirhead/Barassie 2, Barassie PS, Near 72 Beach Road, Barassie	0	0	0	0	0
36	Loreny P.S., 4 Umberly Road, Kilmarnock	16	1	16	1	0
37	Magnum Car Park (Side of Magnum), Irvine	0	0	0	0	0
38	Marr Screening Chamber, Troon	17,320	36	17,439	36	119
39	Meadowhead Treatment Works - Inlet Works Emergency Screen Chamber	0	0	0	0	0
40	Meadowhead Treatment Works, Irvine	154,212	26	189,766	34	35,554
41	No.11 Furnace Court (behind); Hurlford	108,573	67	134,656	72	26083
42	No.6 Cheapside Street (behind); Kilmarnock	30,795	18	31,104	18	309
43	Pan Rocks Emergency Overflow, North Shore Road @ Barassie Street, Troon (140m beyond MLWM)	62,870	19	62,081	19	-789
44	Rear 75 Dean Street, Kilmarnock	5,333	11	4,160	12	-1173
45	Rowallan Tanks;opp 136 Glasgow Road, behind Rowallen Creamery, Kilmarnock	1,321	18	1,336	18	15
46	Scott Ellis Siphon, where A77 crosses River Irvine, South of Linfern Avenue East, Kilmarnock	258	1	299	1	41
47	Scott Ellis Tanks, New Mill Road, South of Samson Avenue, Kilmarnock	62,659	8	175,182	73	112523
48	Southhook P.S., Southhook Road, Kilmarnock	165	7	165	7	0
49	St Marnock Street @ St Marnock Place; Kilmarnock	858	2	866	2	8
50	West of Greenholm Street at footbridge, Kilmarnock	12,671	5	12,805	5	134
51	Williamfield Storm Overflow	81,099	38	87,556	53	6457
52	11 Cross Street, Galston	134	3	133	3	-1
53	14 – West Road CSO, Irvine	672,921	53	697,226	53	24305
54	2 George Street Overflow, Ayr	1,287	2	1,258	2	-29
55	9 Kilmaurs Road, Crosshouse	1,070	13	1,166	15	96
56	Annick Water, Irvine	3,058	15	3,078	15	20
57	Auchans PS EO	496	6	495	6	-1
58	Ayr PS Storm Pumps, Ayr	458,747	5	477,913	5	19166
59	Bankhead Avenue CSO	113	2	114	2	1
60	Beldevere View, Galston	136	2	139	2	3
61	Bellisle Golf Course, Ayr	12,559	8	15,127	9	2568
62	Bourtree Hill PS EO, Annick	0	0	0	0	0
63	Breahead Screens EO	135	2	137	2	2
64	Brieryside PSEO, Prestwick	1,971	16	2,002	10	31
65	Brown Street, Newmilns	0	0	0	0	0
66	Burns Street Overflow, Tarbolton 7108/485	1,651	10	1,653	10	2
67	Cambusdoon EO, Ayr	0	0	0	0	0
68	Campbell Place PS CSO, Annick	0	0	0	0	0
69	CSO, IVS south of Nethercraig – between Gatehead and Drybridge	22,369	17	30,390	26	8021
70	Dalmellington Road off Annfield Burn CSO, Ayr	223	2	219	2	-4
71	Esplanade PSEO - 7119/-, Prestwick	30,821	16	31,084	16	263
72	Esplanade PSEO, Prestwick	0	0	0	0	0
73	Former Darvel STW Darvel, Kilmarnock	38,176	39	39,137	38	961
74	Former Galston STW (low)	15,621	24	15,806	24	185
75	Fullarton, Irvine	1,321	6	1,336	6	15
76	Garrier Bridge CSO, Springside	5,200	25	5,205	25	5
77	Girdle Toll PS EO, Annick	0	0	0	0	0
78	Goldfields CSO, Irvine	76,666	53	88,738	53	12072

