REDROW HOMES (SCOTLAND) LTD

PROPOSED A8/M8 INTERCHANGE
BISHOPTON

FLOOD RISK AND SURFACE WATER DRAINAGE IMPACT ASSESSMENT REPORT

DOUGALL BAILLIE ASSOCIATES
Civil Structural Transportation
3 Glenfield Road
Kelvin
East Kilbride G75 0RA

August 2006

Document Control

Document Title: -	Proposed A8/M8 Interchange, Bishopton Flood Risk and Surface Water Drainage Impact Assessment Report
Project Number: -	06667
Project Title: -	Proposed A8/M8 Interchange, Bishopton
Directory and File Name: -	V:\06600s\06667 Bishopton Drainage\Admin\Reports\06667rep01 (Flood Risk and Drainage Impact Assessment).doc

Document Approval:

Originator:	Gregor Muirhead	Date	31.08.06
Checked By:	René Dobson	Date	31.08.06
Authorisation:	Allan Thomson	Date	31.08.06

Issue	Date	Distribution	Comments
Draft	31.08.06	Redrow Homes (Scotland) Ltd	For Comment
Fianl	19.09.06	Issued for detailed Planning Application	-

CONTENTS

Page

APPENDICES

1.0 INTRODUCTION

Principle of Drainage Strategy

1.1 Dougall Baillie Associates (DBA) have been appointed by Redrow Homes (Scotland) Ltd (RHS), to undertake an appraisal of the constraints to drainage associated with the proposed M8/A8 Interchange at Bishopton. The purpose of this report is to allow a Drainage Strategy to be developed that is acceptable to the adopting authorities of Renfrewshire Council and Scottish Executive/Amey Highways. In addition the Scottish Environment Protection Agency (SEPA) have been consulted with respect to water quality, the preservation of habitat and the promotion of sustainability. Due to the vicinity of Glasgow International Airport, British Airports Authority (BAA) have been consulted with respect to their views on open water SUDS techniques and associated birdstrike to aircraft risk.

1.2 In accordance with the recommendations set out in Planning Advice Note 61: Planning and Sustainable Drainage Systems (Scottish Executive 2001), the SUDS Manual (CIRIA Report C521) and Renfrewshire Council's Drainage Assessment – Notes for Guidance document, this consultation was undertaken during the Master Planning stage of the proposed development.

Drainage Parameters

1.3 During preliminary discussions between DBA, Renfrewshire Council and SEPA it was considered that the following parameters should be achieved during the design of the storm water drainage system for the interchange: -

- *Runoff arising from developed areas should undergo appropriate stages of SUDS treatment in accordance with the principles outlined in CIRIA 521 Sustainable Urban Drainage Systems – Design Manual for Scotland and Northern Ireland.*

- *The development should have no adverse affect on flood risk within, upstream or downstream of the development, in accordance with SPP7 - Planning and Flooding (Scottish Executive 2004).*

- *Surface water runoff in excess of the existing 1 in 2 year 'greenfield' runoff rate should be attenuated onsite up to the critical 1 in 200 year storm event plus an allowance for climate change.*

1.4 These issues will be addressed within the following sections of the report, establishing a basis for the progression of the Detailed Planning Application.

2.0 SITE DESCRIPTION

2.1 The development site is located on the M8 motorway approximately 1 kilometre south of the existing Erskine Bridge turn off (Junction 30) and about 13 kilometres northwest of Glasgow city centre (*Appendix A*). The site is centred at National Grid Reference NS 449 692 and is bound to the west by the former Southbar Landfill facility and to the north by the existing A8 Greenock Road. To the east and south the site abuts existing farmland.

2.2 The M8 motorway passes through the middle of the site in a north-south orientation at an elevation in the region of 9.5m AOD. To the west of the motorway a series of settlement ponds are located which are fed by a minor land drainage ditch which routes around the former landfill site. West of the settlement ponds the topography rises moderately at a gradient of approximately 1 in 6 within the former landfill site. To the north the site is dominated by the supporting embankments of the A8 carriageway as it rises to pass over the M8 motorway. Further north the topography is generally flat and characterised by farmland however a hummock, which rises to some 45m AOD, is located approximately 400m northeast of the site. To the east and south the topography is essentially flat with a slight inclination to the south.

2.3 A review of the available Site Investigation reports for the area suggest that the superficial deposits across the site consist principally of relatively impermeable raised marine clay and silt. Areas of made ground deposits were encountered in parts of the site associated with the former landfill, as well as locations close to the A8 and M8. These onsite conditions are considered unsuitable for SUDS soakaway techniques and therefore such methods for surface water disposal will not be considered within this report.

3.0 BASELINE CONDITIONS

3.1 Baseline conditions were assessed by a desk study, literature review of available geological and environmental reports, and a site walkover survey on 31 July 2006.

Historic Site and Surrounding Conditions

3.2 Historic site conditions were assessed by reviewing the available historical mapping which dates back the 1860's.

3.3 From the 1860's to 1970 the site and surrounding area comprise of agricultural land however Greenock Road (A8) is shown passing through the northern portion of the site and the Glasgow-Greenock railway line is located approximately 400m west of the site.

3.4 By the mid-seventies roads infrastructure development is noted with construction of the M8 motorway through the centre of the site. To facilitate construction of the motorway the A8 Greenock Road has been raised with supporting embankments to allow an overbridge to be formed.

3.5 From 1981 to 1999 phased landfill operations where ongoing immediately west of the site. During this period it is estimated that some 500,000 tonnes of waste, consisting principally of demolition rubble and soil, was disposed to the landfill site, namely Southbar Landfill.

3.6 From the 1990's to present day little change has occurred within the vicinity of the site however the former Southbar Landfill facility is now disused and has since been capped, re-seeded and restored to agricultural use.

Existing Hydrological Regime

3.7 The development site falls within the natural drainage catchment of the Lin Burn which is served by a series of small land drains which converge to the south of the site within the farmland between the A8 and M8. Approximately 900m downstream of this confluence the Wheel Burn discharges to the Lin Burn. Downstream the Lin Burn discharges to the River Gryfe, which in turn is a tributary the Black Cart Water, and ultimately the River Clyde.

3.8 The Lin Burn is little more than constructed land drainage which facilitates drainage of the surrounding farmland. The Lin Burn originates as a formal channel close to Southbar House and flows in a southwesterly direction towards the A8. Approximately 100m north of Greenock Road the watercourse enters a 300mm diameter concrete pipe culvert which conveys flows in a southerly direction. This culvert outlets on the southern side of the A8 via a 600mm high by 1m wide box culvert. Downstream the watercourse continues in an open channel flowing in a southwesterly direction for approximately 90m before converging with a land drainage ditch which flows from the southwest. At this confluence the watercourse changes direction and continues in a southeasterly direction, away from the proposed site.

3.9 The former landfill to the west of the motorway is surrounded by a series of drainage ditches. The ditch that routes around the north and east of the landfill drains to a series of treatment ponds which are located between the landfill and M8 carriageway. At the time of inspection treatment potential of the ponds was considered to be greater on the western extents with vegetation colonisation noted to be less dense adjacent to the M8.

3.10 A review of the surface water sampling carried out by BAE Systems Environmental as part of the Site Investigation Report dated July 2006 indicates that the former landfill site is having a detrimental impact on the quality of surface water within the land drainage ditches. A comparison of surface water samples taken upstream and downstream of the treatment ponds indicate increased concentrations in lead, mercury, zinc and chromium which are likely a result of slight leachate leakage from the landfill between the sampling points. However concentrations of chloride, ammoniacal nitrogen, biochemical oxygen demand (BOD) and suspended solids were reduced in the downstream samples indicating that the treatment ponds provide a degree of water quality remediation.

3.11 Flows discharging from the downstream treatment pond enter a short section of 750mm diameter concrete culvert. The outlet from this culvert meets another 750mm diameter outlet which conveys flows from the southern side of the landfill. Immediately downstream of this confluence flows enter a 750mm diameter concrete culvert which conveys flows east under the M8 carriageway. On the eastern site of the motorway the culvert discharges to an open channel which continues east for some 100m where it converges with the Lin Burn.

3.12 To the northwest of the site a small drainage ditch runs along the toe slope of the northern embankment of the A8. This drainage path flows in an easterly direction prior to entering a 600mm diameter concrete culvert which conveys flows east beneath the M8 motorway. At the time of inspection the outlet from this culvert was not identified however it is believed to continue east beyond the motorway and discharge to a small unnamed land drainage ditch within the adjacent farmland, which ultimately discharges to the Lin Burn. Drainage of the A8 Greenock Road, to the west of the M8 overpass, is facilitated by sheet flow from the carriageway directly into the ditch along the toe slope of the northern embankment.

3.13 Formal drainage of the A8 to the east of the M8 overpass is provided by a traditional gully and pipe system which is believed to discharge freely into the Lin Burn at the culvert outlet on the southern side of the carriageway.

3.14 Under existing conditions the M8 motorway is served by a traditional gully and pipe drainage system which, in the vicinity of the site, is believed to discharge to the 750mm diameter culvert beneath the carriageway to the south and the 600mm diameter culvert beneath the carriageway located immediately north of the A8 overpass.

3.15 It is considered likely that under existing conditions surface water runoff arising from the surrounding farmland will follow the existing ground profile and discharge to the nearest drainage ditch and ultimately the Lin Burn.

3.16 At the Lin Burn and land drainage ditch confluence within the farmland between the M8 and A8 the catchment area of the watercourse is in the region of 1.31 km^2. This value has been obtained from the FEH CD-Rom digital terrain model and manually verified using 1:10000 scale Ordnance Survey Maps of the area.

Geology and Hydrogeology

3.17 The extrusive onsite investigations carried out by BAE Systems Environmental in April 2006 confirm that made ground arisings are present in part of the site associated with the former landfill and close to the existing A8 and M8 footprints.

3.18 The published Geological Survey Maps for the area indicate that the underlying superficial geology across the site is likely to be Late Devensian Glaciomarine Deposits comprising intertidal and subtidal clay and silt of the Linwood and Paisley Formation. These in turn overly glacial diamictions of the Wilderness Till Formation which comprise of bounders and stones in a hard to stiff sandy silt and clay matrix.

3.19 The solid geology across the site is indicated to consist of two formations of Carboniferous Age. To the northeast is the Limestone Coal Formation of Upper Carboniferous Period, which generally comprises cyclic sequences of sandstones, siltstones, mudstones, coals, blackband and clayband ironstones and seatrocks. To the southwest is the Lower Limestone Formation of the Lower Carboniferous Period, which generally comprises mudstones with sandstones, siltstones, marine limestones, thin coals and clayband ironstones.

3.20 The available Hydrogeology Maps for the area indicate that the Carboniferous sedimentary bedrocks are moderately productive comprising primarily of fracture and intergranular flow. The Groundwater Vulnerability Map of Scotland classifies the underlying solid strata as moderately permeable strata. These strata seldom produce large quantities of water for abstraction, however may be important for providing base flows for rivers. The overlying glacial till deposits are non-aquifer and have some potential to attenuate, diffuse and free-phase contaminants.

Flood Risk Assessment

3.21 Current best practice and planning advice recommends that all new developments should be free from significant flood risk from any source and should not materially increase the probability of flooding elsewhere. For the purposes of this report existing flood risk has been considered from the following sources;

Fluvial Flood Risk

3.22 It is considered that the only feasible source of fluvial flood risk arises from the Lin Burn and other land drainage ditches which flow through the proposed site.

3.23 At the confluence of the Lin Burn and the land drainage ditch from the east, the catchment area is in the region of 1.31 km^2 and is predominately characterised by undeveloped farmland and rough pasture. This catchment area has been determined from the FEH CD-Rom digital terrain model and manually verified using 1:10000 scale Ordnance Survey Maps of the area.

3.24 There are no known flow gauging stations on the Lin Burn and the estimation of surface water runoff and flood flows arising from small catchments with no flow records is inherently difficult. In the absence of direct measurements of rainfall and runoff, a variety of techniques are available as described in the Flood Studies Report, Institute of Hydrology Supplemental Reports, Flood Estimation Handbook and guidance notes for agricultural drainage, all of which are based upon assumptions with regard to the proportion of rainfall contributing to runoff.

3.25 For flood flow estimation it is prudent to use more than one flow estimation technique to increase confidence limits in the adopted design flow. For the purposes of this Report likely flood flows have been estimated using the FEH Rainfall-Runoff method, Revitalisation of the FSR/FEH rainfall-runoff method and Institute of Hydrology Flood Estimation for Small Catchments methodology (IH Report 124).

FEH Rainfall-Runoff Method

3.26 The rainfall runoff method is based on a simple triangle-shaped unit hydrograph that is defined by time to peak (T_p). The FEH recommends that T_p should be derived from rainfall and flood event data by flood event analysis. In the absence of event data a less reliable method of $T_p(0)$ can be made from catchment descriptors.

3.27 The method is largely influenced by the estimate of percentage runoff, as the flood peak derived is directly proportional to the percentage runoff. Percentage runoff is a combination of standard percentage runoff (SPR) representing the normal capacity of the catchment to generate runoff, and dynamic percentage runoff (DPR), representing the variation in runoff depending on the state of the catchment prior to a storm event and the storm event itself.

Revitalisation of the FSR/FEH rainfall-runoff method

3.28 The FSR/FEH rainfall runoff method is a widely used and is commonly accepted for flow estimation within the UK. This first method was initially documented in 1975 through the Flood Studies Report and has since been improved and updated in numerous studies. The latest research in this methodology was in published in 1999 though Volume 4 of the Flood Estimation Handbook. Despite these improvements, the basic design model structure for this method has remained largely unchanged since the FSR version.

3.29 The revitalised FSR/FEH rainfall runoff method was produced in July 2005 and seeks to improve the FSR/FEH rainfall runoff method by taking advantage of new data, updated analytical techniques and recent advances in computation. The fundamental change with the revitalised method is the newly developed Revitalised Flood Hydrograph (ReFH) which replaces the unit hydrograph and losses model at the core of the FSR/FEH rainfall runoff method.

Institute of Hydrology Flood Estimation for Small Catchments Method

3.30 The IH R124 flood estimation for small catchments method is based the FSR mean annual flood plus growth curve approach, and research carried out on 71 small rural catchments. The Report describes an alternative procedure to calculate $Q_{BAR(rural)}$, the mean annual flood for small rural catchments, to which geographically based growth curves are applied to estimate flow for a given return period.

Lin Burn 1 in 200 year Peak Flow

3.31 It must be emphasised that due to the lack of suitable gauge data and relatively small contributing catchment area the peak design flood estimates for the Lin Burn at the development site have been estimated using a range of methods based on a 'no data' approach.

3.32 For the methodologies used the peak 1 in 200 year flow immediately downstream of the Lin Burn and drainage ditch confluence in the farmland between the A8 and M8 is estimated to be 3.2 m^3/s, 3.4 m^3/s and 3.7m^3/s for the IH R124, ReFH and FSR/FEH rainfall runoff methods respectively (*Appendix B*).

3.33 As previously stated flood flow estimation using 'no data' approaches are dependent on model assumptions and confidence limits for peak flow estimates are relatively low compared to other methods. Therefore for design purposes the upper flow estimation calculated using the FSR/FEH rainfall runoff method has been applied to give a conservative 1 in 200 year flow of 3.7 m^3/s.

3.34 Due to the capacity of the upstream culverts within the catchment peak flows arising at site are likely to be controlled by the conveyance potential of these structures and only a small fraction of this calculated design flow would be observed at the site. It is also considered that the existing online treatment ponds between the M8 and former landfill will provide a degree of attenuation further reducing peak flows at the site. However, to estimate 'worst case' conditions within the site it has been assumed that the upstream culverts do not restrict flow and that the online treatment ponds do not provide attenuation potential. These assumptions allow a robust and conservative view on existing flood risk status of the site to be undertaken which is based on uncontrolled peak flows from the catchment arising at the site.