id	CSO Name / Location	Existing Bathing season spill volume (m³)	Existing Bathing season spill frequency	Future Bathing season spill volume (m³)	Future Bathing season spill frequency	Spill Volume increase (m³)
79	Greenan PS EO, Ayr	3,198	6	3,494	7	296
80	Greenside, Newmilns	1,014	10	1,018	11	4
81	Holmsbridge PS CSO, Springside	0	0	0	0	0
82	Holmsford Bridge CSO, Springside	1,874	10	1,877	10	3
83	Holmston PS No. 1 CSO, Ayr	0	0	0	0	0
84	Holmston PS No. 2 CSO, Ayr	115	2	118	2	3
85	Holmston Storm Tank, Ayr	16,028	3	16,052	3	24
86	Kilmarnock Road CSO, Springside	1,899	15	1,905	15	6
87	Kilmaurs PS Tank EO	14,716	35	15,785	37	1069
88	Kilwinning Rd, Irvine	1,427	6	1,447	6	20
89	Kirkton Road, Fenwick	1,959	17	2,118	17	159
90	Lamont Drive, Irvine	2,405	12	2,406	12	1
91	Larch CSO, Crosshouse / Knockentiber	42	1	35	2	-7
92	Loundon Road West, Newmilns	10,416	19	10,466	20	50
93	Low Green Siphon, Irvine	459	7	506	7	47
94	Mason Holms Syphon, Newmilns	1,587	11	1,593	11	6
95	McIntyre Court PSEO - 7342/-, Prestwick	0	0	0	0	0
96	Morton Park Darvel, Kilmarnock	3,812	11	3,851	12	39
97	Nelson Street syphon	946	5	949	5	3
98	Newmilns Road Pumping Station; Galston (G6)	0	0	0	0	0
99	Newton EO, Ayr	6,680	2	6,670	2	-10
100	No name, Irvine CSO	0	0	0	0	0
101	Olympic Complex CSO No1, Dundonald	10,150	16	10,185	16	35
102	Olympic Complex CSO No2, Dundonald	2,043	19	2,169	20	126
103	Pan Rock PS, Troon	59,074	29	57,645	27	-1429
104	Perceton Village PS CSO, Annick	219	1	226	1	7
105	Polwarth Street, Galston	6,140	15	6,237	16	97
106	Pow Burn Storm Tanks, Prestwick	47,753	16	48,173	16	420
107	Pow Burn EO	2,275	3	2,324	3	49
108	Pow Burn CSO	44,737	13	45,011	13	274
109	Puddleford, Irvine	5,483	35	5,711	34	228
110	Queens Crescent, Newmilns	1,309	7	1,311	7	2
111	Red Burn PS (Kilwinning Road), rear of 19 Fairways, Irvine	2	1	2	1	0
112	Shewalton PS CSO, Annick	0	0	0	0	0
113	Sillars Meadow, Irvine	9,424	17	9,741	17	317
114	Smithfield Crescent Overflow, Tarbolton	2,160	12	2,224	10	64
115	St Andrews Caravan Park CSO , Prestwick	12	1	42	1	30
116	St Andrews PSEO - 7341/- Prestwick	4,505	7	5,631	8	1,126
117	St Quivox, Prestwick	152	4	152	4	0
118	Strath Yard, Newmilns	12,260	22	12,525	22	265
119	Tarryholme PS EO, Annick	0	0	0	0	0
120	Water of Fail CSO, Tarbolton	11,695	34	11,612	34	-83
121	Waterside Septic Tank, Irvine	30,801	53	30,848	53	47
122	Montgomery Street CSO, Irvine	0	0	0	0	0
123	Thistle PSEO, Irvine	533	9	532	9	-1
124	Ayr PS EO, Ayr	0	0	0	0	0

Key

Future system performance worsened
Future system performance remains the same
Future system performance improved

Table 7: Meadowhead Bathing Season TSR Analysis – Comparison of Existing system and Future system Overflow performance

A similar pattern is predicted for the bathing season model predictions, with the same key CSOs predicted to spill increase in spill by the greatest amounts. The exact relative magnitude changes slightly, but the data confirms that the CSOs that are significantly impacted under typical storms for the full year are also significantly impacted under bathing season conditions.

The TSR analysis carried out on the overflows within the Stevenston catchment predicted that the annual spill frequency of the overflows would increase from 1,139 times to 1,150 times, an increase of 1%. As a consequence the total spill volume for the annual period would increase from 711,230m³ to 751,932m³, an increase of 6%. The spill volume increase of the individual overflows is displayed on Plan 4. Table 9 summarises the performance of the overflows for the bathing season period. The total overflow spill frequency for this period increased from 332 times to 335 times, equating to an increase of 1%. The spill volumes for this period are predicted to also increase from 246,089m³ to 264,187m³.

A total of 17 CSOs within the Stevenston catchment are predicted to increase in total annual spill volume by 25m^3 or more, and 16 predicted to increase in predicted bathing season volume by 25m^3 or more.

The spill volume increase of the individual overflows is displayed on Plan 4. It can be seen from Plan 4 that the largest increases in overflow spill volumes are focussed in the following areas:

- Saltcoats TPS
- Holmes Road CSO

It is not surprising that the CSOs that appear to be affected the most by the proposed development are those located in downstream locations, such as terminal pumping stations.

Two CSOs are predicted to increase in annual spill volume by greater than 10,000m^3, and these are the Holmes Road CSO Kilbirnie, and the Saltcoats PS CSO. These are not surprising as previous studies have suggested these are the largest spilling CSOs within the catchment. Of the other CSOs predicted to increase in annual spill volume by more than 1,000m^3, one is located in Beith (Main Road CSO), one is located in Kilwinning (West Area Moor Park Road East), one is located in Ardrossan (Harbour Road No1 Pumping Station) and the remaining three are located in West Kilbride (27 Glenside Overflow No1, West Kilbride TPS CSO, and one unnamed CSO).

It is notable that these CSOs are spread across the catchment and are mostly hydraulically independent of one and another. This is mainly due to the geographical spread of the villages throughout the catchment resulting in relative isolation to the individual CSOs.

id	CSO Name	Existing Annual spill volume (m³)	Existing Annual spill frequency	Future Annual spill volume (m³)	Future Annual spill frequency	Spill Volume increase (m³)
1	Unknown	26739	19	29973	19	3234
2	Unknown	8707	9	11955	8	3249
3	27 Glenside Overflow (No1)	3731	18	7609	17	3878
4	Summerlea Road	38	1	37	1	-1
5	Seamill (New Mill Overflow)	0	0	0	0	0
6	Kilbride Bridge Overflow	0	0	0	0	0
7	Canal Place EO	869	2	797	2	-72
8	Harbour Road No1 Pumping Station	74578	36	76567	40	1988
9	The Pavilion Emergency Outfall	2745	105	2813	106	68
10	27 North Crescent Road	2984	2	3069	2	85
11	The Pavilion Emergency Outfall	270	58	272	58	2
12	Holm Plantation / Bute Terrace Overflow	1188	2	1190	2	2
13	Parkhouse Road	476	2	476	2	0
14	Saltcoats PS EO	252184	65	262676	70	10492
15	West Area Moor Park Road East	48117	42	49361	42	1244
16	55 Shore Road	2477	7	2481	7	5
17	Stevenston WwTW Overflow	0	0	0	0	0
18	7 Hayocks Road	34	1	34	1	0
19	Pumping Station EO	Not modelled in current version of model				
20	Braidwood Road No.1	26277	75	27019	78	743
21	Nethermains Road	10959	27	10910	27	-49
22	Woodwynd	8720	27	8973	27	253
23	Bridge End Bannoch Burn Overflow	7749	40	7592	37	-157
24	David Gage Street CSO	1504	16	1507	16	3
25	Waterside Overflow, 23 Waterside Road (Braidwood Road No. 2)	652	13	658	13	6
26	Dirrans PS	278	6	279	6	0
27	Longford Bridge CSO	0	0	0	0	0
28	Almswall Road PS EO	0	0	0	0	0
29	Nethermains Road N.2	57	1	58	1	0
30	West Area Putyan Overflow	12688	31	12969	32	281
31	7 Bridgend Overflow Chamber	2744	54	2745	54	1
32	2 Blair Road Overflow	1846	26	1843	26	-3
33	21 Braehead Overflow	1047	23	1047	24	1
34	Holmes Road	117593	157	130410	157	12817
35	Mains Road CSO	53832	100	55321	101	1489
36	Westfield Sewer River Crossing	27755	117	28429	116	675
37	Hawthorn Crescent	6658	24	6960	24	302
38	Garnock Street (Townhead)	4810	26	4933	28	123
39	(Down stream of Holmes road CSO)	0	0	0	0	0
40	Fudstone Pumping Station	0	0	0	0	0
41	11 Townhead Overflow	33	1	39	1	6
42	Main Road	891	6	929	5	38