3.35 A review of the existing Lin Burn channel geometry indicates that the capacity of the watercourse corridor as it flows from the A8 culvert outlet to the convergence with the land drainage is in the region of 3.5 m^3/s. Using a pro rata approach the estimated 1 in 200 year peak flow through this reach is likely to be in the region of 2.8 m^3/s.

3.36 The existing capacity of the ditch which flows from the 750mm culvert beneath the M8 to the convergence with the Lin Burn is estimated to have a bankfull capacity in the region of 1.9 m^3/s. Using the pro rata approach it is considered that the peak 1 in 200 year flow through this reach is likely to be 0.9 m^3/s.

3.37 A comparison review of likely flood flows against estimated channel capacities indicate that that the 1 in 200 year flows at the site will be contained within the watercourse corridor. However, in the unlikely event that out of bank flow occurs a review of the topographical survey information indicates that any overland flows would follow the natural ground profile south, away from the development site.

3.38 Given these considerations and in accordance with risk framework outlined in SPP7 – Planning and Flooding (Scottish Executive 2004) it has been conservatively concluded that the site is at little or no flood risk from fluvial flooding and as such is not considered as functional flood plain.

Groundwater Flood Risk

3.39 Due to the depth of ground water over the site and the characteristics of the underlying and relatively impermeable clay based stratum it is considered that there is no material risk of ground water flooding to the road base construction.

Overland Flows and Surface Water Ponding

3.40 The general ground profile of the site and surrounding area is gently undulating with local inclinations in all directions. Overland flows arising from the surrounding areas will follow the natural ground contours into the Lin Burn or nearest land drainage ditch.

Post Development Flood Risk

3.41 The change in post development runoff regime incurred by a change in land use could significantly impact on the hydrological regime of the catchment, by decreasing base flows in receiving waters, increasing peak flows during short duration high intensity storm events, possibly leading to erosion and increasing downstream flood risk. In accordance with SPP7 - Planning and Flooding (Scottish Executive 2004) the interchange must not materially increase downstream flood risk therefore post-development runoff will be managed to provide a neutral or better impact on the existing hydrological regime.

4.0 PROPOSED DEVELOPMENT

4.1 As part of the redevelopment of the former Royal Ordnance Factory in Bishopton Redrow Homes (Scotland) Ltd are proposing a new junction on the M8 motorway.

4.2 The proposed interchange incorporates westbound off ramp and eastbound on ramp to the M8. Both slip roads will connect to the existing A8 Greenock Road through the formation of two new roundabouts which result in minor realignment of the existing A8 to facilitate roundabout approach geometry. Both new slip roads, associated roundabouts and realignment of the A8 will be constructed above surrounding ground levels and as such require new supporting embankments.

4.3 The proposed interchange layout is attached in A*ppendix C.*

5.0 MITIGATION

5.1 Current planning advice and best practice recommends that the disposal of surface water runoff from new developments discharging to controlled waters should be undertaken in a sustainable manner. This requires the developer to control and treat surface water runoff prior to discharge into controlled waters so that there should be no increase in flood risk to the site or other property, no significant affect to base flows and no adverse affects on water quality or amenity. These requirements can be achieved by applying the principles of Sustainable Urban Drainage Systems (SUDS).

Changes in Site Characteristics

5.2 Changes in the characteristics of the site and the resulting changes in runoff regime can be mitigated by the implementation of SUDS. The existing drainage paths and seasonal fluctuation of water levels within the watercourses must be maintained to ensure the appropriate conditions remain to sustain the watercourse corridor. It is suggested that this could be achieved by discharging treated and attenuated post development runoff to the same pre-development receiving watercourses.

Surface Water Management

5.3 The basic data required for surface water management is the catchment characteristics and rainfall likely to fall over the development site for any given return period and duration. These design values can be acquired from the Centre of Ecology & Hydrology Flood Estimation Handbook CDROM.

5.4 As previously discussed the estimation of surface water runoff and flood flows arising from small natural catchments with no flow records is inherently difficult. In the absence of direct measurements of rainfall and runoff, a variety of techniques are available as described in the Flood Studies Report, Institute of Hydrology Supplemental Reports, Flood Estimation Handbook and guidance notes for agricultural drainage all of which are based upon assumptions with regard to the proportion of rainfall contributing to runoff.

5.5 For the Bishopton area, Renfrewshire Council is the Local Authority responsible for carrying out the Statutory Duties of flood prevention legislation, The Flood Prevention Act, 1961, as amended by The Flood Prevention and Land Drainage Act, 1997. It is the responsibility of the Developer to demonstrate to the satisfaction of the Local Authority that any proposed discharge of surface water runoff from the interchange to any watercourse should have no adverse effect on any watercourse located within, upstream and downstream of the proposed development.

5.6 Given these constraints it will be necessary to provide formal storage within the interchange drainage network to attenuate and reduce discharges to the receiving network. This storage can take many forms ranging from traditional methods such as oversized pipes and tanks to more innovative methods such as SUDS source control and site controls. If suitable, the storage structure can also be designed to provide a stage of treatment for managing runoff quality.

5.7 To determine an acceptable post development discharge limit an estimate of greenfield runoff was calculated using the methodology outlined in the FEH Rainfall-Runoff method, Revitalisation of the FSR/FEH rainfall-runoff method and Institute of Hydrology Flood Estimation for Small Catchments methodology (IH Report 124). The IH R124 method automatically calculates greenfield runoff release rates for a range of return periods by applying growth curve factors to the mean annual peak runoff. Greenfield runoff rates from the FEH Rainfall-Runoff method and Revitalisation of the FSR/FEH rainfall-runoff method have been determined by expressing estimated flood flows as runoff per unit area.

5.8 In accordance with current Renfrewshire Council policy, as outlined in their guidance note on Drainage Assessments, surface water discharges from new developments directly to a watercourse should be limited to the existing 1 in 2 year ‘greenfield’ runoff rate. A review of the hydrological calculations indicate that the existing 1 in 2 year ‘greenfield’ runoff rate for the site is in the region of 8 litres per second per hectare (l/s/ha) (*Appendix B*). This runoff rate is considered to be conservative (i.e. low) for the site given the extent of underlying impermeable till.

5.9 A review of the proposed interchange layout indicates that approximately 3.6 ha of impermeable area will contribute to the proposed interchange drainage network. This includes a portion of the existing M8 and A8 which will drain to the new interchange network. The remaining impermeable area arises from the new roundabouts and slip roads. Based on the overall contributing area a conservative discharge limit for the whole interchange is 29 l/s, based on a 1 in 2 year 'greenfield' runoff rate of 8 l/s/ha.

Required Storage Volumes

5.10 In accordance with current Renfrewshire Council policy storage volumes will be required on site to reduce the post-development 200 year runoff to pre-development 1 in 2 year 'greenfield' flows without causing any flood risk to buildings or resulting in unacceptable depth of inundation on emergency access. Storage volumes will also depend on the hydraulic capacity of the piped system, type of storage used and the efficiency of the flow control structure.

5.11 It should be recognised that due to the different adopting authorities of the interchange, namely Renfrewshire Council for the A8 and associated roundabout and Scottish Executive / Amey Highways for the new M8 off and on ramps, drainage is facilitated by separate networks for separately adopted areas.

Effects of Climate Change

5.12 Surface water runoff is primarily a function of rainfall and antecedent catchment wetness. In the future the effects of climate change will likely continue to cause an increase in global temperature and the result will likely be a change in weather patterns. While little data is available on the predicted change in rainfall patterns for the UK it is generally accepted that the frequency of extreme rainfall events will increase during the next 100 years.

5.13 As previously stated, Renfrewshire Council act as the flood prevention authority and in this capacity have the responsibility for setting the appropriate water quantity control criteria. To compensate for the possible effects of climate change current best practice requires that property be protected against flooding up to the Year 2080. Given the uncertainty inherent with climate change prediction it is suggested that a rainfall uplift factor equivalent to 10% be included within post development drainage and attenuation calculations.

Water Quality Management

5.14 The proposed interchange has the potential to impact on the water quality of the receiving watercourse, both during the construction phase and on completion of the interchange. Given the sensitive nature of natural watercourses all measures to treat surface water runoff should be in place prior to works commencing. The design of any SUDS scheme should be in accordance with the principles outlined in the CIRIA Manual C521 Sustainable Urban Drainage Systems – Design Manual for Scotland and Northern Ireland.

5.15 The potential risk of construction phase pollution can be significantly reduced by implementing good site practice and following the guidance outlined in the Pollution Prevention Guidelines, PPG01 – General guide to the prevention of water pollution, PPG05 – Works near or liable to affect watercourses and PPG06 – Working at construction and demolition sites, published by SEPA. The CIRIA Manual C532 – Control of Water Pollution from Construction Sites, provides further guidance and should be consulted.

Implementation of SUDS

5.16 SUDS systems now represent best practice in drainage management and their adoption is being promoted in both planning and building control guidance.

5.17 In July 2001, the Scottish Executive published Planning Advice Note 61: Planning and Sustainable Drainage Systems. The PAN gives good practice advice for planners and developers. Later, in September 2001, Part M of the Building Regulations was amended to include SUDS as the preferred method of surface water disposal. These were designed to complement the Sustainable Urban Drainage Systems Design Manual for Scotland and Northern Ireland, published by CIRIA in March 2000.

5.18 The SUDS Manual contains a 'Selection Tool' to guide designers through the process of selecting the appropriate method of achieving this criteria based on development type. This tool promotes risk management with prevention as the preferred option, followed by source control through to end of pipe, site control and regional control systems.

Device	Residential	Non-Residential	Industrial
Prevention	*	*	*
Containment	-	-	1
Permeable Surfaces	1	1	1 (Contained)
Filter Strips/Treatment Swales	1	1	2
Filter Drains/Pavement Sub-Base	1	1 or 2	2 (Contained)
Swales	1	1 or 2	2
Extended Detention Basins	1	2	2
Soakaway/Infiltration Trenches	1	2	3
Infiltration Basins	1	2	3
Retention Ponds	1	2	3
Wetlands	1	2	3
Levels of Treatment Required	**1**	**2**	**3**

Table 5.1 – Summary of design strategies for water quality.

Key

** - Always Required*
1 - First Level of Treatment
2 - Second Level of Treatment
3 - Third Level of Treatment

For a particular land use, the number and order of treatment stages are shown, with alternative drainage methods shown for each level. For example, an industrial site requires three levels of treatment. The first level can be achieved using a lined porous or permeable pavement, with a filter strip or swale providing the second level, followed by a wetland or retention basin to give the third level of treatment. The classification of roads is determined on a site-by-site basis.

5.19 On review of the interchange layout it is considered likely that the drainage network will have to be split into three separate systems given the proposed finished road levels and the separate adoption of the A8 roundabout and the M8 slip roads by Renfrewshire Council and Scottish Executive / Amey Highways respectively.

5.20 Due to the heavy sediment loading likely on the interchange it is proposed that runoff arising from all impermeable areas undergo robust SUDS treatment prior to discharge to the receiving watercourse.

5.21 Given the likely constant and heavy pollutant loading associated with the interchange the use of vegetative dependant source controls, specifically swales and grass filter strips, are considered unsustainable since vegetative growth is unlikely to prosper with the harsh pollutant loadings. It is further considered that filter trenches along the alignment of the carriageway will quickly become clogged and, although still efficient for draining the carriageway, the treatment potential of these systems will be significantly reduced over time unless they are subject to an onerous maintenance regime.

5.22 It is therefore recommended that the most practical, robust and sustainable system for drainage of the interchange is in the form of a traditional gully and pipe or filter trench system designed to convey runoff to three site control wetlands incorporated into the interchange landscaping, one wetland for each of the proposed drainage networks. Using this form of SUDS treatment facilitates efficient pollution removal, visual detection of abnormal pollution loading, ease of maintenance, potential for habitat and visual enhancement.

5.23 These wetlands will be sized to have a permanent water volume equal to three times the Treatment Volume (V_t) as calculated using the standard methodology outlined in the SUDS Manual (CIRIA Report C521) (*Appendix D*). In accordance with current SEPA guidance providing three times V_t will maximise pollution removal through sedimentation and biological uptake.

5.24 In addition to SUDS treatment the outlet from the wetland or pond will incorporate a hydraulic throttle subject to the approval of Renfrewshire Council and Scottish Executive / Amey Highways, designed to release flows at a controlled rate. Flows in excess of the network discharge limit will be attenuated within storage capacity provided above the permanent water level in the wetland. As the storm peak recedes attenuated runoff will slowly release to the watercourse.

5.25 In the event of a serious spillage or pollution incident on the interchange that would overwhelm the treatment potential of the SUDS wetlands it is proposed that a pollution control valve, in accordance with Renfrewshire Council, Scottish Executive / Amey Highways and SEPA, be fitted downstream of the hydraulic throttle to allow defence against downstream pollution.

5.26 In accordance with current Renfrewshire Council policy surface water discharges from new developments directly to a watercourse should be limited to the existing 1 in 2 year 'greenfield' runoff rate estimated to be in the region of 8 l/s/ha.

5.27 Given the above considerations the following design parameters are assigned to the three separate drainage networks -

Drainage Network	Contributing Area (ha)	Treatment Volume (3Vt) (m^3)	Network Discharge Limit (l/s)	Approximate Attenuation Storage* (m^3)
Western Roundabout and associated realignment of A8 to west of M8.	1.37	495	11	770
Eastern Roundabout and associated realignment of A8 to east of M8	0.42	150	4	210
On and Off Ramps to and from M8	1.72	620	14	970

Table 5.2 – Summary of drainage network design parameters (Refer to Appendix D for calculations)

*(Note - *preliminary estimate of storage required for critical 200 year event plus 10% climate change allowance)*

5.27 Given the proximity of Glasgow International Airport, which is sited some 3km from the proposed interchange, it is feasible that the incorporation of any new large open water zones would represent an increased birdstrike to aircraft risk. This has been addressed through consultation with statutory consultee BAA, owners and operators of Glasgow International Airport, and it is considered that where SUDS wetlands are necessary birdstrike risk can be minimised through a number of design techniques which reduce the attractiveness of the water bodies to large birds.

5.28 It is therefore recommended that the wetlands have a significant proportion of shallow (< 0.5m) waters that through reduction in open water are less attractive to large birds. Inturn significant areas of shallow waters encourage natural colonisation of emergent plants on the pond bed improving the treatment / biodiversity potential and reducing adverse Health and Safety risk. Varying depths and baffles should been incorporated within the wetland or pond design ensuring an extended drainage path through the pond to enhance treatment, create a wide range of habitats and increase visual amenity.

5.29 It is recommended to drain the wetlands via a submerged reverse pipe outlet, which ensures a robust design against blockage, visual impact and conveyance of any residual light oil pollution to the receiving watercourse.

5.30 It is recognised that SUDS wetlands provide an intrinsically attractive feature and focal point within the landscape attracting adults and children alike to investigate the water features, leading to an increased risk of accidents such as drowning.

5.31 In order to accurately quantify the risk to public health a Risk Assessment and Risk Control Strategy should be compiled in accordance with Safety at Inland Water Sites – Operational Guidelines published by the RoSPA 1999 and should be carried out as part of the detailed design process.

Proposed Wetland Locations

5.32 On review of the interchange layout it is considered that the most feasible location for a wetland to provide treatment for the drainage network serving the western roundabout is to the east of the proposed roundabout in the farmland between the A8 and the M8.

5.33 To provide the necessary treatment of the eastern roundabout drainage network it is considered that the most practical location for a SUDS wetland is within the existing farmland between the proposed M8 on ramp and the A8, adjacent to the Lin Burn.