Key

Future system performance worsened
Future system performance remains the same
Future system performance improved

Table 8: Stevenston Annual TSR Analysis – Comparison of Existing system and Future system Overflow performance

id	CSO Name	Existing Bathing Season spill volume (m³)	Existing Bathing Season spill frequency	Future Bathing Season spill volume (m³)	Future Bathing Season spill frequency	Spill Bathing Season increase (m³)
1	Unknown	4	11233	6	15040	3234
2	Unknown	4	6324	4	8441	3249
3	27 Glenside Overflow (No1)	4	2703	7	6885	3878
4	Summerlea Road	1	38	1	37	-1
5	Seamill (New Mill Overflow)	0	0	0	0	0
6	Kilbride Bridge Overflow	0	0	0	0	0
7	Canal Place EO	2	869	2	797	-72
8	Harbour Road No1 Pumping Station	7	31193	10	32923	1988
9	The Pavilion Emergency Outfall	30	2134	44	2198	68
10	27 North Crescent Road	2	2984	2	3069	85
11	The Pavilion Emergency Outfall	20	135	28	137	2
12	Holm Plantation / Bute Terrace Overflow	2	1188	2	1190	2
13	Parkhouse Road	2	476	2	476	0
14	Saltcoats PS EO	12	71967	20	74199	10492
15	West Area Moor Park Road East	9	20693	14	20847	1244
16	55 Shore Road	2	2404	3	2407	5
17	Stevenston WwTW Overflow	0	0	0	0	0
18	7 Haycocks Road	1	34	1	34	0
19	Pumping Station EO					
20	Braidwood Road No.1	17	8804	26	8968	743
21	Nethermains Road	7	5986	10	5950	-49
22	Woodwynd	7	4478	11	4578	253
23	Bridge End Bannoch Burn Overflow	11	4135	16	3723	-157
24	David Gage Street CSO	4	1173	6	1176	3
25	Waterside Overflow, 23 Waterside Road (Braidwood Road No. 2)	4	525	5	529	6
26	Dirrans PS	3	210	3	210	0
27	Longford Bridge CSO	0	0	0	0	0
28	Almswall Road PS EO	0	0	0	0	0
29	Nethermains Road N.2	1	57	1	58	0
30	West Area Putyan Overflow	7	5834	11	5969	281
31	7 Bridgend Overflow Chamber	13	985	19	986	1
32	2 Blair Road Overflow	7	1102	11	1099	-3
33	21 Braehead Overflow	5	707	9	707	1
34	Holmes Road	50	25190	71	28520	12817
35	Mains Road CSO	26	17559	39	17820	1489
36	Westfield Sewer River Crossing	34	8143	48	8278	675
37	Hawthorn Crescent	6	4155	10	4187	302
38	Garnock Street (Townhead)	6	2637	10	2710	123
39	(Down stream of Holmes road CSO)	0	0	0	0	0
40	Fudstone Pumping Station	0	0	0	0	0
41	11 Townhead Overflow	1	33	1	39	6
42	Main Road	3	812	2	823	38

Key

Future system performance worsened
Future system performance remains the same
Future system performance improved

Table 9: Stevenston Bathing Season TSR Analysis – Comparison of Existing system and Future system Overflow performance

2.1.6 CSO/Overflow analysis – Formula A Assessment

The Formula A assessment for the Meadowhead catchment indicated a number of interesting trends. Firstly, a total of 42 CSOs are predicted to pass Formula A during spill periods for a 1 year return period storm event. Secondly, an additional 40 CSOs can be considered to be performing satisfactorily as they did not spill during the 1 year return period event. A total of 41 CSOs are predicted to not pass Formula A during the spill period for a 1 year return period event.

When the future developments are considered, and the Formula A recalculated and the model simulations repeated for the future system, only one additional CSO within the Meadowhead catchment was predicted to not pass Formula A that previously did pass Formula A. This CSO is located at 51 Main Road Hurlford.

The Formula A assessment for the Stevenston catchment indicated that a total of 21 of the 41 CSOs are predicted to pass Formula A during spill periods for a 1 year return period storm event for the existing scenario.

When the future developments are considered, and the Formula A recalculated and the model simulations repeated for the future system, only one additional CSO within the Stevenston catchment was predicted to not pass Formula A that previously passed using the existing system model. This CSO is located at West Kilbride TPS.

In terms of the strategic optioneering, this could be considered encouraging, as there is no significant impact from proposed development in terms of CSO Formula A performance.

3 Hydraulic Analysis Summary

This section of the report summarises the findings of the study following the initial modelling analysis.

The hydraulic model predicted changes in flooding within both the Meadowhead and Stevenston catchments due to the impact of the proposed development. Flood volumes were predicted to increase up to 20% in Meadowhead. However, due to unpredictable model instabilities a degree of caution was applied to the predicted flooding data and a screening exercise was undertaken to remove what appeared to be erroneous flood volumes. As discussed earlier, this complex macro model has historically been focussed on CSO analyses, and as a result less confidence can be placed in the predictions relating to flood volumes. The model predicted no significant patterns to increases in flooding. Much of the increases in flooding are located in more upstream areas and can be considered relatively localised. It is considered that at this initial review stage, strategic optioneering be focused on the key deficiencies within the catchment (primarily CSOs) rather than the flooding issues, particularly as flooding is not perceived to be a major issue by SW within the Meadowhead and Stevenston catchments.

The TSR analysis predicted significant increases in annual and bathing season spill frequency and volume at many of the CSOs across the Meadowhead and Stevenston catchments. Total annual spill volumes were predicted to increase by 15% in the Meadowhead catchment and 6% in the Stevenston catchment. It is highlighted that the volume of spill increase is a number of orders of magnitude greater than the predicted increases in flood volume. The CSOs exhibiting the largest increases in spill volume due to the future development are located in downstream locations along the IVTS, terminal pumping stations at Irvine, Prestwick and Ayr, and Meadowhead WWTW. In the Stevenston catchment, the pattern of affected CSOs is different due to the geographical spread of the villages and Towns, with more isolated CSOs being affected by the proposed development high up the system.

A number of the CSOs predicted to worsen significantly due to the proposed development are known deficient CSOs to both SEPA and SW (for example, the Gatehead Tanks and Meadowhead WWTW).

The Formula A assessment predicted that the proposed development would have little impact on the performance of the CSOs in terms of Formula A. Only one CSO in the Meadowhead catchment is predicted to not pass Formula A during future conditions yet does so during existing conditions. Similarly for the Stevenston catchment, the Formula A assessment predicted that the proposed development would have little impact on the performance of the CSOs in terms of Formula A. As with the Meadowhead catchment only one CSO, which previously passed Formula A, was shown to fail under the future scenario.