5.34 It is considered that the most practical location for the SUDS wetland to serve the proposed M8 on and off ramps is to the southeast of the proposed interchange in the existing farmland between the proposed on ramp and the Lin Burn. To convey flows to this location from the proposed off ramp a new sewer requires to be constructed beneath the existing M8 carriageway.

5.35 The SUDS Masterplan drawing for the development, attached in *Appendix E*, shows the proposed wetland locations and indicative envelope spaces. More detailed drawings for the proposed SUDS wetlands can be found in *Appendix F*, *Appendix G* and *Appendix H* for the western roundabout, eastern roundabout and on/off ramp facilities respectively.

Watercourse/Ditch Diversion Works

5.36 As discussed above it is considered that the most feasible location for a wetland to provide treatment for the drainage network serving the western roundabout is to the east of the proposed roundabout in the farmland between the A8 and the M8. To facilitate the new roundabout, associated realignment of the A8 and the proposed SUDS wetland area it is considered necessary to divert the existing land drain which runs along the northern toe slope of the existing A8. It is therefore proposed to create a new channel from Lochranza Cottage which will follow the northern toe slope of the new embankments associated with realigned A8 and proposed roundabout. Downstream of the roundabout it is proposed to route the diverted channel around the northern and eastern side of SUDS wetland and then along the top slope of the realigned A8 embankments before rejoining the original channel immediately upstream of the 600mm diameter culvert beneath the M8.

5.37 The proposed off ramp alignment requires diversion of the existing drainage ditch which flows south easterly along the north eastern boundary of the former landfill site. Following consultation with SEPA it was indicated that the preferred route for the diverted ditch would be to the northeast of its existing alignment to reduce the risk of leachate pollution from the former landfill. On review of the proposed interchange layout routing the existing ditch to the northeast is considered unfeasible given the lack of space between the proposed off ramp and the A8. It is therefore proposed to divert the ditch to the southwest of its existing alignment but keeping it as close as practically possible to the off ramp embankment. To provide protection from potential leachates entering the watercourse from the landfill the new diverted channel will be lined with a robust and sustainable self sealing geosynthetic clay liner.

5.38 The road corridor of the proposed off ramp and associated supporting embankments encompass a marginal portion of the existing treatment ponds between the motorway and the former Southbar Landfill site. At the time of inspection the eastern extents of the existing treatment ponds, which will be replaced by the off ramp embankments, were noted to be less densely vegetated than the western majority of the ponds. It is considered that the majority of the treatment potential through these ponds is provided by the more densely vegetated zones adjacent to the former landfill site. It is therefore considered that the partial loss of some of the eastern extents of the existing treatment ponds is unlikely to have a material impact on downstream water quality as the more densely vegetated zones remain unaffected. It is further considered likely that the upstream works to divert the ditch will reduce pathways from the former landfill to the watercourse thus potentially increasing water quality.

5.39 The SUDS Masterplan drawing for the development, attached in *Appendix E*, shows the proposed watercourse diversions. More detailed drawings for the proposed watercourse diversions can be found in *Appendix F* and *Appendix H* respectively.

Proposed Culvert Crossing

5.40 Due to the proposed on ramp layout a new crossing over the existing land drainage ditch is required approximately 15 metres downstream of the outlet from the 750mm diameter culvert which conveys flows beneath the M8. The preferred option, a bottomless arch profile culvert is considered unpractical at this location given the relatively flat surrounding topography and arch profile required. It is therefore proposed to construct a 26 metre length, 1200mm diameter concrete pipe culvert in accordance with the Design Manual for Roads and Bridges (DMRB HA 107/04), subject to approval from Renfrewshire Council, SEPA and Amey Highways. By utilising a concrete pipe culvert as an alternative to a bottomless arch structure, design levels of the on ramp are lowered and as a result the overall footprint of the carriageway and associated embankments is reduced.

5.41 The SUDS Masterplan drawing for the development, attached in *Appendix E*, shows the proposed culvert crossing location. More detailed drawings for the proposed crossing can be found in *Appendix H*.

6.0 RECOMMENDED DRAINAGE STRATEGY

6.1 In developing this Flood Risk and Drainage Impact Assessment Report for the proposed M8/A8 Interchange at Bishopston the recommendations have focused on three main issues, managing water quantity and quality using sustainable urban drainage systems in accordance with the SUDS design manual for Scotland and Northern Ireland, without compromising public health and safety, and minimising the environmental footprint of the proposed development by improving the current ecological status of the site, inline with SEPA's Habitat Enhancement Initiative.

6.2 In order to minimise the affect of the proposed development on the receiving waters, it is the recommendation of this report that the surface water drainage system be designed in such a way that flows discharge from the interchange at a controlled rate after undergoing robust treatment using SUDS site controls.

General Recommendations

6.3 To reduce the risk of water pollution it is recommended that prior to the commencement of on-site works the Developer compile method statements, which will be subject to the approvals of Renfrewshire Council and SEPA detailing proposals to limit the risk of water pollution during the construction phase of the interchange.

6.4 It is recommended that post-development runoff be limited to the existing 1 in 2 year 'greenfield' runoff rate, estimated to be equivalent to 8 litres per second per hectare, up to the critical 1 in 200 year design storm event. Attenuating post development discharges through adoption of this post development discharge limit will allow development of the interchange whilst achieving a neutral or better effect on downstream flooding issues within the receiving catchment.

6.5 To facilitate construction, maintenance and post-development monitoring of the SUDS management train, it is recommended that the development be drained in a similar manner throughout.

6.6 On review of the interchange layout it is considered likely that the drainage network will have to be split into three separate systems given the proposed levels and the separate adoption of the A8 roundabout and the M8 slip roads by Renfrewshire Council and Amey Highways respectively. These systems will serve the eastern roundabout, western roundabout, and M8 slip roads respectively.

6.7 It is suggested that the most suitable method of providing SUDS treatment would be to incorporate site control wetlands for each drainage network within the development landscaping. The outflows from each wetland will be fitted with a hydraulic throttle, subject to the approval of Renfrewshire Council, Scottish Executive / Amey Highways and SEPA, designed to release flows at a controlled rate. Flows passing through the throttle would then outfall to the nearest watercourse through a suitable outlet structure acceptable to the appropriate authorities. During more extreme storm events flows which are throttled will be temporary stored above permanent water level within the wetlands. As the storm peak recedes this attenuated runoff will slowly be released to the watercourse via the throttle.

6.8 It is recommended that to provide protection against a serious spillage or pollution incident on the interchange, that would overwhelm the treatment potential of the receiving SUDS wetlands, that pollution control valves be fitted downstream of the hydraulic throttle allowing protection against downstream pollution. Such controls should be designed in accordance with HD 33 (DMRB 4.2) and subject to the approval of Renfrewshire Council, Scottish Executive / Amey Highways and SEPA. Means of control should be simple to operate and capable of being managed easily and quickly by the emergency services. Signages to aid emergency services locate control devices should be erected in accordance with HD 33 (DMRB 4.2).

6.9 It should be noted that special design parameters need to be considered for wetlands at this location given the proximity of Glasgow International Airport. BAA have indicated that any surface water bodies proposed as part of the interchange must meet their safeguarding requirements to ensure that large birds are not attracted to these features which may in turn pose a risk to operations assocated with the airport.

6.10 It is recommended that as part of the detailed design process the developer undertake a holistic sensitivity analysis of the surface water drainage system for what is termed the critical 2, 25 and 200 year storm event demonstrating any temporary surface water storage areas, overland flow paths and the sensitivity of the site attenuation structures during extreme rainfall events. The sensitivity analysis should include a 10% rainfall uplift factor to assess the possible impact of future climate change.

6.11 To accommodate the new interchange layout it is necessary to divert some existing ditches within the vicinity of the site. The formation of a new roundabout on the A8, to the west of the M8, and associated realignment works to the A8 to accommodate the new roundabout require the existing ditch to the north of the A8 carriageway to be diverted. The proposed diversion route takes the ditch along the northern toe slope embankments of the realigned A8 and western roundabout, around the proposed SUDS wetland prior to discharging into the existing 600mm diameter culvert beneath the M8.

6.12 It is also deemed necessary, that to facilitate the proposed off ramp, to divert the existing drainage ditch which flows in the strip of land adjacent to the landfill and A8 then M8 respectively. On review of the interchange layout the only practical location for this diverted channel is to the south. It is recognised that this encroaches closer to the former Southbar Landfill site therefore it is recommended that the new channel is protected from potential leachate contamination via a robust liner.

6.13 It is recommended that trial pits investigations be carried out along the alignment of the proposed ditch diversion adjacent to the proposed off ramp. Should any landfill material be encountered during these investigations or during construction of the new channel then it should be adequately removed, disposed to a suitably registered landfill and replaced with inert material.

6.14 The supporting embankments of the proposed off ramp encompass a marginal portion of the existing treatment ponds located between the former landfill site and the M8. It is considered that the partial loss of some of the existing treatment ponds is unlikely to have a material impact on downstream water quality. Given the upstream diversion to the ditch, which will reduce vectors from the landfill to the watercourse by robust lining of the new channel, it is considered that the works to this catchment have the potential increase downstream water quality over existing conditions.

6.15 It is recommended that the necessary crossing over the existing drainage ditch to facilitate the proposed on ramp is achieved by using a pipe culvert designed in accordance with DMRB standards and subject to the Approval of SEPA, Renfrewshire Council and Scottish Executive / Amey Highways. It is recognised that a pipe arch culvert is SEPA's preferred option; however, this type of crossing at this location is considered unpractical and could result in an elevated road profile which would increase embankments widths and length of culverted watercourse.

6.16 It is further recommended that an ownership plan and maintenance regime be established for all diverted ditches/watercourses, the existing treatment ponds and proposed SUDS wetlands to ensure long term sustainability. It is recommended that the maintenance regime be forwarded to SEPA, Renfrewshire Council and Scottish Executive / Amey Highways for Approval prior to implementation.

6.17 Under the Water Environment and Water Services (Scotland) Act 2003 the recently introduced Water Environment (Controlled Activities) (Scotland) Regulations 2005 (or CAR) brings into force new controls for point source discharges, abstractions, impoundments, and engineering works in or near inland waters. Given that the interchange requires realignment works of existing ditches and a new culverted section to be constructed a complex CAR license for the works will need to be made to SEPA for authorisation.

6.18 It is essential to maintain the integrity of the existing drainage paths under the M8 motorway provided by the 600mm and 750mm diameter culverts. Given the proximity of these culverts to the proposed interchange, it is recommended that pre and post development CCTV surveys are carried out. This will provide evidence of fitness for purpose and baseline of pre-construction conditions.

7.0 CONCLUSIONS

7.1 This report has been produced to assess the methods by which surface water flows arising from the proposed M8/A8 Interchange at Bishopton may be managed to achieve the requirements of the Renfrewshire Council, Scottish Environmental Protection Agency, Amey Highways and British Airports Authority.

7.2 Within the proposals, consideration has been given to the guidance set out in the SUDS Manual, the Statutory Requirements of Renfrewshire Council and Scottish Planning Policy 7 – Flooding and Planning (2004). Further the requirements of SEPA and BAA have been considered in determining the most suitable drainage strategy for interchange.

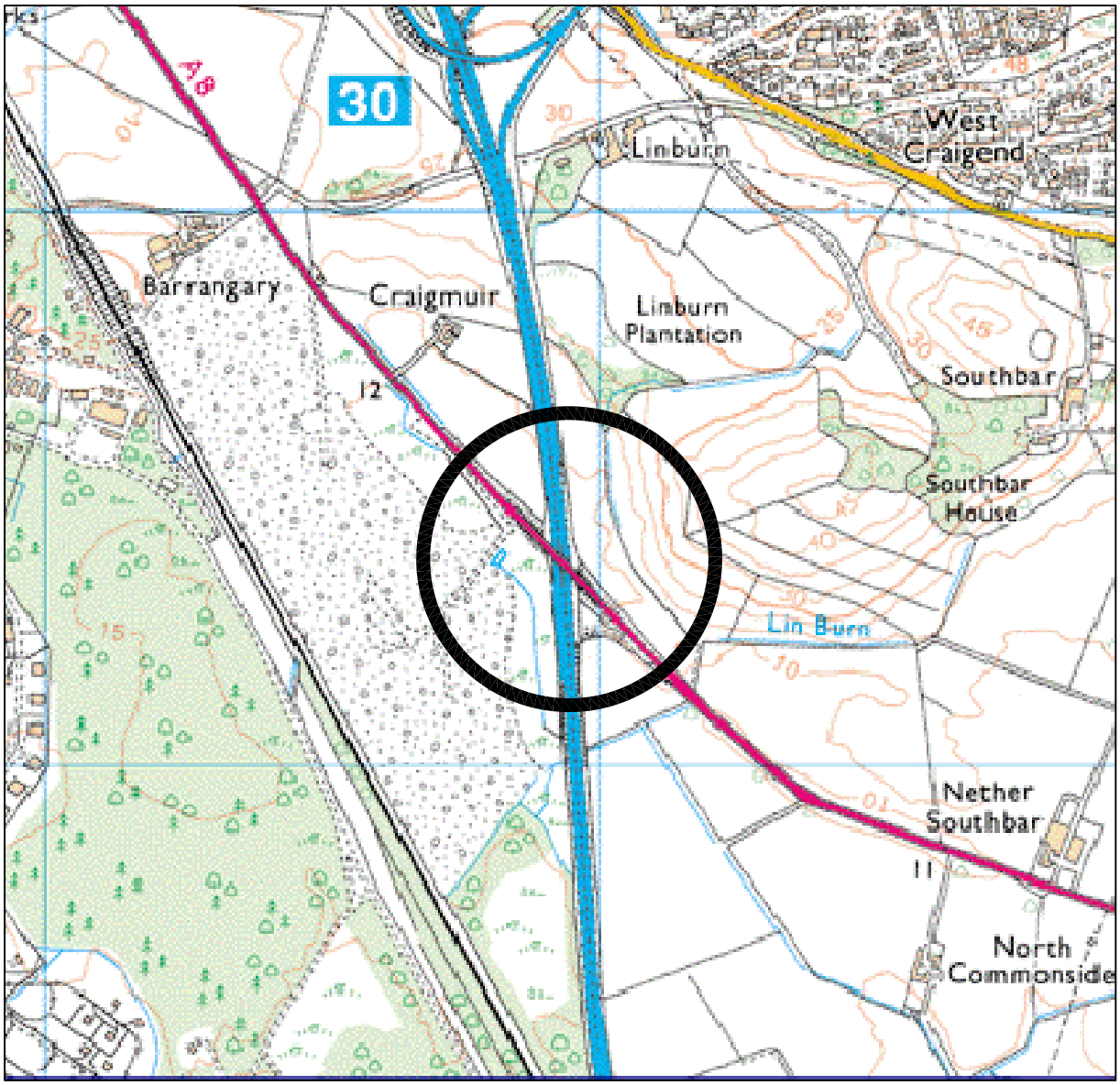
7.3 It is the conclusion of this report that by adopting the recommendations detailed within this report the M8/A8 Interchange at Bishopton will have a neutral or positive affect on the receiving catchment. This will be achieved by protecting the receiving catchment from flash floods and erosion usually associated with the urbanisation of sites. It is considered that development at this location provides an opportunity to increase water quality status of the existing drainage ditch adjacent to the former landfill site by diverting the ditch through a new lined channel and therefore preventing leachate from the landfill laterally migrating into the watercourse at this location. Water quality discharge from developed areas will be maintained as part of a robust SUDS treatment system.

7.4 After acceptance of the recommendations set out in this report, the information will form the basis for the detailed design of the drainage for the development site, which should be verified by analysing the SUDS holistically for what is termed the critical 200-year storm event including a factor of safety of 10% to allow for possible climate change.