As a result, the Formula A criteria is not considered significant in terms of strategic optioneering.

4 Strategic Optioneering Review

As discussed in Section 3 of this report it is believed that the flooding predictions of the hydraulic models are somewhat dubious due to the instabilities that are introduced when large return period design storms are simulated. Therefore, it is considered that the predicted overflow performance is a more accurate indicator into the overall performance of the sewer system and the impact of any future development. Therefore, any notional strategic options should be targeted toward those overflows that are the worst performers. By targeting these overflows it is likely that some upstream flooding problems would also be addressed.

In terms of strategic optioneering, the scope of this study is to assess the improvements that would be required to be made to the sewer system to maintain existing system performance. It is not the scope of this study to identify what improvement options would be required to meet SW or SEPA regulatory requirements (for example 3 spills per bathing season).

As a result, this assessment will pay no attention as to whether a CSO meets the regulatory requirements or whether a particular flooding location is outside the regulatory trigger level, it will only focus on providing sewerage improvements to maintain the existing system performance, and thus mitigate the impact of the proposed future developments.

4.1 General CSO storage

As a baseline notional strategic option, storage could be added at each of the CSOs within the catchment where the proposed development has increased the volume of spill. Storage should be provided so that the performance of each overflow remains the same as the existing system performance. The extent of this strategic option can be calculated relatively simply, without the need for additional modelling. By simply dividing the increase in annual spill volume by the annual spill frequency, a rough cut estimate of the additional storage required at each CSO to maintain existing system performance can be calculated.

This rough-cut analysis indicates that approximately 30,000m^3 of CSO storage would be required across the Meadowhead catchment and approximately 1,500m^3 of CSO storage would be required across the Stevenston catchment. As expected, the largest requirements for additional storage would be the Gatehead Tank, Ayr PS, Meadowhead WWTW and the Scott Ellis Tanks.

It is highlighted that this is a very high level estimate of storage based on a very simple calculation. It is recommended that at the next phase of strategic optioneering, consideration be given to calculating the required storage volume for each CSO in a more refined manner. This can be undertaken with a more detailed spreadsheet analysis, rather than the simple calculation described above.

It is also highlighted that these simple approaches to calculating equivalent storage volumes do not take into account factors such as:

- the impact of tank emptying on the system and CSOs downstream,
- the impact of successive storms on the required tank volume,
- the need for additional compensation storage at CSOs downstream due to the emptying of upstream tanks

These factors are very much inter related, and it is recommended that should any CSO storage solutions be progressed to a more detailed stage in the future then modelling be undertaken to ensure that these factors are considered and that the solution is operating as intended. In terms of progressing this strategic option to the next level for the purposes of this study, it is recommended that a more detailed spreadsheet analysis be undertaken to give more confidence in the storage estimates.

Significant increases in spill volume are predicted at Meadowhead WWTW, Gatehead Tanks, Holmes Road CSO, Ayr PS, Scott Ellis Tanks, and a number of other CSOs in Irvine, Upper Towns and Prestwick. In reality, the additional storage required at these key CSOs, and the culmination of other catchment CSOs may be even higher than the initial estimates due to the cumulative effect of upstream CSOs delaying the emptying period of these tanks significantly. Furthermore, the impact of such a large amount of storage across the catchment may cause the downstream WWTW to be running at FFT for a considerable period following a storm event, which may in turn, lead to even greater spills at the downstream CSO at Meadowhead WWTW. The implication of this is that simple widespread catchment storage may not be the most robust solution for the Meadowhead catchment. As a result, alternative strategic solutions should be considered to maintain existing system performance and mitigate the impact of future development.