7.5 It will be the requirement of the Developer to demonstrate that the criteria set out in this report can be achieved to the satisfaction of the Renfrewshire Council, Amey Highways and SEPA who will enforce this under the Roads (Scotland) Act, National Planning Policy NPPG7 - Planning and Flooding, Sewerage (Scotland) Act and Water Environment and Water Services (Scotland) Act 2003 through implementation of the Water Environment (Controlled Activities) (Scotland) Regulations 2005 respectively.

7.6 For the Bishopton area, Renfrewshire Council is the Local Authority responsible for carrying out the Statutory Duties of flood prevention legislation, The Flood Prevention Act, 1961, as amended by The Flood Prevention and Land Drainage Act, 1997. It is the responsibility of the Developer to demonstrate to the satisfaction of the Local Authority that any proposed discharge of surface water run-off from the proposed development to any watercourse should have no adverse effect on any watercourse located within, upstream and downstream of the proposed development.

APPENDIX A
SITE LOCATION PLAN
(DBA DRG. NO. 06667(20)01)



SITE LOCATION
Grid reference at centre of site - NS 449 693 GB Grid

DO NOT scale from this drawing

Client: REDROW HOMES (SCOTLAND) LTD	Drawing Title: SITE LOCATION PLAN			Rev. / Revision details / By Date / Checked Date	
Project: M8 BISHOPTON INTERCHANGE	Drawn: N.I.	Checked: R.J.D.		DOUGALL BAILLIE ASSOCIATES CONSULTING ENGINEERS Civil . Structural . Transportation 3 Glenfield Road Kelvin East Kilbride G75 0RA Tel: 01355 266480 Fax: 01355 221991	
	Date: 26.06.06	Date: 26.06.06			
	Scale: 1:12500	Drg. No. 06667(20)01			

APPENDIX B
FLOOD FLOW AND GREENFIELD RUNOFF ESTIMATES

Dougall Baillie Associates
CONSULTING ENGINEERS

3 GLENFIELD ROAD, KELVIN
EAST KILBRIDE G75 0RA
Tel: (01355) 266480 Fax: (01355) 221991
E-Mail: enquiries@dougallbaillie.com

Calculation No.	06667calc01	Page No. 1 of 2
Calculation	Summary of Flood Flow and Greenfield Runoff Estimates	

Revisions					Rev. Date

Date	Initials	Checked
28.08.06	GM	RJD

Project
Redrow Homes (Scotland) Ltd
M8/A8 Interchange, Bishopton

Flood Flow and Greenfield Runoff Estimations

There are no known flow gauging stations on the Lin Burn and the estimation of surface water runoff and flood flows arising from small catchments with no flow records is inherently difficult. In the absence of direct measurements of rainfall and runoff, a variety of techniques are available as described in the Flood Studies Report, Institute of Hydrology Supplemental Reports, Flood Estimation Handbook and guidance notes for agricultural drainage, all of which are based upon assumptions with regard to the proportion of rainfall contributing to runoff.

For the purposes of this Report likely flood flows and greenfield runoff release rates have been estimated using the FEH Rainfall-Runoff method, Revitalisation of the FSR/FEH rainfall-runoff method and Institute of Hydrology Flood Estimation for Small Catchments methodology (IH Report 124).

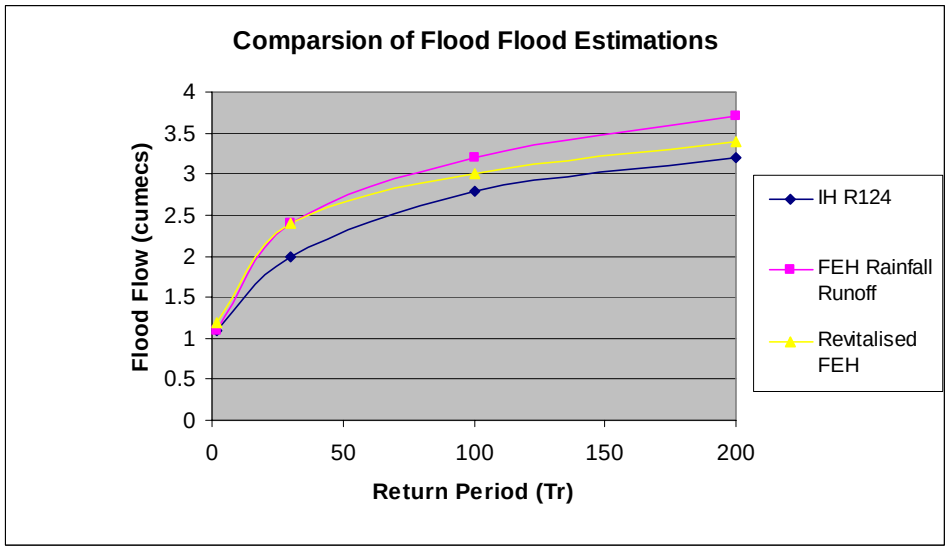


Figure 1 – Comparison of Flood Flow Estimations

A review of Figure 1 indicates that the FEH rainfall runoff method yields the highest estimate of flood flows. It is therefore recommended that this method is selected for design flood flows as this provides the most conservative flow estimations.

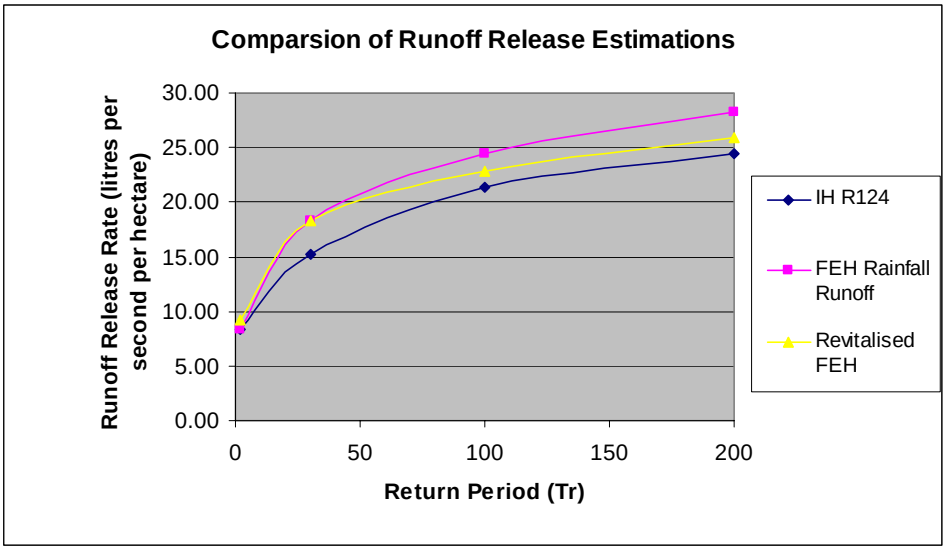


Figure 2 – Comparison of Greenfield Release Estimations

In accordance with current Renfrewshire Council policy surface water discharges from new developments directly to a watercourse should be limited to the existing 1 in 2 year 'greenfield' runoff rate. A review of Figure 2 indicates that all three methods estimate a 1 in 2 year greenfield runoff rate in the region of 8 l/s/ha. It is therefore recommended that this rate is adopted for determination of post-development discharge limits for the site.

FEH RAINFALL RUNOFF METHOD

(USING JBA FLOOD ESTIMATION SOFTWARE)

Flood Estimation Software

Catchment:	River Gryfe	**OS NGR:**	NS 69100 45100 669100 245100
Watercourse:	Lin Burn	**Area (km²):**	1.31
Site:	A8/M8 Interchange	**Site Code:**	Lin Burn

Project Details

Project Title:	A8/M8 Interchange Bishopton
Project Code:	06667
Project Manager:	Rene Dobson
Project Modeller:	Gregor Muirhead
Office:	Dougall Baillie Associates
Client Name:	Redrow Homes (Scotland) Ltd
Client Contact:	Redrow Homes (Scotland) Ltd
Client Department:	Redrow Homes (Scotland) Ltd

Catchment Image

Not Available

Catchment Descriptors

Descriptor	Value	Altered	Notes
Area (km²)	1.31		
SAAR (mm)	1099		
BFIHOST	0.414		
SPRHOST	41.5		
URBEXT	0.031		
FARL	1		
DPLBAR (km)	1.02		
PROPWET	0.61		
DPSBAR (m/km)	43.9		

Software Version 1.3.11

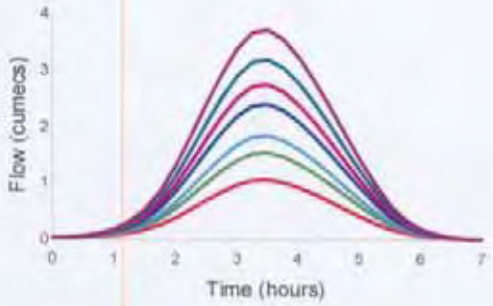
Flood Estimation Software Results

Catchment:	River Gryfe	**OS NGR:**	NS 69100 45100 669100 245100
Watercourse:	Lin Burn	**Area (km²):**	1.31
Site:	A8/M8 Interchange	**Site Code:**	Lin Burn

FEH Statistical Method

Analysis not available

FEH Rainfall Runoff Method



T (Yrs)	AEP (%)	Peak Flow (m³/s)	Peak Flow (l/s/ha)	Volume ('000m³)
2	50.00	1.1	8.2	10.7
5	20.00	1.6	11.8	15.2
10	10.00	1.9	14.1	18.0
30	3.33	2.4	18.4	22.0
50	2.00	2.8	21.1	26.4
100	1.00	3.2	24.4	30.5
200	0.50	3.7	28.3	35.3

Rational Method

Analysis not available

Modified Rational Method

Analysis not available

Software Version 1.3.11

Flood Estimation Software Parameters

Catchment:	River Gryfe	**OS NGR:**	NS 69100 45100 669100 245100
Watercourse:	Lin Burn	**Area (km²):**	1.31
Site:	A8/M8 Interchange	**Site Code:**	Lin Burn

FEH Rainfall Runoff Method

	Estimates From Catchment Descriptors	Best Estimates	Adjusted
Time to Peak Tp(0) (hours)	1.43	1.43	
Timestep (hours)	0.25	0.25	
Standard Percentage Runoff (%)	41.50	41.50	
Baseflow (cumecs)	0.043	0.043	
Storm Duration (hours)	3.25	3.25	
Areal Reduction Factor	0.972	0.972	

Flow RP (years)	**2**	**5**	**10**	**30**	**50**	**100**	**200**
Rainfall RP (years)	2	8	17	50	81	140	247
Rainfall Depth (mm)	18.5	27.0	32.4	41.7	46.7	53.0	60.4

Catchment Wetness Index 123.34 **Storm Profile** Winter

Comments

None

Rational Method

Analysis not available

Modified Rational Method

Analysis not available

Software Version 1.3.11

Flood Estimation Software Parameters

Catchment:	River Gryfe	**OS NGR:**	NS 69100 45100 669100 245100
Watercourse:	Lin Burn	**Area (km²):**	1.31
Site:	A8/M8 Interchange	**Site Code:**	Lin Burn

FEH Statistical Method

Analysis not available

Pooling Group Stations

Analysis not available

Software Version 1.3.11

REVITALISED FSR/FEH RAINFALL RUNOFF METHOD

(USING SPREADSHEET IMPLEMENTATION OF THE DESIGN METHOD.
SPREADSHEET APPLICATION VERSION 3.1)

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Gregor Muirhead	**Catchment name**	Lin Burn @ M8/A8	**Date/time modelled**	31-Aug-2006 14:29
Company name	Dougall Baillie Associates	**Catchment easting**	245100	**Version**	1.3
Project name	Bishopton A8/M8 Intercha	**Catchment northing**	669100		
		Catchment area	1.31		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	2	**C_{max} (mm)**	291	**T_p (hr)**	0.85	**BL (hr)**	20
Duration (hr)	1.9	**C_{ini} (mm)**	145	**U_p**	0.65	**BR**	1.21
Timestep (hr)	0.1	**α factor**	1	**U_k**	0.8	**BF_0 (m^3/s)**	0.1
Season	Winter						

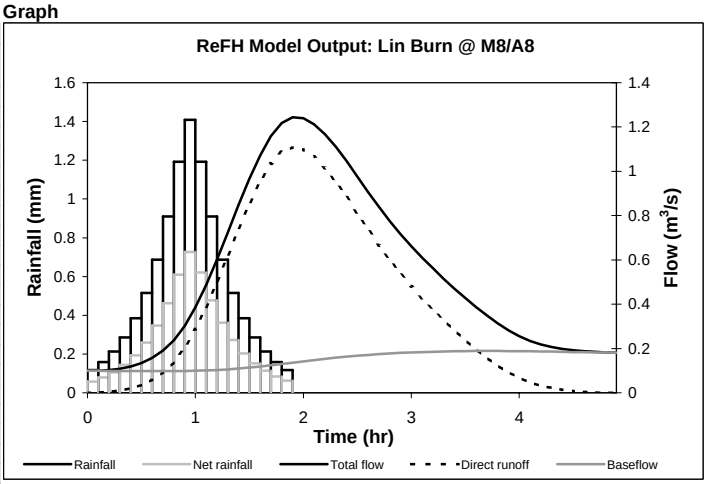
Summary of results

FEH DDF rainfall (mm)	14.9	**Peak rainfall (mm)**	1.4
Design rainfall (mm)	10.3	**Peak flow (m^3/s)**	1.2

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	**mm**	**mm**	**m^3/s**	**m^3/s**	**m^3/s**
0.0	0.1	0.1	0.0	0.1	0.1
0.1	0.2	0.1	0.0	0.1	0.1
0.2	0.2	0.1	0.0	0.1	0.1
0.3	0.3	0.1	0.0	0.1	0.1
0.4	0.4	0.2	0.0	0.1	0.1
0.5	0.5	0.3	0.0	0.1	0.1
0.6	0.7	0.3	0.1	0.1	0.2
0.7	0.9	0.5	0.1	0.1	0.2
0.8	1.2	0.6	0.1	0.1	0.2
0.9	1.4	0.7	0.2	0.1	0.3
1.0	1.2	0.6	0.3	0.1	0.4
1.1	0.9	0.5	0.4	0.1	0.5
1.2	0.7	0.4	0.5	0.1	0.6
1.3	0.5	0.3	0.6	0.1	0.7
1.4	0.4	0.2	0.7	0.1	0.8
1.5	0.3	0.2	0.9	0.1	1.0
1.6	0.2	0.1	1.0	0.1	1.1
1.7	0.2	0.1	1.0	0.1	1.2
1.8	0.1	0.1	1.1	0.1	1.2
1.9	0.0	0.0	1.1	0.1	1.2
2.0	0.0	0.0	1.1	0.1	1.2
2.1	0.0	0.0	1.1	0.1	1.2
2.2	0.0	0.0	1.0	0.2	1.2
2.3	0.0	0.0	1.0	0.2	1.1
2.4	0.0	0.0	0.9	0.2	1.0
2.5	0.0	0.0	0.8	0.2	1.0
2.6	0.0	0.0	0.7	0.2	0.9
2.7	0.0	0.0	0.7	0.2	0.8
2.8	0.0	0.0	0.6	0.2	0.8
2.9	0.0	0.0	0.5	0.2	0.7
3.0	0.0	0.0	0.5	0.2	0.7
3.1	0.0	0.0	0.4	0.2	0.6
3.2	0.0	0.0	0.4	0.2	0.6
3.3	0.0	0.0	0.3	0.2	0.5
3.4	0.0	0.0	0.3	0.2	0.5
3.5	0.0	0.0	0.2	0.2	0.4
3.6	0.0	0.0	0.2	0.2	0.4
3.7	0.0	0.0	0.2	0.2	0.3
3.8	0.0	0.0	0.1	0.2	0.3
3.9	0.0	0.0	0.1	0.2	0.3
4.0	0.0	0.0	0.1	0.2	0.3
4.1	0.0	0.0	0.0	0.2	0.2
4.2	0.0	0.0	0.0	0.2	0.2
4.3	0.0	0.0	0.0	0.2	0.2
4.4	0.0	0.0	0.0	0.2	0.2
4.5	0.0	0.0	0.0	0.2	0.2
4.6	0.0	0.0	0.0	0.2	0.2
4.7	0.0	0.0	0.0	0.2	0.2
4.8	0.0	0.0	0.0	0.2	0.2
4.9	0.0	0.0	0.0	0.2	0.2
Total (mm)	**10.3**	**5.3**	**5.3**	**2.1**	**7.4**