4.2 Meadowhead System Upgrade

Numerous strategic solutions have been suggested as part of earlier studies to upgrade the Meadowhead sewerage system to ensure it meets regulatory requirements. Whilst this study is not concerned with developing solutions to address regulatory requirements, it is considered that the strategic solutions suggested through these earlier studies be used as a starting point for the strategic options developed as part of this study to maintain existing system performance.

As discussed, any high level catchment wide strategic solution would likely centre around the IVTS, the Gatehead Tank, the Irvine Town trunk sewer, the terminal pumping stations at Irvine, Troon, Prestwick and Ayr, and finally the Meadowhead WWTW. Two potential strategic solutions have been considered at this stage.

4.2.1 Strategic Solution 1

Many of the CSOs affected by development are located at Kilmarnock and Upper Towns and spill due to incapacity on the IVTS. In other catchments the CSOs spill due to downstream controls such as local trunk sewers or terminal pumping stations.

Upsizing 25km of the IVTS through Upper Towns and Kilmarnock would address many of the CSO issues in this area. Localised upsizing of the spine sewers connecting to the IVTS, particularly within Kilmarnock, would also help address those CSOs, such as the Scott Ellis Tanks, located off the IVTS. The extent of this spine upsizing would obviously depend on how far any key CSOs are located away from the IVTS. For example, the Scott Ellis Tanks are located less than a kilometre from the IVTS. In addition to this, localised trunk sewer upsizing and increases in the capacity of the terminal pumping stations at Ayr, Prestwick, Irvine, Springside and Dreghorn, and Troon would also address many of the CSO issues in these towns.

However, simply increasing pass forward flows from each of these areas would transfer additional spill volume to Meadowhead WWTW, where it would be spilled to sea at the CSO.

It may be possible that the current primary and secondary treatment facilities at Meadowhead works can be upgraded to treat this additional pass forward flow without causing an increase in spill at Meadowhead WWTW. The available spare capacity at the Meadowhead WWTW should be confirmed at this stage. Alternatively, discussions should be sought with SEPA as to the viability of discharging more spill flow at Meadowhead WWTW, although given the current issues regarding bathing beach compliance, it is unlikely that SEPA would permit additional spill to sea.

As a result, it may be necessary to also consider upgrading Meadowhead WWTW to cope with additional pass forward flows from the upstream catchments due to the proposed development. This may involve additional treatment facilities, or may involve additional compensation storm storage at the WWTW. Additional compensation storage at the WWTW is faced with many of the same problems as simply locating the required storage at the CSOs across the upstream catchments. Often, the same catchment CSO volume is required at the WWTW as would be required across the catchment, and thus the main benefit is really only less disruption and less localised works across the upstream catchment. However, this may be negated by the fact that this option involves a significant amount of trunk sewer upsizing in many of the upstream catchments anyway.

It is likely that this strategic solution would cost more than isolated CSO storage to maintain existing system performance, but is by far the more robust long term solution.

4.2.2 Strategic Solution 2

Rather than upsizing the IVTS along its full length to Meadowhead WWTW, it would be possible to upsize the IVTS to the Gatehead Tanks. At this point, constructing a new primary and secondary WWTW would allow the Kilmarnock and Upper Towns portion of any flow to be removed from the Meadowhead drainage area. This in turn would free up available capacity at the Meadowhead WWTW, which in turn would allow the trunk sewers and terminal pumping stations in Prestwick, Irvine, Troon and Ayr to be upsized to address the impacts at the CSOs within these catchments. Free outfalls would also effectively occur in the IVTS between Gatehead Tanks and Meadowhead WWTW, allowing CSOs from Crosshouse & Knockentiber, Springside, Dreghorn and Dundonald to be addressed.

As with strategic option 1, it is likely that the cost of this solution would be in excess of simply constructing localised CSO storage, however, it is again a much more robust long term alternative.

4.2.3 Interaction with SW Upgrade Programme

It is important to highlight at this stage that the extent and scope of any strategic solution to maintain the existing system performance due to the impact of future development is likely to be considerably less than the extent and scope of works required to be undertaken should a strategic solution be implemented by SW to address CSO deficiencies and meet regulatory requirements as part of any future Q&S periods.

It is also likely that the next stage of modelling as part of this study will demonstrate that constructing a strategic solution simply to address the impact caused by future development is not cost effective. Whilst there is a significant impact in terms of CSO spill, addressing the portion directly attributable to future development may only require relatively minor increases in pipe size or relatively small increases in WWTW treatment capacity. However, the extent of the IVTS that would require upsizing or parallel pipe constructing is very large, resulting in a costly solution.

With this in mind, it is still important to go through the process of determining the exact strategic solution requirements to address the impacts of future development. Should SW decide to construct a robust long term strategic solution in the future to address all key catchment deficiencies, then this analysis will allow the portion directly attributable to future development to be determined.

The proportional cost would also decrease if the future development portion of any solution was designed and constructed at the same time as any SW strategic solution to address other catchment deficiencies. For example, there would be a greater cost benefit in doubling the size of the IVTS to address all catchment deficiencies than simple upsizing the IVTS by a single pipe size to address the relative small impact of future development.

It is recommended that this study be used to develop conservative solution and cost estimates by developing the strategic solution based only on addressing the impact caused by future development. However, it is strongly recommended that should the solution be required to be constructed in the future, then attempts be made to tie the construction of this future development solution with any strategic solution been developed to address other drivers within the catchment.

4.3 Stevenston System Upgrade

It is evident that due to the geographical spread of the various systems within Stevenston and a high proportion of long small interconnecting trunk sewers, the solutions in the Stevenston catchment are likely to be more localised in comparison with the Meadowhead catchment strategy solutions. The Stevenston catchment strategy is likely to involve the construction of storage or small amounts of pipe upsize at each of the localised CSOs where required. As a result, a number of small schemes are likely to be required rather than one overall strategic solution such as upsizing a trunk sewer.

It is likely that the vast majority of the storage will be allocated to Saltcoats TPS and Holmes Road CSO locations. Consideration should also be given to the rationalising of CSO additional storage locations where appropriate. This is more likely to occur along the coastal communities where there is more hydraulic interaction between the local CSOs.

5 Conclusions and Recommendations

The Meadowhead and Stevenston macro models have been used to assess the impact of proposed future development on the performance of the Meadowhead and Stevenston sewer systems. The extent of the proposed future development was provided by the AJSPTC.

The model predictions identified localised increases in flooding across the catchment, however, the level of confidence that could be placed in the model predictions relating to flooding is limited due to the occurrence of instabilities within the model.

The model predicted significant increases in total annual CSO spill volumes across both catchments due to the additional flows from the future developments. The CSOs predicted to worsen the most in performance are generally located along the downstream trunk sewers or at terminal pumping stations.

The model is considered a more applicable tool for assessing CSO performance under low return period rainfall rather than flooding performance under more extreme events. Results of model simulations indicate that some form of sewer improvement strategy would be required to mitigate the impact of the future development on the performance of the sewer system.

Initial strategic options have been considered, ranging from wholesale localised storage solutions at each individual CSO to trunk sewer upsize to the Meadowhead WWTW. Due to the issues with instabilities and flooding, it was agreed with SW that any improvement strategy should initially focus on addressing the key downstream CSOs where the impact of future development is most noticeable.

It is recommended that the study move to the next stage, where a strategic solution to mitigate the impact of future development can be modelled and scoped. It is highlighted at this stage that this modelling study will scope the solution only in terms of maintaining existing system performance and will not scope a strategic solution to address catchment deficiencies in terms of SW or SEPA regulatory requirements. This 'future development' solution will then allow the proportion of cost directly attributable to the future development to be determined, so that this can subsequently be incorporated into any potential future SW strategic solution to address regulatory requirements.