Graph



Audit comments

Catchment

Catchment descriptors imported from file
Catchment descriptor file = 'Lin Burn.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.414 used
PROPWET value of 0.61 used
SAAR value of 1099 used
DPLBAR value of 1.02 used
DPSBAR value of 43.9 used
URBEXT value of 0.031 used
C value of -0.019 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

D1 value of 0.407 used
D2 value of 0.4 used
D3 value of 0.412 used
E value of 0.253 used
F value of 2.352 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.72 applied
ReFH design standard Areal Reduction Factor of 0.97 applied

Loss Model
C_{Max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Gregor Muirhead	**Catchment name**	Lin Burn @ M8/A8	**Date/time modelled**	31-Aug-2006 14:29
Company name	Dougall Baillie Associates	**Catchment easting**	245100	**Version**	1.3
Project name	Bishopton A8/M8 Intercha	**Catchment northing**	669100		
		Catchment area	1.31		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	30	**C_{max} (mm)**	291	**T_p (hr)**	0.85	**BL (hr)**	20
Duration (hr)	1.9	**C_{ini} (mm)**	145	**U_p**	0.65	**BR**	1.21
Timestep (hr)	0.1	**α factor**	0.91	**U_k**	0.8	**BF_0 (m^3/s)**	0.1
Season	Winter						

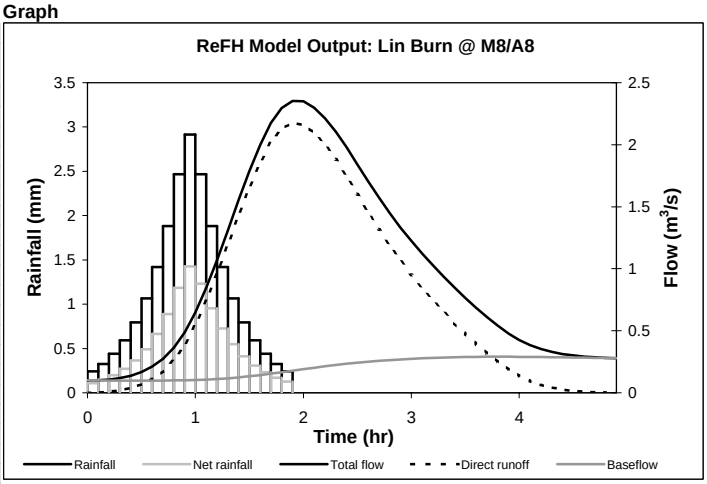
Summary of results

FEH DDF rainfall (mm)	30.8	**Peak rainfall (mm)**	2.9
Design rainfall (mm)	21.4	**Peak flow (m^3/s)**	2.4

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	**mm**	**mm**	**m^3/s**	**m^3/s**	**m^3/s**
0.0	0.2	0.1	0.0	0.1	0.1
0.1	0.3	0.1	0.0	0.1	0.1
0.2	0.4	0.2	0.0	0.1	0.1
0.3	0.6	0.3	0.0	0.1	0.1
0.4	0.8	0.4	0.0	0.1	0.1
0.5	1.1	0.5	0.1	0.1	0.2
0.6	1.4	0.7	0.1	0.1	0.2
0.7	1.9	0.9	0.2	0.1	0.3
0.8	2.5	1.2	0.3	0.1	0.4
0.9	2.9	1.4	0.4	0.1	0.5
1.0	2.5	1.2	0.5	0.1	0.6
1.1	1.9	1.0	0.7	0.1	0.8
1.2	1.4	0.7	1.0	0.1	1.1
1.3	1.1	0.5	1.2	0.1	1.3
1.4	0.8	0.4	1.4	0.1	1.6
1.5	0.6	0.3	1.7	0.1	1.8
1.6	0.4	0.2	1.9	0.1	2.0
1.7	0.3	0.2	2.0	0.2	2.2
1.8	0.2	0.1	2.1	0.2	2.3
1.9	0.0	0.0	2.2	0.2	2.4
2.0	0.0	0.0	2.2	0.2	2.3
2.1	0.0	0.0	2.1	0.2	2.3
2.2	0.0	0.0	2.0	0.2	2.2
2.3	0.0	0.0	1.9	0.2	2.1
2.4	0.0	0.0	1.7	0.2	2.0
2.5	0.0	0.0	1.6	0.2	1.8
2.6	0.0	0.0	1.5	0.3	1.7
2.7	0.0	0.0	1.3	0.3	1.6
2.8	0.0	0.0	1.2	0.3	1.4
2.9	0.0	0.0	1.1	0.3	1.3
3.0	0.0	0.0	1.0	0.3	1.2
3.1	0.0	0.0	0.8	0.3	1.1
3.2	0.0	0.0	0.7	0.3	1.0
3.3	0.0	0.0	0.7	0.3	0.9
3.4	0.0	0.0	0.6	0.3	0.8
3.5	0.0	0.0	0.5	0.3	0.8
3.6	0.0	0.0	0.4	0.3	0.7
3.7	0.0	0.0	0.3	0.3	0.6
3.8	0.0	0.0	0.3	0.3	0.5
3.9	0.0	0.0	0.2	0.3	0.5
4.0	0.0	0.0	0.1	0.3	0.4
4.1	0.0	0.0	0.1	0.3	0.4
4.2	0.0	0.0	0.1	0.3	0.4
4.3	0.0	0.0	0.0	0.3	0.3
4.4	0.0	0.0	0.0	0.3	0.3
4.5	0.0	0.0	0.0	0.3	0.3
4.6	0.0	0.0	0.0	0.3	0.3
4.7	0.0	0.0	0.0	0.3	0.3
4.8	0.0	0.0	0.0	0.3	0.3
4.9	0.0	0.0	0.0	0.3	0.3
Total (mm)	**21.4**	**10.5**	**10.5**	**2.9**	**13.3**

Graph



Audit comments

Catchment

Catchment descriptors imported from file
Catchment descriptor file = 'Lin Burn.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.414 used
PROPWET value of 0.61 used
SAAR value of 1099 used
DPLBAR value of 1.02 used
DPSBAR value of 43.9 used
URBEXT value of 0.031 used
C value of -0.019 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

D1 value of 0.407 used
D2 value of 0.4 used
D3 value of 0.412 used
E value of 0.253 used
F value of 2.352 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.72 applied
ReFH design standard Areal Reduction Factor of 0.97 applied

Loss Model
C_{Max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Gregor Muirhead	**Catchment name**	Lin Burn @ M8/A8	**Date/time modelled**	31-Aug-2006 14:28
Company name	Dougall Baillie Associates	**Catchment easting**	245100	**Version**	1.3
Project name	Bishopton A8/M8 Intercha	**Catchment northing**	669100		
		Catchment area	1.31		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	100	**C_{max} (mm)**	291	**T_p (hr)**	0.85	**BL (hr)**	20
Duration (hr)	1.9	**C_{ini} (mm)**	145	**U_p**	0.65	**BR**	1.21
Timestep (hr)	0.1	**α factor**	0.83	**U_k**	0.8	**BF_0 (m^3/s)**	0.1
Season	Winter						

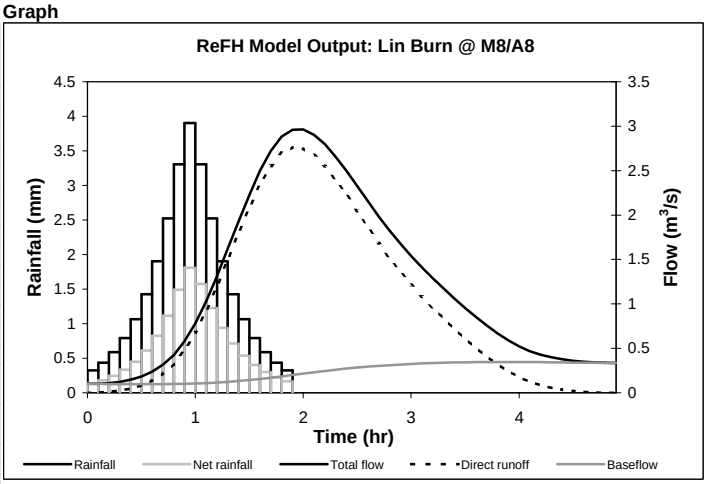
Summary of results

FEH DDF rainfall (mm)	41.3	**Peak rainfall (mm)**	3.9
Design rainfall (mm)	28.6	**Peak flow (m^3/s)**	3

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	**mm**	**mm**	**m^3/s**	**m^3/s**	**m^3/s**
0.0	0.3	0.1	0.0	0.1	0.1
0.1	0.4	0.2	0.0	0.1	0.1
0.2	0.6	0.2	0.0	0.1	0.1
0.3	0.8	0.3	0.0	0.1	0.1
0.4	1.1	0.5	0.0	0.1	0.1
0.5	1.4	0.6	0.1	0.1	0.2
0.6	1.9	0.8	0.1	0.1	0.2
0.7	2.5	1.1	0.2	0.1	0.3
0.8	3.3	1.5	0.3	0.1	0.4
0.9	3.9	1.8	0.5	0.1	0.6
1.0	3.3	1.6	0.7	0.1	0.8
1.1	2.5	1.2	0.9	0.1	1.0
1.2	1.9	0.9	1.2	0.1	1.3
1.3	1.4	0.7	1.5	0.1	1.6
1.4	1.1	0.5	1.8	0.1	1.9
1.5	0.8	0.4	2.1	0.1	2.2
1.6	0.6	0.3	2.3	0.2	2.5
1.7	0.4	0.2	2.6	0.2	2.7
1.8	0.3	0.2	2.7	0.2	2.9
1.9	0.0	0.0	2.8	0.2	3.0
2.0	0.0	0.0	2.7	0.2	3.0
2.1	0.0	0.0	2.7	0.2	2.9
2.2	0.0	0.0	2.6	0.2	2.8
2.3	0.0	0.0	2.4	0.3	2.7
2.4	0.0	0.0	2.2	0.3	2.5
2.5	0.0	0.0	2.0	0.3	2.3
2.6	0.0	0.0	1.9	0.3	2.2
2.7	0.0	0.0	1.7	0.3	2.0
2.8	0.0	0.0	1.5	0.3	1.8
2.9	0.0	0.0	1.4	0.3	1.7
3.0	0.0	0.0	1.2	0.3	1.5
3.1	0.0	0.0	1.1	0.3	1.4
3.2	0.0	0.0	1.0	0.3	1.3
3.3	0.0	0.0	0.8	0.3	1.2
3.4	0.0	0.0	0.7	0.3	1.1
3.5	0.0	0.0	0.6	0.3	1.0
3.6	0.0	0.0	0.5	0.3	0.9
3.7	0.0	0.0	0.4	0.3	0.8
3.8	0.0	0.0	0.3	0.3	0.7
3.9	0.0	0.0	0.2	0.3	0.6
4.0	0.0	0.0	0.2	0.3	0.5
4.1	0.0	0.0	0.1	0.3	0.5
4.2	0.0	0.0	0.1	0.3	0.4
4.3	0.0	0.0	0.1	0.3	0.4
4.4	0.0	0.0	0.0	0.3	0.4
4.5	0.0	0.0	0.0	0.3	0.4
4.6	0.0	0.0	0.0	0.3	0.3
4.7	0.0	0.0	0.0	0.3	0.3
4.8	0.0	0.0	0.0	0.3	0.3
4.9	0.0	0.0	0.0	0.3	0.3
Total (mm)	**28.6**	**13.3**	**13.3**	**3.3**	**16.6**

Graph



Audit comments

Catchment

Catchment descriptors imported from file
Catchment descriptor file = 'Lin Burn.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.414 used
PROPWET value of 0.61 used
SAAR value of 1099 used
DPLBAR value of 1.02 used
DPSBAR value of 43.9 used
URBEXT value of 0.031 used
C value of -0.019 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

D1 value of 0.407 used
D2 value of 0.4 used
D3 value of 0.412 used
E value of 0.253 used
F value of 2.352 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.72 applied
ReFH design standard Areal Reduction Factor of 0.97 applied

Loss Model
C_{Max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

User name	Gregor Muirhead	**Catchment name**	Lin Burn @ M8/A8	**Date/time modelled**	31-Aug-2006 14:29
Company name	Dougall Baillie Associates	**Catchment easting**	245100	**Version**	1.3
Project name	Bishopton A8/M8 Intercha	**Catchment northing**	669100		
		Catchment area	1.31		

Summary of model setup

Design rainfall parameters		Loss model parameters		Routing model parameters		Baseflow model parameters	
Return period (yr)	200	**C_{max} (mm)**	291	**T_p (hr)**	0.85	**BL (hr)**	20
Duration (hr)	1.9	**C_{ini} (mm)**	145	**U_p**	0.65	**BR**	1.21
Timestep (hr)	0.1	**α factor**	0.79	**U_k**	0.8	**BF_0 (m^3/s)**	0.1
Season	Winter						

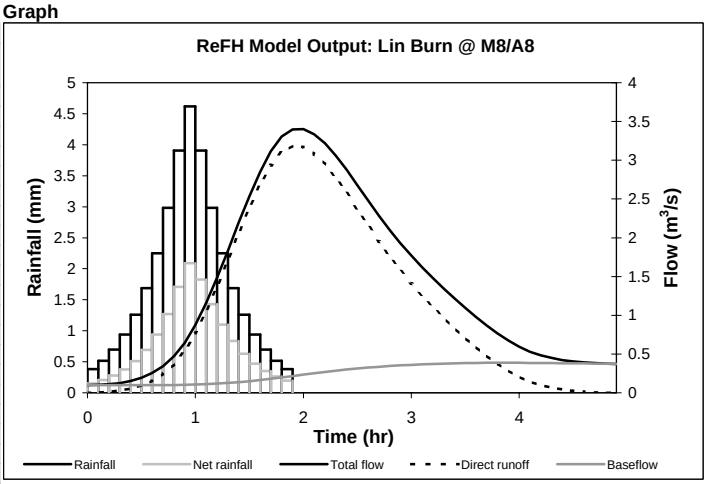
Summary of results

FEH DDF rainfall (mm)	48.8	**Peak rainfall (mm)**	4.6
Design rainfall (mm)	33.9	**Peak flow (m^3/s)**	3.4

Results

Series	Design Rainfall	Net rainfall	Direct runoff	Baseflow	Total flow
Unit	**mm**	**mm**	**m^3/s**	**m^3/s**	**m^3/s**
0.0	0.4	0.2	0.0	0.1	0.1
0.1	0.5	0.2	0.0	0.1	0.1
0.2	0.7	0.3	0.0	0.1	0.1
0.3	0.9	0.4	0.0	0.1	0.1
0.4	1.3	0.5	0.1	0.1	0.2
0.5	1.7	0.7	0.1	0.1	0.2
0.6	2.2	0.9	0.2	0.1	0.3
0.7	3.0	1.3	0.2	0.1	0.3
0.8	3.9	1.7	0.4	0.1	0.5
0.9	4.6	2.1	0.5	0.1	0.6
1.0	3.9	1.8	0.8	0.1	0.9
1.1	3.0	1.4	1.0	0.1	1.2
1.2	2.2	1.1	1.4	0.1	1.5
1.3	1.7	0.8	1.7	0.1	1.8
1.4	1.3	0.6	2.1	0.1	2.2
1.5	0.9	0.5	2.4	0.2	2.5
1.6	0.7	0.4	2.7	0.2	2.9
1.7	0.5	0.3	2.9	0.2	3.1
1.8	0.4	0.2	3.1	0.2	3.3
1.9	0.0	0.0	3.2	0.2	3.4
2.0	0.0	0.0	3.2	0.2	3.4
2.1	0.0	0.0	3.1	0.3	3.3
2.2	0.0	0.0	2.9	0.3	3.2
2.3	0.0	0.0	2.8	0.3	3.1
2.4	0.0	0.0	2.6	0.3	2.9
2.5	0.0	0.0	2.4	0.3	2.7
2.6	0.0	0.0	2.2	0.3	2.5
2.7	0.0	0.0	1.9	0.3	2.3
2.8	0.0	0.0	1.8	0.3	2.1
2.9	0.0	0.0	1.6	0.4	1.9
3.0	0.0	0.0	1.4	0.4	1.8
3.1	0.0	0.0	1.3	0.4	1.6
3.2	0.0	0.0	1.1	0.4	1.5
3.3	0.0	0.0	1.0	0.4	1.3
3.4	0.0	0.0	0.8	0.4	1.2
3.5	0.0	0.0	0.7	0.4	1.1
3.6	0.0	0.0	0.6	0.4	1.0
3.7	0.0	0.0	0.5	0.4	0.9
3.8	0.0	0.0	0.4	0.4	0.8
3.9	0.0	0.0	0.3	0.4	0.7
4.0	0.0	0.0	0.2	0.4	0.6
4.1	0.0	0.0	0.1	0.4	0.5
4.2	0.0	0.0	0.1	0.4	0.5
4.3	0.0	0.0	0.1	0.4	0.4
4.4	0.0	0.0	0.0	0.4	0.4
4.5	0.0	0.0	0.0	0.4	0.4
4.6	0.0	0.0	0.0	0.4	0.4
4.7	0.0	0.0	0.0	0.4	0.4
4.8	0.0	0.0	0.0	0.4	0.4
4.9	0.0	0.0	0.0	0.4	0.4
Total (mm)	**33.9**	**15.3**	**15.3**	**3.6**	**18.9**

Graph



Audit comments

Catchment

Catchment descriptors imported from file
Catchment descriptor file = 'Lin Burn.csv'
Catchment decriptor file exported from CD ROM version 1
BFIHOST value of 0.414 used
PROPWET value of 0.61 used
SAAR value of 1099 used
DPLBAR value of 1.02 used
DPSBAR value of 43.9 used
URBEXT value of 0.031 used
C value of -0.019 used

Revitalised FSR/FEH rainfall runoff method

Spreadsheet application report

D1 value of 0.407 used
D2 value of 0.4 used
D3 value of 0.412 used
E value of 0.253 used
F value of 2.352 used

Rainfall
Recommended season is Winter, as URBEXT < 0.125
ReFH design standard Seasonal Correction Factor of 0.72 applied
ReFH design standard Areal Reduction Factor of 0.97 applied

Loss Model
C_{Max} derived from catchment descriptors
ReFH design standard C_{ini} used
ReFH design standard α factor used

Routing Model
T_p derived from catchment descriptors
ReFH design standard used for U_p
ReFH design standard used for U_k

Baseflow Model
BL derived from catchment descriptors
BR derived from catchment descriptors
ReFH design standard BF_0 used

INSTITUTE OF HYDROLOGY FLOOD ESTIMATION FOR SMALL CATCHMENTS METHOD

(IN ACCORDANCE WITH METHODOLOGY OUTLINED IN DEFRA/ENVIRONMENT AGENCY TECHNICAL REPORT PRELIMINARY RAINFALL RUNOFF MANAGEMENT FOR DEVELOPMENTS)

Dougall Baillie Associates
CONSULTING ENGINEERS
3 GLENFIELD ROAD, KELVIN
EAST KILBRIDE G75 0RA
Tel: (01355) 266480 Fax: (01355) 221991
E-mail: enquiries@dougallbaillie.com

Job No.	6667
Calculation	Defra/Environment Agency Preliminary rainfall runoff management for developments Greenfield Peak Flow Runoff Analysis (IH R124)
Project	M8 Bishopton Interchange Redrow Homes (Scotland) Ltd

Date:	Initials	Checked	Revisions
28.07.06	NI	RJD	

Greenfield Estimation of Peak Flow Rate of Runoff (in accordance with methodolgy outlined in Defra/Environment Agency Technical Report Preliminary Rainfall Runoff Management for Developments.

	User Data Input
	Automatic Data Input
	Automatic Calculation
	User Calculation

1. Hydrological Region (1 - 9)	(R)	2		UK is divided up into 10 hydrological regions reflecting the different flood frequency growth curves (Appendix 1, Figure 1.1)
2. (SOIL) type (1 - 5)	(S)	4		Refer to Wallingford Procedure WRAP map or FSR maps (Appendix 1, Figure 5)
3. Catchment Size	(a)	131	ha	The size of the gross catchment excluding large parkland areas being allocated as public open space which remain unmodified

4. Method of Greenfield Analysis

If catchment area is greater than 200 ha a full FEH analysis is recommended to obtain a more accurate estimate of greenfield runoff characteristics

5. Site Area	(A)	2.78	ha	Excluding public open space not modified by the development
6. Annual Rainfall	(SAAR)	1108	mm	SAAR - use either SAAR from FSR/FEH CD-ROM or AAR from FEH (Appendix 1, Figure 4)
7. Soil runoff coefficient	(SPR)	0.47		SPR value for SOIL - this is not the FSR index class value for SOIL (1 - 5) but is corresponding runoff coefficient as follows:

SOIL	1	2	3	4	5
SPR	0.10	0.30	0.37	0.47	0.53

Dougall Baillie Associates
CONSULTING ENGINEERS
3 GLENFIELD ROAD, KELVIN
EAST KILBRIDE G75 0RA
Tel: (01355) 266480 Fax: (01355) 221991
E-mail: enquiries@dougallbaillie.com

Calculation: Defra/Environment Agency
Preliminary rainfall runoff management for developments
Greenfield Peak Flow Runoff Analysis (IH R124)

Project: M8 Bishopton Interchange
Redrow Homes (Scotland) Ltd

Date:	Initials	Checked	Revisions
28.07.06	NI	RJD	

8. Site mean annual peak flow
$= 1.08(A/100)^{0.89}.SAAR^{1.17}.SPR^{2.17}$ (Q_{BAR}) **23.0** l/s

For sites of 50 ha or less, use 50 ha when applying formula. Subsequently factor the resulting value by the ratio of the site area to 50 ha (i.e. if the site is 10 ha divide the answer by 5)

9. Mean Annual peak flow per unit area
(Q_{BAR}/A) **8.3** l/s/ha

For SOIL type 1 and occasionally type 2 Q_{BAR}/A will generally have a value less than 1. If so use 1 l/s/ha (*see note 2*)

10. Minimum limit of discharge ($Q_{throttle}$) **N/A**

Minimum discharge (*see note 3*) Enter value or "N/A"

10.1 100 year flow rate per unit area ($Q_{throttle}/A$) **N/A**

Use this value as (Q_{BAR}/A) if it is greater than item 9

10.2 Equivalent mean annual peak flow per unit area ($Q_{throttle}/3.5A$) **N/A**

Use the larger of the 2 values of item 9 and 10.2 for calculating 11.1 to 11.3

11. 1 year, 30 year, 100 year and 200 year peak discharge rate of runoff per unit area

11.1 (Q_{BAR}/A) x 0.85	Q_{1yr}	7.0	l/s/ha
11.2 (Q_{BAR}/A) x GC_{30}	Q_{30yr}	15.5	l/s/ha
11.3 (Q_{BAR}/A) x GC_{100}	Q_{100yr}	21.4	l/s/ha
11.4 (Q_{BAR}/A) x GC_{200}	Q_{200yr}	24.5	l/s/ha

GC30, GC100 and GC 200 are the growth curve ratios Q/Q for the 30 year, 100 year and 200 year events for the relevant hydrological region. The factors are found from Appendix 1, Figure 1.2 from FSSR 14.

Note 1 - HOST classes for soil also have SPR values. Although derived a little differently these values can also be used (IH Report 126 - Hydrology of Soil Types)

Note 2 - Very low values of Q_{BAR}/A result in excessive storage volumes. As Long Term storage for SOIL type 1 is large, a minimum value of QBAR/A of 1 is to be used.

Note 3 - Minimum sizes of an orifice may limit the minimum hydraulic control flow rate. This allows the derivation of an equivalent value of a Q_{BAR}/A.

APPENDIX C
PROPOSED INTERCHANGE LAYOUT
(DBA DRG. NO. 06667(20)02)

DO NOT scale from this drawing

Rev.	Revision details	By	Date	Checked	Date
A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	N.I.	09.08.06	R.J.D.	09.08.06

Client: REDROW HOMES (SCOTLAND) LTD

Project: M8 BISHOPTON INTERCHANGE

Drawing Title: PROPOSED INTERCHANGE LAYOUT

Drawn	N.I.	Checked	R.J.D.
Date	09.08.06	Date	09.08.06
Scale	1:1000	Dwg No.	06667(20)02

DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil . Structural . Transportation
3 Glenfield Road
Kelvin
East Kilbride G75 0RA
Tel: 01355 266480
Fax: 01355 221991
DBA

APPENDIX D
SUDS TREATMENT VOLUME AND DISCHARGE LIMITS

Dougall Baillie Associates
CONSULTING ENGINEERS
3 GLENFIELD ROAD, KELVIN
EAST KILBRIDE G75 0RA
Tel: (01355) 266480 Fax: (01355) 221991
E-Mail: enquiries@dougallbaillie.com

Date	Initials	Checked
28.08.06	GM	RJD

Calculation No. 06667calc02

Page No. 1 of 2

Calculation SUDS Calculations

Revisions					Rev. Date

Project
Redrow Homes (Scotland) Ltd
M8/A8 Interchange, Bishopton

SUDS Treatment Philosophy

The Surface Water Drainage Strategy Report, in accordance with the guidance outlined in CIRIA Report 512 Sustainable Urban Drainage Systems – Design Manual for Scotland and Northern Ireland and CIRIA Report 609 Sustainable Drainage Systems – Hydraulic, structural and water quality advice, the recommends that surface water runoff arising onsite should undergo robust SUDS treatment prior to discharge to the receiving watercourses.

Treatment Volumes

In accordance with CIRIA Report 512 Sustainable Urban Drainage Systems – Design Manual for Scotland and Northern Ireland the Treatment Volume (V_t) has been calculated using the first 12mm of rainfall falling on impermeable areas.

Attenuation Criteria

In accordance with current Renfrewshire Council policy surface water discharges from new developments directly to a watercourse should be limited to the existing 1 in 2 year 'greenfield' runoff rate which has been estimated to be in the region of 8 l/s/ha.

Western Roundabout Network

Approximate contributing area = 1.37 hectares

Treatment Volume, V_t = contributing area x 12mm
= $13700m^2$ x 0.012m
= $165m^3$

Required Treatment Volume = 3 x V_t
= 3 x $165m^3$
= **$495m^3$**

Discharge Limit = contributing area x 8 l/s/ha
= 1.37 ha x 8 l/s/ha
= **11 l/s**

Dougall Baillie Associates
CONSULTING ENGINEERS
3 GLENFIELD ROAD, KELVIN
EAST KILBRIDE G75 0RA
Tel: (01355) 266480 Fax: (01355) 221991
E-Mail: enquiries@dougallbaillie.com

Date	Initials	Checked
28.08.06	GM	RJD

Project
Redrow Homes (Scotland) Ltd
M8/A8 Interchange, Bishopton

Eastern Roundabout Network

Approximate contributing area = 0.42 hectares

Treatment Volume, V_t = contributing area x 12mm
= $4200m^2$ x 0.012m
= $50m^3$

Required Treatment Volume = 3 x V_t
= 3 x $50m^3$
= **$150m^3$**

Discharge Limit = contributing area x 8 l/s/ha
= 0.42 ha x 8 l/s/ha
= **4 l/s**

On Ramp and Off Ramp Network

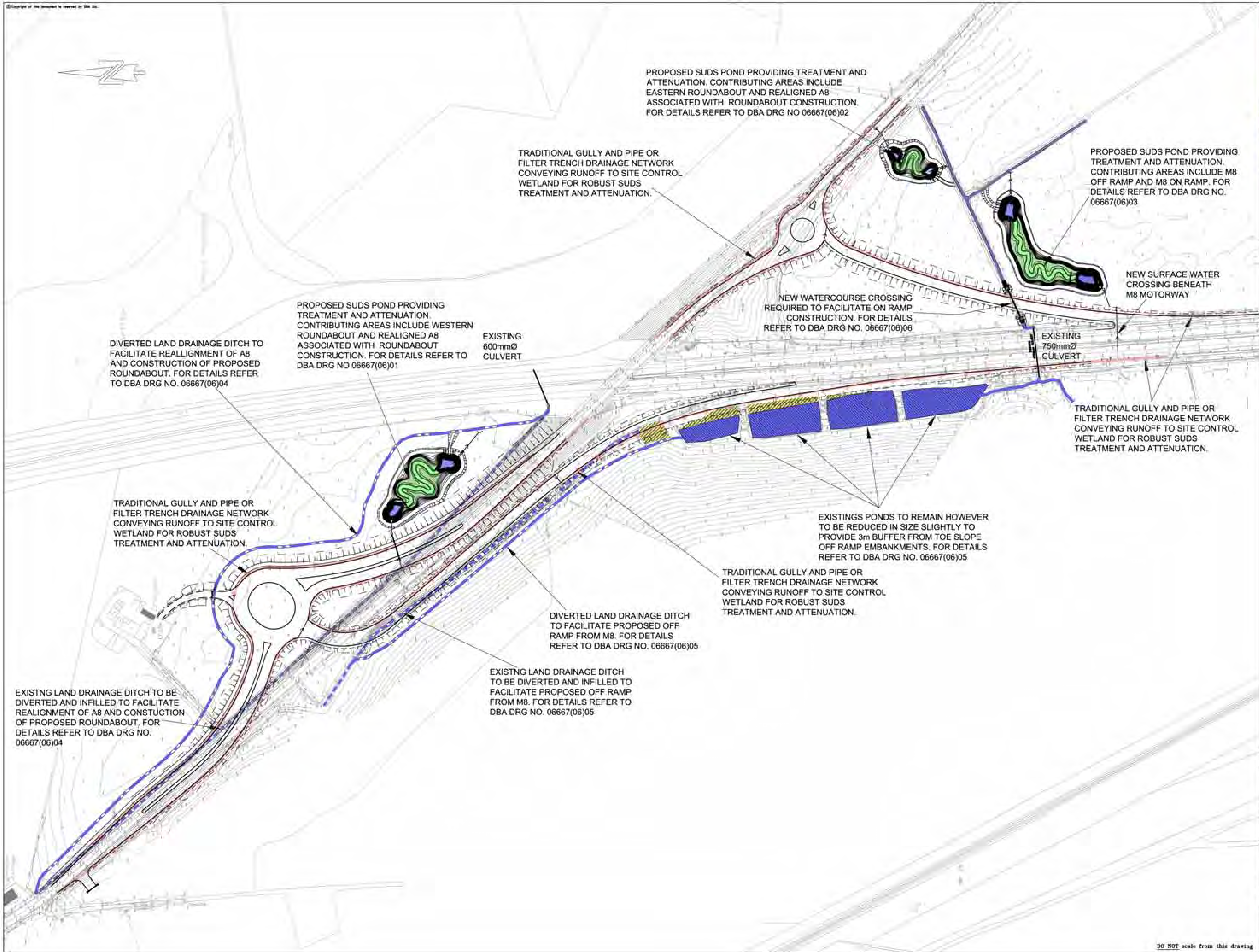
Approximate contributing area = 1.72 hectares

Treatment Volume, V_t = contributing area x 12mm
= $17200m^2$ x 0.012m
= $210m^3$

Required Treatment Volume = 3 x V_t
= 3 x $210m^3$
= **$630m^3$**

Discharge Limit = contributing area x 8 l/s/ha
= 1.72 ha x 8 l/s/ha
= **14 l/s**

APPENDIX E
SUDS MASTERPLAN
(DBA DRG. NO. 06667(20)03)



LEGEND

A	REVISED TO SUIT LATEST OFF RAMP LAYOUT		
Client	REDROW HOMES (SCOTLAND) LTD		
Project	M8 BISHOPTON INTERCHANGE		
Drawing Title	PROPOSED SUDS MASTERPLAN		
Drawn	N.I.	Checked	R.J.D.
Date	09.08.06	Date	09.08.06
Scale	1:1000	Drg No.	06667(20)03

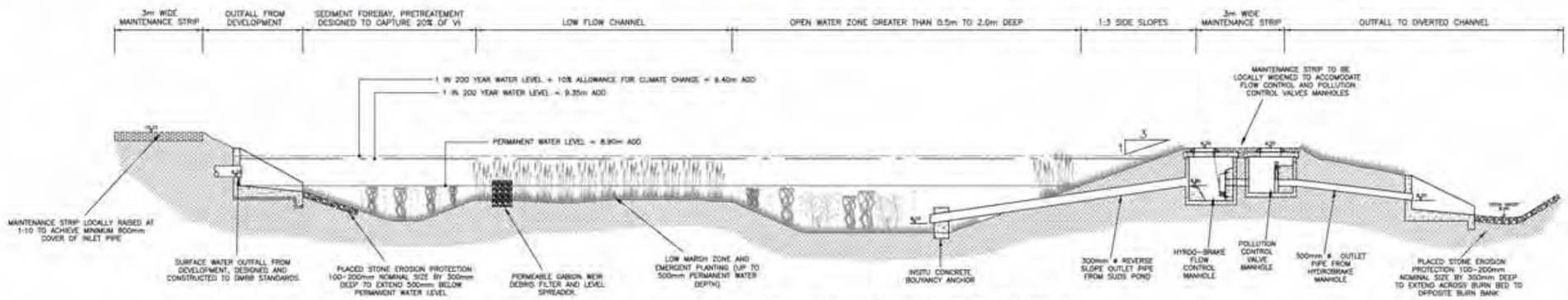
DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS

DBA

DO NOT scale from this drawing

APPENDIX F
WESTERN ROUNDABOUT DRAINAGE STRATEGY PLANS
(DBA DRG. NO.'S 06667(06)01 AND 06667(06)04)

SUDS LAYOUT PLAN
(SCALE 1:250)



TYPICAL SCHEMATIC CROSS SECTION
(NOT TO SCALE)

LEGEND

PLANTING ZONE — WATER DEPTH

HIGH GRASS, DRY SLOPE, MEADOW OR SEASONAL FLOODING — 200mm ATTENUATION STORAGE

LOW MARSH EMERGENT PLANTING — 0-0.2m

HIGH MARSH EMERGENT PLANTING — 0.2-0.5m

OPEN WATER ZONES FLOATING PLANTING — 0.5-1.0m

OPEN WATER PONDS — 1.0-1.6m

MAINTENANCE STRIP

PERMEABLE GABION WEIR

SWITCH LAND DRAINAGE

EXISTING LAND DRAINAGE TO BE DIVERTED

NOTES

1. ALL SURFACE WATER SUDS DESIGNED IN CONJUNCTION WITH THE GUIDANCE OUTLINED IN CIRIA STL01, SUDS DESIGN MANUAL FOR SCOTLAND AND NORTHERN IRELAND AND CIRIA 609E, SUDS HYDRAULIC, STRUCTURAL AND WATER QUALITY ADVICE AND TO THE REQUIREMENTS OF SEPA.

2. ALL CONTOURS SHOW 0.1m CHANGE IN ELEVATION.

SURFACE WATER TREATMENT VOLUMES

Vt = 12mm CONTRIBUTING FROM IMPERMEABLE AREAS

Vt = (0.012 x 13700) = 165m3

SUDS POND DESIGNED IN ACCORDANCE WITH DRAINAGE STRATEGY TO PROVIDE 3 x TREATMENT VOLUME.

3Vt = (3 x 165) = 495m3

DESIGN CONSIDERATIONS

MINIMUM VOLUME OF SEDIMENT FOREBAY TO BE 20% Vt = 100m3

ACTUAL VOLUME PROVIDED = 100m3

STORM WATER ATTENUATION

ALL FLOWS TO BE CONTROLLED TO GREENFIELD RUNOFF RATE = 8 l/s/ha

MAXIMUM ALLOWABLE DISCHARGE UP TO CRITICAL 200 YEAR EVENT = 11 l/s

ALLOWANCE FOR CLIMATE CHANGE 10%

CRITICAL 200 YEAR PLUS 10% ALLOWANCE FOR CLIMATE CHANGE STORAGE VOLUME IN POND = 770m3

DO NOT scale from this drawing

A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	N.J.	23.08.06
No.	Revision details	By	Date

Client: REDROW HOMES (SCOTLAND) LTD

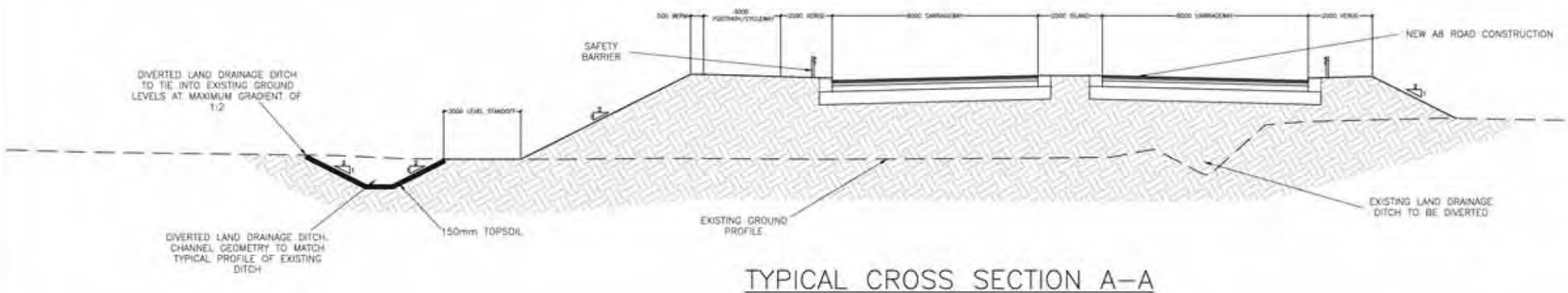
Project: M8 BISHOPTON INTERCHANGE

Drawing Title: WESTERN ROUNDABOUT SUDS LAYOUT AND TYPICAL SCHEMATIC CROSS SECTION

Drawn	N.J.	Checked	G.M.
Date	23.08.06	Date	23.08.06
Scale	AS SHOWN	Drg. No.	06667(06)01

DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
3 Cadogan Road
Ayr
Tel: 01292 286487
Fax: 01292 611661
DBA

WATERCOURSE DIVERSION WORKS LAYOUT PLAN
(SCALE 1:1000)



TYPICAL CROSS SECTION A–A
(SCALE 1:100)

DO NOT scale from this drawing

LEGEND

DIVERTED LAND DRAINAGE

EXISTING LAND DRAINAGE TO BE DIVERTED

Rev.	Revision details	By / Date	Checked / Date
A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	N.I. 24.08.06	R.J.D. 24.08.06

Client: REDROW HOMES (SCOTLAND) LTD

Project: M8 BISHOPTON INTERCHANGE

Drawing Title: WESTERN ROUNDABOUT LAND DRAINAGE DIVERSION WORKS

Drawn: N.I.	Checked: G.M.
Date: 24.08.06	Date: 24.08.06
Scale: AS SHOWN	Drg No.: 06667(06)04

DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil - Structural - Transportation
3 Glenfield Road
Kelvin
East Kilbride G75 0RA
Tel: 01355 226480
Fax: 01355 221991

APPENDIX G
EASTERN ROUNDABOUT DRAINAGE STRATEGY PLANS
(DBA DRG. NO. 06667(06)02)

SUDS LAYOUT PLAN
(SCALE 1:250)

SUDS LAYOUT IN RELATION TO SITE
(SCALE 1:1000)

LEGEND

PLANTING ZONE — WATER DEPTH

ROUGH GRASS SIDE SLOPES TOLERANT OF OCCASIONAL FLOODING — 100% ATTENUATION STORAGE — 0 - 0.1m

LOW MARSH EMERGENT PLANTING — 0 - 0.2m

HIGH MARSH EMERGENT PLANTING — 0 - 0.2m

DEEP WATER ZONE/ FLOATING PLANTING — 0.2 - 1.2m

OPEN WATER POND — 0.2 - 1.2m

MAINTENANCE STRIP

PERMEABLE GABION WEIR

EXTENT OF TREATMENT PONDS TO BE INFILLED TO FACILITATE SAT RAMP FORMATION

EXISTING TREATMENT PONDS TO BE RETAINED

EXISTING WATERCOURSE TO BE RETAINED

NOTES:

1. ALL SURFACE WATER SUDS DESIGNED IN CONJUNCTION WITH THE GUIDANCE OUTLINED IN CIRIA C521, SUDS DESIGN MANUAL FOR SCOTLAND AND NORTHERN IRELAND AND CIRIA 609, SUDS HYDRAULIC, STRUCTURAL AND WATER QUALITY ADVICE AND TO THE REQUIREMENTS OF SEPA.

2. ALL CONTOURS SHOW 0.1m CHANGE IN ELEVATION.

SURFACE WATER TREATMENT VOLUMES

Vt = 12mm CONTRIBUTION FROM IMPERMEABLE AREAS.

Vt = (0.012 x 4175) = 50m3

SUDS POND DESIGNED IN ACCORDANCE WITH DRAINAGE STRATEGY TO PROVIDE 3 X TREATMENT VOLUME.

3vt = 3 x 50 = 150m3

DESIGN CONSIDERATIONS

MINIMUM VOLUME OF SEDIMENT FOREBAY TO BE 20% Vt = 10m3.

ACTUAL VOLUME PROVIDED = 27m3

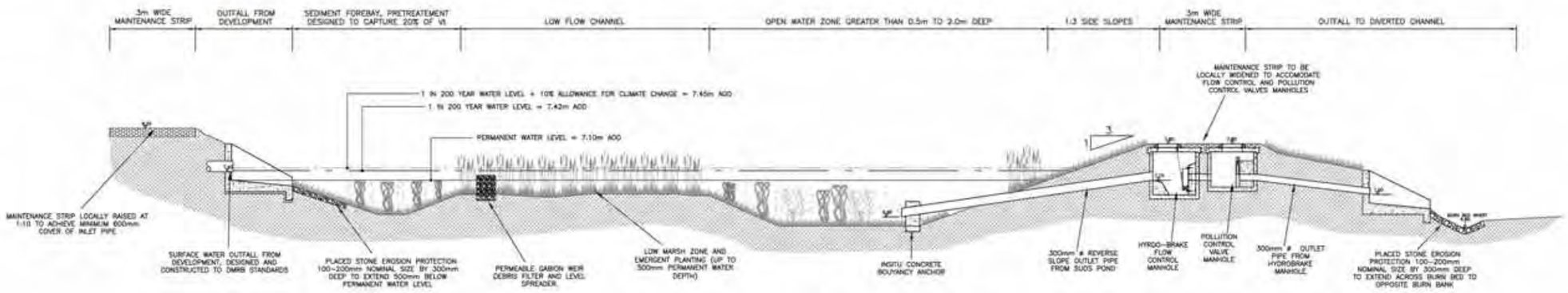
STORM WATER ATTENUATION

ALL FLOWS TO BE CONTROLLED TO QMED GREENFIELD RUNOFF RATE = 4 l/s/ha

MAXIMUM ALLOWABLE DISCHARGE UP TO CRITICAL 200 YEAR EVENT = 4 l/s

ALLOWANCE FOR CLIMATE CHANGE 10%

CRITICAL 200 YEAR PLUS 10% ALLOWANCE FOR CLIMATE CHANGE STORAGE VOLUME IN POND = 210m3



TYPICAL SCHEMATIC CROSS SECTION
(NOT TO SCALE)

DO NOT scale from this drawing

A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	N.I.	G.M.
Rev	Revision details	By	Checked
		Date	Date

Client: REDROW HOMES (SCOTLAND) LTD

Project: M8 BISHOPTON INTERCHANGE

Drawing Title: EASTERN ROUNDABOUT SUDS LAYOUT AND TYPICAL SCHEMATIC CROSS SECTION

Drawn N.I.	Checked G.M.
Date 29.08.06	Date 29.08.06
Scale AS SHOWN	Dwg No 06887(06)02

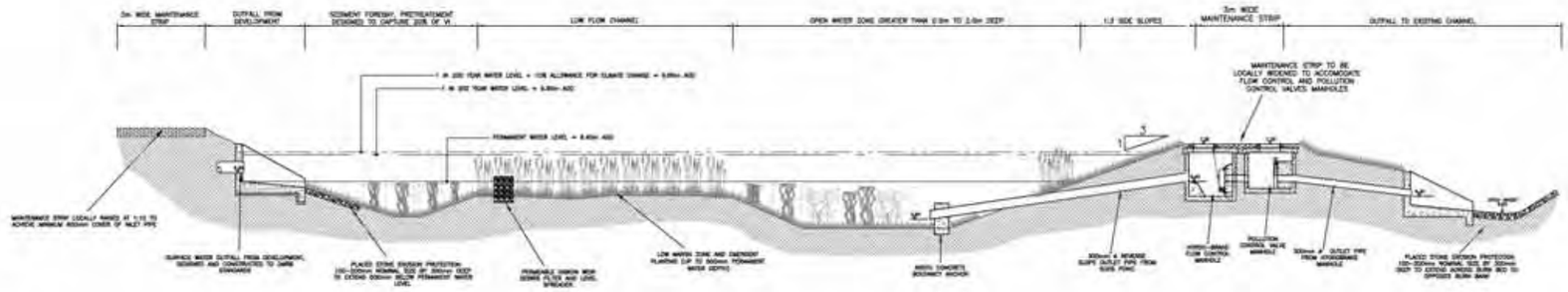
DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil - Structural - Transportation
3 Glenfield Road
Kilsyth
Tel: 01355 [illegible]
Fax: 01355 221491

APPENDIX H

ON RAMP/OFF RAMP DRAINAGE STRATEGY PLANS (DBA DRG. NO.'S 06667(06)03, 06667(06)05 AND 06667(06)06)

SUDS LAYOUT PLAN
(SCALE 1:250)

SUDS LAYOUT IN RELATION TO SITE
(SCALE 1:1000)



TYPICAL SCHEMATIC CROSS SECTION
(NOT TO SCALE)

DO NOT scale from this drawing

LEGEND

PLANTING ZONE — WATER DEPTH

YEARLY GRASS CUT SLOPE SUBJECT TO OCCASIONAL FLOODING — DRY / FLUCTUATION ZONE / 0m

LOW MARSH EMERGENT PLANTING — 0 to 0.3m

HIGH MARSH EMERGENT PLANTING — 0.3 to 0.6

OPEN WATER ZONES FLOATING PLANTING — 0.6 to 1.0

OPEN WATER PONDS — 1.0 to 2.0m

MAINTENANCE STRIP

PERMEABLE GABION WEIR

EXTENT OF TREATMENT PONDS TO BE INFILLED TO FACILITATE DRY RAMP FORMATION

EXISTING TREATMENT PONDS TO BE RETAINED

EXISTING WATERCOURSE TO BE RETAINED

NOTES

1. ALL SURFACE WATER SUDS DESIGNED IN CONJUNCTION WITH THE GUIDANCE OUTLINED IN CIRIA C521, SUDS DESIGN MANUAL FOR SCOTLAND AND NORTHERN IRELAND AND CIRIA 609, SUDS HYDRAULIC, STRUCTURAL AND WATER QUALITY ADVICE AND TO THE REQUIREMENTS OF SEPA.

2. ALL CONTOURS SHOW 0.1m CHANGE IN ELEVATION

SURFACE WATER TREATMENT VOLUMES

Vt = 12mm CONTRIBUTING FROM IMPERMEABLE AREAS

Vt = (0.012 x 17200) = 210m3

SUDS POND DESIGNED IN ACCORDANCE WITH DRAINAGE STRATEGY TO PROVIDE 3 # TREATMENT VOLUME

3Vt = (3 x 210) = 630m3

DESIGN CONSIDERATIONS

MINIMUM VOLUME OF SEDIMENT FOREBAY TO BE 20% Vt = 126m3

ACTUAL VOLUME PROVIDED = 140m3

STORM WATER ATTENUATION

ALL FLOWS TO BE CONTROLLED TO QMED GREENFIELD RUNOFF RATE = 8 l/s/ha

MAXIMUM ALLOWABLE DISCHARGE UP TO CRITICAL 200 YEAR EVENT = 14 l/s

ALLOWANCE FOR CLIMATE CHANGE 10%

CRITICAL 200 YEAR PLUS 10% ALLOWANCE FOR CLIMATE CHANGE STORAGE VOLUME IN POND = #70m3

A	REVISED TO SUIT LATEST ROADS LAYOUT AND TO INCORPORATE SEPA DRAINAGE STRATEGY	N.J.	16.08.06
No.	Revision details	Drn.	Date

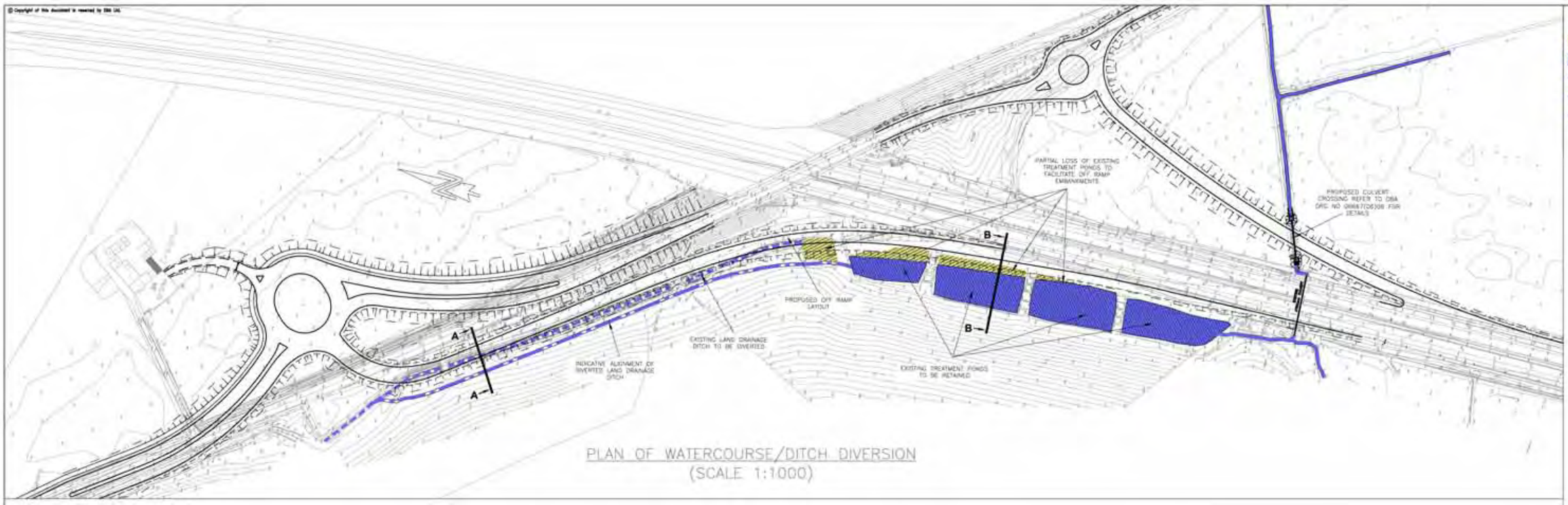
Client: REDROW HOMES (SCOTLAND) LTD

Project: M8 BISHOPTON INTERCHANGE

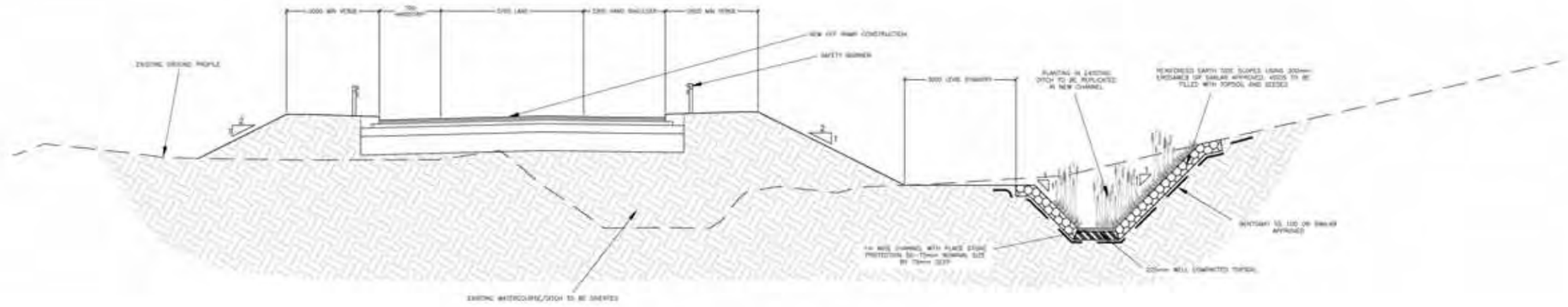
Drawing Title: ON RAMP/OFF RAMP SUDS LAYOUT AND TYPICAL SCHEMATIC CROSS SECTION

Drawn	N.J.	Checked	R.J.D.
Date	16.08.06	Date	16.08.06
Scale	AS SHOWN	Dwg No.	06667(06)03

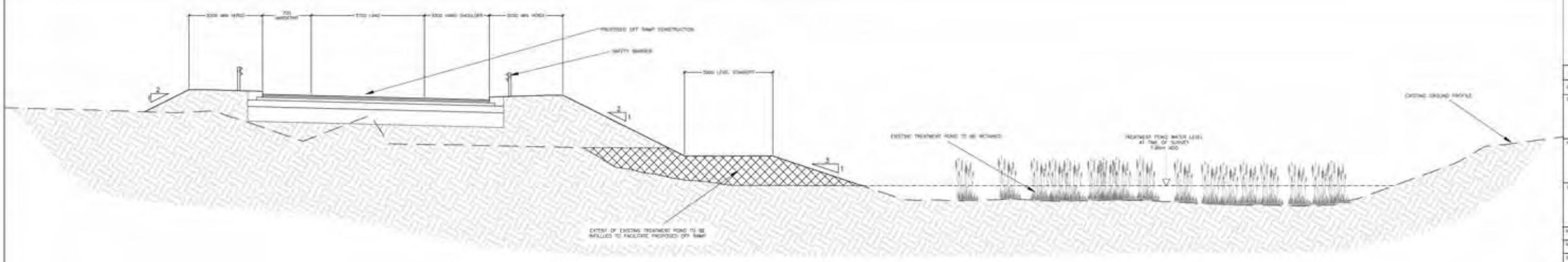
BOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil · Structural · Transportation
3 Eastfield Road
Carluke
East Kilbride G75 0RA
Tel: 01555 290480
Fax: 01555 251987
DBA



PLAN OF WATERCOURSE/DITCH DIVERSION
(SCALE 1:1000)



TYPICAL CROSS SECTION A–A
(SCALE 1:50)



TYPICAL CROSS SECTION B–B
(SCALE 1:50)

DO NOT scale from this drawing

A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	K.L.	24.08.09
Rev	Revision details	By	Date

Client: REDROW HOMES (SCOTLAND) LTD

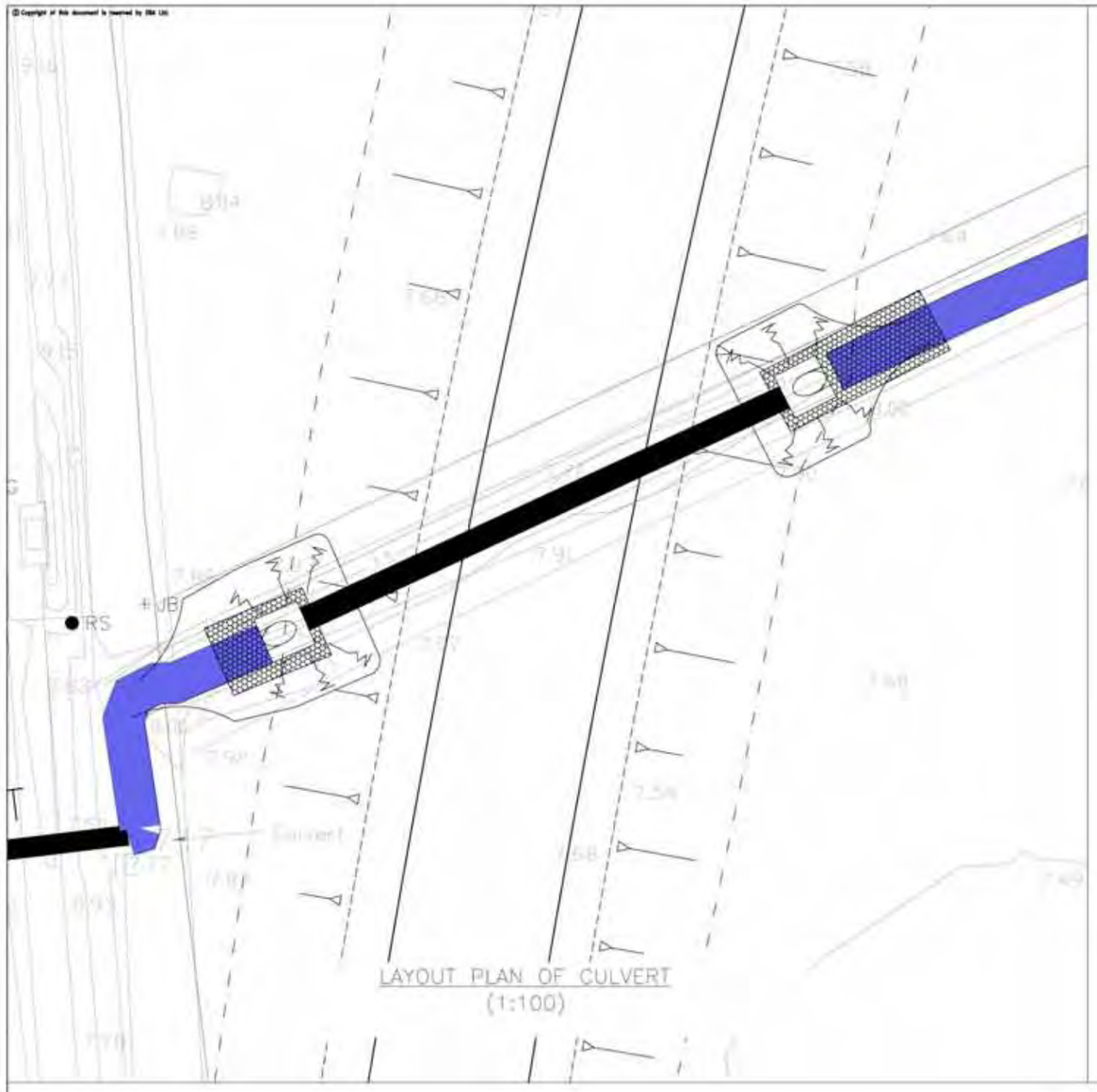
Project: M8 BISHOPTON INTERCHANGE

Drawing Title: OFF RAMP LAND DRAINAGE DIVERSION WORKS

Drawn: N.I	Checked: C.M
Date: 24.08.09	Date: 24.08.09
Scale: AS SHOWN	File No: 06667(D6305

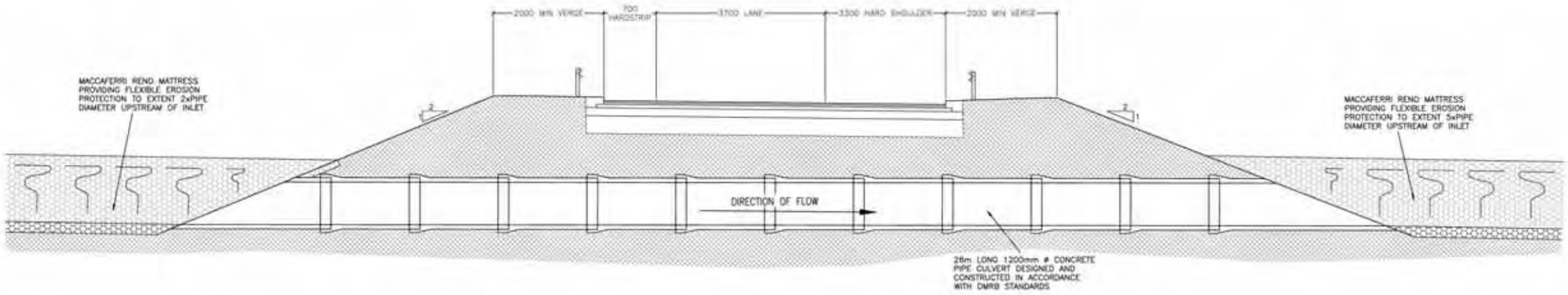
DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil . Structural . Transportation
3 Glenfield Road
Bearsden
East Kilbride G75 0RA
Tel: 01355 266480
Fax: 01355 221481

DBA



LAYOUT PLAN OF CULVERT
(1:100)

LOCATION IN RELATION TO DEVELOPMENT
(SCALE 1:1000)



TYPICAL CROSS SECTION THROUGH CULVERT
(SCALE 1:50)

DO NOT scale from this drawing

A	REVISED TO SUIT LATEST OFF RAMP LAYOUT	N.J.	25.08.06
Rev.	Revision details	By	Chkd Date

Client: REDROW HOMES (SCOTLAND) LTD

Project: M9 BISHOPTON INTERCHANGE

Drawing Title: PROPOSED CULVERT CROSSING

Drawn: N.J.	Checked: C.M.
Date: 25.08.06	Date: 25.08.06
Scale: AS SHOWN	Dwg No: 06667(06)06

DOUGALL BAILLIE ASSOCIATES
CONSULTING ENGINEERS
Civil Structural Transportation
2 Gardner Road
Ayr
Scotland KA7 3AA
Tel: 01292 285480
Fax: 01292 287287